Provision of Human Capital Evidence Review

A Report for the Office for National Statistics

by

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Table of Contents

1. Introduction .......................................................................................................................... 5

2. Factors affecting human capital accumulation and their measurement .............................. 8
   2.1. Family background and household structure ............................................................. 10
       2.1.1. Parental education and educational attainment .............................................. 10
       2.1.2. Parental education and cognitive and non-cognitive skills .................................. 15
       2.1.3. Family structure and offspring education ...................................................... 17
       2.1.4. Wider family and environmental factors ....................................................... 22
   2.2. The role of health in human capital accumulation ....................................................... 24
       2.2.1. Ageing ................................................................................................................. 25
       2.2.2. Health and education ....................................................................................... 27
       2.2.3. Health and labour supply ................................................................................. 29
       2.2.4. Provision of and access to health care ............................................................. 30
       2.2.5. Earning effects on health .................................................................................. 32
       2.2.6. Lifestyle, access and health conditions ............................................................ 34
   2.3. Job mobility, skills, and training .................................................................................... 40
       2.3.1. Firm, industry and occupation-specific human capital ..................................... 41
       2.3.2. Work characteristics ....................................................................................... 41
       2.3.3. Estimating the costs of mobility ....................................................................... 43
       2.3.4. Job mobility in the UK ..................................................................................... 47
   2.4. Within-country migration ............................................................................................. 49
   2.5. Crime ............................................................................................................................ 53
       2.5.1. Economics of education and crime ................................................................. 54
       2.5.2. Family and crime ............................................................................................. 58
       2.5.3. Educational/vocational programs and recidivism ............................................. 58
   2.6. Learning .......................................................................................................................... 59
       2.6.1. Education environment .................................................................................... 59
       2.6.2. Adult learning ................................................................................................... 63
   3. Determinants of earnings and their use in valuing human capital ..................................... 65
      3.1. Returns to education .................................................................................................... 66
          3.1.1. Educational qualification, degree subject, and institutional quality ....................... 67
          3.1.2. Higher education and earnings ........................................................................ 68
          3.1.3. Institutional characteristics .............................................................................. 69
3.1.4. Identifying causal effects

3.2. Skills and personality traits

  3.2.1. Cognitive skills

  3.2.2. Personality traits

3.3. Family background and earnings

3.4. Health as an earnings determinant

3.5. Job mobility

3.6. On-the-job training

4. Conclusion

5. References
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>AI</td>
<td>Artificial Intelligence</td>
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<tr>
<td>BCS</td>
<td>British Cohort Study</td>
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<td>BHPS</td>
<td>British Household Panel Survey</td>
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<td>DiD</td>
<td>Difference-in-Difference</td>
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<td>GLS</td>
<td>Generalised Least Squares</td>
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<td>HESA</td>
<td>Higher Education Statistics Agency</td>
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<td>ILO</td>
<td>International Labour Organization</td>
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<td>IGE</td>
<td>Intergenerational Elasticity</td>
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<td>IQ</td>
<td>Intelligence Quotient</td>
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<td>IV</td>
<td>Instrumental Variable</td>
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<td>LFS</td>
<td>Labour Force Survey</td>
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<td>NCDS</td>
<td>National Child Development Study</td>
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<td>NHS</td>
<td>National Health Service</td>
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<td>NLSY</td>
<td>National Longitudinal Survey of Youth</td>
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<td>NPD</td>
<td>National Pupil Database</td>
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<tr>
<td>OECD</td>
<td>Organization for Economic Co-operation and Development</td>
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<td>OLS</td>
<td>Ordinary Least Squares</td>
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<td>ONS</td>
<td>Office for National Statistics</td>
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<td>PIAAC</td>
<td>OECD Survey of Adult Skills</td>
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<td>PISA</td>
<td>Programme for International Student Assessment</td>
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<td>STEM</td>
<td>Science, Technology, Engineering and Mathematics</td>
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<td>TTWA</td>
<td>Travel To Work Area</td>
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<td>UNICEF</td>
<td>United Nations International Children's Emergency Fund</td>
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<td>WHO</td>
<td>World Health Organisation</td>
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1. Introduction

The measurement of human capital stock is high on the policy agenda given its importance as a driver of economic growth. Although there has been increased interest in the measurement of human capital, particularly in recent times, the concept of human capital goes back almost 250 years. Adam Smith (1776) described human capital as “the acquired and useful abilities of all the inhabitants or members of the society” which, once acquired, are “a capital fixed and realised, as it were, in his person”. Starting in the 1960s, economists treated these abilities as assets and used the notion of human capital to explain output differences which they could otherwise not explain by traditional inputs. As a consequence, the definition of human capital evolved over time and later was broadened to encompass the knowledge, skills, capacities and abilities embodied in an individual that contribute to economic production and social well-being (Schultz, 1961; OECD, 1998; World Bank, 2006). Despite this evolved definition, previous research tended to proxy human capital with education, measured mainly by schooling (Schultz, 1961; Mincer, 1974; Lucas, 1988; Barro, 1991; and Mankiw et al., 1992). The fundamental insight of human capital is that education can be considered as an investment into the knowledge and skills of individuals (Checchi, 2006). Existing evidence so far indicates that higher levels of acquired schooling improve individual earnings (Psacharopoulos and Patrinos, 2018) and also productivity (Wössmann, 2016).

At the national level, human capital is strongly correlated with economic growth (Hanushek and Wössmann, 2012). Recently, the World Bank developed a human capital index that attempts to identify the trajectory of individuals and how they impact on the productivity of the next generation of workers. Specifically, the index captures the amount of human capital a child born today could expect to attain by age 18, taking into account current risks of poor health and poor education. It uses under-age-5 mortality rates taken from the United Nations Child Mortality Estimates, adult survival rates, age-specific enrolment rates, prevalence of stunting taken from the United Nations International Children’s Emergency Fund (UNICEF), the World Health Organisation (WHO) as well as the World Bank Joint Malnutrition Estimates, and harmonised test scores from international student achievement testing programs. Another recently developed human capital index measure is by the World Economic Forum which covers 130 countries. The index is based on 21 indicators including literacy, numeracy, educational attainment and enrolment, (un)employment rates, school quality, among many others, obtained mostly from publicly available data originally collected by the International Labour

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1 For more detailed information on the data and methodology, please refer to the following report published in 2018 http://documents.worldbank.org/curated/en/300071537907028892/pdf/WPS8593.pdf

2 For more detailed information on the data and methodology, please refer to Appendix B of the following report published in 2017 (see https://weforum.ent.box.com/s/dari4dktg4jrt2g9xo2o5pksjpatavwdb).
Organization (ILO), the United Nations Educational, Scientific and Cultural Organization and qualitative survey data from the World Economic Forum’s Executive Opinion Survey.\(^3\)

In the UK, the Office for National Statistics (ONS) current estimates of human capital stock are based on the Jorgenson and Fraumeni (1989, 1992) income-based approach.\(^4\) In this approach, potential lifetime earnings of each individual in the active population are calculated, differentiated by gender, age and education and taking account of the probabilities that those in younger age groups remain in education. These earnings are then summed across people in each age, gender and education qualification group to yield an overall figure for human capital stock. Although this is in line with the United Nations Economic Commission for Europe guidelines on Measuring Human Capital and allows for education, employment and demography to interact and jointly explain economic changes, this approach is heavily reliant on education as a human capital driver and leaves no room for other determinants. Therefore, this literature review has been carried out on recent important developments that are necessary to help the ONS to identify other possible factors which can be relevant in its own attempts at developing a more comprehensive measure of human capital.

In this review, focus is put on the UK context and studies published within the last 10 years although we also cover relevant and timely evidence for other countries as well as older highly influential papers that help set the context and contribution of the review. We find that while some factors offer insightful views and findings on the underlying determinants of human capital, the lack of evidence in the UK and occasional contradicting results plague some of the conclusions drawn. The review is based mostly on evidence from studies with a quantitative approach which have been published in high-ranked academic journals that are regarded as leaders or among the leaders in their respective discipline or area. As a guide for selecting the journals, we rely on the Association of Business Schools rankings.\(^5\) In exceptional cases, we review articles and publications that are not listed in this ranking but are innovative, of good methodological quality or are widely cited in their respective field. We also resort to published works by reputable organisations such as the Organisation for Economic Co-operation and Development (OECD), the World Bank, the Institute for Fiscal Studies, among others.

\(^3\) Very recently, Angrist et al. (2019) with the help of the World Bank, constructed a database of globally comparable learning outcomes for 164 countries and territories covering 98 per cent of the global population from 2000 to 2017. They aim for this dataset to be updated annually to allow observing human capital accumulation over time. For more detailed information on the data employed, please refer to their Appendix A.

\(^4\) There are essentially three methods employed to measure human capital stock, cost-based, attainment-based or income-based (see Jones and Chiripanhu (2010) for reviews). Other international examples of measuring human capital accumulation include: Australia (see Wei, 2004, 2008), Canada (see Gu and Wong, 2010), China (see Li et al., 2013), New Zealand (see Le et al., 2006), Norway (see Liu and Greaking, 2009), Sweden (see Ahlroth et al., 1997) and the US (see Christian, 2010).

\(^5\) https://charteredabs.org/academic-journal-guide-2018/
The review is structured as follows: first, it discusses the individual and combined role of factors that are considered to be relevant in the process of human capital accumulation. These include family background and household structure, ageing and health, job mobility, skills and training, within-country migration and crime. Second, it reviews determinants of earnings and their use in valuing human capital. This section focuses on studies on returns to education, cognitive skills and personality traits, family background, health and job mobility as well as on-the-job training. A large majority of the studies covered in this part of the review are considered of high methodological quality both in terms of data and econometric techniques. We end this literature review with a concluding chapter on the emerging findings.
2. Factors affecting human capital accumulation and their measurement

This section aims to highlight some of the factors associated with human capital development. First, the review starts with a look at the role of family background, namely, parental education, and family structure. These two are known to play an influential part on early childhood development and in forming the foundation for future economic success. Secondly, the interest in health (and also ageing) as a component of human capital is considered. Health is viewed as an investment good, which has the ability to improve individual well-being and, at the same time, increases time that people can allocate to work in order to accumulate wealth. Thirdly, an efficiently functioning labour market is continuously reallocating labour in response to changing demands. Therefore, we review literature on job mobility and the need to develop new skills and enhance existing skills through training which all become increasingly relevant in today's modern economy. Fourthly, we review the role of regional migration in generating knowledge and shaping the redistribution of human capital. Finally, human capital accumulation can be affected by criminal activities and, therefore, we review literature on the relationship between criminal participation and education, family background as well as intervention programs.

Key findings show that indeed family background plays a fundamental role in shaping future economic prospects of individuals (Dearden et al., 1997; Delaney et al., 2011; Corak, 2013). Studies that examine causal mechanisms, mostly using education policy reforms as an identification strategy for the case of the UK, provide further understanding of the linkage between parental education and children’s human capital development (Chevalier et al., 2013). Results from these studies suggest positive effects on children’s education, although the magnitude of maternal and paternal schooling differs among studies. There is however limited understanding of causal mechanisms for the UK, owing largely to small sample sizes and limited (administrative) data availability on twins, siblings and adopted children. In contrast, many studies for Nordic and other Scandinavian countries use samples of twins, siblings and adopted parents as identification strategies (Plug, 2004; Björklund et al., 2006; Sacerdote, 2007; Holmlund et al., 2011; Pronzato, 2012). In terms of children’s cognitive and non-cognitive skills development, results indicate a positive association with parental cognitive skills at younger ages (Blanden et al., 2007; Brown et al., 2011; de Coulon et al., 2011). These findings suggest that children pick up most of the important attributes and skills needed to perform well in life at earlier stages of their lives. Family structure, such as size of family (Black et al., 2010; Angrist et al., 2010), birth order (Booth and Kee, 2009; Pavan, 2016; Lehmaann et al., 2018), parental presence (Kalil et al., 2016; Gould et al., 2019), gender of siblings (Cools and Patacchini, 2017; Rao and Chatterjee, 2017; Brenøe, 2018) and spillover from siblings (Breining, 2014; Breining et al., 2015; Black et al., 2017; Nicoletti and Rabe, 2017; Qureshi, 2018) also seem to have impacts on children’s education. Later-born children appear to
have lower educational outcomes than their older siblings and this effect tends to be larger in bigger families. This may be mitigated to some extent by spillovers from older siblings performing well in school to younger siblings. Since most studies on family structure and children’s development relate to Scandinavian countries, more evidence is needed for the UK (with the exception of Booth and Kee, 2009 as well as Nicoletti and Rabe, 2017).

A growing body of literature suggests that education has benefits beyond increases in labour market productivity which extend to health. The literature review has highlighted that the majority of UK based studies exploit the increase in the minimum school-leaving age in 1947 and/or 1973 as an exogenous change in the amount of schooling received to examine the causal effect of education on health conditions (e.g. biomarkers), subjective general health and health behaviour, such as smoking. Albeit the common strategy, scholars draw different conclusions and find mixed evidence for the causal effect of education on health (Oreopoulos, 2006; Blanchflower and Oswald, 2008; Silles, 2009; Powdthavee, 2010; Devereux and Hart, 2010; Clark and Royer, 2013; Jürges et al., 2013). Although evidence for the opposite direction of the relationship suggests a health selection process which generates socioeconomic inequalities in child- and young adulthood, the large majority of work is carried out in the US and mainly relies on standard logit regression models. When looking at the context of labour supply, the majority of UK based evidence comes from the British Household Panel Survey (BHPS) and the Understanding Society Survey and the indirect role of informal care provision associated with third parties’ health rather than from the role of individual health (Michaud et al., 2010; Carmichael and Ercolani, 2016; Carr et al., 2016). The same data sources are used in studies on the impact of earnings on health, which mainly use the minimum wage legislation implemented in 1999 as an instrument (Kronenber et al., 2017; Lenhart, 2017; Reeves et al., 2017).

Parts of the literature find evidence suggesting the loss of human capital as a result of movement between jobs and/or occupations; this is evident not only for the individual who may face a significant change in the sets of tasks to perform, but also for firms, which need to bear some of the costs of (re)training the worker (Cortes and Gallipoli, 2017; Artuç et al., 2010; Dix-Carneiro, 2014). In contrast, some literature highlights that human capital may be more portable across occupations than previously thought, as long as job mobility is accompanied to a certain extent by skills transfer (Autor et al., 2003), albeit empirically this has been shown to be more relevant for highly-skilled workers (Poletaev and Robinson, 2008; Carrillo-Tudela et al., 2016). For the UK, the evidence also shows under-utilisation of skills may result from moving from a full-time to a part-time job (Connolly and Gregory, 2008).

On the role of migration, highly educated individuals are found to exhibit highest levels of spatial mobility (Faggian et al., 2015), which contribute to the process of knowledge transfer. The human capital externalities associated with migration behaviour of skilled individuals are found to be a
significant determinant of innovation in British local areas (Gagliardi, 2015) but this relationship is bi-directional as the innovativeness of a region appears as one of the major factors encouraging graduates to seek employment in that region.

Lastly, the review on crime and human capital highlights the role of early educational intervention in reducing criminal activity. Although different features of crime incidence affect human capital, the most widely studied area involves education which reveals that human capital increases the opportunity costs of crime from foregone work and expected costs with incarceration (Lochner, 2004; Lochner and Moretti, 2004). It is important to note that this area of research is growing but it is also mainly carried out using US and Scandinavian administrative data. The few UK based exceptions use the increase in the minimum schooling age in 1997 as an identification strategy (Sabates and Feinstein, 2008; Machin et al., 2011; 2012). The review has further highlighted the lack of empirical evidence for the opposite direction which is mainly due to the difficulty of identifying exogenous variations in criminal involvement.

2.1. Family background and household structure

Among the many factors shown to contribute to human capital development and adulthood labour market outcomes, family background has been found to be the most important characteristic (Heckman et al., 2006a; D’Addio, 2007). The range of family characteristics that have been shown to influence human capital development are parental education, family structure (Ermisch et al., 2012), cultural background and ethnicity, among others. This section provides a review of the literature in relation to the role of family background, namely parental education and family structure. Parental education is a direct input into the education production (see Checchi, 2006) and can affect the choice of other inputs (Chevalier et al., 2013).

2.1.1. Parental education and educational attainment

Numerous studies have found a strong association between parental background, often father’s earnings, and children’s earning (mostly sons). This correlation ranges between 0.2 and 0.5, although some studies find a slightly higher correlation for the UK (see Corak, 2013). The importance of parental education cannot be ruled out when examining the process of human capital development. Estimates of the education intergenerational elasticity (IGE), which shows by how much a child’s earnings change with changes in his/her parents’ earnings, range from 0.14 to 0.45 in the US (Mulligan, 1999) and from 0.25 to 0.40 in the UK (Dearden et al., 1997).

Explanations for the role of parental education on

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6 See Narayan et al. (2018) and OECD (2018) for a thorough discussion on intergenerational mobility.
Evidence of the positive relationship between parental education and children’s education is well documented in the literature, both for the UK and elsewhere. For instance, for the UK Ermisch et al. (2001) use data from the BHPS to show that parental educational attainment is a powerful predictor of children’s educational attainment (see also Blanden and Gregg, 2004). In a recent study on higher educational attainment, Delaney et al. (2011) use data designed and collected on behalf of the Irish University Association as part of the Irish Universities Study to provide decomposed estimates of the magnitude of the intergenerational relationship between parental education and grade performance at university (and also returns from university education). They find that, although the effect of parental education is small, on average 10 years of additional combined parental education is associated with one percentage point increase in grade outcome in university, with the effect being higher for males than for females. They also find different parental-gender effects. For instance, they find maternal education to be more important in predicting educational attainment of males in university.

Even more recently, Anders et al. (2017) use data from Next Steps, previously known as Longitudinal Study of Young People in England, and the National Pupil Database (NPD) to analyse the importance of subject choice in the probability of attending university or a highly competitive university in England. The authors also consider the association between socioeconomic status and young people's subject choices, and the extent to which this acts as a transmission mechanism between socioeconomic status and inequality in attendance at university. Their result suggests that high achieving students are directed towards particular subjects. Undoubtedly, such a finding has important policy implication for the UK where recent government initiatives have aimed to facilitate equal opportunity and access to children and families from diverse backgrounds.

A strand of the literature focuses on the causal mechanisms underlying the link between parental education and children’s education. Understanding the mechanisms by which parental education affects children outcomes, although challenging empirically, could be more relevant for policy. Causal effects
of parental education on children’s education have often been examined using different identification strategies such as instrumental variable (IV) techniques and, more recently, using different samples of twin parents, siblings or adoptees. This section provides a review of the literature on some of the causal mechanisms using these identification strategies with a focus on the UK where possible.

In his 2004 paper, Chevalier investigated whether the effect of parental education on children’s educational attainment in the UK is causal. In particular, the author focused on the intergenerational educational choice, that is, children staying in education beyond the compulsory school-leaving age. The author used data on individuals aged between 16 and 18 from the British Family Resources Survey, a national dataset that contains data on both children and parents. To determine the causal link between parental education and children’s education, the author uses School Leaving Age, which was introduced in the 1970s, as an instrument for parental education. The use of policy reform as an IV for parental education has been well documented for other countries - Black et al. (2005) for Norway; Oreopoulos (2006) for the US; and Lundborg et al. (2014) for Sweden. By assuming exogeneity of parental education, similar to Black et al. (2005), the author finds parental education to be significant for children’s schooling. Specifically, each additional year of parental education increases the probability of children staying on in school by around 4 percentage points. The effects of mother’s and father’s schooling on children education were however not statistically different from each other. In a relaxed specification of the exogeneity of parental education, the authors instrument for parental education using school-leaving age and find similar effects of maternal education on children’s education, while for fathers the effect was found to be insignificant and negative. In a further analysis, when the sample is restricted only to natural parents, the author finds paternal and maternal education to have a similar effect on children’s propensity of staying on in school. This finding is a possible indication for own birth parents, rather than step-mothers or –fathers, to be more altruistic towards their own children (Case et al., 2000). Interestingly, the author also finds possible evidence of the role model effect; that is, maternal education is important for daughters’ schooling while paternal education is important for sons.

In a similar and more recent study, Chevalier et al. (2013) used data from the UK Labour Force Survey (LFS) to investigate the relationship between early school-leaving (at age 16) and parental education (and also income). Ordinary Least Squares (OLS) estimates indicated stronger effects of maternal education compared to paternal education, with effects on sons being stronger than daughters. In IV estimates that used paternal union status, and its interaction with occupation as instruments, the result improved the significance of paternal education on the offspring’s likelihood of staying in school. The IV estimates showed no significant effects of maternal education. Dickson et al. (2016) perform a similar exercise using the Avon Longitudinal Study of Parents and Children to examine the causal effects at different stages of the child’s life. They find parental education to be important at earlier age
(4 years) and throughout the child’s schooling years up until the age of 16. Other studies including Sabates and Duckworth (2010), who only consider maternal schooling, and Silles (2010) have used the school leaving age reform as an instrument to examine the causal effects on children’s cognitive and non-cognitive outcomes. The former paper found that an additional year of maternal schooling is significantly associated with improvements in mathematics attainment for their children, but fail to find convincing evidence for differences in reading and behavioural outcomes. The latter paper fails to find sufficient evidence to suggest that parents’ school had a positive impact on children’s cognitive and non-cognitive development.

Other recent studies that use an IV technique to address endogeneity of maternal schooling include Carneiro et al. (2013). The authors instrument maternal education with variation in schooling costs during maternal adolescence. This study focused on a host of outcomes including cognitive achievement, measured as test score, grade repetition and behavioural problems, using a matched data of females from the National Longitudinal Survey of Youth (NLSY) 1979 and their children. The novelty of this study as claimed by the authors is related to the systematic treatment of a large range of inputs and outputs in the child’s development process at different ages. The authors further compared the relative roles of maternal education and cognitive ability and demonstrated how maternal education varied with different characteristics of the child, i.e. gender and race, and also with the cognitive ability of the mother. Their results in relation to educational outcomes showed that maternal education increases children’s performance in math and reading at the ages 7 to 8, with a reduced effect at the ages 12 to 14. Maternal education was also found to reduce grade repetition. In terms of investment in other inputs, the authors found that more educated mothers are more likely to invest in their children through provision of books, special lessons, and availability of computers.

In relation to the use of other identification strategies, Pronzato (2012) uses a sample of twin parents from the Norwegian register data to examine the intergenerational transmission of education. The use of twins to address issues of unobserved heterogeneities is interesting in a number of ways: firstly, twins share the same family background; experience similar lifetime events and; most importantly, share the same genes. The twin-estimator study indicated positive and significant effects of parental education on children’s education, although the effects of maternal education were found to be smaller (0.096 for mother’s compared with 0.158 for fathers). The OLS estimator also showed significant effects of mother’s (0.242) and father’s schooling (0.214) on children’s schooling. To distinguish between monozygotic and dizygotic twins, the authors perform an exercise that allows them to select siblings born very close together (9 to 13 months of age difference) and compare these with estimates from the twin sample. The authors performed this exercise partly because their data did not allow them to distinguish directly between monozygotic and dizygotic twins. The results from this exercise indicated
similar directional effects with mother’s schooling increasing children’s schooling by 0.139, and 0.123 for fathers. The authors did not find significant differences between the effects of mother’s and father’s schooling using the twin estimator and the sibling estimator (with the 9 to 13 months of age difference). Focusing on different parts of the distribution of parents’ education, the author found the effects of maternal education strongest at the lowest part of the distribution (albeit insignificant), compared to fathers’ where the effects were significant and stronger at the top part. This result is similar to Ermisch and Pronzato (2011) who found the effects of maternal education to be larger among poorer educated parents, whereas the effects of paternal education is larger among better educated parents. Their results, which are based on Norwegian data, indicated that an additional year of either mother’s or father’s education increased their children’s education by as little as one-tenth of a year. Holmlund et al. (2011) illustrate the findings across methodologies using cohorts of parents and children from Swedish register data. Their dataset includes data on dizygotic twins with parents born between 1935 and 1943, and children born before 1983 (at 23 or older) at the time of the study. They find no effect of the maternal education on child outcomes when controlling for assortative mating, i.e. similarities of education levels of mothers and fathers achieved by including the spouse’s education, but they do find a positive effect otherwise.

A recent working paper by Papageorge and Thom (2018) further exploits advances in genetics to explore the relationship between a genetic index, educational attainment and labour market outcomes, using US data from the Health and Retirement Study. They use a polygenic score (a weighted sum of individual genetic markers) to predict educational attainment and they interact this genetic information with childhood environments to assess their role in determining educational outcomes. They demonstrate a strong relationship between the polygenic score and educational attainment and show that this association differs by childhood socio-economic status. Their results also suggest the possibility that early investments in human capital may substitute for genetic endowments in preventing very low levels of educational attainment. However, these same investments could complement genetic endowments in generating higher levels of educational attainment such as college completion.

Again, in Pronzato (2012), the author examines intergenerational transmission of education using a sample of siblings with different distances in age as the identification strategy. The aim of this experimentation was to determine whether the findings would be similar to the ones from the twin-estimator. Similar to the twins, siblings share the same family characteristics but differ in terms of genes. The author finds the results to be in the same direction to the results from the twin sample,

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7 See Amin et al. (2015) for a more recent study on Sweden.
8 The markers most heavily weighted in this index involve early brain development and processes related to neural communication.
although the effects from the sibling estimates underestimated the effects of paternal education in all estimations. The effects of mothers’ education were larger, averaging around 0.128. While using siblings instead of twins for studies on causal effects of parental education is more advantageous, due to larger sample sizes, and can provide more precise estimates, evidence from such studies are limited for the UK. An exception is Ermisch and Francesoni (2000) who analyse the BHPS and find parents’ educational attainment to be strongly associated with that of children with maternal education having a stronger positive association with the child’s educational attainment than the educational attainment of the father.

The use of adopted children as identification strategy has also gained considerable attention in the literature (Plug, 2004; Björklund et al., 2006; Sacerdote, 2007; Holmlund et al., 2011). Plug (2004), for instance, found significant effects of mothers’ and fathers’ education on schooling of own birth children. However, when they examine the effect of parental education on a sample of adopted children, they do not find any significant effects of maternal education on children’s schooling (they found a significant effect for fathers). Their findings showed a significant reduction in the effects of parental schooling (especially mothers’) between own birth children and adopted children. Björklund et al. (2006) showed that pre and post-birth factors influence intergenerational earnings and education transmissions where the pre-birth factors play a greater role for mothers’ education, and less so for fathers’ income. Sacerdote (2007) uncovered evidence to show that the shared family environment explains 14 per cent of the variation in educational attainment, 35 per cent of the variation in college selectivity, and 33 per cent of the variation in the drinking behaviour. Additionally, there are significant, positive effects on the adopted children’s education, income, and health when the assigned parents are more educated and have smaller families. There is evidence to suggest that the correlation of parental education as well as family size and adoptee outcomes is much greater than the correlation between parental income, or neighbourhood characteristics and adoptee outcomes. This approach is appealing because there is no genetic transmission of ability between parents of adopted children and adopted children themselves. A major downside of this method, however, is that the process of allocating children to adopted homes is not random and sample sizes may be smaller. In addition, parents that tend to adopt are often more educated (hence wealthier). To the best of our knowledge, there is no evidence for the UK that uses data on adoption to examine causal effects of parental education on children’s educational attainment. See Holmlund et al. (2011) for a comparison of different methodological approaches.

2.1.2. Parental education and cognitive and non-cognitive skills

The role of parental education extends beyond just years of schooling. Similar to many developed countries, the UK government is pursuing policies to raise literacy and numeracy levels of children,
especially in the aftermath of the introduction of the PISA (Programme for International Student Assessment) test for OECD countries. For instance, a large proportion of the UK adult population has poor literacy and numeracy skills (see Leitch, 2006). This has implications on individuals during adulthood since they are more likely to be unemployed and, even if employed, they are more likely to be in low paid jobs. It also impacts on firms, which have a higher demand for skilled workers. Available evidence for the Czech Republic (Fischer and Lipovska, 2013) shows that parental educational attainment has a significant impact on the initial educational level of children as well as on their lifelong learning participation.

Many of the studies on intergenerational transmission of cognitive skills have been analysed in the contexts of Scandinavia (Black et al., 2009; Björklund et al., 2010; Grönqvist et al., 2017), the US (Agee and Crocker, 2002) and Germany (Anger and Heineck, 2010; Anger, 2011). Exceptions for the UK are work carried out by Brown et al. (2011) and de Coulon et al. (2011). There is also evidence for OECD countries of indirect effects of parental education on cognitive ability. Better-educated parents have higher awareness of quality of life that indirectly raises the cognitive ability of their children – parental education significantly increases children's schooling and reduces their fertility rates (Burhan et al., 2017). In a related study by Lipovska and Fischer (2016) for the Czech Republic, the authors try to identify who talented students are (since it could signify ability), which background they come from, and how family background influences them. The authors find that most talented students come from highly educated families with tradition in their field of interest and long positive attitudes towards knowledge acquisition. They also show that there is a close relationship between talented children’s reading ability and the accumulation of human capital. For example, if all six ancestors, comprising of both parents and the maternal and paternal grandparents of the child gained a university degree, 82 per cent of talented students could read before entering elementary school.

Despite the limited evidence for the UK, existing findings show a positive intergenerational relationship between parents’ childhood cognitive skills and offspring skills (Blanden et al., 2007; Brown et al., 2011). Using data from the British National Child Development Study (NCDS), Brown et al. (2011) show that a parent’s test scores at age seven have a positive influence on the performance of their children when they were as young as five years old. Using the same dataset, de Coulon et al. (2011) draws on the 1970 cohort and uses test scores of parents at age 34, which they compare with test scores of their children at the ages three to six. Their results show strong evidence that parents with better numeracy and literacy in adulthood have children who perform better in early cognitive and non-cognitive tests.
Evidence on the intergenerational transmission of non-cognitive skills is limited. In a recent study, Anger and Schnitzlein (2017) estimate sibling correlations in cognitive (Intelligence Quotient (IQ) tests) and non-cognitive skills (locus of control, reciprocity, and the Big Five personality traits) based on data from the German Socio-Economic Panel Study. Although the study does not clearly distinguish between genetic and environmental effects, the authors find sibling correlations of personality traits range from 0.22 to 0.46, while sibling correlations in cognitive skills were found to be higher than 0.50. Their results show that around half of the inequality in cognitive abilities can be explained by shared family background. A similar exercise by Grönqvist et al. (2017) reveals that, despite the positive relationship shown by previous studies, not correcting for measurement error in cognitive and non-cognitive abilities substantially underestimates the effect of intergenerational ability correlations. They use two sets of IVs to correct for paternal abilities; ability evaluations of father at age 14 and ability evaluations of the son’s uncle. For maternal abilities they use evaluations of their brothers. Specifically, they find mother–son correlations in cognitive abilities are stronger than father–son correlations, whereas no such difference is apparent for non-cognitive abilities.

Other aspects of family background have been considered in the literature. For instance, Coelli (2011) investigates the link between parents’ job loss and the enrolment of children in universities or post-secondary education institutions. Using data for Canadian households from the Survey of Labour and Income Dynamics for the period 1993 to 2007, the author found a negative effect of job loss from layoffs or business failure on children enrolment in universities or community colleges. The authors attempted to address possible sample selection bias but there was not enough evidence to suggest that estimated results suffered from selectivity bias in the first place. Chowdry et al. (2013) also analysed the impact of both family income and education on the participation rates of pupils in UK higher education. They used linked data from the NPD, the National Information System for Vocational Qualifications, and the Higher Education Statistics Agency (HESA) for two cohorts of individuals between 2004 and 2005 and between 2006 and 2007 aged from 11 to 20 years old. They show that, although family income matters in explaining lower participation rates in higher education for pupils from poorer families, the most important factor seems to be pupils’ achievements in secondary education. These findings were true for both private and public-school pupils and suggested the need for policy to improve the access to higher education for pupils from a lower socio-economic background (as also suggested by Coelli, 2011).

2.1.3. Family structure and offspring education

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9 See also Anger and Heineck (2010).
An extensive body of research has identified family characteristics as key factors associated with later adulthood achievements and education choices (McLanahan and Sandefur, 1994; McLanahan et al., 2013). Findings from these studies are informative for policymakers and suggest where interventions could address the issue of early inequality and intergenerational transmission of disadvantage. This literature emphasises that there may be differences in children’s outcomes as a result of growing up in different families. Family structure affects children’s outcome by determining parental patterns of investment. Empirical studies have mostly focussed on five home environment characteristics: family size, birth order, parental presence, gender of siblings and spillover from siblings. By using linked administrative data, researchers have tried to identify the causal impact of childhood conditions on achievement with precision. As these studies require rich longitudinal information on all family members, they have mostly been based on Scandinavian, US and Israeli administrative records, with the exception of one study based on English education records. Below we describe the most recent literature grouped by family characteristics.

**Family size**

Early work based on observational studies usually finds large negative associations between family size and the attainment of the offspring. These results may be driven by the fact that family size is usually correlated with unobservable characteristics of the family that also affect children’s achievements.

Empirical research that tries to identify the causal link between quantity of children and their outcomes is limited. Black et al. (2010) use rich administrative data linked to military records for recent cohorts of Norwegian men and study the effect of family size on IQ by instrumenting the family size with two different exogenous variables: 1) the event of a twin second or third birth in the family; 2) the sex composition of the first two births. They find negative effects of third or higher parity births on IQ (-15 per cent) of first and second born individuals when they use the twin instrument. When they use the gender composition as an instrument, they find no effect of family size on IQ. It is however likely that the difference in these IV estimates results is driven by idiosyncratic characteristics of twin births; twins are usually born with lower birth weight and no spacing between them, requiring therefore more investment in terms of money and time from their parents and therefore a reallocation of resources from other siblings. Further data analysis by the same authors shows that estimates based on twins as exogenous variation in family size should not be generalised to other types of variation of family size and pertains to families with twins.

Angrist et al. (2010) combine the two instruments used by Black et al. (2010), which are the event of a twin second or third birth in the family and the sex composition of the first two births and use Israeli
census data linked to the population registry. This study finds no effect of family size on schooling of older children. The authors argue that their results are driven by the choice of empirical strategy, which is based on the joint use of the instruments and the high fertility population of interest, with demographic and social characteristics closer to developing countries.

**Birth order**

There is an extensive literature on the relationship between birth order and educational attainment that finds consistent negative associations: later-born children have lower educational outcomes than their older siblings and this effect tends to be larger in bigger families. This literature review will consider three recent interesting studies that investigate the channels through which birth order is likely to affect education outcomes. Booth and Kee (2009) use retrospective family background data from wave 13 of the BHPS and create a birth order index that accounts for family size; they find that later-born children receive a smaller share of their parents’ resources. Similarly, Pavan (2016) uses a US survey and family fixed effects to estimate the birth-order effect. The results show a sizeable positive firstborn effect on many cognitive tests. An investigation of the possible mechanisms explaining these results documents considerable gaps in parental investment across birth order. Lehmann et al. (2018) examine the possible causes of the achievement gap between later-born children and their older siblings by exploring US survey data. In particular, they find that mothers take more risks during pregnancy and are less likely to breastfeed and to provide cognitive stimulation for later-born children.

In a more recent non-UK study, Breining et al. (2017) use data from the Danish Birth Register and data from Florida Departments of Education and Health to examine possible mechanisms of differences in birth order for Denmark and Florida. They find surprisingly that second-born children are no worse off in terms of the quality of school attended and are also more likely to attend pre-school. The authors however find that second-born boys, compared to older siblings, achieve lower reading and math test scores in Denmark and in reading scores in Florida.

**Parents’ absence**

The absence of one of the parents is likely to have a lasting effect on children’s achievement through a substantial reduction of investments in their human capital. The absence of a parent because of his or her death is more likely to be an exogenous event compared to the absence caused by divorce or abandonment. However, the empirical evidence is scant as the precise identification of causal relationships requires large administrative datasets. Kalil et al. (2016) use administrative data from Norway to analyse how fathers’ presence affects the intergenerational transmission of educational
attainment. They exploit within-family variation in father exposure that occurs across siblings in the event of paternal death, and find that longer paternal exposure amplifies the father-child association in education and attenuates the mother-child association. These effects are stronger for boys than for girls. Gould et al. (2019) use a big sample of Israeli children born between 1974 and 1991 and estimate the effect of parental death and divorce. Specifically, they test the effects of parental schooling on three separate sets of children: children that did not lose either parent by age 18; children that lost a mother or a father before the age of 18; and children that lost a mother or a father, but after the age of 18. Using variation in the age of a child when the parent died across these groups, the authors test the idea that a child’s human capital should depend on whether that parent was alive and able to interact with the child before the end of secondary education. Using divorce as a source of parental influence is analogous where it is tested whether mothers’ education (the custodial parent in most cases) becomes more important relative to the father if the divorce occurred before the age of 18. Their results show that parental education impacts significantly on children’s human capital accumulation and that the size of this effect depends on the length of time parents and children spend together. For instance, when a parent dies, his or her education becomes less important for the child’s outcomes while the other parent’s education plays a larger role. This is in line with much earlier findings which suggest that children growing up in single-parent headed households, rather than with both parents present, achieve lower education levels (McLanahan and Sandefur, 1994) and that children raised with both biological parents present have better educational outcomes than children from blended families, i.e. are stepchildren or have half-siblings (Ginter and Pollack, 2004).

Children who are, or have been, in care are among the lowest performing groups in educational outcomes internationally (Flynn et al., 2013). By linking data from the NPD and the Children Looked After Database (CLAD), Sebba et al. (2015) assess how educational attainment differed between Children in Need (CIN), Children Looked After (CLA) and Children not in care or need (Comparison Group). CLA were split into separate categories: long term early entry (in care 12 months or more continuously at the end of KS4 who were also in care at the end of KS2), long term late entry (in care 12 months or more continuously at the end of KS4 who were not in care at the end of KS2), and short term (under 12 months in care at the end of KS4). The authors find that the comparison group significantly outperformed all other groups in terms of mean GCSE points scores. Out of CIN and CLA groups, CLA short term significantly underperformed, with the authors citing a possible reason for this being that, those entering care in adolescence are associated with more challenging difficulties. CLA short term – are therefore less likely to achieve greater educational attainment. The author’s cite absences, exclusions and school moves as explanations for the large amount of the disadvantage that CIN and CLA suffer. DFE (2019) showed supporting evidence of CIN under achieving academically, followed by CLA, followed by children not in need nor looked after. Results are further supported by
analysis carried out by Sebba et al. (2015), that CIN and CLA are much more likely to have at least one fixed period exclusion.

**Sibling gender**

Gender composition of siblings is a key aspect of the childhood family environment. In recent years, economics and education researchers have studied its role in the determination of intra-family gender norms that affect education choices, particularly of girls. Brenøe (2018) uses Danish administrative data to estimate the effect of having a younger sister on first-born education choices. The identification is possible because of the random assignment of gender of the second-born child. This study finds that having a second-born brother relative to a sister increases first-born women’s gender conformity: women with a brother are less likely to study STEM (Science, Technology, Engineering and Mathematics) subjects. Further analysis shows that parents of mixed-sex children invest their time more gender-specifically to their first-born daughter compared with parents of same-sex children. These findings are supported by Cools and Patacchini (2017) and Rao and Chatterjee (2017); their research based on US survey data provides evidence that women with brothers hold more traditional gender attitudes than those without brothers.

**Sibling spillover**

Black et al. (2017) use administrative data matched to education and medical records of very recent cohorts from Florida and Denmark to estimate the effect of siblings spillovers in the presence of a family shock. Specifically, the authors focus on families with three children and use a difference-in-difference (DiD) research design that controls for birth order to estimate the effect of having a disabled third sibling. With both sets of data, the study finds consistent evidence indicating that the second child in a family is more adversely affected relative to the first born when the child is disabled, and these results survive several robustness checks. Qureshi (2018) uses US administrative data to investigate the spillover effect of an older sibling’s achievement on younger siblings. As siblings share the same home environment, it is likely that some unobservable characteristics of the family affect the human capital of all siblings. To estimate the causal effect of older siblings’ human capital on younger siblings’ outcomes, Qureshi instruments the achievement of older siblings with an indicator of the quality of their teachers. This study finds that an improvement in older siblings’ test scores leads to a statistically significant increase in younger siblings’ test scores in maths and reading. This result is important as it shows the role of schools in reinforcing social inequalities as well as its role in social remediation. Similar results are found by Breining et al. (2015) as they investigate the spillover effects of early-life medical treatments on the siblings of treated children. By using administrative data from Denmark and
a regression discontinuity design that exploits the changes in medical treatments across the very low birth weight cut-off, the study finds substantial positive effects on academic achievement of siblings of treated children. An analysis of the possible mechanisms suggests that improved interactions within the family may be an important pathway behind the observed spillover effects. Breining (2014) uses high quality register data from Denmark to study the spillover effects on firstborns from having a younger sibling suffering from an attention deficit hyperactivity disorder. Estimating a model with cousin fixed effects the author finds that the educational outcomes of healthy firstborn children are significantly reduced by the presence of a disordered sibling.

Finally, Nicoletti and Rabe (2017) estimate the direct effect of sibling spillover in school achievement by using the NPD which includes administrative education records for pupils in England. They exploit the variation in school test scores across three subjects observed at the two ages as well as variation in the composition of school peers between siblings. These results provide empirical evidence of positive spillover effects from the older sibling to the younger, but not vice versa, and reinforces the conclusion of the paper by Qureshi (2018) that school can have an important role in social remediation through intra-family spillovers.

### 2.1.4. Wider family and environmental factors

Case et al. (2005) investigate the lasting effects of mother’s prenatal health, childhood health and economic circumstances on adult health, employment and socioeconomic status. Using data from the NCDS the authors follow a birth cohort from birth into middle age. OLS Regression is used to predict total O-level passes by age 16, controlling for parental income, education and social class. Among other findings, the authors show that mother’s smoking during pregnancy is associated with significantly fewer O-levels passes, with children whose mothers had reported smoking heavily during pregnancy passing 0.4 fewer O-level exams. Korhonen et al. (2012) use longitudinal data to assess how maternal prenatal, postnatal and/or current maternal depressive symptoms is associated with measures of the child’s wellbeing (social competence). Evidence suggest that concurrent depressive symptoms are a risk for both sexes of children, whereas prenatal and postnatal depressive symptoms are only a risk for boys.

Desforges and Abouchaar (2003) carry out a literature review assessing how parental involvement, parental support and family education affect pupil achievement. Numerous studies show how differing parental involvement variables linked to the child’s outcomes. Parental involvement/support and family education variables included: reading, library visits, playing with letters and numbers, painting and drawing, teaching (through play) the letters of the alphabet, playing with numbers and shapes, teaching
nursery rhymes, singing, having an educated mother, a helpful father, parental involvement in support of schooling and degree of discipline exerted by the parents. These factors are primarily assessed against educational attainment, as well as other more specific mechanisms such as cognitive development, sociability, confidence and resilience. The common theme across much of the literature was that parental involvement does have a significant positive effect on children’s behaviour and achievement, whilst controlling for factors such as social class or family size. There was also some evidence that the parental involvement effect diminished slightly over time as children reached school leavers age, though the relationship is relatively strong. The authors suggested there is perhaps less of a relationship with achievement, but a greater relationship with staying on rates and pupils’ educational aspirations. Lessof et al. (2018) use the Longitudinal Study of Young People in England (LSYPE) to assess how different aspects of the home environment, pupils’ actions and personal characteristics affect GCSE scores. Bivariate analysis and multilevel modelling approaches were implemented. Key findings show that children were more likely to attain higher GCSE scores if they: are living with both their biological parents, have a mother who is highly educated, have parents who always discussed their school reports, are living in a mortgaged/owned property, are provided with internet-connected home desktops/laptops, are less psychologically stressed, do not truant, usually do all their homework and are female. The authors also went on to explain the gender differences in GCSE scores, citing that: boys have greater likelihood of special educational needs and disabilities which affect schooling, as well as parents being more likely to expect their daughters to attend university and less likely to want their daughters to look for options outside education after year 11 (e.g. apprenticeships).

Sammons et al. (2015) investigate the effects of pre-school and early home learning on A-level outcomes. Logistic regression and multilevel model techniques are employed on the NPD and Effective Pre-school, Primary and Secondary Education dataset. Conclusions from the analysis were that, attending pre-school improved students are more likely to partake in A-levels; although, there is an insignificant effect on the students grades in A-levels. However, the quality of the home learning environment that pupils experience before they attended school does have a significant effect on both staying on for A-levels as well as the grades achieved at this stage. Home learning environment is based on the frequency of specific activities involving parent and child, including: teaching the child the alphabet, playing with letters and numbers, library visits, reading to the child, teaching the child songs or nursery rhymes. The authors suggest that pre-schooling largely operates through increasing student’s GCSE grades, whereas early home learning has a more lasting effect through to overall A-level attainment. Currie and Almond (2011) survey recent work into human capital development under the age of 5, stating “Child and family characteristics measured at school entry do as much to explain future outcomes as factors that labour economists have more traditionally focused on, such as years of education”. Studies surveyed are based from data from the NLSY and the NCDS. NLSY studies
included that of Cunha and Heckman (2008), who assess the extent to which parental investments (e.g., number of child’s books, whether the child has a musical instrument, whether the child receives special lessons, how often the child goes to museums, how often the child goes to the theatre, etc) increases the child’s future earnings and likelihood of graduation from high school, and how much of the increase is as a result of cognitive or non-cognitive skills. Results showed increasing parental investment by 10% at ages 6-7 increases children’s earnings by 24.9% (with both cognitive and non-cognitive skills equally as important) and increases likelihood of graduating high school by 64.4% (mainly through cognitive skills). Additionally, Dearden (1998) uses data from the NCDS to show that child’s reading and maths scores (age 7), type of school, family composition, teachers assessment of interest shown by parent in their child’s education, type of school attended, family financial status, region, fathers socio-economic status and parental education are all significant predictors of the number of years the child stays in full time education.

Covay and Carbonaro (2010) analyse after-school activities in more detail. Using a US early childhood longitudinal study, OLS regression is used to predict cognitive and non-cognitive skills. Different models were created including extracurricular activities (EAs) only; SES only; SES and EAs; EAs, SES and the interaction between EAs and SES. The authors found that participation in different types of extracurricular activities (sports, dance, music, arts and performing arts) explain a moderate portion of the SES advantage in non-cognitive and cognitive skills. Results suggest that pupils who participate in sports benefit more than those who took part in other extra curriculum activities. Schuller and

2.2. The role of health in human capital accumulation

Although the vast majority of the early literature on human capital focuses mainly on returns to education (Mincer, 1958; Psacharapoulos and Patrinos, 2018), health has been increasingly recognised as a crucial component of human capital (see Becker, 1962; Mushkin, 1962; Becker, 2007). This was especially true since Grossman (1972a, 1972b and subsequently 2000, 2006) developed a model for the demand for health capital in the early 1970s. The model assumes that an initial health stock is inherited by individuals, which depreciates with age and can be increased through health care consumption, nutrition and exercise. These types of investment improve well-being and increase the available time in which individuals can work and accumulate wealth. Though scholars have acknowledged that health plays a significant role in generating human capital, existing measures of its stocks do not adequately account for health status.10 The existing measures take account of mortality by incorporating survival

10 Recommendations for new measures have been developed by the Atkinson Review (Atkinson, 2005), the Commission on the Measurement of Economic Performance and Social Progress (Stiglitz et al., 2009) and a consortium of 15 OECD countries, Israel, Russia, Romania, Eurostat, the ILO and ONS.
rates into the model but ignore any other aspect of health, focusing mainly on the contribution of education.

With an ageing population, health has a profound but ambiguous impact on labour market activity and its outcomes and, therefore, on human capital accumulation. Longevity may not necessarily be associated with good health, as survival into older age is increasingly accompanied by morbidity. Therefore, the willingness to supply labour may decline, which is reflected in earlier retirement or increasing absenteeism from work. Against this, poor health is associated with medical care needs, which often require financial commitments at an accelerating rate for the elderly. Therefore, labour supply may actually increase in order to compensate for these financial constraints. If poor health does not lead to absence from work or early retirement, it can still reduce on-the-job productivity and work quality, which is referred to as presenteeism in the occupational health literature (Burton et al., 1999). Consequently, morbidity impacts on the quality, as well as the quantity of labour supplied which affect human capital stock by reducing the productive capacity of the workforce. In addition, there are likely to be spillover effects on the work routine of healthy co-workers (Goetzel et al., 2003), which further increases the costs of ill-health to the economy. Work by O’Mahony and Samek (2019) has quantified the combined effects of both absenteeism and presenteeism for the UK economy, and has found that human capital would increase by 11 per cent if workers in poor health moved to good health. This is found to be driven by a number of factors, including a larger effect for males than females reflecting higher retirement rates, lower relative wages due to poor health, and the fact that males account for a greater share of the aggregate human capital stock due to their higher earnings. Likewise, while the human capital stock reduction due to ill-health for those with low qualifications is relatively lower than for those with university degrees, most people in poor health also have lower qualifications.

This section reviews studies on the relationship between health and human capital. In particular, it discusses ageing and the relationship between health and education, also known as the education-health gradient; how health impacts on labour supply; health care access and its provision. Finally, the link between earnings and health is considered by reviewing studies which have examined the causal impact of earning effects on health. The reverse relationship, i.e. presenteeism, is further discussed in the literature review on earnings determinants.

2.2.1. Ageing

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11 They evaluated the extent to which poor health reduces the potential human capital by removing people from the active population and reducing the productive human capital stock by diminishing the effectiveness of human capital, through absenteeism and presenteeism.
Almost every country is projected to experience an increase in the proportion of the population aged 60 and above between 2005 and 2050 (United Nations, 2009). This will undoubtedly affect economic growth through changes in labour supply and human capital accumulation. This is related to the fact that the elderly tend to work and save less and often require financial support to afford costly health care. The shift in the age distribution affects aggregate human capital stocks because longevity is often accompanied by worsening health, and relatively large cohorts with low or moderate levels of formal education are replaced by relatively small cohorts with high levels of formal education. While this suggests a reduction in overall labour supply, migration, which is discussed in detail in chapter 2.4, can mitigate some of these adverse effects of ageing by shaping the redistribution of human capital within countries. Additionally, Bloom et al. (2010) predict that OECD countries will experience only a modest growth decline as a result of these demographic changes because of increases in the statutory retirement age and behavioural changes. Although there is no empirical evidence yet on the implications of the abolishment of the UK Default Retirement Age in 2011, similar policy reforms in other European countries find expected or actual retirement ages to increase as a result (see Mastrogiacomo, 2004; Bottazzi et al., 2006 on Italy; Coppola and Wilke, 2014 on Germany; Manoli and Weber, 2016 on Austria). Coppola and Wilke (2014), for instance, apply a DiD procedure in studying the German case and observe an increase in the expected retirement age by approximately two years. Their results are in line with figures obtained from studies on Italy. Manoli and Weber (2016) use a regression kink design and find individuals delay their retirement in Austria by five months with every one-year increase in the expected retirement age. If working lives are prolonged, returns to investments in education and the updating of skills to increase productivity increase and take place more frequently. While it can be argued that different conclusions can be drawn when focussing on individuals in poor health, the elderly have become healthier over time (either because of shorter periods and/or later periods of morbidity, or because of longer lives) which is often referred to as the compression of morbidity.

One strand of the literature argues that the compression of morbidity is a result of intergenerational spillovers from well-educated children to their parents. This arises as the offspring has better knowledge about health, more resources to invest in their elderly parents’ health, they can improve their parents’ morale and hence their mental health, and are able to provide informal care, medication adherence or act as their agents in the health and long-term care system (Zimmer et al., 2007; Torssander, 2013; Friedman and Mare, 2014). Empirical evidence for this causal relationship is found by Lundborg and Majlesi (2018) who use a Swedish compulsory schooling reform, which was implemented in the 1950s and 1960s at different points in time across municipalities. They find that children’s years of schooling (imputed from the highest educational attainment according to Holmlund et al.’s (2011) approach)

12 Brugiavini (1997) exploits the same strategy and uses Italian data but does not find any significant changes in retirement behaviour.
drives their parents’ longevity.

2.2.2. Health and education

Understanding the sources of health inequalities requires understanding the role of an individual’s education, behaviour and preferences. While it is widely accepted that there is a gradient linking educational attainment and health, the direction of causation remains unclear. Does better education result in better health or do healthier people become more educated? Or are there confounding factors which improve health and education at the same time? A growing body of literature suggests that education has benefits beyond increases in labour market productivity which extend to health and other outcomes. There are different ways in which education possibly improves health, which are discussed by Cutler and Lleras-Muney (2008) in detail and are summarised as follows: more educated people can be more likely to work in a relatively safe environment (as opposed to lower skilled occupations); they can be more likely to exercise and engage in healthy behaviour as they can to be more aware of the health consequences of their behaviour; they can have better health insurance and experience better access and higher quality of health care provision; and, lastly, they can be more future-oriented and hence invest more in long-term health.

The majority of work, which examines the causal effect of education on health using biomarkers from the Health Survey for England, exploits the increase in the minimum school-leaving age in 1947 and/or 1973 in the UK, which acts as an exogenous change in the amount of schooling received. However, evidence is mixed. Neither Clark and Royer (2013) nor Jürges et al. (2013) find any evidence that more schooling reduces the risk of adult hypertension or blood fibrinogen and C-reactive protein levels, respectively and Blanchflower and Oswald (2008) find an adverse effect of schooling on blood pressure, albeit of very small magnitude. Powdthavee (2010) finds that one extra year of schooling reduces hypertension by slightly more than 10 per cent for both men and women. Using the New Earnings Survey Panel Data, Devereux and Hart (2010) also detect an impact on hypertension but only for men and not for women. Besides these studies, there is little evidence on the impact of education on objectively measured health in the context of the UK.

Other work that also exploits the increase in the UK school-leaving age as an instrument for years of schooling but produces findings derived from self-assessed health outcomes, also comes to mixed conclusions. For instance, Silles (2009) uses the General Household Survey for England, Scotland and Wales in her IV approach and finds that an extra year of secondary school increases the probability of being in good health by 4.5 percentage points. A very similar approach was employed by Oreopoulos (2006). Although this paper’s main focus was on the education-earnings nexus, other health outcomes
were taken into account and by using the General Household Survey in an IV approach, he only finds small and statistically insignificant effects of education on self-assessed health. These results are consistent with findings by Clark and Royer (2013), who build on Oreopoulos’s (2006) work by combining the General Household Survey with the Health Survey of England in a regression discontinuity design.

A very different approach is adopted by Conti et al. (2010), who use the British Cohort Study (BCS) to follow individuals born in 1970 through the age of 30. They estimate a multi-factor model of schooling, earnings and health and find that education has an important causal effect on smoking behaviour (it explains 60 to 70 per cent of the differences in smoking behaviour), self-reported health (35 to 55 per cent) and men’s obesity (one third). They observe the largest effects for the highly cognitive skilled population and that non-cognitive skills are almost as important as early health endowments in explaining these three health outcomes in adult life.

Less commonly examined in the literature, especially in the UK context, but equally relevant is the health gradient in education, i.e. healthier adolescents selecting into higher education. Poor health can delay cognitive development; it can lead to social isolation and disengagement from school; and it can impact on perceived prospects and life expectancy reducing long-term investments in education. Equally, factors such as family background, psychological traits and cognitive as well as non-cognitive skills can all be confounding factors explaining the education-health gradient. The large majority of work on this relationship is based on the US and uses the 1997 cohort NLSY to examine the mechanisms linking health to the educational attainment of adolescents (Haas and Fosse, 2008; Lynch and von Hippel, 2016; Benson et al., 2018; Carroll et al., 2018). By estimating standard logit and sibling fixed-effects models, Haas and Fosse (2008) find that, after controlling for sociodemographic family characteristics, adolescents in poor self-assessed health are less likely to complete high school by their 20th birthday and to transition to post-secondary education, which is partly driven by cognitive and academic achievements as well as psychosocial factors. These findings are consistent with the results reported by Lynch and von Hippel (2016) who use self-assessed health at age 17 in an ordinal logistic regression model to predict highest degree obtained by age 31 and argue that the positive relationship is a result of early advantages in academic performance, college plans, and family background. Benson et al. (2018) and Carroll et al. (2018) also use an ordinal logistic regression but use obesity and a number of different health impairments, respectively. Benson et al. (2018) find that overweight adolescents are less likely to obtain high school diplomas and bachelor's degrees while Carroll et al. (2018) find that individuals, who have mental or multiple health impairments prior to high school completion or college-going, are less likely to initially enroll in 4-year postsecondary institutions than healthy adolescents. A slightly different approach is applied in early work by Palloni (2006), who uses the 1958 cohort of the
NCDS in a Monte Carlo simulation model and finds that childhood health is important but not the only determinant in accession to adult social class positions.

This empirical evidence highlights the role of health selection processes in generating socioeconomic inequalities in early adolescence to young adulthood. Moreover, together with the fact that causal effects of education on health are often smaller than the observed cross-sectional relationship between education and health amongst adults, these results suggest that covariates are inadequate in cross-sectional analyses as they cannot fully account for the selection of healthier adolescents into higher education and thus the causal effect of education on health is likely to be overestimated.

2.2.3. Health and labour supply

Latest figures published by the ONS (2018) show that the average absence due to sickness has almost halved since records began in 1993 with employees now taking around 4 days per annum, compared to approximately 7 days 25 years ago. Sickness absence has been falling since 1999 and the proportion of working hours lost due to sickness absence has decreased from 2.4 to 1.9 per cent since the financial crisis. While this is a very promising development and suggests health improvements, the observed reduction in absenteeism might take place at the expense of rising presenteeism, where individuals work in poor health. Reducing workplace absence due to poor health has always been of interest but its importance is reinforced by Dame Carol Black’s review in 2008 on the health of the working age population, which estimates that the total economic cost of ill health is over £100 billion in the UK alone. A report published by the Sainsbury Centre for Mental Health (2017) highlights that mental health problems alone costed employers almost £35 billion in 2016, of which almost £11 billion came from sickness absence. Presenteeism contributed nearly twice that and around £3 billion was a result of staff turnover. Interestingly, the cost of sickness absence has increased by 26 per cent from £8.4 billion in 2006, mainly as a result of an increase in the total number of employees in the UK (increasing the costs at the aggregate level) and the number of workers with mental health problems.\textsuperscript{13}

There have been many governmental initiatives in promoting health and increasing awareness of the role employers can play in preventing poor health and facilitating job retention. However, the literature on the link between health and hours worked is scarce (an exception is a study carried out by Cai et al.

\textsuperscript{13} They calculate the average cost of a working day lost based on national accounts data for average gross compensation per employee (i.e. wage plus national insurance and pension contributions), adjusted downwards to take account of the evidence given in absence surveys that lower-paid workers tend to take more time off work than those on higher earnings.
(2014) in Australia\textsuperscript{14}, especially in the context of the UK. Existing UK-based research has instead focused on the effects of health on labour force entry and exit (e.g. García-Gómez et al., 2010) and in particular on the effect of third party’s health on labour supply decisions. The latter literature strand has been growing in recent years due to the rising need for informal care (Carers UK, 2014), which is likely to have an impact on labour market outcomes of healthier individuals. We further elaborate on this literature in the following section.

\textbf{2.2.4. Provision of and access to health care}

Although life expectancy has increased in England over the past few decades, a social gradient across the country exists, with people living in the most deprived areas having on average the shortest lives (Public Health England, 2017). For instance, life expectancy is highest for both men and women in the South East with 80.5 and 84.1 years, respectively. It is the lowest in the North East with and expectancy of 77.9 and 81.6 years for men and women, respectively.

Lenhart (2019) uses the BHPS and finds that negative health shocks increase health care usage and the likelihood that individuals pay for this care out of their own pocket. This is particularly likely immediately after the onset of the health shock, although its effect remains large and significant even in later periods. Since annual GP visits and hospital night stays, which are two of the health care usages he captures, imply absenteeism from work, they may also partially explain associated earning losses. Even though health care is universally provided by the National Health Service (NHS), it is likely that individuals want to forego long waiting times and receive immediate treatment through private health care. This is underpinned by the fact that for the first time since the implementation in 2015 the NHS did not meet the goal of treating at least 92 per cent of patients within 18 weeks (Murray, 2016).

These types of health care usage are likely to reduce labour and to a larger extent household income, if other household members also take time off work to help with GP appointments and hospital visits or, in extreme cases, engage additionally in informal care (see previous section). Therefore, health care increases longevity, labour participation and productivity but it can also divert labour away from production because the available time to provide care is constrained, increasing pressure on combining caregiving and work duties. The additional burden of caregiving is associated with an opportunity cost since time needs to be taken away from work or leisure to carry it out, which is often called the

\textsuperscript{14} They use the Household, Income and Labour Dynamics in Australia and find that lower health status results in fewer working hours. They use a dynamic random effects Tobit model to account for zero working hours and follow Heckman by predicting individual health status to account for measurement error and endogeneity.
substitution effect. Carmichael and Ercolani (2016) estimate that unpaid caregiving will draw in more than a third of the UK adult population at some point during their lives.

The literature on employment outcomes and health effects of informal caregiving has been growing in recent years, especially as the ageing population increases in the UK. Older individuals are increasingly expected to care for relatives while governments extend their working lives at the same time by increasing retirement ages. By following individuals aged 50 to 75 from the Understanding Society Survey and using discrete-time survival models, Carr et al. (2016) find that co-residential caregiving, i.e. when the caretaker and the care recipient live within the same household, increases the likelihood of exiting work. When distinguishing between care recipients, they find that women are more likely to exit work when caring for their spouse while men do not adjust their working hours if their spouse is in poor health. Female part-time and full-time workers who cared for more than 10 hours per week were between 2.64 and 4.46 times more likely to leave work, compared to female non-carers.

Bauer and Sousa-Poza (2015) find that, albeit the small proportion of the labour force affected, caregiving tends to lower the quality of the caregiver’s psychological health, which also has a negative impact on physical health outcomes. Michaud et al. (2010) use the BHPS and rely on caregiving dynamics to account for unobserved heterogeneity. They find a negative effect of co-residential caregiving on future employment and a negative effect of employment on future co-residential and extra-residential caregiving, i.e. when the caretaker and the care recipient do not live in the same household. In an earlier mixed methods study, Carmichael et al. (2008) find that the length and the intensity of the caring episode, together with potential financial considerations and employers’ attitude, are amongst aspects of the decision-making process that constrain carer’s labour supply.

However, empirical evidence of caregiving histories has often drawn on time lags and leads of caregiving, employment or family circumstances to explain the relationship at a certain point in time (see Stern, 1995; Heitmueller, 2007; Michaud et al., 2010; Carmichael et al., 2010). Only in recent work by Carmichael and Ercolani (2016) the caregiving trajectories over life-courses are explored. Using the harmonised BHPS-Understanding Society Survey in an optimal matching and cluster analysis, they find that individuals differ in terms of life-stage, gender and attitudes towards family and gender roles prior to their caregiving duties. By applying a DiD approach, the authors show that those following the most caregiving-intensive pathways not only end up poorer but also experience a relative decline in subjective health and wellbeing.

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15 Carmichael et al. (2010) use the BHPS to examine the reverse relationship and find that employment participation and earnings both impacts negatively on willingness to supply informal care.
2.2.5. **Earning effects on health**

There is now a very substantial literature that has established a strong association between higher socio-economic status and better health of individuals, which has been observed in numerous countries and across a wide range of different health outcomes. These results are also extended to broader family relationships as studies show a link between parental income and their children’s health (Adda et al., 2009; Currie et al., 2007; Propper et al., 2007). The WHO highlights that children in the bottom percentiles of the income distribution are twice as likely of experiencing harmful illnesses or premature death compared to the ones at the top of the distribution (UNICEF, 2018).

However, this raises the question of whether poor health is the result of low income as it reduces the ability to work, or whether it is rather the cause. If individuals maximise their utility, which is considered to be a function of health and the consumption of other goods, subject to budget and time constraints, a sudden income increase relaxes the budget constraint resulting in better health (assuming health is a normal good). However, health is likely to depend on other components of the utility function, which can be positively correlated with utility but negatively correlated with health. Such examples include risky activities or smoking, which have an adverse effect on health, and as such higher income would have an ambiguous effect on health overall. Moreover, genetic endowment or school quality are likely to impact on both health and earnings, which explains their correlation but does not suggest any causal relationship. Therefore, scholars have increasingly employed natural experiments to address the issue of reverse causality (health as a determinant of earnings is discussed at a later stage in this literature review) by examining health effects of the Great Recession of 2008, or exploiting governmental assistance programs of lower income families, lottery winnings or the introduction of a minimum wage. The majority of the literature has focused on other countries than the UK, and only very recently have these approaches been applied to the context of the UK using exclusively the BHPS.

Recently published work by Reeves et al. (2017), Kronenberg et al. (2017) and Lenhart (2017) use the minimum wage legislation, implemented in 1999, which increased hourly wages to at least £3.60, to

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16 Iceland: Ásgeirsdóttir et al., 2014; Sweden: Cesarini et al., 2016; US: McInerney et al., 2013
17 US: Hoynes et al., 2011; Evans and Garthwaite, 2014; Hoynes et al., 2015; Canada: Milligan and Stabile, 2011
18 See Apouey and Clark (2015) for a UK based study which uses monetary lottery winnings as exogenous shocks to individuals’ wealth to estimate its effect on general self-assessed (whether the respondent is in excellent health or not), mental and physical health as well as health behaviours, such as smoking and social drinking. They find that the sudden increase in income has a significant effect on mental but not on overall health, which they observe is driven by the association between lottery winnings and smoking and social drinking. Since general health encompasses mental health as well as these behaviours, it does not improve following the positive income shock. For earlier work, see Gardner and Oswald (2007).
explain earnings effects on health in the UK.\textsuperscript{19} They all use different time periods from the BHPS and employ a DiD approach to compare health effects of higher wages on recipients of the minimum wage with otherwise similar but unaffected individuals. Although Reeves et al. (2017) and Kronenberg et al. (2017) both examine the legislation’s effect on mental health, using the 12-item General Health Questionnaire as a continuous variable, they come to different conclusions. While Reeves et al. find that higher wages improve mental health with an effect size (0.37 of a standard deviation) comparable to the impact of antidepressants on depressive symptoms (0.39 of a standard deviation), Kronenberg et al. do not identify any significant effect. However, Kronenberg et al. use a longer pre-legislation period (waves 7 to 9 compared to waves 8 and 9 in Reeves et al.) and both studies differ with respect to the definitions of treatment and control groups. Both scholars use a wage based-comparison, as one set of groups where they examine eligible recipients versus ineligible non-recipients. In an alternative set of treatment and control groups, Reeves et al. base their analysis on the initial treatment assignment rather than the actual treatment received.

When Reeves et al. (2017) examine blood pressure, smoking or hearing ability (which was used as a control) as potential health outcomes, they do not detect any significant earnings effects. This contrasts findings by Lenhart (2017), who used 10 waves of the BHPS to identify significant health improvements after the legislation was implemented when using self-assessed health, health conditions and health care usage as key health outcomes. Given that the UK health care service is mainly paid for by taxes, a reduction in the usage of any kind of health services, including doctor visits, is considered a health improvement by the authors. The reduction in health conditions is driven by a decrease in those that can potentially be treated by over-the-counter medicine (e.g. body pain, skin problems and allergies or hearing and eye sight difficulties) and not by changes in relation to chronic conditions, such as epilepsy or asthma. These findings indicate that self-treated medication is a normal good and, if the budget constraint is relaxed, consumption behaviour may change, explaining the observed health improvements.

While all three papers identify a reduction in low-wage workers’ financial strains on health, Lenhart finds that there are a combination of channels explaining the relationship between wages and health, including health-related behaviour (e.g. reduced smoking) and leisure expenditure (e.g. increased holidays and sports club memberships). Like many natural experiments in this subject area, these papers are limited by small sample sizes, attrition and the potential for an anticipation effect, selection bias between the treatment and the control group, and the spillover effect to wages from individuals just

\textsuperscript{19} Previous work on the implementation of the national minimum wage in the UK has shown no significant employment effects (Connolly and Gregory, 2002; Dickens and Manning, 2004; Stewart, 2004) and no effects on hours worked (Connolly and Gregory, 2002).
above the minimum wage threshold. Furthermore, they only examine short-run effects and they are likely to capture some counteracting effects to mental health improvement based on the stigma often associated with minimum wages.

2.2.6. Lifestyle, access and health conditions

There are many aspects of individuals’ lifestyles that are identified as having an impact on human capital outcomes. This section will review the effects of sleep, nutrition, exercise and stress as factors which enable the accumulation (or, indeed, lead to a loss due to poor health, for example) of human capital. The mechanism in which some of these aspects of an individual’s lifestyle affect human capital, however, is often through effects on self-reported or objective health that then enables human capital to be accumulated or lost.

One widely identified trend in the literature is that, across the lifetime of an individual, there are age-related changes in sleeping patterns (Scullin and Bliwise, 2015). While these findings are often disputed (Ohayon et al, 2004), the effect of sleep quality cannot be overlooked despite natural changes, or the lack thereof, as an individual gets older. By looking at indicators of sleep quality, assessed using the Pittsburgh Sleep Quality Index (PSQI), Gadie et al (2017) find that better self-reported sleep is associated with better health outcomes – especially so for mental health and moderately so for cognitive and physical health. Furthermore, Eide and Showalter (2012) investigate the effect of sleep on student achievement and find that there is an optimal number of hours of sleep that boost test scores which varies by age. Too much sleep, they find, leads to a reduction in test scores and hence a less desirable outcome in terms of improving an individual’s human capital. Alhola and Polo-Kantola (2007) find that, across the sleep-deprivation literature, there is a consistent negative effect of both acute total and chronic partial sleep deprivation on both attention and working memory. Within this review are also documented effects of a lack of sleep on long term memory, visuomotor performance and reasoning ability. Drummond et al (2000) find that, with 35 hours of sleep deprivation, free recall of verbal learning in normal young volunteers is impaired compared to the rested state. Furthermore, there are wider labour market related outcomes affected by the level of sleep an individual gets.

Continuing with sleeping patterns, Hafner et al (2017) find that, across five different OECD countries (Canada, Germany, Japan, the UK and the US), workers who sleep less than six hours per day report on average 2.4 percentage point higher productivity loss due to the implication of absenteeism or presenteeism – this is compared to workers sleeping between seven to nine hours per day. They also estimate that an individual who gets less than six hours sleep loses around 6 working days due to absenteeism/presenteeism per year more than an individual sleeping seven to nine hours, while a person sleeping six to seven hours loses on average 3.7 working days more per year. Hafner et al (2017) use the data generated during the ‘Britain’s Healthiest Workplace’ competition for the 2015 and 2016
combined waves. The sleep variables is derived from the question in the survey on how many hours of sleep the individual gets on average in a 24 hour period which is then grouped into the following four categories: < 6 hours, 6 to 7 hours, 7 to 9 hours, ≥ 9 hours. In order to quantify the economic costs of different sleep amounts, the authors use absenteeism and presenteeism as a proxy for productivity by using the Work Productivity and Activity Impairment Questionnaire (General Health) which is incorporated into the BHW survey. Two empirical methods were used to measure the effect of sleep on the ‘% work impairment (WPAI-GH scale) absenteeism/presenteeism’: OLS and a fractional response estimator – of the two, the parameter estimates are preferred over the fractional response estimator.

The effect of nutrition is another aspect of individuals lifestyles that can affect their outcomes. Many studies tend to focus on the investigation of malnutrition and its subsequent negative effects on health and other life outcomes. However, Cade et al (2004) use the UK Women’s Cohort Study to compare various types of diet in the UK. They use a food-frequency questionnaire to look at the difference between meat eaters, fish-eaters and vegetarians and find that oily fish-eaters have the highest total energy intake with vegetarians having the lowest which also resulted in higher nutrient intakes for oily fish eaters than the other groups. Vegetarians also have the lowest absolute protein, fat and saturated fat intakes. Diet is important to look at in this way and aids the literature which looks at the different effects of diet on other health outcomes – as diet is found to significantly affect the likelihood of developing certain diseases (see Ascherio et al, 1996; Key et al, 1996 for example). Appleby et al (2016) look at the long-term health outcomes of vegetarians and vegans, and use a type of systematic review of the literature to investigate the likelihood of having obesity, diabetes, cardiovascular disease, cancer and other such diseases. Meredith and Dwyer (1991) look specifically at adolescent health and the important role both nutrition and exercise must have for young adults to improve their health. This is a review of the nutritional needs of adolescents as they age and the risk different demographics face to developing eating problems such as anaemia, obesity and eating disorders while also accounting for the effects of puberty on a change in nutritional and exercise requirements.

Exercise is another of the biggest positive influences over an individual’s health. By exercising the recommended amount, the risk of developing long-term conditions such as heart disease, type 2 diabetes, stroke and some cancers (NHS, 2018) is reduced significantly. The National Health Service website states that, across the lifetime, different lengths of daily exercise are required to maintain good health. However, the effect of exercise has focused mainly on the benefit to an individual’s health, while wider labour market outcomes, among others, are not well established. Lechner and Downward (2013) undertook a matching analysis to examine the effects of sports participation on labour market outcomes in England. Three surveys were used: Active People Survey (England-based survey of sports participation by people aged 16 and over), Annual Population Survey (socio-economic information aggregated to local authority level to be matched to Active People Survey), and the Active Places
Survey (reports on the actual supply of sports facilities at local authority level). Using these data, the authors apply non-parametric econometric matching methods to find the relationship between participation in sports and people’s labour market outcomes. They also used probit analysis to investigate how participation varies with exogenous factors not influenced by current sports participation. The study finds that sports participation has positive associations with individual income of working age males and females and that individuals are more likely to be in work aged 26 to 45. Further analysis suggest that these differences varies by age between gender (it is found that, compared to males, females who switch from racquet and outdoor sports to team sports experience higher employability when they are older). Barron et al (2000) look at the links between athletic participation in high school and the acquisition of human capital. The US study finds that men are no more likely to be employed if they participated in high school athletics. However, the wage for males who participated in sports in high school is 12% higher in the National Longitudinal Study of the High School Class of 1971 (NLS-72) and 32% higher in the NLSY. Lechner and Sari (2015) use Canadian panel data which follows a population of age 20 to 44 in 1994 through to 2008. It is based on the three classifications of activity (inactive, moderate, active) which were defined in 1996 and look at the earnings and employment consequences of moves between these groupings. Their empirical analysis suggests that increasing activity from moderate to active positively affects earnings (increases in wages of 10-20% after 8-12 years) however the effect of moving from inactivity to moderate sports activity has no detectable effect. The effects on employment, however, suggest that moving from inactive to moderate and also active participation down to moderate increases employment, while the effect on hours worked is negligible. Lechner and Sari argue that one of the reasons for the surprising finding that moving from active down to moderate participation may be “a further increase of sports and exercise activities beyond a moderate level increases the value of leisure time” therefore this individual is more likely to substitute work for leisure which increases their sports participation. The authors do recognise that this is a speculative justification for this finding and cite that further research is required to back up this finding. Exercise is also known to have effects on cognitive ability.

Stress is another factor which contributes to poorer health and increase the risk of developing severe long-term issues. Stress in the workplace (organizational stress) also has implications on an individual’s performance at work as it is seen to hinder day-to-day tasks. Sullivan and Bhagat (1992) describe four main hypotheses surrounding the effect of stress on performance; the inverted U-shape, a positive linear relationship, the negative linear relationship and then there being no relationship between stress and performance. The first of these argues that a moderate amount of stress is necessary to facilitate performance at work as it motivates an individual to get more work done. Below this level of stress, there is little motivation and too much stress diverts attention away from work and towards coping with stress. Their findings support a negative relationship between the amount of stress an individual feels and their job performance. However, they also note that there is some inconsistency across studies.
where the measures of stress were different (for example, the difference of functional vs dysfunctional stress, plus looking at short-term effects on performance against long-term effects). Some studies focus on occupation-specific stress – such as nurses, child welfare workers, physicians and call centre employees – and discuss the effects of organizational stress on their work specifically. Travis et al (2015) look at role conflict and role ambiguity as work stressors for social welfare workers, where role conflict refers to the conflicting demands employees deal with and role ambiguity is where the expectations of others are unclear (Kahn et al, 1964). The study found that work stressors including work-family conflict and role conflict were positive and significant predictors of emotional exhaustion which is consistent with literature surrounding job-burnout (see Allen et al, 2000; Maslach, 2003 and Peeters et al, 2005). Work-family conflict is based on the work of Kahn et al (1964) and relates specifically to the study of organizational stress as a stressor whereby it is “a form of interrole conflict in which the role pressures from the work and family domains are mutually incompatible in some respect” which Greenhaus and Beutell (1985) categorise into: Time-based conflict, Strain-based conflict, and Behaviour-based conflict. Emotional exhaustion and job-burnout have negative effects on an individual’s job performance. (see article “The relationship of emotional exhaustion to work attitudes, job performance and organizational citizenship behaviours” – need to properly reference)

As mentioned previously in this review, Lenhart (2019) uses the BHPS to analyse the relationship between the labour market and health outcomes. Through this, the author looks at changes in the frequency of healthcare usage which affects the labour market outcomes of individuals through taking time away from work and work-related activities. Part of the focus of the study was to determine potential mechanisms through which health shocks negatively affect labour market outcomes. The author finds that increasing usage of health care can contribute to the “persistent negative effects of health shocks on labour market outcomes. One factor limiting the ease of access to healthcare services is the disparity between rural and urban areas in most countries – including more developed countries such as Canada, Australia and the US. Sibley and Wiener (2011) state that the conclusions as to whether rural populations have limited access to healthcare compared to urban areas have been “contradictory and inconclusive”. They state that the inconsistency in results is dependent upon which measure of access to healthcare is used and whether geographic characteristics – which go beyond whether the individual is in a rural or urban area – are controlled for. Their econometric method is the calculation of unadjusted odds ratios to compare access measures across the rural-urban line.

‘Distance decay’ is one central theory which investigates the relationship between the distance to healthcare services and the likelihood of use. A report by Imison et al (2014) for the King’s fund stated that the distance decay effect is where “distance from hospital services reduces patients’ utilisation of them (services are taken less often or later)”, however they state that the exact relationship between distance from health services and the outcome on health is yet to be conclusively corroborated across
academic papers. A systematic review by Kelly et al (2016), however, find 77% of the 108 studies they reviewed found a distance decay relationship for healthcare where those living in rural areas had reduced healthcare usage as a result of being further away from services.

Many papers cite the Behavioural Model of Health Services Use (see Andersen, 1995; Babitsch et al, 2012; Litaker et al, 2005) which was modelled to incorporate both individual and contextual factors which determine individual’s use of healthcare. The model identifies ‘predisposing’ (including demographic information about an individual such as their age, sex, ethnicity etc.), ‘enabling’ (such as financial situation, education level and employment status) and ‘need’ factors (e.g. self-reported health, diagnosed medical conditions), all of which have sub-themes and include a multitude of different indicators – hence studies that use this model have observed different outcomes depending on the research question. Babitsch et al (2012) state that, alongside income factors which enable healthcare usage, transportation, travel times to and waiting times for healthcare services all affect healthcare use.

There is also some evidence for the effects of specific health conditions and their effect on labour market outcomes. Seuring et al (2015) conduct a cross-country systematic review of the economic costs of type 2 diabetes and find that, across all but 2 studies, the employment probabilities of men with type 2 diabetes were more negatively affected than those of women (however the extent of interpretation of this relationship is dependent on the statistical methods used in the studies to account for reverse causality or other unobservable factors). Holmes et al (2003) use the TARDIS study which is UK-based and captures the full costs of care for a sample of people with type 2 diabetes – collecting data both on patients and carers. There is a question on the questionnaire which asks “Are you not working, or working only part time, because of your diabetes?” which was used in the empirical analysis for those aged <65 years where the patient or the carer had responded that they were not working or only working part time because of their diabetes (or due to caring for someone with diabetes). They find, looking at the mean earnings loss, that patients lose £869 of their earnings whereas carers lose £1,300. For context, using the Annual Survey of Hours and Earnings data for 1998, the total loss of earnings for patients was 5.1% of average earnings, and for carers, it is 7.6%.

There are many existing cost-of-illness reports which look at the burden of specific health conditions such as back pain, inflammatory bowel disease and bipolar disorder (see Bassi et al, 2004; Maniadakis and Gray, 2000; Gupta and Guest, 2002).

Maniadakis and Gray (2000) extrapolated data from the Census and Labour Force Survey for Great Britain to the UK using the population ratio published by the ONS. The authors estimate that in 1998, £9090 million (1.9% of total compensation received by employees) were “lost due to incapacity to

20 Calculations were made using the Annual Survey of Hours and Earnings (ASHE) data for 1998, from the Office for National Statistics. Gross weekly earnings for all employees were multiplied by 52 to obtain the annual earnings estimate.
21 Calculations were made using the Office for National Statistics compensation of employee’s series from the GDP Income tables.
work attributed to back pain” - £6538 million (1.4% of total compensation received by employees) of which was due to males and £2552 million (0.5% of total compensation received by employees) for females. The number of days out of work attributed to back pain is the main empirical focus of the study – which is a focus on the absenteeism as a result of a specific health condition. Begley and Beghi (2002) review existing literature of cost-of-illness reports on the economic cost of epilepsy and cite the indirect costs of epilepsy include the cost of unemployment (attributed to the presence of epilepsy in the individual). This is estimated as the lost earnings and/or the imputed value of lost household work associated with morbidity and mortality referred to as the human capital approach. The human capital approach is also reviewed by Luppa et al (2007) who define this to measure “the potential loss in production for a society as the consequence of an illness, namely in terms of lost earnings”. This is another literature review but of the cost-of-illness of depression – which looks to examine both studies finding direct cost effects and indirect cost effects and finds that the indirect morbidity costs per case were between $3656.34 and $5360.99 per year were reported.

Jones et al (2016) study the outcomes of acute health shocks on labour market outcomes and find some evidence of causal impacts of the incidence of acute health shocks affect labour supply decisions. They define acute health shocks as the onset of a cancer or stroke or myocardial infarction (heart attack) and that labour market participation reduces significantly after a health shock where the average labour market exit risk doubles afterwards. However, for those who remain active following a deterioration in health, there is no significant effect on hours and earnings detected. The study uses Understanding Society data from the UK Household Longitudinal Study (UKHLS) to identify the short run labour supply response to a health shock which occurred between $t-1$ and $t$. The sample size is reduced to 428 looking at those who experienced an acute health shock in the UKHLS which is small, but they state this is consistent with the literature. A matching algorithm is implemented using coarsened exact matching (CEM) and propensity score matching following a method set out by Ho et al (2007) to estimate the average treatment effect on the treated (ATT). To estimate the ATT, parametric models (probit or OLS depending on the distribution of the outcome) are used with the weights obtained from the CEM which contrasts purely nonparametric comparison of weighted means and allows the authors to condition further on observable and time-invariant unobservable confounders, proxied by lagged outcomes.

Much research has been carried out to show how air and noise pollution effect a person’s ability to develop human capital. Suglia et al. (2007) use longitudinal data on children in Boston, Massachusetts, USA, to assess whether higher levels of black carbon (which is common near busy roads) predict decreased cognitive function (assessed through verbal and nonverbal intelligence and memory). To estimate black carbon levels, an existing spatiotemporal regression model is used to predict traffic exposure throughout a day. Cognition is assessed through two assessments: Kaufman Brief Intelligence
Test (K-BIT) and the Wide Range Assessment of Memory and Learning (WRAML). The effects of predicted black carbon on cognition is assessed via the implementation of a linear regression, adjusting for child’s age at cognitive assessment, gender, race/ethnicity, exposure to in-utero/postnatal second-hand smoke, birth weight, blood lead level and maternal education. Results show black carbon to be a significant predictor of cognitive function. Clark et al. (2005) investigate the association between noise pollution and measures of cognition. The 2001–2003 Road Traffic and Aircraft Noise Exposure and Children’s Cognition and Health (RANCH) project is analysed using multilevel modelling. It is found that aircraft noise exposure at home and at school are highly correlated with impaired reading comprehension, however road traffic noise exposure is not. Clark et al. (2012) however hypothesize that air pollution explained the association between noise exposure and child’s cognition. Using the same RANCH data, the authors find that adjustment for air pollution has little influence on the association previously found between aircraft noise exposure at school and children’s cognition.

2.3. **Job mobility, skills, and training**

In this section we review a number of recent papers that aim to shed light on the implications that the increase in job mobility may have on the re-training needs of workers (and different types of workers), and the extent to which these costs will be borne by the firms. This issue is strongly related to the literature that debates on whether human capital is more firm or industry specific, with some recent contributions suggesting that it may be increasingly linked to specific occupations or tasks; which may mean an increase in the degree of transferability of skills across firms and even industries.

Understanding the effects of a rapid introduction of Artificial Intelligence and robotisation on the labour market, and on the economy as a whole, is emerging as an issue of key interest. Undoubtedly, the resulting changes in production processes could be profound and likely to have important consequences for the organisation of work. One strand of the literature investigates the degree as to which robots are likely to be substituting for labour (Acemoglu and Restrepo, 2017; Arntz et al., 2017), while others explore the rise of new job roles and occupations and attempt to understand what types of skills are likely to be more complementary to new forms of capital. The displacement of labour in automated tasks could be counteracted by an increase in the productivity in non-automated tasks which may enhance the demand for new tasks and counterbalance the negative effects of automation on employment. In this respect, the adjustment will depend, largely, on the appropriateness of the match between the skills of the workforce and those required by new technologies (Acemoglu and Restrepo, 2018).

We highlight issues surrounding job mobility and occupational change in particular for the UK, but we find that the evidence is scant compared to other countries that can make use of richer surveys. All of
the UK evidence we have reviewed mainly uses the BHPS or the LFS. In addition, it is worth noting that there is to date little evidence specific for the UK on the relationship between automation and robotisation and the displacement of workers while Frey and Osborne (2017) find that in the US 47 per cent of workers are at risk due to automation.

2.3.1. Firm, industry and occupation-specific human capital

Initially the literature emphasised the importance of firm-specific capital acquired by workers; Becker’s (1964) initial discussion focused on the dichotomy between firm-specific and general capital. This distinction was crucial because while workers could have strong incentives to invest optimally in general human capital, there could be potential incentive problems in financing firm-specific human capital. Subsequent research suggested that an important component of human capital could be industry-specific and can be lost only when the worker switches to a different industry (Neal, 1995; Parent, 2000). A more recent strand of literature concludes that a major component of human capital is occupation-specific (Kambourov and Manovskii, 2009; Sullivan, 2010). In particular, Kambourov and Manovskii (2009) argue that the evidence supporting the prevalence of industry-specific capital is misleading as they find that tenure in an industry has a small effect on wages once the effect of occupational experience is accounted for. Lazear (2009) proposes a theoretical skill-weight model where most capital is general human capital and uses are specific to the firm. The assumption is that there are a variety of skills used on each job, and each of these skills is general in the sense that it is used at other firms as well. The difference, however, is that firms vary in their weighting of the different set of skills. Therefore, this theoretical model predicts that most forms of skills will not be truly “firm specific”, and there should be less loss of human capital following an involuntary job loss, especially when industry and occupation effects are taken into account.

The process of changing occupation (not just jobs) however should not necessarily be associated with loss of human capital (which can be the case mostly when the job change is involuntary) as some occupational change can also be the result of natural career progression, for example as workers achieve promotions that result in wage gains. Moreover, mobility across firms and occupations can be an important adjustment mechanism in a dynamic labour market; for instance, Autor et al. (2003) introduces a task-based approach to model job skill demand and point out that there is a decline in the demand for routine intensive occupations, to which workers can adjust through occupational mobility.

2.3.2. Work characteristics
There has been a growing area of research around structured management practices and firm performance – including productivity (Bloom et al. 2013, ONS 2017, Bender et al. 2016, Broszeit et al. 2016). Using the survey of management practices in the US, conducted in over 30,000 plants, Bloom et al (2013) found that structured management practices for performance monitoring, targets and incentives are linked to better performance of firms, with firms adopting these practices displaying greater productivity, profitability, innovation, and growth. Furthermore, firms with a higher share of managers and employees with a degree, tend to have a higher management score. In addition, Bloom et al (2017) found casual impacts of education on management practices. They find large significant effects on management practices of being near a land-grant college with a range of controls for other local variations in population density, income and other county-level and firm-level controls.

Within the work environment, it is important that workers are engaged - defined as a positive, fulfilling, work-related state of mind that is characterized by vigor, dedication, and absorption (Schaufeli et al., 2002). Using structured qualitative interviews with a group of Dutch employees from different occupations, Schaufeli et al. (2002) found that engaged employees have high energy and self-efficacy, while Schaufeli et al (2006) found that engaged employees often experience positive emotion, which may explain why they are more productive. In addition, an alignment of values can also have an impact on worker engagement.

One approach taken by employers to increase the development of their workers is the implementation of a mentoring system. Through this, mentees are able gain and develop new knowledge, skills and abilities, as well as recognition within the organisation from more senior workers (Tong & Kram, 2013). However, the benefits of mentoring are not limited to mentees, with mentors having increased opportunity to demonstrate leadership as they guide and advise their mentees (Dawson et al, 2015).

A study by Orpen (1995) looked at 97 British employees in their first job. During the 6th month of their employment, each participant had assessed the extent of the mentoring they received, measured by a 15-item scale. Data on the number of promotions and salary growth Four years later were used as measures of career success. In addition, there was a significant relationship between career coaching mentoring and positive outcomes. Those who experienced more career-related support from their mentors had a higher organizational reward. Further work done by Orpen (1997) looked at the effects of a formal mentoring programme on the work motivation, organizational commitment and job performance of mentees. The performance of each mentee was given by ratings from their managers, with results showing that formal mentoring can improve employee attitudes without necessarily raising their performance, at least in the short term.

The move towards flexible working arrangements has been identified as a way for workers to balance out work responsibilities and other commitments (Evans 2001; Glass and Estes, 1997: Dex and
Smith, 2002). Using survey data of 398 health professionals who had children aged 16 years or younger at home, supportive practices at work, such as flexible working, decreased work/family conflict, decreased depression, fewer somatic complaints, and lower blood cholesterol (Thomas & Ganster 1995). In addition, supportive supervisor behaviour of non-work demands also showed consistent positive effects on job satisfaction and health outcomes for those responding to the survey. Using the Workplace Employee Relations Survey (WERS), Dex and Smith (2001) examined the effects on firm’s performance associated with firms giving their employees an entitlement to any one of 10 family-friendly or flexible working arrangements in 1998. Using an OLS, logistic regression or ordered Probit to estimate models of labour productivity, firm performance, among others, they find that the provision of family-friendly policies relating to child care and working from home were associated with greater employee commitment, captured by employees’ feelings of loyalty or shared values with the organisation. Further to this, it has been noted in the literature that once becoming a mother, women might choose to offset higher earnings for more desired working conditions (Felfe, 2012). Using data from the 1979 National Longitudinal Survey of Youth, and an endogenous switching wage equation model to account for the self-selection, Amuedo-Dorantes and Kimmel (2008) assessed the role of employment-based health insurance offers in explaining the motherhood wage gap. The authors find a negative compensating wage differential arising for the relative job preference of mothers from an important component of non-wage compensation, namely, health insurance coverage.

Kidd et al. (2003) examines the outcomes on employee capability that resulted from the career discussions of 104 employers. The results show that employees benefit from discussions about their careers, with multiple outcomes being experienced, from short-term outcomes on improved self-insight and feeling more confident and reassured, to longer-term outcomes on job moves, or increase opportunities to develop new skills. It is important to recognise the role that line managers can play in creating an environment that empowers self-development.

2.3.3. Estimating the costs of mobility

Cortes and Gallipoli (2017) estimate, using US data, that the transition costs across occupations can be substantial, which complements other evidence regarding transition costs across industries (Artuç et al., 2010; Dix-Carneiro, 2014). They draw from a model of occupational choice with a gravity equation linking worker flows to occupation characteristics, and to transition costs. In evaluating the cost of switching occupations Cortes and Gallipoli stress the importance of ‘task distance’, that is, the degree of dissimilarity in the mix of requirements needed to perform a job. The costs of occupational mobility should be increasing in task distance, and a considerable share of human capital would be lost when a worker experiences a large change in the set of tasks she/he performed. Cortes and Gallipoli’s model
also allows for occupation-specific entry costs, which are independent of task content and may vary over time; these entry costs capture institutional barriers faced by potential entrants to an occupation, such as qualification credentials, professional training and union membership requirements. They estimate the gravity equation using a range of proxies for occupational mobility costs and draw from data on monthly worker flows across two-digit occupations from the Current Population Survey for the period 1994 to 2012. This study exploits the fact that individuals' occupations are observed over consecutive months, as data on job-to-job transitions are available at a monthly frequency. They characterise occupations according to a number of variables regarding a number of dimensions of complexity of work, general education development, specific vocational preparation requirements, aptitudes, temperaments and physical demands, among others.

Cortes and Gallipoli find that task distance is a significant component of the cost of switching occupations, suggesting an important role for task-specific human capital. In particular, an increase of one standard deviation in task distance is estimated to increase the cost of switching occupations by nearly 20 per cent. They consider fixed cost of switching across occupations that belong to different major task groups (non-routine cognitive, routine cognitive, routine manual or non-routine manual), as there may be costs associated with these switches that exceed what is captured by the distance measure. They find that if the switch is to a different major task group, the increases are larger, that is, depending on the type of transition. For example, the additional costs are estimated to be between 14 percentage points (for transitions into ‘routine cognitive’ occupations) and 58 percentage points (for transitions into ‘routine manual’ jobs). The results are robust when the analysis is restricted to younger workers for whom occupational mobility rates tend to be higher. Despite the considerable role of the ‘task content’ variable, they find that the largest part of occupation mobility costs can be attributable to task-independent entry costs into the occupations.

Gathman and Schönberg (2010) also study the transferability of skills accumulated in the labour market, building on the concept of ‘task-specific human capital’; this is in line with previous literature that consider that occupations are characterised by a vector of skill or task characteristics (Autor et al., 2003). The underlying notion is that if human capital is task-specific, it should be partly transferable across occupation pairs, in which a similar mix of tasks is performed. To measure the transferability of skills

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22 Routine cognitive occupations include: Sales supervisors and sales reps, finance and business; retail and other salespersons, office supervisors and computer operators, secretaries, stenographers, and typists, information and records processing, except financial; financial records processing occupations, office machine operators and mail distributing; other administrative support occupations, including clerical.

23 Routine manual occupations include: mechanics and repairers; construction trades; other precision production occupations; machine operators and tenders, not precision; fabricators, assemblers and hand working occupations; production inspectors and graders; transportation and material moving; helpers, construction and production occupations; freight, stock and material handlers.
empirically, they combine a high-quality panel on complete job histories and wages, with information on tasks performed in those occupations. They use data on job histories and wages from a 2 per cent sample of all social security records in Germany, providing a complete picture of job mobility and wages for more than 100,000 workers during the period 1975 to 2001. These data have several distinct advantages over data used in the previous literature on occupational mobility. First of all, and compared to household data, the use of administrative data allows for a more precise record of the dates of job changes; second, there is more guarantee that occupational titles are consistent across firms as they form the basis for wage bargaining between unions and employers; and third, there should be less measurement error in earnings and occupational titles compared to typical surveys, as misreporting is subject to severe penalties. The authors then use data on detailed information on tasks performed in occupations (from the repeated cross-section German Qualification and Career Survey), to identify how similar occupations are in their skill requirements. In this survey, individuals are asked whether they perform any of 19 different tasks in their job, and they categorise these 19 tasks into three aggregate groups: ‘analytical tasks’, ‘manual tasks’, and ‘interactive tasks’. This study introduces a continuous measure of how occupations are related to each other in terms of their skill requirements, and concludes, after exploring wage changes, that specific human capital should not be fully lost after an individual leaves an occupation. They conclude that human capital is more portable across occupations, particularly for the high-skilled, than previously considered. Poletaev and Robinson (2008) find a similar result for the US, building also on the idea that jobs can be characterised by their skill vector rather than their narrow industry or occupation codes. Drawing from evidence from the US Displaced Workers Survey (for the period 1984 to 2000), they find that displaced workers, which in a large majority were reallocated across standard occupations and industry codes (after in this case plant closures), tend to experience wage losses to some degree. They observe that those workers with the largest losses were also those that experienced more significant switch in their skill portfolio. If human capital is specific and can be narrowed down to a small number of basic skills, then a substantial deviation in the skill portfolio mix between pre- and post-displacement jobs would result in a loss of specific capital, and the patterns of wage losses are consistent with this idea. Conversely, many switches of industry or occupation codes are not significant skill portfolio switches, and in these cases the wage losses are relatively lower.

A number of OECD papers focus on how education and training policies can facilitate transitions across occupations, while maintaining workers in quality jobs that can maximise the use of their skill set (Bechichi et al., 2018; Andrieu et al., 2018). Bechichi et al. (2018) provide evidence on the quantity and type of training needed to facilitate certain job-to-job transitions and investigate what influences skills distances across occupations have. They use PIAAC data on 31 countries and their results show that training needs are not equal across all occupations and level of skills. Skills distances in terms of
cognitive skills are higher among groups of low-skilled occupations or from mid-skilled to high-skilled occupations than among higher skilled occupations. The analysis of occupational moves within high-skilled occupations, for instance moving from professionals to managers or within the group of professionals, conversely shows that skill distances are larger when it comes to task-based skills and relatively smaller for cognitive skills.

Building on these studies, Andrieu et al. (2018) propose an experimental methodology to estimate empirically the monetary cost of training needed to move workers across occupations for a sample of OECD countries. They estimate re-training costs of both direct and indirect nature. Indeed, the direct cost of re-training can be proxied with two main elements: a) a country’s yearly expenditure in education per pupil and b) the average re-training time between the occupation of origin and all the ‘acceptable’ occupations of destination. Occupations are regarded ‘acceptable’ when they are relatively close in terms of skills requirements to those of the occupation of origin, and any wage cut is of maximum 10 per cent. The direct cost of undertaking the training is however only one of the components of the total costs, and this methodology also considers the workers’ opportunity costs in terms of the foregone wages throughout the duration of the training spell. The indirect costs of training are defined here as the wages and bonuses a worker sacrifices while in training, which corresponds to the opportunity cost of retraining from a worker’s point of view. This study estimates that the average direct (re)training costs per worker is estimated to be around $1,600 for small training needs (up to 6 months); it is double than that ($3,200) in a moderate training scenario (up to 1 year), and rises sharply in a more intensive training scenario (up to 3 years) to $12,600. The average per-person opportunity cost (i.e. the indirect cost) is about $4,300 in the case of the first scenario, $9,900 in the moderate one, and rises sharply to $37,000 in the case of the intensive training scenario. They estimate the opportunity cost of training represents approximately 75 per cent of the per-person total cost. The total cost (that is, the sum of the direct and indirect costs) is generally larger for highly skilled than for low-skilled occupations, given the larger opportunity costs.

This study also finds that a workers’ average age is positively correlated with the cost of moving the worker to a different occupation, which highlights the challenges of occupational mobility for older workers. They also find, similarly, occupations with higher proportions of young (older) workers display significantly lower (higher) total retraining cost per worker on average. These results are derived using country-occupation data, and conclude that an increase of one year in the average age of workers (in a given occupation and cluster of countries24) would be associated with an increase of approximately 11 per cent in the average cost of re-training for each worker. Similarly, an increase in the proportion of young workers by one percentage point would be associated with a decrease in average cost of

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24 Cluster countries are based on relative similarities of type of tasks performed on jobs.
retraining each worker by approximately 3.7 per cent. The observation of an association between age and per-worker cost of retraining and acquiring the cognitive skills need to move across occupations, is however likely to be driven by differences in the age composition of occupations, and not by a direct relationship between the average worker’s age and the cost of re-training in a given occupation. Once one accounts for the fact that occupations with lower total cost of re-training have a higher proportion of younger workers, the remaining association between age and cost becomes often statistically insignificant. This is however not a main result of the paper and deserves further exploration.

2.3.4. Job mobility in the UK

Longhi and Brynin (2010) investigate the implications of changes in occupation using UK (BHPS)\textsuperscript{25} and German (German Socio-Economic Panel) panel data. This study finds that year on year, over 10 per cent of people change their occupation in Britain (they consider movements across two-digit occupation codes), while this figure is 5 per cent in the case of Germany. The UK ranks relatively high in terms of occupational mobility compared to other countries in Europe too, and recent evidence shows that the level of occupational mobility in Britain is one of the highest only behind Estonia and Sweden (Bachmann et al., 2017). These figures are still lower than those available for the US, with evidence of an annual mobility of 15 per cent (Kambourov and Manovskii, 2009).

Longhi and Brynin (2010) analyse the factors associated with job and occupational moves using Cox proportional hazard models, where they take into account the effect of time variant as well as time-invariant covariates. They distinguish between two types of changes: job moves within and moves between occupations. Longhi and Brynin find that those who change occupation tend to be relatively poorly matched to their job compared to those who change job but remain in the same occupation. The results suggest that factors specific to the individual, as indicated by (proxy) measures of ability and motivation, represent a major impetus to change occupation, and that occupational changes might be rational choices that relate to an initial poor occupational decision and to general aspirations about the job and work-life balance. They conclude that despite differences in occupational turnover between Britain and Germany, the factors driving change as well as the effects on the workers are not too distant across the two countries. In Britain, however, occupational change is less likely at the top of the occupational ladder, and compared to Germany, there is less evidence of an orderly career progression channelled through change of occupation.

In terms of job satisfaction, German data is richer and allows us to understand the beneficial effects of changing occupation, based on a number of subjective evaluations by workers. In the case of Britain, it

\textsuperscript{25} Nationally representative household survey providing rich information on individual demographic, socioeconomic and work-related characteristics.
is only possible to know if job satisfaction has improved or worsened after an occupational change. The results overall show both positive and negative effects of change, but overall slightly more marked improvement in circumstances after an occupation change, relative to a job change within the same occupation. In terms of skills, the results show that those who change occupation experience greater decline in the use of their skills than do other job changers. The ‘use of skills’ is evaluated using a measure of job match, which aims to capture whether the worker is overqualified. For Germany, this analysis is more straightforward; it is derived from a question on “What training is required for your job?”, which is then compared to actual qualifications. No equivalent exists in the BHPS, so for the UK, they use the ‘average’ method, which implies computing the education typically needed to perform a certain job, derived using the LFS. These are merged back into the BHPS per occupation and a dummy indicating ‘overqualification’ is computed, by a simple comparison of qualifications ‘held’ and ‘needed’.

Panos et al. (2014) investigate the inter-related dynamics of dual job-holding, human capital, occupational choice and mobility, using a panel sample of UK employees from the BHPS during the period 1992 to 2004. Multiple job-holding is estimated to be an important determinant of job mobility decisions, and individuals doing different occupations in their secondary employment are more likely to change jobs in the following year. From a policy point of view there is interest in understanding whether multiple job-holding can lead to the more efficient acquisition of skills, and to promote future potential entrepreneurial initiatives. This UK study shows that individuals may be using multiple job-holding as a vehicle for obtaining new skills and expertise and as a stepping stone to new careers, also involving self-employment opportunities, but it depends on the level of education and/or income. The study finds that individuals who enjoy a relative sense of financial security are found to be more likely to explore different occupational paths in their secondary employment to satisfy their intrinsic preferences. Instead, those individuals facing increased financial constraints are found to be more likely to do the same occupation in both their primary and secondary job, thus exploiting the higher earnings opportunities associated with their accumulated occupational experience.

Connolly and Gregory (2008) provide further evidence for the UK of the nature of occupational change studying transitions of women between full-time and part-time work. Unsurprisingly, they show higher occupational mobility for part-time workers than for full-time employees in the UK. Using information from the New Earnings Survey Panel Dataset and the BHPS for the period 1991 to 2001, they show that around one-quarter of women moving from full- to part-time work move to an occupation that requires lower level of qualifications. Downgrading affects approximately 29 per cent of women from professional and corporate management jobs, and up to 40 per cent in jobs for those with intermediate skills. While some professional women switching to part-time work do move into a new career requiring
a higher level of skills, at least as many take up jobs in a range of low-skill occupations, underutilising between three and five years of higher education and professional training.

Carrillo-Tudela et al. (2016) look at both occupational and sectoral mobility of workers in the UK labour market during the period 1993 to 2012, drawing from the UK LFS. Given the relatively long timeframe of this study, the authors are able to explore the incidence of career changes over time, in particular in relation to the Great Recession. They estimate that workers who change employers have around a 50 per cent chance of switching to another occupation or industry. Career changes are more likely for (a) those workers actively searching for a job, (b) those that made voluntary transitions (i.e. those who ‘resigned’ from jobs, or gave up for ‘family or personal reasons’, as opposed to those that were made ‘redundant’ or ‘dismissed’) and (c) those workers that work part-time or as temps. Across occupations, career changes that involve an upgrade in the skill level are more likely through voluntary employer-to-employer transitions, while instead, career changes that involve a step down in skill level are more likely after spells of non-employment.

Across industries, they find that low-skilled workers have a higher probability of a career change than medium and high skilled workers. Across occupations, it is only the unemployed high and medium skilled workers that have shown a higher propensity to change career. These authors find that broad-based shortfall in economic activity has significantly prevented workers from pursuing alternate careers thus sacrificing substantial wage gains. In terms of the effects of human capital on the probability of a career change, they find that age decreases the probability of a career change, pointing to the importance of on-the-job human capital accumulation.

Using comparative panel data of 14 European economies for the period 1994 to 2001 (European Community Household Panel), Muffels and Luijxk (2008) find, in line with most of the literature, that with age, occupational mobility slows down. However, they find a positive sign for the age-squared variable in their regression, which indicates that beyond some age threshold both upward and downward mobility increase again. This upward mobility at higher ages is more likely to occur just before retirement age (at 50 years), whereas downward mobility is likely to occur somewhat earlier (at 48 years) either due to demotion on the job, due to moving to a lower level job with another employer, or due to moving into self-employment. Muffels and Luijxk (2008) also conclude that education strongly increases the chances for upward mobility and lowers the likelihood of downward mobility into lower-level jobs. These results are consistent with human capital predictions.

2.4. Within-country migration
Regional education, mainly through education of workers, of entrepreneurs, and the realisation of human capital externalities, emerges as a critical determinant of regional development (Gennaioli et al., 2013). At the same time the literature stresses, that patterns of internal migration can significantly shape the redistribution of human capital within countries and thus affect regional economies. In this section we focus on the how within-country migration patterns can be closely related to the process of knowledge generation and development of regions. Wherever possible we focus on evidence for the UK and also review some relevant and current international studies. The analysis of the determinants and consequences in relation to international migration flows is beyond the scope of this study.

Focusing on the UK, a number of papers focus on the relationship between migration flows and innovation performance of a region. Faggian and McCann (2009) employ a simultaneous equation model to relate human capital inflows to a region’s innovativeness as well as to other regional factors (including the number of job vacancies, the level of regional unemployment, the quality of life, the regional real wage, the geographic periphery of the region, the density of universities, and the regional R&D expenditure, etc.). The main sources used in this study include labour market information on student leavers for the year 2000 (from HESA) and measures of innovation based on number of patent applications. They show that the innovativeness of a region is one of the major factors encouraging university graduates to seek employment in that region, while at the same time, inflows of highly mobile university graduates promote regional innovation, at least within England and Wales.

Using British data, Gagliardi (2015) also provide evidence of a causal link between an increase in the average stock of human capital, which arises from the inflow of skilled migration inflows, and the innovative performance of local areas. An OLS regression is estimated in differences where the dependent variable is the innovation performance of a region measured as the share of innovative firms in a travel to work area (TTWA) (that is, the difference between time t and time t-1). The main variable of interest is the influx of migrants, proxied by the share of skilled population in TTWA; but the regression includes other controls such as the change in the average ratio of skilled over unskilled labour and other indicators of TTWA controls. The specification in differences allows for removing any time-invariant unobserved heterogeneity across regions. The paper focuses on the role of human capital externalities as a crucial determinant of local productivity and innovative performance. In this context, skilled migration becomes a crucial channel of knowledge diffusion broadening the geographical scope of human capital externalities. The estimation procedure adopted is constructed around a place-based knowledge production function defined for TTWA level. The empirical analysis draws from the Community Innovation Survey and the LFS. The main challenge in performing this estimation strategy is related to the endogeneity of the regressors of interest. Firstly, migrant inflows and innovative performance may be correlated due to common fixed influences, as immigrant population may be
concentrated in certain areas as a consequence of historic settlement patterns. This may explain a positive correlation between skilled migration and innovative performance of a region, even when there is no a genuine casual effect. Endogeneity in this case is minimised by estimating the relationship using differences, that is, by relating changes in immigrant concentration between two points in time to changes in the innovative performance of the areas of destination. Second, this type of estimation is likely to be affected by reverse causality bias. Skilled migration inflows can be considered a fundamental determinant of innovation since they act as channels of knowledge transfer, and reduce the geographically localised nature of human capital externalities. To address this source of bias, this paper adopts an IV approach, drawing from variables that are likely to be correlated with inflows, but not otherwise associated with the dependent variable through unobserved local characteristics. For example, the variation in the share of skilled migrants is instrumented by a shift-share instrument constructed using LFS data on country of birth (this identification strategy combines local economic compositions with shifts on the aggregate level to predict variation in a variable of interest). The results of this paper show human capital externalities related to the migration behaviour of skilled individuals are a significant determinant of innovation in British local areas; but there is not much evidence for the existence of additional human capital externalities in cities related to the effects of urban agglomeration.

A recent strand of literature draws from micro-level administrative data to show that patterns of internal migration play a decisive role is the spatial distribution of human capital. The study by Kooiman et al. (2018) follows the birth cohort 1979 from age 16 until age 35, comparing spatial trajectories between university graduates and their lower educated peers. This paper uses data from the System of Social statistical Datasets of Statistics which covers the complete registered population of the Netherlands; individuals are traced longitudinally and spatially from 1995 until 2014 and this data is enriched with demographic and socio-economic information. They observe that the highest educated individuals are more than others attracted to metropolitan core areas. They also find that employees in the largest cities make more wage progression than their peers in smaller cities and villages because they increase the number of hours worked and they are employed in industries characterised by above-average wage progression. A question of importance highlighted in the literature relates to the reason why lower educated workers do not migrate to the same degree as university graduates do.

The results in Kooiman et al. are consistent with those in Moretti (2012), who shows for the US that lower educated workers tend to stay put in regions with relatively scant opportunities. This relative immobility of the lower educated is argued to be attributed to a number of reasons. For example, they have a lower ability to process and analyse information with regards to the availability of alternative opportunities elsewhere and they have a stronger reliance on family and friends (Faggian et al., 2015). A possibility is that for the lower educated these spatial bounded benefits are predominantly financial,
as they may enjoy better wages for the same job, while for university graduates metropolitan areas offer more opportunities for career progression.

Comunian et al. (2016) discusses the contribution of different ‘types’ of human to local development. They investigate whether creative human capital, that is, ‘the human capital specifically developed via education and advanced training in creative and artistic subjects’, play the same role as more scientific-oriented human capital (e.g. STEM) in fostering local development, as the recent literature on human capital and regional economic development has become increasingly concerned with the role of the ‘creative occupations’. They explore the transition period from university education to employment of creative graduates, with the aim of advancing the understanding of the relationship between creativity and mobility of human capital. This study provides the first empirical analysis of the role played by creative graduates’ subject background in influencing their migration choices in the UK. It expands from other prior studies in the field by looking more specifically at the migration behaviour of subgroups of creative graduates. The main sources for this study are the Students in Higher Education and the Destinations of Leaves from Higher Education surveys, both collected by HESA. The first one contains data on all students enrolled in UK Higher Education Institutions, while the second one is a survey undertaken every year that generally covers British domiciled students to collect information about graduates’ employment activities six months after graduation. Since the main interest is migration, the focus here on British-domiciled students (both part-time and full-time) for which full location information (post code information for pre-university, university, and job location) is available. The results confirm the role of London as a hub for talent, but also as magnet attracting creative students from all over the UK and retaining almost three quarters of them. They also find, consistent with previous literature, that creative graduates have lower salaries but they find that migration mitigates some of their difficulties allowing them to find a better occupation more fitted to their skills. The fact that ‘return migration’ is the most common choice of creative graduates suggest that networks and peer-to-peer support play a key role after graduation. For music graduates in particular they find university networks play a crucial role in helping them to eventually secure successful careers.

Huttunen et al. (2018) analyse the geographic mobility of workers after a permanent job loss, and investigate factors that influence workers’ migration decision. They provide evidence on the importance of non-economic factors in explaining migration decisions and income losses following job displacement. They draw from rich Norwegian register data that includes information about the workers’ characteristics, location and employment histories, as well as information about spouses, children, parents and siblings. A key feature of the data is that it tracks individuals even after leaving the labour force. Moreover, it allows the analysis of earnings and employment patterns several years before the job loss, thus assessing the selection into mobility. Having detailed information on spouses,
the age of children and the location of parents and siblings help assessing the effect of family networks on mobility decisions. Also, this study provides evidence of how earning losses after job displacements are related to migration. This research assesses the post-displacement labour market experience of movers and stayers, comparing displaced movers and stayers with a control group of non-displaced workers. A key aim is to understand whether earnings differential between displaced movers and stayers is a causal effect of moving and the selection issue in the decision to move. This is an important consideration as while some literature finds that migrants tend to be favourably self-selected, it is also possible that the most productive workers are best rewarded in their local labour market, and hence have less need to move.

The results show that family ties are very important for workers’ mobility decisions. Workers who move to a new region after a job loss suffer larger income losses than stayers, although the difference between the movers and the stayers in total family income is smaller and tends to disappear over time. They find that the difference in individual earnings between displaced movers and stayers is driven entirely by workers who move to rural regions or to regions where they have close family networks.

2.5. Crime

The labour market outcome of an individual is strongly related to their human capital which, as discussed earlier, is linked to family background, health and many other factors. In this section of the literature review, the role of criminal activity is discussed. In particular, papers that examine the causal effect of educational attainment on crime (and vice versa) are studied. Policymakers put a lot of emphasis on enforcement and punishment to tackle crime, but a lot of empirical evidence highlights the role of early intervention with regards to education in reducing criminal activity. Although different features of crime incidence are worth studying, the most widely examined area (by economists) involves education. This focus is not surprising given that a survey of newly sentenced prisoners in the UK showed that in 2005/2006 47 per cent had no educational qualification, compared to 15 per cent for the general population (Hopkins, 2012). Therefore, most of the reviewed studies in this section examine the economics of education and crime, while the remaining section discusses the role of family life, and how educational or vocational intervention programs in prison may affect human capital.

According to a review carried out by Draca and Machin (2015) the prominence of economics of crime as a research field on its own has risen drastically over the last two decades. However, this review shows that the majority of papers published, especially the most widely cited ones use US data, and more recently Scandinavian administrative data (for example, Bennet, 2018). Only very little work has been
carried out using recent UK data, which is partly the result of limited availability for identification strategies and partly because of the lack of administrative data.

2.5.1. Economics of education and crime

The existing socio-economic literature has identified some mechanisms through which education impacts on crime: income, preferences, social interaction and time availability. Education is considered a main driver in human capital accumulation which improves work opportunities and in turn discourages criminal activities. Widely cited work by Lochner based on the US argues that human capital increases the opportunity costs of crime from foregone work and expected costs with incarceration (Lochner, 2004; Lochner and Moretti, 2004). In other words, investments in human capital, through education for example, should reduce crime if human capital increases marginal returns from working more than returns from participating in crime. This is in line with empirical evidence which finds a negative relationship between wages and criminal activities (Machin and Meghir, 2004) and a positive relationship between education and wages (see section on earnings determinants for a detailed review). While this is plausible for most types of street crime, there is the argument that white collar crime and education are positively correlated because illegal activities, such as fraud or embezzlement, are likely to require skills obtained in school (Lochner, 2004).

Besides the wage-related mechanism, Hjalmarsson and Lochner (2012) bring forward the argument that education can reduce crime through changes in risk-related preferences and social interaction. This is based on the assumption that education can encourage risk-aversion and more educated people tend to interact with like-minded people who are discouraged from engaging in crime. However, the latter argument can be questionable since this is likely to depend on the quality of school provided. Although there is no empirical evidence for this relationship, research on school choice and desegregation in the US offer some support for the role of school quality in explaining the education-crime nexus (Guryan, 2004; Cullen et al., 2006; Weiner et al., 2009; Deming, 2011).

Another literature strand builds on the incapacitation effect and argues that education discourages crime not only later in life, but also during school enrolment, since students are less likely to commit any crime while being in a classroom (Tauchen et al., 1994; Anderson, 2014; Bell et al., 2016, 2018). Furthermore, skills obtained as a result of school attendance may enhance labour market prospects and discourage a life of crime by making juvenile arrests more costly. Early empirical evidence on the incapacitation effect in the US is presented by Jacob and Lefgren (2003) who use exogenous teacher training days, and Luallen (2006), who uses unexpected school closures as a result of teacher strikes, as instruments for student absence from school. Both find incapacitation effects of education on
criminal activity, with higher crime rates during days off. Similar findings are observed by Anderson (2014) who exploits variation across states in the minimum high school dropout ages to estimate the effect on juvenile arrest rates between 1980 and 2008.

There is also an argument for the opposite direction of this relationship to be true since crime can also affect educational attainment if arrest and incarceration incentivise school drop outs (Lochner, 2004, 2011; Sweeten, 2006; Hjalmarssson, 2008), the accumulation of criminal capital replaces the need to invest in education (Lochner, 2004; Ward and Williams, 2015) or interactions with the criminal justice system harm non-cognitive skills of adolescents which can reduce motivation or aspiration and hence influence educational outcomes negatively (Behncke, 2012). However, while this literature review revealed that evidence for the negative causal effect of education on crime is growing, it has also highlighted the lack of empirical evidence for the opposite direction which is mainly due to the difficulty of identifying exogenous variations in criminal involvement. One exception is a recently published paper by Rud et al. (2018), which uses administrative data from the Netherlands to examine the effect of early criminal activity on school dropouts and to analyse underlying factors of this relationship. They use an OLS regression set-up with a large number of observable family and individual characteristics as well as school, class, sibling and twin fixed effects and find that criminal activity is associated with an 11 percentage point higher probability of school dropout with a stronger effect size if juveniles are involved in severe criminal activities. However, the magnitude reduces when unobserved and observed heterogeneity is controlled for and, therefore, they conclude that, if present, the treatment effect is relatively small. A very similar strategy is employed by Webbink et al. (2013) who use Australian cohort data on twins in a fixed effect estimation. They find that early arrests decrease the probability of completing high school for fraternal twins and decrease educational attainment in general. By using a male sample from the US NLSY 1997 in a multivariate mixed proportional hazard framework to control for common unobserved confounders and address reverse causality, Ward et al. (2015) find that arrest and delinquency both incentive school dropouts and that the effect of delinquency is driven by income generating crimes.26 Aizer and Doyle (2015) use an IV approach and exploit exogenous variation in juvenile incarceration as a result of the random assignment of juveniles to judges with different tendencies to sentence youths to imprisonment. They use uniquely linked administrative data for over 35,000 juveniles over 10 years from a juvenile court in Chicago and find that juvenile incarceration decreases the probability of graduating from high school.

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26 They estimate in a baseline scenario with a reference male that was neither involved in delinquency nor was arrested, that he is 35 per cent more likely to leave school at age 18 or earlier, which increases to 42 per cent if he initiates delinquency at age 16 and is not arrested, and to 55 per cent if he has been delinquent at age 16 and has been arrested at age 17. As a result, being delinquent at age 16 increases the probability of school leaving by age 18 by 20 per cent, while subsequently being arrested at age 17 increases it by a further 37 per cent.
Although evidence for a negative relationship between education and crime is already found in very early studies, they are often based on standard regression models that only control for individual and family characteristics (see, for instance, Ehrlich, 1975 and Witte, 1997). These results do not necessarily imply causality because unobserved individual characteristics, such as the previously mentioned risk aversion, are likely to impact on both schooling and the choice to commit a crime. More recent studies address these issues by exploiting policy changes to schooling ages to create exogenous variation in educational attainment. While our review has revealed that significant research progress has been made in establishing a causal link between average educational attainment and arrest, conviction or incarceration rates, most of the empirical evidence comes from studies carried out in the US (most commonly known is the work by Lochner and Moretti, 2004 but most recent data up to 2015 has been used by Bell et al., 2016, 2018) or Scandinavian countries (for example, Meghir et al., 2012; Brugård and Falch, 2013; Hjalmarssson et al., 2015; Landerosa et al., 2016). Another strand of literature adopts an experimental research design based on US interventions, such as the 1960s High/Scope Perry Preschool Program or the Moving to Opportunity experiment, which allocate people randomly into programs aimed at improving skills. Cost benefit-analyses have shown long-run crime reductions through improved male child development (Belfield et al., 2006; Heckman et al., 2013) and short-run reductions in violent crime due to improved neighbourhood conditions (Kling et al., 2005; Scandria et al., 2013).

The few exceptions of work carried out in the UK are studies conducted by Machin et al. (2011), Machin et al. (2012) and Sabates and Feinstein (2008). Similar to most US based work, Machin et al. (2011) exploit the increase in the minimum schooling age from 15 to 16 in England and Wales in the school year of 1972/1973 to estimate the effect of education on property and violent crimes convictions between 1972 and 1996. They used an IV and regression discontinuity setting to study cohort-level changes for cohorts turning 15 just before and after the change in the law. They find that the schooling reform increased educational attainment in the reduced-form and first-stage by generating a significant causal estimate for the effect of education on crime, which was almost twice the size of the corresponding OLS estimate. More precisely, Machin et al. (2011) find a decrease in conviction rates for men committing property crimes by 20 to 30 per cent with every one-year increase in average schooling levels. The effect on violent crime is also sizeable but statistically insignificant and education affected neither of these crime types when committed by women. In the US, schooling effects were smaller on property crime and larger on violent crime (Lochner and Moretti, 2004). Machin et al. (2012) examined a similar relationship but adopt a different identification strategy. In this case they exploit the increase in education levels across the whole education distribution, which was the result of a large expansion of the UK post-compulsory education system that occurred in the late 1980s and early 1990s. Their IV setting reveals that education reduces adolescent crime but also affects qualification attainment and wages suggesting that additional time spent in school, i.e. the incapacitation effect, is not the sole
mechanism through which education impacts on crime participation. More precisely, they demonstrate that a one per cent increase in the proportion of male (female) students reduces male (female) youth crime by around 1.9 per cent (1.1 per cent) and a one per cent increase in the proportion of men (women) staying on at school after the compulsory school leaving age reduces male (female) youth crime by around 1.7 per cent (1.3 per cent). Similar to Machin et al.’s (2011) observation, these causal effects are considerably larger than those from the OLS estimates. Sabates and Feinstein (2008) exploit two contemporaneous events in a DiD approach to examine burglary activities in the UK. Between 1999 and 2002 the Educational Maintenance Allowance was piloted which provided a financial reward to incentivise school attendance for low-income 16 to 18-year old students in 15 local areas with particularly low attendance. At the same time, the Reducing Burglary Initiative was established to fund a number of local burglary reduction schemes. They find that in areas where both schemes were implemented, burglary rates decreased by about 5.5 per cent relative to matched comparison areas. The effects were slightly lower when only considering the subsidy.

However, education not only has a direct effect on crime but also an indirect one through earnings, since low income may incentivise crime by shifting the relative preferences associated with participating in legitimate work and committing crimes. Machin and Meghir (2004) find empirical support for this argument when examining the effect of wage changes at the bottom end of the wage distribution of the retail trade sector on crime rates, using data on the police force areas of England and Wales between 1975 and 1996. They find that the marginal effect of a 10 per cent increase in the wages corresponds to a 0.7 percentage point fall in the crime rate (where the baseline crime rate is 8 per cent or 80 crimes per 1000 people). This is robust to controlling for the conviction rate (additionally instrumented by sentence lengths) and the inclusion of lagged dependent variables to account for persistence in crime rates. Therefore, relative wage changes across regions can explain relative changes in crime rates. Albeit the outdated data use in this research, these findings are consistent with other studies which find that declining labour market prospects shape criminal careers because they are likely to shift incentives towards criminal activities and away from labour market participation (Gould et al., 2002 using US data; Fougere et al., 2009 using French data; Grönqvist, 2013 using Swedish data). Bell et al. (2018), for instance, demonstrate that a recession (proxied by an unemployment rate of 5 percentage points higher than a normal unemployment rate) in the UK is associated with a 5.7 per cent increase in the probability of ever being arrested (the effect is larger for individuals with fewer years of schooling). This study draws from both panel data on year of birth cohorts over space and time and individual data from the Offenders Index Database and the Police National Computer between 1980 and 2010. They estimate the long-run effect of initial labour market conditions by exploiting the regional variation in entry unemployment rates across cohorts.
2.5.2. Family and crime

There is extensive literature that suggests that family life, including parental management, family size and marital status, are strong predictors for children’s offending and criminal participation (Leschied et al., 2008; Derzon, 2010). A meta-analysis based on longitudinal studies and carried out by Derzon (2010) finds that the strongest predictors of criminal behaviour are in descending order parental education, child-rearing skills and parental discord. For violent behaviour parental supervision and family size were the most important predictors. With increasing numbers of children, parents’ attention given to each of the children is reduced and this overcrowding can lead to conflict. An extensive summary of the role of family size is provided in the Handbook of Crime Correlates by Ellis et al. (2009).

There is also the argument that crime runs within families because criminal parents tend to have delinquent children. The most comprehensive research on the concentration of offenders within families was carried out in the prospective longitudinal Cambridge Study in Delinquent Development which followed more than 400 males aged 8 to 48 living in South London. It revealed that criminal parents or siblings predicted the boys’ own convictions (Farrington, 1996; Farrington et al., 2006; 2009) where, for instance, 63 per cent of the boys with criminal fathers were criminal themselves and older siblings were stronger predictors. A good summary of the relationship between family characteristics and crime is provided in the book Crime and Public Policy by Wilson and Petersilia (2011, chapter 2).

2.5.3. Educational/vocational programs and recidivism

Duwe and Clark (2014) examine the role of obtaining secondary and post-secondary degrees during imprisonment in Minnesota on recidivism and post-release employment. They apply propensity score matching to reduce observable selection bias and observe offenders, who were released between 2007 and 2008, through the end of 2010. Although Duwe and Clark (2014) cannot control for any work history or post-release educational attainment, they make contrasting observations about the impact of qualification: While they find positive effects of obtaining secondary degrees on securing post-release employment, these do not necessarily lead to higher wages (or more hours worked) and more consistent employment. Post-secondary degrees, in comparison, did not improve the chances of entering employment post-release but individuals earned higher income as a result of longer working hours. These differential observations are likely to be the result of the different nature of the degrees, with the secondary degrees focusing on basic skill development and post-secondary degree focusing on discipline-specific knowledge.
Since the 2002 report by the Social Exclusion Unit on reducing recidivism, attention has moved to improving literacy and numeracy in UK prisons, and the role of education and training has been reemphasised by policy makers after the White Paper on Prison Reform was published in November 2016 (Ministry of Justice, 2016). However, many UK based studies so far have demonstrated the need for educating prisoners rather than evaluating the efficiency of prison education. The exception is a report commissioned by the Prison Education Trust from the Justice Data Lab, which examined imprisoned offenders in England between January 2002 and March 2013 who applied to participate in distance learning courses and buy learning materials (Ministry of Justice, 2015). The report reveals that general participation in the program reduced re-offending by between 6 and 8 percentage points. Participation in an academic course reduced it by 4 to 8 and in a vocational course by 6 to 9 percentage points. Although the administrative data employed in this study is rich (e.g. it includes age, gender, ethnicity as well as criminal, benefit and employment history), the potential influence of unobserved characteristics, such as motivation, or other intervention programs cannot be accounted for.

2.6. Learning

2.6.1. Education environment

It is possible to explain some of an individual’s knowledge and skills accumulation through their actions and interactions. Gurria (2016) released the results of the triennial OECD Programme for International Student Assessment (PISA). Although not specific to the UK, numerous associations were made between student activities and outcomes relating to school and the individual’s wellbeing. These included:

- frequent bullying is associated with worse educational outcomes;
- physically active students are less likely to truant, feel very anxious, or be frequently bullied;
- students who spent the most time online outside school are more likely to be less satisfied with their life, feel lonely and be less proficient in school;
- students who have a job alongside school are more likely to feel like an outsider at school, have low expectations of further education, arrive late to school and truant.

Antonio (2004) analyse the spill-over effect among social groups during education, finding that students who have best friends with relatively high levels of intellectual self-confidence or greater expectation to attend university tend to exhibit the same qualities. Mora and Oreopoulos (2011) additionally assess the impact of social groups on education. Assessing the marginal effects of a probit model it is found that a 10-percentage point increase in the proportion of reciprocating friends intending to drop out increased the likelihood of also dropping out by 1-2 percentage points.
Student’s traits and well-being levels have been found to have an impact on educational attainment. Andrews and Wilding (2004) use longitudinal data to assess how depression and anxiety were related to life stress and student achievement. A sample of UK graduates were asked to complete a Hospital Anxiety and Depression Scale as well as fill out if they had been exposed to a list of threatening experiences before university and mid-course. The authors find depression and financial difficulties are the only two factors significantly related to subsequent exam performance, showing that both account for an additional 1.8% of the variance in exam marks. However, only depression has a significant regression coefficient, the authors suggest that depression mediate the relationship between financial difficulties and exam results. Owens et al. (2012) supports this idea, finding greater levels of anxiety and depression are related to lower academic performance. Hattie (2009), however, found anxiety to be more significantly related than depression. Through the author’s meta-analysis, it is found that reducing student anxiety had above average effect size (as measured by Cohen’s d) on students learning outcomes, whereas student depression has a smaller effect size. It should be pointed out that meta-analysis is conducted across literature from all countries, and therefore some factors may have more of an effect in some countries than others.

Students personality traits are deemed to have an impact on a person’s education in many studies. One such trait investigated is Emotional intelligence, which is the capacity for recognising our own feelings and those of others, managing emotions in ourselves and in our relationships (Goleman, 1998). It is important to recognise that emotional intelligence is not distinct from other personality traits but a combination of them, which include self-awareness, motivation, self-regulation, empathy, and adeptness in relationships (Cherniss and Goleman, 1998, Boyatzis, 2008, and Goleman, 2000). Many studies show emotional intelligence is associated with academic achievement (Parker, Summerfeldt, Hogan, & Majeski, 2004, Petrides, 2004). Petrides, Frederickson, and Furnham (2004) examine the relationship of 650 year 11 students among EI, cognitive ability, and academic performance. They find emotional intelligence had moderated the relationship between academic performance and cognitive ability. Petrides et al. (2004) also find that emotional intelligence is negatively associated with deviant school behaviours, such as unauthorized absences or being expelled from school, likely to influence their academic performance.

Attention is referred to as “all those aspects of human cognition that the subject can control and to all aspects of cognition having to do with limited resources or capacity, and methods of dealing with such constraints” (Shiffrin, 1988, p. 739). McClelland et al (2013) use the Colorado Adoption Project (CAP), a longitudinal study containing 245 adopted children, their biological parents, and their adoptive families. The authors found that children’s age 4 attention span-persistence significantly predicted math and reading achievement at age 21 after controlling for achievement levels at age 7 and social-
demographic factors. Furthermore, the authors find that those age 4 attention span-persistence skills significantly predicted the odds of completing college by age 25, with children who were rated one standard deviation higher on attention span-persistence at age 4 had 48.7% greater odds of completing college by age 25.

Creativity is seen as the ability to make or bring something new to existence, providing a solution to a new problem, a new method, device, or an artistic object to form (Nami et al, 2014). Ai (1999) examine students who were randomly selected from 68 schools, with (2,264 students, 38% were boys and 62% were girls). A number of tests were administrat ed to students around creativity. Using a self-reported achievement scores in four areas, which included English, natural science, mathematics, and social science, it is found that creativity was related to academic achievement for both boys and girls. Other studies show a relationship between creative and academic achievement (Coyle and Pillow, 2008; Palaniappan, 2005; Palaniappan, 2007a; Steinmayr and Spinath, 2009).

Resilience is defined as the “process of effectively negotiating, adapting to, or managing significant sources of stress or trauma” (Windie, 2011). According to Alvord & Grados (2005), resilience indicates the possession of several skills, in varying degrees, that help a person to cope, with Bernard, (1993, 1995) suggesting that resilient children have five attributes: social competence, problem-solving skills, critical consciousness, autonomy, and a sense of purpose. Using data from the British Household Panel Survey, (Windie, 2011) find that those with increased scores on a mental status measure (GHQ_12) after exposure to adversity, such as bereavement, poverty, among others, returned to their pre-exposure level after 1 year, bouncing back from their adversity. Schoon et al (2004) examines the influence of socioeconomic adversity from school adjustment, on children age 16 and the long-term consequences of school adjustment on those aged 33, considering factors such as parental, individual resources, teacher expectations that might alleviate such adversity. The authors find that socioeconomic adversity was a significant risk factor for educational failure and has an influencing impact on health-related outcomes of age 33.

The environment the students learn in, including the structure and the quality of the learning environment, is shown to influence student’s knowledge and skills in many studies. Stewart (2008) use hierarchical linear modelling to show that school structural characteristics such as school size have relatively small effects on student achievement when compared with individual-level characteristics including school commitment and parent-student discussions. Ou and Reynolds (2008) find that changes in the learning environment, more specifically frequent school mobility is linked to significantly lower levels of educational attainment. Oishi and Schimmack (2010) show an additional adverse effect of school moves, finding that these are also negatively associated with well-being.
Hughes and Karp (2004) survey literature around the topic of availability of school-based career advice, finding that students benefit vocationally and academically from career course participation. Another structural factor that is found to have an effect was standard school hours. Wheaton et al. (2016) investigates this element in greater detail by reviewing literature around the subject, finding that later start times tended to improve attendance, reduce tardiness, reduce falling asleep in class and improve grades. Being a literature review, it is not clear as to what additional variables were additionally controlled for.

There is much literature around the role that teachers play in knowledge and skills transfer and the factors that affect these. Darling-Hammond (2000) use Schools and Staffing Surveys data to show that measures of teacher quality (including certification status, degree class, and whether they had a master's degrees) are strong correlates of students’ achievement in reading and maths in the US. Clotfelter et al. (2007) reinforces the idea of teacher’s previous educational outcomes having an effect on student’s outcomes, finding that test scores and regular licensure have positive effects on student achievement. Teachers’ experience is also cited as having a significant effect in this study. It is important to acknowledge that as overall school quality is not controlled for, this result could’ve arisen because better-qualified teachers may go to better achieving schools. Atkinson et al. (2009) assesses an additional measure of teacher quality by assessing the impact of performance-related pay schemes for teachers in England. The authors employ a difference in difference model, controlling for pupil effects, school effects and teacher effects. Results show that schemes did improve test scores on average by half a grade per pupil. This effect is only observed in English and science teachers, maths teachers show no significant improvement.

Rice (2010) examines the impact of teacher experience in more depth via an evidence review. The key finding is that student achievement increased with teacher experience, with experience being more valuable when teaching younger age groups. Teacher experience also shows a diminishing return after 4 years’ experience, implying a nonlinear relationship. The author cited a possible reason for this being that inexperienced teachers are more likely to teach in high poverty schools. Harris and Sass (2011) reinforce the idea of experience being an advantage. Using panel data, the authors show content-focused teacher professional development and teacher experience has a positive effect on children’s educational outcomes, however pre-teaching (undergraduate) training and teachers’ school test scores when they were students has none. Hanushek et al. (1999) investigated the idea of salary as a measure of teacher quality, finding that a significant relationship between salary and student achievement only exists for experienced teachers. However, it is not clear if the salary is a signal of a better teacher or if it is received as a result of being one.
Teachers have been found to work some of the longest hours, more than police officers and nurses during an average working week which can create pressure and stress (Worth et al, 2018). Arens and Morin (2016) investigate the effect this had on students, showing there is a significant negative relationship between teachers’ emotional exhaustion and student achievement. Klem. and Connell (2004) show how student reported teacher support for students is linked to student engagement in school which in turn is associated with higher attendance and test scores. Lee (2012) supports this idea further, showing supportive teacher–student relationships is significantly related to behavioural and emotional student engagement, as well as being a significant predictor of reading performance. Gurria (2013) argues that the mechanism through which teacher-student relations benefits students is greater student engagement at school.

Carpenter (2006) analyse how different teaching methods affected educational outcomes using a repeated measures ANOVA procedure. Findings suggest that moderately-active teaching methods such as the jigsaw method are more effective than the more passive styles such as lecture, lecture/discussion, and case study methods. Yoder and Hochevar (2005) support this result, finding that students scored higher and with less within-class variation on tests where the information is presented via active learning in comparison to lecture, autonomous readings, or video without discussion coverage. Freeman et al. (2014) support evidence further, conducting a large meta-analysis to determine how effective active learning (defined as learning through activities and/or discussion in class) is in comparison to traditional lecture style learning (passively listening to an expert). Results show that student performance increased by approximately half a standard deviation with active learning compared to lecturing.

2.6.2. Adult learning

Using the longitudinal panel dataset, the NCDS, Galindo-Rueda et al. (2003) identified the effects of lifelong learning on wages and employment, controlling for other factors that affect labour market outcomes. Their results found that those in the labour market in 1991 were more likely to be in work in 2000 if they had undertaken lifelong learning within the period. They also found convincing evidence that learning leads to more learning. Those undertaking one episode of lifelong learning increased the probability of the individual undertaking more learning. The results also show that, for individuals with no qualifications in 1991, those who undertook lifelong learning between 1991 and 2000 were earning higher wages in 2000 than those who had not engaged in lifelong learning over this period. In contrast, Silles (2007) reported no returns to earning from adult schooling for men, so the definition of adult learning is important in this mechanism. For example, Livingstone (2001) documents the large extent of self-directed informal adult learning, whether relating to paid work, unpaid work, general interest, or ‘community work-related’ activities such as developing interpersonal and communication skills.
Desjardins (2011) implement a literature review to show the differing benefits of adult learning. Evidence suggest that learning in adulthood is associated with positive labour market outcomes such as being less likely to be unemployed and being more likely to experience wage growth. Wider benefits include being associated with reduced criminal activity, increased social cohesion, savings in welfare and medical costs, and increased voter participation. The Government Office for Science (Hyde and Phillipson, 2014) looks into lifelong learning, including continuous training within the UK labour market. They find at the individual level, participating in learning activities has shown improvement in life satisfaction, well-being and self-confidence. At the macro-level, they find increasing the skills of the workforce could generate an additional £80 billion for the economy, while also improving employability of older workers. However, they also find barriers that might prevent people from undertaking lifelong learning, highlighting three particular barriers: attitudinal, situational and institutional. Attitudinal barriers include older individuals responding they were less likely to want to take work-related training, but they were also less likely to be offered it. Situational barriers include financial and time constraints, which have been consistently shown to be the most important reasons why people do not participate in learning or training, as well as Institutional factors, such as the availability of workplace training. In addition, Midtsundstad (2019) produced a review looking into the research literature on adult learning and employability. The author found evidence to support that acquiring higher education has a positive impact on employment and earnings while also having a positive impact on upward mobility. Social skills and continuous learning ability influenced the career success and career satisfaction of older workers, with older workers being more satisfied with their career and hence continued to be in employment.
3. Determinants of earnings and their use in valuing human capital

In this section we review the literature on the determinants of earnings, and focus on the role of education, skills, family background, health, and job mobility and on-the-job training. While we acknowledge that there are a host of other factors that may affect earnings including individual factors, such as ability, unique talents and effort, they are unobservable. Other earnings determinants also include institutional factors, such as seniority wages and barriers to entry, restricting the supply of e.g. professionals (doctors, lawyers) but they are likely to be fixed over long periods of time in any one country due to union wage bargaining and collective agreements and other labour market institutions. Therefore, we focus on the ones listed above as they are measurable and allow a more granular representation of existing human capital stock values. For instance, while the current methodology employed by ONS considers the impact of qualifications on earnings, skills gained through learning and on-the-job training are arguably the true earnings determinant.

The first part of this section considers the role of education, which is widely recognised as one of the key determinants of earnings. We depart from the standard analysis of returns to education (years of schooling) and instead consider more specific types of educational attainment. This is followed by a review of the literature on skills. In this sub-section, we focus on cognitive and non-cognitive skills (personality skills), both of which have gained considerable attention (especially personality traits) among policy makers and researchers. The importance of family background followed by the role of health are then considered. The last two sub-sections review the literature on job mobility and on-the-job training.

Overall, findings from the review are as follows. In terms of the role of education as a determinant of earnings, subject degree and educational institution quality is found to be of key importance. For instance, individuals who studied or graduated with degrees in any of the STEM subjects, economics and law, were found to receive wage premiums compared to individuals who graduated in other humanities and social science degrees (Walker and Zhu, 2011; Belfield et al., 2018). Educational institution quality also matters for earnings (Chevalier and Conlon, 2003; Hussain et al., 2009; Chevalier, 2014; Britton et al., 2016) in that students, who graduated from high-quality institutions, received a wage premium. While the relationship between educational attainment, including institutional characteristics, clearly indicates the existence of positive returns, a further understanding of causal mechanisms are needed. There is consistent evidence of positive effects between family background and a child’s future earnings (Bjorklund and Jantti, 1997, 2009; Chadwick and Solon, 2002; Solon, 2002; Corak, 2006; Chetty et al., 2015; Jerrim, 2017), regardless of country of study, although the intergenerational elasticity is found to be higher for the UK compared to other countries. A key
concern with studies in this area relates to how family background is measured – earnings or income
and the time length over which these earnings are observed (Mazumder, 2005).27 The findings from the
skills sub-section show that higher ability during childhood (in terms of test scores) translates into
higher wages in adulthood (McIntosh and Vignoles, 2001; Vignoles et al., 2011; Vignoles, 2016). Non-
cognitive skills are also seen to raise earnings (Heckman et al., 2006b; Heineck, 2011; Heckman and
Kautz, 2012), although the effect depends on the type of skills examined, such as social skills and the
Big Five personality traits. The findings on the effects of health on earnings are mixed. For instance,
there are negative effects on earnings for those that experience a health shock (Lenhart, 2019), while
other studies show that the main effects of health manifest through preventing people from working;
when selection into employment is taken into account, poor health is not found to reduce wages (Brown
et al., 2010). Others, such as Kidd et al. (2000), found wage and participation rate differences between
disabled and able-bodied men, with disabled men characterised by lower wages and lower rates of
participation. Lastly, the review of the effects of job mobility as well as training and earnings show
relatively fewer evidence for the UK, and the results are often mixed. While parts of the literature show
that workers that change occupation mostly benefit in terms of higher wages relative to those who do
not experience such change (Longhi and Brynin, 2010), others such as Carrillo-Tudela et al. (2016)
show instead low wage growth.

3.1. Returns to education

For the past 40 years, considerable attention has been given to the role of human capital in economic
growth and development (Wößmann, 2016). It is now widely recognised that education (years of
schooling) plays a fundamental role in determining future earnings of individuals (Psacharopoulos,
earnings originated mainly from the work on human capital theory (Smith, 1776; Marshall, 1890).
Human capital theory emphasises that, investment in education (in particular higher education) will
increase future productivity and lead to greater earnings (Becker, 1964; Lucas, 1988). This implies that
different degrees add differing amounts of productivity and therefore will differ in their impact on
employment and wages. A number of explanations have been given to explain the positive relationship
between earnings and (higher) education, most notable among them suggesting that there is a signalling
effect in the labour market (Chevalier, 2004). High-productivity individuals may signal their superior
productivity by acquiring more education than individuals who are less productive. See Arteaga (2018)
for more on this. There is also the issue of selection since more able individuals, that is, those with
higher levels of prior academic achievement, stay longer in school.

27 This strand of the literature largely focuses on the relationship between parental earnings (or income) and
children’s earnings and does not control for genetic factors.
Studies that model the returns to education date back to the mid-20th century (Schultz, 1960, 1961; Becker, 1962, 1964; Becker and Chiswick, 1966; Mincer, 1974) with interest in this broad area of research persisting right into the 21st century (Card, 2001; Duflo, 2001; Heckman et al., 2006a; Heckman et al., 2016; Psacharopoulos and Patrinos, 2018). The focus of most of these studies has been on dimensions such as the relative returns to education by gender, subject, qualification, institution, ethnicity, and social class (Belfield et al., 2018). For example, in relation to the returns to educational qualification, private returns seem to be greatest for primary education and education of women (Psacharopoulos and Patrinos, 2018). The most widely-used method when estimating the returns to education is the Mincer earnings function (Mincer, 1958, 1974), which models the natural logarithm of wages as a function of education, experience, and a range of additional observable characteristics that have the potential to impact earnings.

This section will deviate from the usual examination/review of the general literature on returns to education, mainly years of schooling (see Psacharopoulos, 1985, 1989, 1994; Psacharopoulos and Patrinos, 2004; Walker and Zhu, 2008), and focus instead on more specific types of educational attainment, namely higher education, degree subject, and institutional characteristics. This direction is motivated by the fact that estimates of a single rate of return may not be very informative if returns to education differ by education level or differ across populations (including by social strata). The importance of this for policy can by no means be understated, although methodologically there are concerns about these estimates.

### 3.1.1. Educational qualification, degree subject, and institutional quality

A number of studies have analysed the returns to education, most popular amongst them being the recent global update by Psacharopoulos and Patrinos (2004) (most recent is the 2018 version). There are also numerous studies for the UK, with recent evidence indicating a high level of variation in the earnings of graduates who study different subjects or who attend different higher education institutions (Britton et al., 2016; Walker and Zhu, 2017, Espinoza and Speckesser, 2019). Starting at relatively lower levels of educational attainment, the Department for Education (2014) used the LFS over the period 2006 to 2013 to examine the returns to different educational qualifications. They found the estimated returns to GCSEs and A-levels are lower at earlier years of an individual’s career, increase and peak at approximately age 35 and then fall over the course of an individual’s lifecycle. In contrast to academic qualifications, the earning returns of vocational level 2 and 4 apprenticeships were considered highest in the first few years and then diminished at higher years. The authors also discounted productivity gains, where the productivity gains are with respect to society and defined as lifetime wage returns for an individual of obtaining some higher-level qualification relative to a lower level qualification. The
lifetime productivity gains to GCSEs, A-levels, and apprenticeships were higher compared to similar individuals with lower qualifications. Despite the gains in higher educational qualifications, evidence suggests that some of these differences are gendered (Psacharopoulos and Patrinos, 2018). More specifically, the average lifetime productivity gains for individuals with five or more GCSEs including mathematics and English amounts to £63,000 for males and £54,000 for females compared to those with qualifications below level 2. Moreover, the marginal lifetime productivity gains in comparison to those of no qualifications are around £283,000 for males and £232,000 for females. A very recently published working paper by Espinoza and Speckesser (2019) compare earnings of people with higher vocational/technical qualifications to those of degree holders using the earliest cohort of English secondary school leavers with newly available Longitudinal Education Outcomes data. They find that in the mid-twenties the initially higher earnings of people with higher vocational education disappear but that high returns to higher vocational/technical education in STEM subjects exist, which remain significantly above those of many degree holders by age 30.

3.1.2. Higher education and earnings

The issue of higher education participation continues to remain a matter of policy concern, primarily due to the higher associated earnings and the lack thereof of individuals from certain socio-economic background not being able to participate meaningfully. Interestingly, existing global evidence suggests that the proportion of young people enrolling into higher education has increased (Becker et al., 2010). Focus has now shifted to examination of the returns to different educational degrees. For example, Belfield et al. (2018) uses administrative data (Longitudinal Education Outcomes) to investigate the returns to higher education in the UK five years after graduation. They find that labour market returns to different degrees vary considerably even after accounting for the differences in student composition. Specifically, their study shows that individuals that studied for a degree in Medicine, Maths, and Economics earned at least 30 per cent more compared to the average graduate. In contrast, creative art graduates earned 25 per cent less. In terms of gender differences, the authors show returns to be greater for females that studied Medicine or English whereas for males, returns were higher for Computer Science graduates. There are also differences in the returns to educational degrees based on family background. For instance, returns were greater for individuals that studied Medicine but from lower socio-economic background, compared with Economics where returns are highest for students from a higher socio-economic background. In addition, they show that after conditioning on all other characteristics, such as degree subject and institution, graduates from independent schools and the top quintile earn around seven per cent to nine per cent more than those graduates from the lowest SES backgrounds. Interestingly, the authors also found that some of the differences in relative earnings could be explained by the university attended (there is limited research on this for the UK), whilst acknowledging that these differences may be underpinned by the demand for various skills in the labour
market and quality of higher education. In particular, high-status universities, such as the Russell Group and universities established before 1992, typically have higher earning graduates, although one must bear in mind that high ability students have a higher likelihood of attending higher-status universities. Walker and Zhu (2011) also provide additional evidence on the relationship between earnings and different degree subjects in England and Wales using data from the LFS. A key consideration of their analysis is the inclusion of postgraduate degrees. Men with Law, Economics, and Management degrees experienced larger returns as well with Science, Technology, Engineering, and Math degrees. The returns were however lower for graduates that studied for a degree in other social sciences subjects and humanities, and for those with combined degrees. The authors also provided analysis of the effect of a rise in tuition fees on earnings and found that although this led to an overall decrease in earnings of around one to three per cent, the differentiated effects on different degree subjects still remained. That is, degrees that offer higher returns remained better off and degrees with lower returns continued to offer poor returns. There is further evidence for the UK on the returns to different degrees (see O’Leary and Sloane, 200528; Chevalier, 201129; Walker and Zhu, 201330; Britton et al., 201631). Evidence of the variation by subject of study and institution has also been found elsewhere, such as the US (Altonji et al., 2012) and Norway (Kirkeboen et al., 2016).

3.1.3. Institutional characteristics

A few studies provide evidence on how earnings vary by institutional characteristics in the UK. Exceptions are Chevalier and Conlon (2003), Hussain et al. (2009), Chevalier (2014) and Britton et al. (2016). These authors use an indicator of university quality, including measures for research intensity and student intake (aggregated), and found that earnings were higher among individuals that attended higher-quality institutions, with the effects strongest at the top end of the earnings distribution. Britton et al. (2016) also analysed the variation in graduate earnings by higher education institution attended using linked administrative tax data. The authors found variations in earnings both within and across different institutions, although most of the variations observed were explained by student background and subject differences. Chevalier (2014) uses data from the Longitudinal Destination of Leavers from Higher Education linked to administrative data from HESA to provide estimates of the effect of institutional quality on earnings of early career graduates in the UK. A strength of this study is that the authors use different identification strategies, including, generalised propensity score matching to

29 Chevalier (2011) utilise data from the Longitudinal Destination of Leavers of Higher Education. This contains a sample of graduates from the 2003 cohort.
30 Walker and Zhu (2013) exploit data from a number of sources including the LFS covering the period from 1981 to 2010, the BHPS starting from 1991 over 18 waves, and the Destination of Leavers from Higher Education.
31 Britton et al. (2016) employ tax and student loan administrative data and data from the UK’s HESA.
address issues of selection into different institutions. For more different techniques to address selection and other causal effects, see (1) Black and Smith (2004, 2006), who use propensity score matching methods to match on the predicted probability of attending a high-quality university, (2) Long (2008), who uses the average quality of colleges within a certain radius of a student as an instrument for the quality of the college at which the student attends, (3) Hoekstra (2009), who exploits a large discontinuity in the probability of enrolment at the admission cut-off, (4) Saavedra (2008), who uses scores on a national college entry test creating exogenous peer and resource quality variation near admission cut-offs, and finally (5) Dale and Krueger (2002), who match students who applied to and were accepted by similar colleges to eliminate the bias that colleges may admit students based on characteristics related to future earning, for more on different techniques to address selection and other causal effects. Their findings suggest evidence of heterogeneity in the returns to institutional quality, which they measured using a set education inputs, namely research assessment score, academic expenditures per student, mean entry grade and graduate prospect, and student-staff ratio. In particular, the authors find almost no returns for below median quality institutions and rather large returns for those that attend high-quality institutions. Their econometric approach also indicated that OLS estimates were biased upwards and larger than the estimates obtained from the generalised propensity score method.

Hussain et al. (2009) also provide further examination of the earnings effects of institutional quality for four graduate cohorts (1985, 1990, 1995 and 1999) for the UK using data from HESA to obtain measures of institutional quality. The authors measure institutional quality using information on research assessment exercise, faculty-student ratio, retention rate, total tariff score (based on A-levels or other qualifications), mean faculty salary, and expenditure per student. While not addressing issues related to selection and unobserved heterogeneities, the authors find similar to previous studies that there is a positive return to attending higher quality institution. They also found differences in earnings along the quality distribution. For instance, students that attended institutions in the top quartile of the research assessment exercise score, retention rate or total tariff, were associated with increases in earnings between 10 and 16 per cent.

A recent study by Belfield and Erve (2018) deviates from the usual examination of the effects of higher education on earnings and considers the implications on later adulthood income of women. The authors show that gaining a higher education qualification increases women’s net family income in adulthood by around 20 per cent relative to leaving school at 18. There are also indirect effects on earnings through the number of hours that women work, in addition to increasing the likelihood that a woman would have a partner with a higher education qualification. The authors further note that higher gross earnings associated with higher educational qualifications could reduce net returns to higher education due to tax payments. In a further examination of some of the causal mechanisms, the authors show that the
mechanism through which higher education affects incomes varies over the life cycle. They show that at earlier ages, the most important mechanism is the woman’s own earnings. However, the impact of woman’s higher education becomes less relevant at around age 42 when instead the partner’s earnings become the most important determinant, i.e. associative mating becomes more important.

Delaney and Devereux (2019) also deviate from the traditional analysis of returns to education by focusing instead on the variation in earnings over time using three different measures of earnings volatility, namely earnings variability, degree of earnings cyclicality, and the probability of receiving a pay cut over a 5-year period. The authors used data from the New Earnings Survey Panel Dataset to estimate a regression discontinuity based on the change in the compulsory schooling reform that took place in the UK in the 1970s. The authors find that each extra year of schooling reduced earnings variability particularly at younger age and reduces earnings cyclicality. Their finding also show that educated men tend to be affected less by wage cyclicality and the probability of receiving pay cut is found to be reduced almost 3.5 percentage points.

3.1.4. Identifying causal effects

A fundamental concern with estimates of returns to education is that measures of education are often considered to be exogenous. However, the literature on returns to education shows that education is endogenous due to certain unobserved factors that influence the individual’s ability to acquire more years of schooling (while not having an independent effect on an individual’s earnings) as well as measurement errors (Harmon et al., 2003; Dickson and Harmon, 2011; Heckman et al., 2018).

Previous studies have addressed these concerns of endogeneity mainly by employing IV estimation techniques (Angrist and Krueger, 1991; Harmon and Walker, 1995; Buscha and Dickson, 2015). Changes in compulsory schooling laws, which occurred in the UK in 1947 and 1973 have been used extensively as a candidate when addressing issues of endogeneity (Harmon and Walker, 1995; Oreopoulos, 2006; Grenet, 2009; Devereux and Hart, 2010). For instance, Devereux and Hart (2010) exploited variation in the school leaving age reform that occurred in Britain in 1947 as an instrument for education and found the returns to education to be around six per cent. Devereux and Fan (2011) also used the school leaving age policy reform to uncover causal effects of education on earnings. The authors showed large increases in educational attainment with larger number of students staying longer in school post the reform, as well as hourly wages and weekly earnings rising over the expansion period. See also Dickson and Smith (2011) who use the school leaving age policy reform as well in addition to another institutional rule, the Easter Leaving Rule, to examine the returns to education. Grenet (2013), on the other hand, found returns close to nil in France using a similar policy reform that took place in France in 1967 as an instrument for education. Building upon the Mincer equation (1974), Heckman et
al. (2016) developed a robust dynamic discrete choice empirical framework that highlights the importance of accounting for the dynamics of schooling choices at different stages of educational decision-making in estimating the causal impact on earnings. This work conformed with the earlier work of Becker (1964), strongly suggesting that education has a significant causal effect on earnings. As a robustness exercise, Dolton and Sandi (2017) provide a reassessment of a number of studies (Harmon and Walker, 1995; Oreopoulos, 2006; Devereux and Hart, 2010) that previously addressed causal effects of education on earnings for the UK, using data from the General Household Survey and the Family Expenditure Survey. The authors found that previous estimates of the returns to education from these studies were sensitive to equation specifications.

Despite IV techniques being the most frequently used, there are concerns about their appropriateness (Heckman and Urzua, 2010), most notable among them being weak instruments which can lead to biased estimates, and the fact that IV estimates rely on strong, a priori data assumptions and are likely to give different results depending on the instrument used and assumptions made. See Heckman and Vytlacil (2005) for more on alternative estimation techniques.

### 3.2. Skills and personality traits

The pursuit of quantifying labour market outcomes, such as wage premiums under the traditional approach where one makes use of human capital variables, such as education and experience, is argued to be insufficient in relatively recent years. It is argued that cognitive skills may result in enhanced performance and productivity differences which could potentially result in wage differentials (Anger and Heineck, 2010). Recent work identified cognitive skills, such as numeracy (Hanushek et al., 2015), problem-solving and ICT skills (Falck et al., 2016), key in explaining most of the variation in earnings differences in technology-rich environments. At the same time, the increase in automation also highlighted the financial returns to non-cognitive skills, such as social skills and personality traits (e.g. Heckman et al., 2006b; Lindqvist and Vestman, 2011; Heckman and Kautz, 2012; Deming and Kahn, 2018) and their complementarity with cognitive skills (Weinberger, 2014; Deming, 2017; Deming and Kahn, 2018). These findings are discussed in detail below.

#### 3.2.1. Cognitive skills

Most of the work investigating the influence of cognitive abilities has focused on the UK and the US, with much evidence of a positive relationship between cognitive abilities and earnings (Cameron and Heckman, 1993; Green and Riddell, 2003; Bronars and Oettinger, 2006; Anger and Heineck, 2010; Lindley and McIntosh, 2015). Others noted that this may not be the case, and in fact, cognitive ability
is a much weaker predictor than education, family background characteristics or the environment (Cawley et al., 2001; Zax and Rees, 2002; Anger and Heineck, 2010). An alternative view is offered by Bowles and Gintis (2000), who compare two wage equations, one with education as a predictor and the second including a measure of cognitive skills as a variable and argue that approximately 20 per cent of the schooling effect on earnings is cognitive. A more recent study conducted by Hanushek et al. (2013) modified the benchmark Mincer equation to reflect cognitive skills - measured across numeracy, literacy, and problem-solving skills - and employed data from PIAAC to analyse the value of these skills for the whole of the labour force spanning 22 countries. They found that a one-standard-deviation increase in numeracy skills is suggested to be linked with higher wages of 18 per cent for prime-aged members of the labour force. However, it is noteworthy that there is a significant amount of heterogeneity among these 22 countries, with the US having the greatest return of 28 per cent which is approximately double the return observed for the countries with the lowest returns; Sweden, Czech Republic, and Norway. Another finding is that the return estimates obtained for workers between the age of 35 and 54 consistently indicated greater and robust returns to these respective cognitive skills than for the members of the labour force, aged between 25 and 34, on average a 4 percentage point difference. Moreover, the empirical results for the wage returns of literacy and numeracy are consistently higher than the returns to problem-solving skills. A similar study that makes use of PIAAC investigated the returns to ICT skills across 19 developed countries. Falck et al. (2016) acquired empirically sound results and highlight that a one-standard-deviation increase in ICT skills is associated with an eight per cent return, with the effect being substantially stronger in Germany. Nonetheless, Vignoles (2016) notes that these studies, that examine skills utilising datasets like PIAAC, are more correlational studies and thus may not necessarily show the true causal impact of cognitive abilities. Nevertheless, they offer insightful evidence since they show that, given a similar level of education, those with a higher quality skillset earn greater wage premia.

With respect to the UK, earlier work that utilises UK birth cohort longitudinal datasets, which provide information on cognitive ability through tests taken in primary and secondary school, show evidence that for a given level of initial ability (test scores) during childhood, those with better basic skills in adulthood tend to earn higher wages and have greater rates of employment (McIntosh and Vignoles, 2001; Vignoles et al., 2011; Lindley and McIntosh, 2015; Crawford and Cribb, 2015; Vignoles, 2016). These studies provide more robust evidence on the impact of basic literacy and numeracy skills on earnings. For instance, findings by Vignoles (2016) suggest that a one-standard-deviation in literacy skills is associated with a wage premium of approximately 14 per cent and numeracy skills with a premium of around 11 per cent obtained from a cohort of 34-year-olds in 2004 via the 1970 BCS. The same dataset is used by Crawford and Cribb (2015) who find that reading skills are associated with significant increases in gross hourly wages and gross weekly earnings, particularly at the ages 38 and
42 and amongst those from poor backgrounds. Lindley and McIntosh (2015) study the rising graduate wage inequality observed in the UK and argue that degree subjects provide variation across graduates which can be exploited to explain potential causes of the growth in graduate wage inequality if inequality has increased more within specific subjects and if such variation is related to graduates’ characteristics in those subjects. They use a combination of datasets (NCDS, the BCS and the Longitudinal Survey of Young People in England) and find that the greater cognitive skills dispersion, measured in terms of maths and reading test scores at the age of 10, are associated with increased graduate earnings inequality over time.

3.2.2. Personality traits

A number of reasons are associated with why personality traits can be important in explaining labour market outcomes. Most prominent among them is that personality can affect individual’s performance on the job (Thiel and Thomsen, 2013) and can be used as a sorting mechanism, whereby individuals with certain traits sort into certain occupations. Personality trait as a source of individual differences in achievements have been examined thoroughly in the psychology literature (see Roberts et al., 2007 for a review), which is now receiving attention in the economics literature (Heckman and Rubinstein, 2001; Cawley et al., 2001) where it is often referred to as non-cognitive skills. Others include Borghans et al. (2008), Heckman and Kautz (2012) and Heckman et al. (2006b). Views from the economics literature indicate a positive association between personality traits and earnings, and also with education. For instance, individuals with certain traits tend to stay longer in school which often demonstrates higher ability and acts as a signal to employers. These individuals are then rewarded with higher wages in the labour market (Weiss, 1995). A number of studies provide support for this of which Anger and Heineck (2010) is an example. Heckman and Kautz (2012) also show the importance of personality traits in determining individual success.

In the economics research community, data limitation explains part of the lack of empirical examination of the role of non-cognitive skills in the labour market. Compared to cognitive skills, which are easily available in many surveys (NCDS for the UK), access to data that captures information on non-cognitive skills are limited and economists are unfamiliar with psychometric measures (Heineck, 2011). Existing empirical evidence shows that non-cognitive skills raises earnings directly through their effect on productivity, while also indirectly raising schooling and other outcomes (Heckman et al., 2006b; Heckman and Kautz, 2012). Cobb-Clark and Tan (2011) provide an assessment of gender differences in non-cognitive skills (measured by the Big Five Personality traits - (McCrae and Costa, 1997) and locus of control) and show how this affects occupational choice and consequently wages for Australia. The authors find non-cognitive skills to impact on employment probability. Specifically, they observe
that despite men and women having similar non-cognitive skills, men and women tend to enter occupations at different rates. The authors further find that non-cognitive skills give women slight wage advantages. In Sweden, Kajonius and Carlander (2017) examined how much of life outcomes were explained by personality traits once childhood socioeconomic status was controlled for. Interestingly, the authors found that personality traits were just as important or even more important in determining adulthood outcomes, including annual income and life satisfaction. Childhood socioeconomic conditions were instead more related to educational attainment.

Personality traits and economic success have also received attention in the UK. Using data from the BHPS, Heineck (2011) provides evidence on the extent to which the Big Five traits, namely, openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism, affect wages. The author finds that agreeableness and neuroticism (females only) are penalised, whereas openness is rewarded in the labour market. Nandi and Nicoletti (2009) provide a decomposition analysis for the UK also using data from the BHPS. Similar to previous studies, the authors find that openness to experience is rewarded positively in the labour market whereas agreeableness and neuroticism are associated with lower wages. Lindley (2018) uses data collected from an online survey of undergraduate students from the King's College London Business School and uses the Big Five personality traits to generate psychopathy, narcissism and Machiavellianism scores. She finds an hourly wage premium to Machiavellianism of around two per cent with every one-point increase on the Machiavellianism scale. This premium is largest at the 90th percentile, over and above all productivity-related explanations.

Continuing with the theme of the big five personality traits, individuals who are more agreeable tend to be more accommodating and cooperative in their attitude within the social environment, agreeable with others, leading to higher academic motivation and behaviours which improve academic performance (Vermetten et al., 2001). While agreeableness is linked to an improvement in academic performance, its impact on wages is ambiguous (Vedel, Anna & Poropat, 2017). Some studies have shown agreeableness having a negative relationship with earnings, with reasons being down to workers helping the interests of others, being poor wage negotiators, having an egalitarian attitude towards work and pay (Nyhus and Pons, 2005). On the other hand, agreeable individuals might be rewarded by employers because they are more likely to respond to incentives by firms (Nyhus and Pons, 2005). On an undesirable note, people with low score on agreeableness may have something in common with Machiavellian intelligence, which has been found to have a positive effect on earnings and occupational attainment (Turner & Martinez, 1977).

In addition, conscientiousness has also been found to be closely related to motivation to learn (Colquitt et al., 2000) and reliability (Mount and Barrick, 1995). Duncan and Dunifon (1998) examined the long-
term effects of workers motivation on wages, exploring the relationship between social psychological traits observed in men aged between 21 and 29 and their labour market attainments 15 to 25 years later. Controlling for schooling, parental background, and cognitive skills, they find that individuals posing both an orientation toward challenge and a belief that their own actions are effective, earn higher wages 20 to 25 years later. Within this work, Duncan and Dunifon (1998) also acknowledged that those individuals with an orientation to achievement and self-efficacy earned considerably higher wages over the same period. Self-efficacy is the belief that an individual has to perform the behaviours needed to achieve a desired outcome (Bandura, 1997). Van Dam, Oreg, & Schyns (2008) found that employees with a high role breadth self-efficacy are more open to organizational change, with Van Dam & Seijts (2007) also finding that employees are more likely to report more learning and innovative behaviours. Schnitker & Emmons (2007) suggested that patience is positively correlated with an individual’s personal well-being, positive coping virtues, and thriving. John, Donahue, & Kentle (1991) found that patience was correlated with higher Agreeableness, higher Openness, and lower Neuroticism, as well as finding a relationship between patience and well-being, decreased depression, lower incidence of health problems, and pro-social traits, such as empathy. Being more agreeable is also related to individuals being more co-operative. Co-operation has been expressed as the individual differences in identification with and the acceptance of other people, with individuals with a high-level of co-operation described as empathetic, tolerant, compassionate, supportive, and fair individuals, who get pleasure from trying to co-operate with others (Kose, 2003).

A very recent literature strand highlights the role of social skills and their complementarity with cognitive skills, but they are all US based (Weinberger, 2014; Deming, 2017; Deming and Kahn, 2018). For instance, Weinberger (2014) uses data from two National Center for Education Statistics longitudinal studies of high school students (National Longitudinal Study of the High School Class of 1972 and the National Education Longitudinal Study of 1988) which provide information on senior year math scores and comparable questions about extracurricular participation, leadership roles, and earnings seven years after the senior year of high school. Deming (2017) uses the NLSY 1979 and 1997 and finds evidence that social skills (measured as a standardized composite of sociability in childhood and adulthood and participation in high school clubs and in team sports) and cognitive skills (measured through test scores) are complements in a Mincerian wage equation. Deming and Kahn (2018) use employment vacancy data provided by Burning Glass Technologies to examine changes in skill requirements demanded by firms and labour markets. To capture cognitive skills, they search for terms, such as problem solving, research, analytical, critical thinking, math, science, or statistics while social skills are comprised of communication, teamwork, collaboration, negotiation and presentation skills. These pieces of work generally find that self-organisation or advanced numeracy skills in digital
intensive industries have particularly high returns. A cross-country comparison using PIAAC shows that workers endowed with a combination of these two skills sets or numeracy skills, managing and communication skills receive an additional wage premium (Grundke et al., 2018). These findings are consistent with the literature strand on dynamic skill complementarities in the production of human capital, which argues that the return to investments in skills, such as ICT skills, is higher when the initial level of skills is already high (e.g. Cunha and Heckman, 2007; Cunha et al., 2010; Aizer and Cunha, 2012).

3.3. Family background and earnings

A strong relationship between family background, often measured as parental income, and children’s economic success is often considered an indicator of equality of opportunity. If most individuals’ socioeconomic outcomes are strongly related to those of their parents, the implication is that children from poor families/backgrounds are more likely to be relatively poor as adults.

The question of how family background influences children’s lifetime economic status has been a subject of considerable interest, beginning with the work of Becker and Tomes (1986). The underpinning hypothesis of this argument is based on the notion of parental altruism towards children and the investment in children’s human capital. Becker and Tomes (1986) also present a number of findings: first, earnings adjust to the mean at a faster rate in richer families than in poorer ones because of capital constraints suffered by poor families; second, consumption, differently from earnings, regress to the mean more rapidly in poorer households than richer households in the case where there is no correlation between fertility and parents’ wealth; third, fertility is positively correlated to family’s wealth but in richer families the regression to the mean occurs as for the relation between consumption per child and of parents.

The economics literature on the role of family background (parental income) on children’s future economic success (intergenerational mobility) often relies on monetary measures, with income or earnings of the child often used as the outcome variable. In addition, most parts of the literature measures mobility (how children’s earnings are shaped by family background) using the correlations between earnings of sons and their fathers (Blanden, 2013). This section of the review will present evidence of the relationship between family background, mainly parental income, and children’s earnings with focus on the UK where possible. Depending on the type of data and cohort used, the few empirical studies that analysed the trend in intergenerational mobility in the UK have produced mixed results.
Blanden et al. (2004) compare two birth cohorts (1958 and 1970) in the UK using NCDS, a survey of all children born in the UK between 3 and 9 March 1958, and the BCS, a survey of all children born between 5 and 11 April 1970. They showed that the link between parental income and children’s (sons) earnings was stronger for the recent cohort compared to the older one. In particular, they found an IGE of 0.12 for the cohort in 1958 and around 0.25 for the cohort in 1970, indicating that children whose parent’s income is higher in the parent’s generation expect their own earnings to be 25 per cent above the average of their own generation. In a similar exercise, Dearden et al. (1997) used the NCDS for a sample of individuals born in 1958 and found IGEs ranging between 0.40 to 0.60 for sons and 0.45 to 0.70 for daughters, depending on the econometric method used. Blanden et al. (2005) uses survey data and registers for Europe and North America, the UK and the US and found the same order of intergenerational mobility (0.27 and 0.29 respectively). Jäntti et al. (2006) found similar results.

Utilising the NCDS, similar to Blanden et al. (2004) and Blanden et al. (2005), Belfield et al. (2017) confirm the strength of the link between parental income and son’s labour market earnings. In Belfield et al. (2017), the authors use net family income rather than gross individual earnings. This enabled the authors to include individuals that were out-of-work. In doing so, they found that for the population of males born in 1970 an increase in parental income at the age of 16 increased net family income of the child by 0.35 per cent at age 42. This increased by 0.12 percentage points from the previous cohort.

According to Haider and Solon (2006), both the elasticity and the correlation coefficients are affected by a life-cycle bias, which depends on the son’s age. This implies that IGE estimates will be underestimated for younger children (sons) and overestimated for older ones. Past studies have attempted to address this by using earnings data for children at older ages and also by averaging parental earnings over a longer period of time rather than using one time period estimates (Solon, 1992; Corak and Heisz, 1999; CBS, 2011). According to Mazumder (2005), using average earnings over a longer period of time mitigates concerns of biasedness in estimated IGEs. Chetty et al. (2014) however argue that the baseline measures do not suffer from substantial life-cycle or attenuation bias as mobility estimates are said to stabilise by the age of 30 and are not significantly sensitive to the number of years used to measure parental income (see Mazumder, 2005; Haider and Solon, 2006; Gregg et al., 2016). In the same study, the authors attempt to address the concern of individuals with zero income. They do this by dropping individuals with zero reported income and as a result they find that estimates are

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32 The NCDS parental income data comes from separate measures of father’s and mother’s after-tax earnings, and other income, whereas the BCS contains data on only combined parental income.

33 The different estimation methods used are: OLS using the estimated residuals; OLS using the predictions approach; and IV estimation with different combinations of instruments (father’s socioeconomic status, e.g. social class; father’s education). OLS estimates were found to be downward-bias.
sensitive to different specifications. Overall, they find IGEs ranging from 0.26 to 0.70. See also Corak (2013), Jerrim (2017), OECD (2018), World Bank (2018) for recent updates on IGE.

The concern of how parental earnings are measured is a contentious one. Previous literature often relied on only paternal earnings, although more recently mother’s earnings have been considered, owing primarily to the recent increase in female labour force participation. In addition, earlier studies considered only father-son correlations. Concerns have also been raised in particular on how family background should be measured, with some arguing that using family income, rather than parental income, may be more appropriate and may have different effects on children’s earnings (Mazumder, 2005; CBS, 2011). Family income could better capture socioeconomic transition and may provide further insight into the effects of family resources on adulthood outcomes. Mazumder (2005) experiment with this and find that family income is less prone to error and can capture a lot more compared to earnings which are mostly observed for individuals in work. Specifically, Mazumder (2005) find that the IGE between family income and children’s earnings is higher than the IGE between father’s earnings and children’s earnings. Chadwick and Solon (2002) observed similar effects.

3.4. Health as an earnings determinant

The association between health and labour market outcomes is theoretically embedded in the notion of human capital investment with most of the early literature studying returns to education rather than health (Mincer, 1958). However, with increasing recognition of health as a significant contributor to human capital (Becker, 1962; Mushkin, 1962; Grossman, 1972a, 1972b), focus shifted and scholars examined empirically its role on the willingness to supply labour and on wages (Grossman and Benham, 1973; Luft, 1975; Bartel and Taubman, 1979; Berkowitz et al., 1983). Grossman (1972) describes health as a “durable capital stock that produces an output of health time” which can be spent on leisure and work. However, poor health reduces the amount of time that can be spent in generating income, which is referred to as ‘absenteeism’ from work. At the same time poor health also affects the quality of the time available and therefore can result in a productivity loss, which is called ‘presenteeism’ in the occupational health literature (Burton et al., 1999). Since hourly wages are assumed to reflect marginal productivity, economists often use earnings as the closest proxy for productivity. However, other reasons put forward as to why health and earnings are associated include that employers may discriminate against individuals in poor health or they may believe that health is correlated with unobserved characteristics which are positively associated with productivity.

Early empirical evidence of presenteeism was limited to the use of cross-sectional data but recently scholars started exploiting longitudinal data to disentangle the fact that health contributes to human
capital stock (Grossman, 1972), which at the same time determines wages (Becker, 1964) and the amount of time spent in the labour market. However, addressing all sources of the endogenous nature of health in the health-employment nexus remains challenging and UK based work is limited. First, there is the issue of reverse causality, which was introduced earlier. Second, there is unobserved time-invariant heterogeneity, where factors, such as personality traits and individual-specific circumstances, can drive the relationship between health and earnings. For instance, very motivated individuals can have higher wages and have better mental health. Lastly, a lot of the existing work relies on self-reported health information but a review of existing literature on the validity of these reveals that this measure is often plagued by measurement error and ‘reporting bias’ (Kerkhofs and Lindeboom, 1995) because individuals are heterogeneous and different sub-groups use different reference points when answering the same health-related question.

Recently published work by Lenhart (2019) examined the health-earnings nexus in the UK using different time periods of the BHPS. By exploiting the longitudinal nature of the survey and using propensity score matching combined with a DiD approach, he matched individuals who experience a worsening in self-assessed health (treated group) to others that are similar but maintain their health status (control group) based on characteristics prior to the health shock and first differenced the outcomes of the treated group and the control group to eliminate any unobservable fixed effect that influence the selection into the groups as well as the employment outcomes. He found that hourly wages decrease by more than £2 when analysing individuals over a 9-year period suggesting that individuals who stay at work after a negative health shock experience lower wage growth. The estimates are comparatively small and imprecise when observing the 3-year period. When examining annual labour income, which implicitly accounts for absenteeism as well as presenteeism, he detects a decline of around £1,200 for the year after the shock when observing individuals over a 3-year period. This figure increases to up to approximately £4,400 when following people over a 9-year period which examines the effects for up to 4 years after the health shock. Therefore, Lenhart argues that people do not necessarily adapt to their health status and that they have difficulties being reintegrated. Since these effect sizes are even larger in magnitude for overall household income, individual health effects are likely to spillover to other household members who take time off from work for caregiving activities. More severe rather than mild health declines lead to higher income reductions with larger effects observed when workers are followed over a longer period, indicating that labour market effects are persistent and not temporary. These findings are replicated when using the onset of a health condition as an adverse health shock. These findings are partly consistent with early and widely cited work by Contoyannis and Rice (2001) who also used the BHPS and self-assessed health, but they identify gender-specific effects on earnings. While they find poor general health to reduce hourly wages only for women, they identified mental health to be the significant determinant of males’ wages.
The problem is that people out of work often differ systematically from individuals who are in work. Since they are more likely to have lower levels of education and a greater incidence of health conditions, they are expected to be on average less productive and, as a result, earn lower wages were they to work according to human capital theory. Brown et al. (2010) addresses this complexity by estimating health effects in earnings in an endogenous switching model which predicts reservation wages for the unemployed and market wages for the employed using the same dataset as Lenhart (2019). They use usual net pay per month converted into weekly wages and the weekly reservation wage of non-working but job seeking individuals provided in the BHPS. They construct their own health variable, based on work on health and retirement behaviour by Bound et al. (1999) and Disney et al. (2006), and predict self-assessed health categories using socio-economic characteristics and health problems in a generalized ordered probit model. This approach allows individuals with the same underlying level of health to choose different health thresholds on the assumed underlying continuous scale (Kerkhofs and Lindeboom, 1995; Lindeboom and van Doorslaer, 2004; Rice et al., 2011). The predicted dummy variables for excellent, good or very good and fair health (poor is the base category) were then used in a full information maximum likelihood approach to estimate the endogenous switching regression model. Using this approach, they come to a different conclusion than Lenhart. They find that the main effect of health is the prevention of people from working but, once they account for selection into the labour market, be it currently employed or unemployed, poor health does not reduce the market or the reservation wage.

Some scholars argue that employment exits of individuals in poor health can be a result of incentives created by disability benefits. However, UK schemes are not linked to previous earnings as it is often the case in other countries and provide benefits at a flat rate instead, which is unlikely to incentivise unnecessary employment exits. For the UK, Walker and Thompson (1996) used the first three waves of the BHPS and found that, after controlling for the endogeneity of schooling, disability has a greater effect on labour market participation than on wages. In a similar vein, Kidd et al. (2000) compare the labour market outcomes of disabled and able-bodied men in the UK using the LFS and find substantial wage and participation rate differences between the two groups with the disabled characterised by lower wages and lower rates of participation with productivity-related characteristics explaining approximately 50 per cent of the differentials. More recently, Jones et al. (2006a) stated that, although the average wages of the disabled are over 85 per cent of their non-disabled counterparts, the rate of participation of disabled people is approximately half that of the non-disabled. Similarly Jones et al. (2006b) provides an extensive review of empirical evidence on how disability has affected labour market outcomes by gender since the introduction of the Disability Discrimination Act in 1995 and...
conclude that differences in employment and wage prospects exists for those with mental health problems.

3.5. Job mobility

There is by now a general agreement that human capital plays a major role in determining earnings. The initial focus of the literature on firm-specific capital motivated the study of the relative importance of specific capital, by examining the effects of firm tenure on earnings profiles. Some of this literature provides conflicting evidence on the magnitude of tenure effects (see e.g., Topel, 1991; Abowd et al., 1999). Parrado et al. (2007) find that in the US occupational movement is associated with lower earnings, even controlling for selection effects (once personal characteristics, such as schooling, work experience, job tenure, marital status, and race are controlled for). They find that older and less educated workers are less likely to shift occupation or industry, as are better paid men. This result is not found for better-paid women; they also stress that the tendency for younger and more educated workers to change occupations and industry more frequently has risen over time.

Longhi and Brynin (2010) find that, both in Germany and Britain, workers who change occupation mostly benefit from the change in terms of wage increases, relative to those who do not experience such change, and while this is no different to those that change job only, they achieve higher satisfaction. Among the benefits associated with job and occupation changes, increase in life satisfaction is the largest. Their analysis shows that change is on average beneficial, in terms of both wages and job satisfaction, with those who change occupation generating a wage premium as high as those who change jobs but do not change occupation. This is different to some of the evidence for the US (see Kambourov and Manovskii, 2008 for the US) which indicates that high occupational turnover results in relatively low growth in wage. Using the LFS, Carrillo-Tudela et al. (2016) distinguishes wage effects in relation to occupational mobility, depending on the level of skills and finds that UK workers at the bottom of the wage distribution, who changed occupations, experienced a fall in real wages, while switchers at the top of the wage distribution are the ones that engendered the largest increases in wages following the transition.

Parent (2000) estimated earning equations using US data and included industry experience in the regressors of wage equations. This paper finds that what matters most for the wage profile in terms of human capital is industry-specificity, not firm-specificity. Including total experience in the industry as an additional explanatory variable, this paper shows that the return to seniority is markedly reduced.
using Generalised Least Squares (GLS) while it virtually disappears using IV\textsuperscript{34}. GLS, at both the one-
digit and three-digit industry levels. The latter two techniques correct for the fact that unobserved
components are likely to be correlated with tenure, total labour market experience, and total experience
in the industry.

Zangelidis (2008) is one of the first empirical papers looking at the specificity of work experience,
drawing from data from the BHPS for the period 1991 to 2001. This paper finds that occupational
experience makes a positive contribution to wage growth, with not much evidence of industry effects,
in contrast to earlier evidence. Zangelidis (2008) finds these positive returns vary across occupations,
and that longevity in occupations is important. This finding is consistent with evidence based on the
US; when occupational experience is taken into account, tenure within an industry or employer has
relatively little importance in accounting for the wage one receives (Kambourov and Manovskii, 2009).
Kambourov and Manovskii (2009) find that five years of occupational tenure are associated with an
increase in wages ranging between 12 and 20 per cent. These findings are consistent with studies
supporting the idea that human capital is largely occupation-specific.

For the US, Sullivan (2010) shows that workers accumulate skills that are specific to both occupations
and industries, while truly firm specific skills contribute little to the growth of wages over the career.
Sullivan (2010) uses an IV approach\textsuperscript{35} to estimate the effects of firm tenure, occupation specific work
experience, industry specific work experience, and general work experience on wages, using data from
the 1979 cohort of the NLSY (for a sample of young men). These estimates indicate that both occupation
and industry-specific human capital are key determinants of wages but there is variability. Human
capital appears to be primarily occupation-specific in occupations such as craftsmen, where workers
benefit from a 14 per cent increase in wages after five years of occupation-specific experience; these
workers do not seem to benefit from industry-specific experience. In contrast, human capital appears to
be primarily industry specific in other occupations such as managerial employment where workers
realise a 23 per cent wage increase after five years of industry-specific work experience. In other
occupations, such as professional employment, both occupation and industry specific human capital are
chief determinants of wages.

Drawing form high-quality German administrative data, Fitzenberger et al. (2015) distinguishes the
wage effects of job mobility from those of occupational mobility. This study provides causal estimates

\textsuperscript{34} Tenure is instrumented with its deviations from job-match means whereas experience is instrumented with its
deviations from individual means. Total experience in the industry is instrumented with its deviations from
industry-match means. The instruments for tenure and experience in the industry are, by construction, uncorrelated
with their respective match quality components, while the instrument for experience is, also by construction,
uncorrelated with the individual component.

\textsuperscript{35} Similar to Parent (2000)
of the wage effects of mobility among graduates from apprenticeship in Germany.\textsuperscript{36} They use the IAB\textsuperscript{37} Employment Sample regional file from 1975 to 2004, a two per cent random sample of all employees paying social security taxes. The analysis distinguishes between pure firm-switchers, within-firm occupation switchers, and across-firm occupation switchers. To identify the causal effect of mobility after apprenticeship on wages, they exploit variation in the local labour market conditions in the year of graduation. The instruments utilised include both push and pull factors, such as indicators regarding tightness of the local labour markets, and group specific mobility rates (which is assumed provide exogenous variation in mobility conditional on the sorting of apprentices by two-digit training occupations, which they account for by including occupation fixed effects). Due to the likely presence of selection based on unobservables, OLS estimates are likely to be biased and they employ an IV approach. The IV results suggest that pure firm changes after apprenticeship lead to wage losses, but the conclusions regarding the wage effects of occupational mobility after apprenticeships are somewhat more positive. The results of the study suggest that the skills acquired through apprenticeship training in a specific occupation are sufficiently general to be useful when working in another occupation.

Using data from the BHPS, Dorsett et al. (2011) find that lifelong learning appears to provide a one-off boost to wages growth for those in stable employment (the study refers only to women). It also influences the probability of being in work and thereby indirectly increases earnings for movers. These results are robust to controlling for the selection in terms of the characteristics of people who undertake lifelong learning. They find that those qualifications, which result in women’s educational status being upgraded, have a clear positive effect on their earnings.

3.6. On-the-job training

Compared to many EU countries, the UK ranks high in the proportion of workers receiving on-the-job training (O’Mahony, 2012). While during the period 2000-2007 the proportion of workers receiving training in the UK was comparable to that in Scandinavian countries and the Netherlands, Green et al. (2016) has identified for the UK a downward trend in training volumes over the period 1997-2012. Squicciarini et al. (2015) present a novel methodology for the measurement of investment in human capital that is related to training. They use an expenditure approach that encompasses investment both in formal and on-the-job training, as well as in informal learning, and estimate how much this broader measure of training impacts on a country’s GDP. In order to arrive at these estimates, they link the incidence of training to PIAAC data and other sources of information. This paper finds that during the period 2011-2012, the UK has invested more in training than many OECD countries, to a level

\textsuperscript{36} In Germany, vocational training in an apprenticeship involves a job in the training firm and training in a specific occupation.

\textsuperscript{37} Institut für Arbeitsmarkt- und Berufsforschung der Bundesagentur für Arbeit (Germany)
comparable to that in countries like Australia, Denmark, the Netherlands and Canada. It is worth pointing out that the observed cross-country heterogeneity in training intensity is mainly driven by differences in formal training, while the differences in on-the-job training are less pronounced. Squicciarini et al. estimate that in the UK formal training represents six per cent of total GDP, on-the-job training represents less than three per cent, and the contribution of informal training is below one per cent of total GDP. Arguably, the investment in formal training in countries like the UK (and also countries such as US, Australia and Canada), where private education is more common and tuition fees are generally higher, the figures for formal training may be overestimated as the cost per student is comparatively higher.

There is a large literature showing that the accumulation of human capital through the formal education system plays a crucial role in determining productivity and earnings of workers (Moretti, 2004), but also that more educated individuals have a higher probability of receiving training (Blundell et al., 1996). Overall there is not much evidence on the effects of training provided by firms. Blundell et al. uses data from the NCDS (a continuous longitudinal survey for people living in Britain with detailed information on individual family background and labour market experience) for the period 1981 to 1991 to look at the wage effects of training on both men and women at age 33. On the returns to training, the paper finds that being involved in employer-provided training courses confer significant wage advantage for men, but interestingly this is more pronounced if this takes place off-the-job. Also, the returns are higher if the training results in a high-level vocational qualification. A surprising finding of this study is that the training provided by a previous employer yields comparatively marginal smaller returns. For women, employer-provided training results in smaller returns than for men, but a relatively larger impact is found for those women undertaking courses that lead to qualifications. The results show, moreover, that the returns to training are complementary to formal qualifications but are higher for those with intermediate-level qualifications (which is recognised as one of the groups that traditionally has received less training).

A number of papers use observational (panel) data, usually on industries or firms, to investigate the causal impact of firm-provided training on productivity and wages. Dearden et al. (2006) examine for the UK the effects of work-related training on direct measures of productivity during the period 1983-1996. Dearden et al. assemble a dataset that aggregates individual-level data on training and establishment data on productivity and investment into an industry panel, and control for unobserved heterogeneity and the potential endogeneity of training using a generalised method moments estimation. They find that there is a significant impact of training on labour productivity for UK industries (measured as value added per hour) and, second, that the effects of training on productivity are larger than the effects of training on wages. They argue that the focus on wages as the only relevant measure
of productivity, that many studies take, ignores additional productivity benefits for firms. They estimate that one percentage point increase in training is associated with an increase in value added per hour of about 0.6 per cent, and an increase in hourly wages of about 0.3 per cent. The authors argue however than the broken link between wages and productivity may be related to imperfect competition prevailing in the labour market as employees may find themselves be paid less than their marginal revenue product.

There are other more recent contributions that estimate the returns of employer-provided training. Using company accounts Belgian data, Konings and Vanormelingen (2015) also find that, after controlling for the possible endogeneity of training, that training boosts marginal productivity of an employee more than it increases its wage. They estimate that the productivity premium for a trained worker is estimated at 23 per cent, while the wage premium of training is estimated to be 12 per cent. There exists considerable sector heterogeneity in the impact of training on both productivity and wages, and they estimate a slightly higher impact of training in non-manufacturing compared to manufacturing sectors. Among different manufacturing sectors, the largest productivity gains can be found in the chemicals and rubber and plastic industries. This type of firm-level analysis is possible because Belgian firms are obliged by law to submit a supplement to their annual accounts statement, which contains information on a number of elements related to training. These include the proportion of workers that receive training, the number of hours they are trained for, and the cost of training to the firm, and these data can then be linked to both wages and productivity at the firm level. They estimate a production function using an estimation strategy that controls for the endogeneity of input factors.

Using unique matched establishment-employee data from Germany, Berg et al. (2017) focus on the role of training for the retention of workers, in particular of older workers. This study is based on the linked German IAB Establishment Panel, an annual nationally representative survey of German establishments, with individual-level administrative data for the employees of participating establishments. They find that when establishments offer special training programs targeted at older workers, women, and especially lower wage women, are less likely to go into retirement. The research provides evidence that training programs are likely to play an important role in retaining and advancing careers in particular of low wage older women. Results suggest this relationship may be related to greater wage growth. For men, the findings suggest that the inclusion in training programs may improve retention particularly of low wage men, but the analysis of pre-existing differences in establishment retirement patterns suggests this relationship may not be causal.
4. Conclusion

It is of major interest to policy makers to understand what drives a country’s human capital accumulation. This literature review makes a contribution to this goal by providing an accessible and comprehensive literature review on (1) the factors that affect human capital accumulation and their measurement and (2) the determinants of earnings, and their use in valuing human capital.

This review has outlined a number of factors which impact on education and earnings, such as family background, cognitive and non-cognitive skills and health, many of which are themselves affected by education and earnings. What emerges is a sense that countries might be able to get on a virtuous cycle of human capital accumulation through better education and training, which increases earnings and impacts future generations allowing them to enjoy better health, greater job mobility in the face of major technological changes which in turn raises productivity and living standards, financing more education and so on. On the other hand, there are many factors which might prevent such an occurrence, such as institutional constraints, cultural conventions and market restrictions.

Much of the literature has focused on identifying causal impacts of individual factors such as family background on education, leading to considerable improvements in our understanding. Nevertheless, finding convincing identification strategies are often difficult, and these are frequently based on experiments which may not be easily generalizable. The use of large scale administrative data offers great potential, but access to such data is only available in a few countries. Far less effort has been devoted to understand how these various factors impact on each other, or interact with the institutional environment, primarily due to lack of good data, but also due to the persistent nature of institutions and culture.

For example, the review of the literature on the role of family background as a determinant of human capital highlighted a lack of detailed and rich data for the UK, comparable to Pronzato’s (2012) Norwegian study and other similar studies on causal effects (using twins, siblings and adopted samples) of parental education. It is also important to understand how education impacts children’s development along the distribution of parental education. Parents, usually mothers with lower levels of educational attainment, often aim to invest more in their children’s education but of course, challenges such as lack of resources and poverty sometimes makes this highly unlikely. This potentially leads to a cycle of generational poverty. Further research is therefore needed to understand some of the causal mechanisms. Similarly, there is dearth of evidence on family background and children’s cognitive skills development. The issue of cognitive and non-cognitive development has also received large attention.
by governments and policy-makers. There are concerns that despite higher levels of educational attainment, a considerable proportion of the UK population have low literacy and numeracy skills. Family background again becomes crucial for addressing this issue. It is therefore important for future studies to examine the extent to which family background plays a role, but of course, such an exercise will require rich data that captures not only numeracy and literacy but also on other soft skills, including personality traits.

A growing body of literature suggests that education has benefits beyond increases in labour market productivity which extend to health. The literature review has highlighted that the majority of UK based studies exploit the increase in the minimum school-leaving age in 1947 and/or 1973 as an exogenous change in the amount of schooling received to examine the causal effect of education on health conditions (e.g. biomarkers), subjective general health and health behaviour, such as smoking. Albeit the common strategy, scholars draw different conclusions and find mixed evidence for the causal effect of education on health (Oreopoulos, 2006; Blanchflower and Oswald, 2008; Silles, 2009; Powdthavee, 2010; Devereux and Hart, 2010; Clark and Royer, 2013; Jürges et al., 2013). Although evidence for the opposite direction of the relationship suggests a health selection process which generates socioeconomic inequalities in child- and young adulthood, the large majority of work is carried out in the US and mainly relies on standard logit regression models. When looking at the context of labour supply, the majority of UK based evidence comes from the BHPS and the Understanding Society Survey and the indirect role of informal care provision associated with third parties’ health rather than from the role of individual health (Michaud et al., 2010; Carmichael and Ercolani, 2016; Carr et al., 2016). The same data sources are used in studies on the impact of earnings on health, which mainly use the minimum wage legislation implemented in 1999 as an instrument (Kronenberger et al., 2017; Lenhart, 2017; Reeves et al., 2017). Here administrative data that links health records to levels of education and earnings would be particularly useful, but face difficult issues relating to data security.

We have investigated the extent to which job mobility and worker turnover is associated with a loss of human capital, as early theories emphasised the importance of firm- and/or industry specific capital. With the rise of the digital economy the degree of worker mobility is on the rise, and the degree of transferability of human capital is an important factor in evaluating the costs of job displacement and the re-training requirements of workers. Our review of the most recent literature has provided a few interesting insights. First, a strand of literature has stressed that a major component of human capital is occupation-specific or task-specific. Nevertheless, some contributions highlight that firm-specific human capital can arise from the different uses that firms make of the general and transferrable pool of skills available in the market. A number of studies estimate that the transition costs across occupations can be substantial, and argue that these depend on the degree of dissimilarity and the mix of
requirements needed to perform a job. But an important factor, which is often overlooked, refers to the occupation-specific entry cost such as qualification credentials and professional training, which are independent of task content. The study of transferability of certain types of human capital has been facilitated by the availability of high-quality data on complete job histories and wages of workers, containing information on tasks performed in a number of occupations, in countries like Germany. In contrast, most of the evidence on occupational mobility for the UK uses panel information from survey data, mainly the BHPS or the LFS.

The degree of **occupational mobility** (not just changing jobs within an occupation) appears to be larger in the UK than in many European countries. In theory the process of changing occupation should not necessarily be associated with loss of human capital, as to some extent occupational change can be the result of natural career progression. Evidence for the UK, however, suggests that occupational change in the UK mostly occurs as a response to a job mismatch, and occurs less as a natural career progression due to promotion (at least compared to other countries like Germany). Occupational change in the UK is also more likely for the low-skilled than the high-skilled workers. Other recent evidence shows that occupational change tends to be enhanced in the case of individuals that enjoy certain financial security, who want to explore an alternative life choice. This is observed also for individuals at later stages of their career, even if in general mobility decreases with age. There is evidence of a deterioration in the deployment of skills after an occupation change, with better results in terms of job satisfaction. We have also explored evidence on whether occupational movement is associated with lower earnings. Research using UK data suggests that workers who change occupation mostly benefit from the change in terms of wage increases and to a larger extent in terms of job satisfaction. This evidence is contradictory to some of the evidence available for other countries like the US that finds that mobility is detrimental for wage growth. Evidence for the UK suggests that the effects may not be uniform across the wage distribution with the most positive wage effects for those workers at the top of the wage distribution. Again the most recent literature suggests that occupation-specific experience matters the most for wage growth, compared to industry-specific or firm-specific experience alone. Some of these recent studies implement IV approaches to derive causal estimates of mobility on wages. The use of administrative data provides a rich and reliable source of information to distinguish the effects on wages of pure firm-switches, within-firm occupation switches, and across-firm occupation switches. This type of studies is emerging for countries such as Germany.

Evidence for the UK suggests that regional variation in human capital stocks may originate from training and education of resident populations, but is also highly affected by spatial flows, that is, the **migration** of the highly educated. Highly educated individuals are found to exhibit highest levels of spatial mobility (Faggian et al., 2015), which contribute to the process of knowledge transfer. IV-based
results show that while the innovativeness of a region is one of the major factors encouraging university graduates to seek employment in that region, the large inflows of highly mobile university graduates also contributes to enhance the innovation performance of a region. The majority of UK-based studies are based on regional data. Thus, they are not able to follow the spatial trajectories of individuals, as is possible using administrative sources, such as recent empirical studies for the Nordic countries. These types of data allow a much richer analysis of patterns and behavioural aspects of interregional migration.

Our review of the existing literature on crime and its effect on human capital has found only a few studies based on the UK, with the majority of studies undertaken for other countries. Most studies use a common methodology by exploiting school age reforms to instrument educational effects on crime. The review highlights the role of early educational intervention in reducing criminal activity. Although different features of crime incidence affect human capital, the most widely studied area involves education which reveals that human capital increases the opportunity costs of crime from foregone work and expected costs with incarceration (Lochner, 2004; Lochner and Moretti, 2004). It is important to note that this area of research is mainly carried out using US and Scandinavian data. The few UK based exceptions use the increase in the minimum schooling age in 1997 as an identification strategy (Sabates and Feinstein, 2008; Machin et al., 2011; 2012). The review has further highlighted the lack of empirical evidence for the opposite direction of criminal activity on educational outcomes which is mainly due to the difficulty of identifying exogenous variations in criminal involvement.

The review on returns to education looked also at the importance of institutional quality, with most studies indicating that high quality education institutions impact positively on individual earnings. This is a matter of potential interest to government, policy makers, and also the higher education institutions themselves. Further studies on how to improve the quality of low performing universities could be beneficial for future generations, through improved learning and higher labour market rewards. This of course requires use of detailed data. As for the issue of subject degrees, the review highlighted stark differences in earnings for different degree programmes. In terms of intergenerational transmission of inequality, more robust evidence is needed for the UK, and there is the need to use rich administrative data, such as the Longitudinal Education Outcomes dataset. A further key consideration will be to acquire data on parental income, not just parental earnings. The use of parental income will be able to capture other sources of income, such as transfer payments, all of which adds to wealth. Econometrically, there is also the need to use techniques that address how people with unreported income and earnings are dealt with.

Recent literature highlights the importance of skills gained through learning and on-the-job training as the true earnings determinant. Empirical evidence suggests that cognitive skills, such as numeracy
(Hanushek et al., 2015), problem-solving and ICT skills (Falck et al., 2016), are key in explaining most of the variation in earnings differences in technology-rich environments. At the same time, the increase in automation also highlighted the financial returns to non-cognitive skills, such as social skills and personality traits (e.g. Heckman et al., 2006b; Lindqvist and Vestman, 2011; Heckman and Kautz, 2012; Deming and Kahn, 2018) and their complementarity with cognitive skills (Weinberger, 2014; Deming, 2017; Deming and Kahn, 2018). However, while information on cognitive skills is easily available in many surveys (NCDS for the UK), access to data that captures information on non-cognitive skills are limited which explains part of the lack of empirical examination of the role of non-cognitive skills in the labour market. Existing work on the UK exploits information on the Big Five traits in the BHPS (Nandi and Nicoletti, 2009; Heineck, 2011) and more recent work uses PIAAC in cross-country comparisons to fill this gap. A very recent literature strand highlights the role of social skills and their complementarity with cognitive skills, but they are all US based (Weinberger, 2014; Deming, 2017; Deming and Kahn, 2018).

The empirical literature exploring the returns of **employer-provided training**, in terms of wages and productivity, is not large. Earlier studies focused on individual wage returns (Blundell et al., 1996) and subsequently the literature stressed the importance of looking at overall productivity effects of firms. Several studies found significantly larger productivity effects of training than those on wages. This ‘wedge’ between wages and productivity pointed to a number of reasons including the existence of important externalities of training at the firm level, and imperfect competition in the labour market. Many early studies faced important data and methodological limitations as training was often measured at single points in time, and thus could be picking up many unobservable firm-specific factors correlated with both training and productivity. The empirical literature attempted to estimate causal effects by relying on panel data of measures of training and firm performance, although aggregated to industries. Dearden et al. (2006) was the first study combining the use of a production function with a wage equation to estimate the effects of training. In this type of industry-level study one would pick up spillovers to training that are taking place within an industry; these effects would not be observed in firm-level analyses, which would potentially miss out on these linkages, underestimating the return to human capital. But there could be important aggregation biases that would lead to potentially conflicting results. A number of recent papers (for other countries than the UK mainly) draw from information of performance and training measures collected at the firm level. Literature is emerging using matched employer-employee data that enables linking firm outcomes to individual characteristics and behaviour.

Overall, the review points to the need to exploit large administrative databases where available. This requires a concerted effort by those gathering the data, the ONS and research users to address concerns
relating to data security, but also requires significant resources in matching datasets and ensuring they are fit for research purposes.

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111


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