# 1. Human capital and returns to education

*Geraint Johnes, Jill Johnes and Laura López-Torres*

## 1. INTRODUCTION

The evaluation of the investment returns in human capital has been at the core of the economics of education since the seminal work of Theodore Schultz (1961). Studies that evaluate this rate of return – either by use of the full method that draws on the techniques of investment appraisal, or, drawing upon the work of Mincer (1974) using an earnings function approach – number in the thousands. Yet significant advances both in methodology and in empirical findings continue to be made.

The most significant methodological advances have come in parallel with more general developments in applied microeconometrics. In particular, recent studies have focused particularly on issues of causality and unobserved heterogeneity by adopting methods such as difference-in-difference, propensity score matching, or regression discontinuity design (see Chapter 10 for further details on these methods). Other studies have focused on the issue of heterogeneity, recognising that estimates of the average rate of return to education do not necessarily hold good at the margin. These draw on techniques such as quantile regression (see Section 7 below for further details).

The new empirical findings document a widespread decline in rates of return to education over time. Moreover, a considerable amount of research effort has focused on drilling down to study rates of return at detailed levels of disaggregation – comparing different levels of education (kindergarten, primary schooling, lower and upper secondary schooling, higher education), different types (general academic or vocational), different modes of delivery (full-time, part-time, distance), or different subject specialisms (particularly in higher education). The results of these studies suggest strongly that the 'eleventh commandment' of Mark Blaug (1970) – that 'thou shalt equalise rates of return in all directions' – is honoured only in the breach.

In this chapter we shall review these developments and present new international comparative results on the heterogeneity of returns to education. The next section discusses the main methods used to calculate rates of return. Some empirical findings are reviewed in Section 3. Section 4 reviews the main findings on return to early years education, the subject of a considerable amount of recent research. Subsequently, we outline the returns to overeducation in Section 5. This is followed by a discussion of, first, endogeneity issues (Section 6), and then heterogeneity (Section 7). Section 8 of the chapter provides conclusions.

## 2. CALCULATING THE RATE OF RETURN

The rate of return to education can, given sufficient data, be evaluated by choosing the discount rate that equates the costs of education to the present value of the stream of



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future returns. Such a calculation requires earnings data to be available for individuals over the course of their life cycle. Typically, the series of earnings are smoothed for groups of individuals with different levels of education, and then compared in order to evaluate the absolute return to schooling at each time point. This method is clearly demanding in terms of data requirements.

Since the pioneering work of Mincer (1974), it has become very common to use instead an earnings function approach, which while making some fairly restrictive assumptions nonetheless allows useful inferences to be drawn about the rate of return. The basic Mincerian approach is to use regression methods to estimate the parameters of an equation of the form:

$$ln\ w = \alpha + \beta S + controls + error$$

where $w$ denotes the hourly wage and $S$ is a measure of the amount of schooling received. The *controls* normally include linear and non-linear measures of work experience, and may also include a variety of worker characteristics. In such an equation, $\beta$, which is a parameter estimated by regression, tells us (approximately) the proportion by which the wage increases if there is a unit increase in schooling. If a worker sacrifices a year of earnings in order to receive an additional year of schooling, then her subsequent earnings will rise by 100b per cent. With a long time horizon (approximated to infinity), 100b can be interpreted as the rate of return to education.

## 3. EMPIRICAL FINDINGS

The results of numerous analyses of the rate of return to education have been surveyed at frequent intervals in a series of World Bank studies (see, for example, Psacharopoulos and Patrinos, 2004; Montenegro and Patrinos, 2013). These have characteristically found that education offers a rate of return that varies across countries and across levels (primary, secondary and higher). In advanced economies, large investments are typically made in education, and this results in a rate of return that is broadly comparable to the returns available from other investments. Elsewhere, there is considerable evidence of underinvestment in education. Rates of return have tended to be higher in East Asian and Latin American countries than in OECD countries, and are particularly high in sub-Saharan Africa. There has also been a persistent tendency for returns to be higher for primary education than for secondary education. These findings have all been influential in determining the investment policies of the World Bank and, in particular, in setting the second of the United Nations Millennium Development goals – namely to achieve universal primary education by 2015.

The most recent of the World Bank exercises (Montenegro and Patrinos, 2013) suggests that many of the differentials between the regions of the world have been declining. The worldwide average rate of return attached to schooling is now estimated to be about 10 per cent. There remains some variation across countries, but much less so than in earlier years. It appears therefore that, in terms of international comparisons at least, the rate of return to education is indeed, albeit slowly over a period of time, being equalised in all directions. That said, the most recent data suggest that the return to tertiary education

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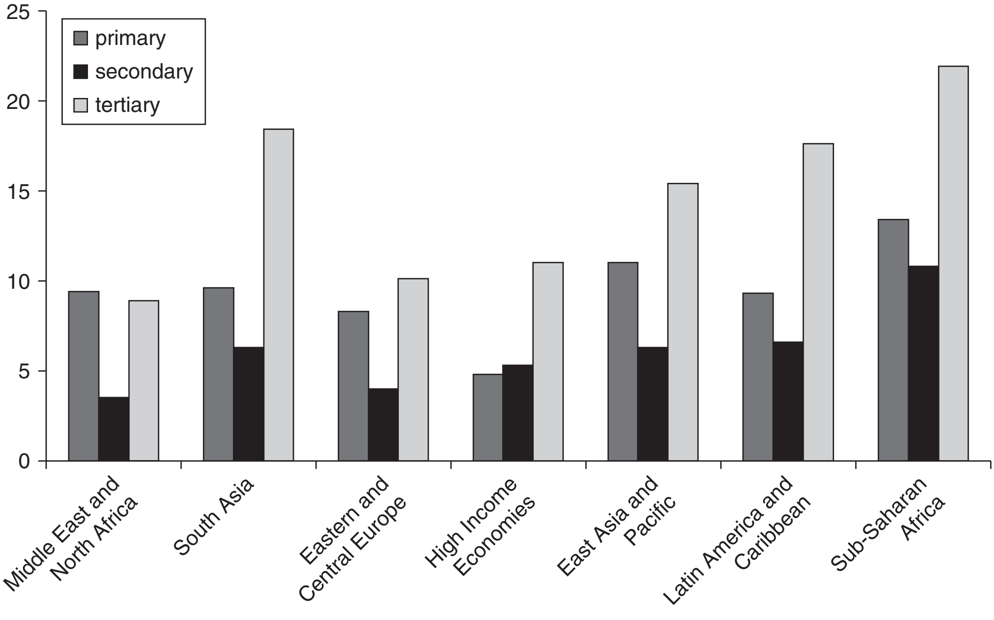


*Source:* Montenegro and Patrinos (2013).

*Figure 1.1 Rates of return to investment in education, by level and region*

has increased relative to those attached to earlier levels of schooling, and that the private return associated with higher education now exceeds that linked to either primary or secondary education. The returns to primary, secondary and tertiary education in various regions are documented in Figure 1.1.

The increased homogeneity of (average, private) rates of return across countries is welcome, not least because it reflects the fact that past underinvestments in less affluent countries have been in great measure redressed. In other respects, however, there are many instances evident of rates of return that differ substantially across groups.

A particularly striking example concerns the choice of subject in which students specialise after they have completed their secondary education. Walker and Zhu (2011) use UK Labour Force Survey data to estimate Mincerian rates of return to different types of undergraduate qualification.[1] They exploit the panel element of the data to correct for cohort effects that might otherwise bias estimates of the rate of return. (Where there has been a large recent rise/fall in demand for certain types of workers, these workers are likely to be rewarded by high/low salaries, but without taking cohort effects into account this effect is likely to be distorted by the presence of older workers in the data.) This allows them to estimate the $\beta$ coefficients reported in Table 1.1, separately for men and for women, and for different groups of subject specialism.

[1] Another source of evidence for the UK, providing broadly similar results, is Conlon and Patrignani (2011).

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*Table 1.1 Rates of return to subjects studied at undergraduate level, United Kingdom*

| | Men | Women |
|---|---|---|
| Science, technology, engineering, maths, medicine | 0.107 | 0.108 |
| Law, business, economics | 0.168 | 0.125 |
| Other social sciences, arts and humanities | 0.131 | 0.089 |
| Combined subjects | 0.116 | 0.085 |

*Source:* Walker and Zhu (2011).

It is clear that some variation is evident across subject areas, in particular with law, business and economics offering higher (average) returns than other subjects for both men and women.[2] In further results, Walker and Zhu (2011) find that the class of degree earned has a differential effect on subsequent earnings across subject areas. Relative to a lower second-class degree or worse, an upper second-class degree raises earnings for male graduates in law, business and economics by at least 18 per cent (and, for women, by at least 13 per cent). The corresponding figures for science, technology, engineering, maths and medicine are lower – at 9 per cent for men and just 2 per cent for women.

## 4. EARLY YEARS EDUCATION

While the overall return to education is of interest, it is also instructive to examine the returns associated with specific parts of the education system. Much recent research has focused on the returns to early years childcare and education, which appear to have important and lasting effects on later life outcomes (Johnes and Hutchinson, 2016). There is growing evidence of the importance of years spent in preschool education. Indeed, it has been argued that a unit investment in early childhood education has greater social return (private return plus social spillovers) than a unit investment in any other level of education (OECD, 2011) as illustrated in Figure 1.2.

The brain is particularly receptive in young children as it is still in development (Finnegan and Lawton, 2016), and this might account for why learning at such an early age is particularly beneficial (OECD, 2011). Long-term benefits of preschooling might arise through improvements in both cognitive and non-cognitive development.[3] In the case of cognitive effects, early years education has a direct effect on developing abilities as measured by standardised tests in literacy, language and mathematics. This is the cognitive advantage hypothesis (see, for example, Conyers et al., 2003). Thus preschooling should benefit later life academic achievement, which in turn will impact post-education returns in the form of enhanced productivity and wages.

However, children's later education achievement can also benefit from preschooling through non-cognitive channels. These can operate through, for example, the home environment (particularly exposure to vocabulary and positive verbal interactions), family

[2] In more recent and more detailed work, the same authors have established that there is a large wage premium attached to law, but a penalty attached to business (Walker and Zhu, 2017).

[3] See Chapter 2 in this volume for more on this subject.

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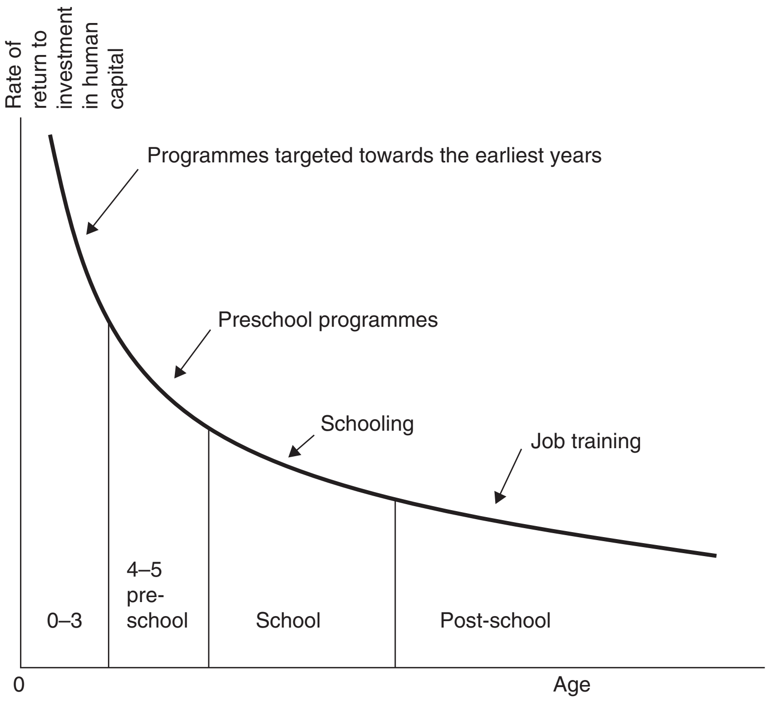


*Source:* https://heckmanequation.org/assets/2017/01/Heckman20Investing20in20Young20Children.pdf.

*Figure 1.2 Rate of return to investment in human capital by age*

income and parents' level of education (OECD, 2011). Early learning programmes, particularly those that actively encourage parental involvement, can have considerable non-cognitive benefits and these are explored further in Chapter 2 of this volume.

The evidence around the effects of learning in early childhood has been gathered from a variety of sources often based on longitudinal studies, from various national contexts, of children from an early age right through to adulthood.[4] One of the most famous is the HighScope Perry Preschool Study[5] which follows the lives of 123 children (in Michigan, USA) from underprivileged African American families considered to be at risk of failing. From 1962 to 1967 some 58 of the 123 children, aged three and four years old, were assigned to a high-quality preschool programme, and the remainder (the control group) were not. The treated and control groups have since been followed though into adulthood until age 40. The various studies based on these data find positive effects of preschooling on social responsibility, academic achievement and socio-economic success including earnings (Parks 2000). The evidence seems to suggest that there are significant returns to investment in preschooling, and that these persist at least up to age 40; some estimates

[4] More comprehensive lists of studies can be found in Almond and Currie (2011) and a report from the Wave Trust (2013).
[5] https://highscope.org/perrypreschoolstudy.

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of the returns are as high as 17 per cent (Belfield et al., 2006),[6] while others are more conservative at 7 per cent to 10 per cent (Heckman et al., 2010).[7]

Other longitudinal studies are not quite so comprehensive in terms of their follow-up as the Perry study. The Carolina Abecedarian Project[8] has followed up 111 children born between 1972 and 1977 in North Carolina, USA. All the children were from poor backgrounds, and the vast majority were of African American origin. Some 57 of the group were randomly assigned to high-quality childcare from infancy through to the age of five years. All the children have been followed up periodically into adulthood up to age 35, and there is also evidence from this study of the positive benefits of early years education (Campbell et al., 2014). Another notable US study includes the Study of Early Child Care and Youth Development (SECCYD)[9] by the National Institute for Child Health Development (NICHD), which covers more children (more than 1300) but follows through only until age 15. The latter finds a positive effect of early childhood education on academic achievement at age 15 (Vandell et al., 2010).

Outside of the USA, there have been similar studies undertaken in, for example, New Zealand and the UK.[10] In New Zealand, the Competent Children, Competent Learners study[11] has followed around 500 children from all backgrounds from just before starting school until age 25. In the UK, the Study of Early Education Development[12] is following over 5000 two-year olds up to age seven, while the Effective Preschool, Primary and Secondary Education (EPPSE)[13] study, launched in 1997, is following over 3000 children from the start of preschool (at around the age of three years). Early studies based on these data suggest the importance of attendance at preschool on achievement at school (see, for example, Sammons et al., 2014).

While the findings from such studies are generally very positive in terms of returns to investment, two results are particularly noteworthy. First, it is clear that the *quality* of the early childhood provision is important (Sylva et al., 2004; OECD, 2011; Sammons et al., 2007; Johnes and Hutchinson, 2016). There is evidence that while preschool attendance (regardless of quality) positively affects children's performance at age five, only attendance at a high quality or more effective preschool affects children's cognitive achievement at age 11; test scores for children attending low quality preschools are the same as for the children who did not attend preschool at all (Sammons et al., 2007). Thus the quality of the early years education seems to affect the duration of the benefits.

Second, and perhaps most importantly, disadvantaged children appear to benefit more from early years education than their more advantaged counterparts. That there is a significant gap in educational performance of children by social background at an early age is well established in the literature (Feinstein, 2003). This means that they are less well prepared for school (Karoly et al., 2005), and that without intervention, children from

[6] Note that this study suggests that males have a much higher rate of return from investment into early years than females: 21 per cent versus 8 per cent.

[7] Other evidence comes from Cunha and Heckman (2009), Doyle et al. (2009), Heckman and Masterov (2007) and Van Huizen and Akgunduz (2017).

[8] http://abc.fpg.unc.edu/.

[9] https://www.nichd.nih.gov/Pages/index.aspx.

[10] Studies have also been conducted in developing countries, for example India (Johnes, 2012).

[11] http://www.nzcer.org.nz/research/competent-children-competent-learners.

[12] https://www.gov.uk/government/collections/study-of-early-education-and-development-seed.

[13] https://www.gov.uk/government/collections/eppse-3-to-14-years.

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disadvantaged backgrounds will have lower academic (and hence lower labour market) performance in later life than those from more advantaged backgrounds (Becker 2011). There is considerable evidence suggesting that children from low-income backgrounds enjoy the greatest benefits of preschool education (Sylva et al.*,* 2004; Reynolds et al*.,* 2011; Cascio and Schanzenbach, 2013).

While the evidence of substantial effects of early years interventions on later life performance appears to be compelling, some shortcomings of the studies should be borne in mind. Some of the most often-cited studies (such as HighScope Perry Preschool Study or the Carolina Abecedarian Project) are based on high-quality preschool interventions targeted at small numbers of the most disadvantaged children. The generalisation of the results of these studies is therefore open to question. Evidence from more general longitudinal data sets such as EPPSE or, more recently, the UK Millennium Cohort Study[14] will provide scope for richer analysis, although problems of endogeneity in analysing the data will pose econometric challenges. This is therefore an interesting area of potential policy intervention and worthy of further investigation.

## 5. RETURNS TO OVEREDUCATION

Public expenditure on education accounted for 3.4 per cent, on average, of GDP in the OECD in 2014. At the same time, public spending on tertiary education amounted to 1.3 per cent of OECD GDP, on average (OECD, 2015). Countries have thus invested heavily in education, as can be seen, amongst other indicators, in the significant rise in the number of students in tertiary education, which almost tripled between 1975 and 2014 (OECD, 2015). At the same time, the demand for skilled labour, for which it was not always necessary to hold a higher education degree, has increased. In this scenario, highly educated workers may fail to find a job in which their skills and those demanded by their employers are matched. In such cases, the worker may be described as overeducated.[15]

The topic of over or undereducation and its effect on wages constitutes one of the main subjects of analysis in the returns to education literature. Since the publication of *The Overeducated American* (Freeman, 1976) we find a growing body of literature on the returns to overeducation. In this section we briefly examine this literature, whilst those interested in further reviews are referred to Groot and van den Brink (2000a), Hartog (2000), Leuven and Oosterbeek (2011) and McGuinness (2006).

The literature on overeducation is grounded in a theoretical debate on how the labour market operates. In the framework of the human capital theory (Becker, 1964) education is a key variable in determining individual productivity and therefore wages. This theory maintains that wages depend primarily on workers' investments in education and other productivity enhancers such as experience. The main empirical approach to assess this prediction is that of Mincer (1974) and, as we have seen earlier, in this approach years

[14] http://www.cls.ioe.ac.uk/page.aspx?sitesectionid=851.

[15] In this context, the literature agrees that overeducation (undereducation) represents the excess (lack) of education of a worker in relation to the qualification required to perform his or her job. Educational mismatch is treated as a synonym, as this phenomenon describes a failure of the labour market. In this chapter we consider these concepts interchangeably.

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of schooling are central in explaining wages (together with experience and other control variables). Within this framework, marginal productivity is determined by labour supply and overeducation appears as a long-term outcome associated with the underutilisation of workers' human capital.

The job-competition model offers an alternative approach (Thurow, 1975). This focuses on the demand side and suggests that job characteristics are the main factors that determine earnings. According to this, marginal product and wages are properties of the job, not of the individual. Workers compete for high wage jobs, and education (and even surplus education) contributes to preserve an individual's position within a particular job queue. The most qualified workers get the best jobs. Nevertheless, once an individual is allocated to a post, the marginal productivity is determined by job characteristics; so returns to surplus education will be zero.

The assignment model (Sattinger, 1993) focuses on the assignment of heterogeneous workers to heterogeneous jobs. It provides a middle ground between the two polar views offered by human capital and job competition by arguing that workers' marginal productivity, and consequently wages, depends on both the demand and supply sides of the labour market, being determined by a general hedonic model that incorporates job characteristics (required education) and individual characteristics (acquired education).

Job search and matching theory focuses on mismatch that occurs due to imperfect information in the labour market. Under this theory, labour market entrants, who have little information on job types, may take up jobs for which they are overeducated. As they accumulate information on the labour market, these workers will tend to move to jobs that provide a better match to their educational attainments, and so the extent of overeducation should decline with labour market experience.

Lastly, the technological change theory was proposed by De Oliveira et al. (2000), who suggested that school-provided skills would be improved upon by the individual over time, through training and experience, to deal with any technological change in a country. Due to adjustment costs, firms may not be able to quickly adapt their workforce (that has lower skills than new workers in the job market) to these changes. Instead, they will slowly adjust their hiring standards and gradually hire new (more educated) workers. These new workers will be overeducated compared to other co-workers who entered the job before (though not necessarily so in any absolute sense). Overeducation will therefore be a by-product of the adjustment mechanism in any labour market characterised by technological change.

In order to take into account the demand and supply sides of the labour market outlined by the theories outlined earlier, it becomes necessary to estimate the degree of match between the workers' level of educational attainment and that required for their jobs. Different measures for educational mismatch (or overeducation) have been proposed in the literature. We can conveniently group these into subjective and objective measures. Subjective measures are based on self-reports provided by the workers themselves about some personal and job-related characteristics and on the rate of skill utilisation. Examples on the application of these measures are found in Dolton and Silles (2008), Dolton and Vignoles (2000), Erdsiek (2016), Foley and Brinkley (2015), Holmes and Mayhew (2015), Iammarino and Marinelli (2015), Johnes (2016), Rumberger (1987) and Sicherman (1991).

Objective measures can be divided into two types. The first are those that are based on

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the analysis of job characteristics, with individuals' characteristics being compared to job requirements. Examples of these measures can be found in Iriondo and Pérez-Amaral (2016), Van der Meer (2006) and Voon and Miller (2005). The second group of objective measures are statistical measures that compare the worker's educational level with that of other workers doing a similar job, taking as reference the statistical mean or the modal value of the distribution. On the one hand, Verdugo and Verdugo (1989) consider that workers are over (under) educated when years of formal education exceed (are below) the occupation-specific mean by more than one standard deviation. Kiker et al. (1997) propose the use of the modal value, arguing that this statistic is less sensitive to the existence of outliers in the distribution. Examples of application using statistical measures are Jauhiainen (2011) and Pecoraro (2016).

Each of these measures has their advantages, limitations and drawbacks. (For a full discussion see Dolton and Vignoles, 2000; Groot and van den Brink, 2000b and Hartog, 2000). Furthermore, there is no clear preference for the use of one of them over the others in the empirical literature and the choice is usually determined by data availability.

The empirical literature on the wage effects of educational mismatch started with the seminal paper by Duncan and Hoffman (1981), who estimated the returns on the years of education required for jobs, and on the years of over or undereducation through the 'ORU' (Overeducation, Required education and Undereducation) earnings equation.

Among the empirical results found in this field, there is a broad consensus on the effects of educational mismatch on wages, with returns to years of undereducation being negative whereas returns to years of overeducation tend to be positive but smaller than those years of required education (Leuven and Oosterbeek, 2011). Hence, it is generally found that wages earned by an undereducated worker are lower than those earned by workers with an educational level in accordance with their job, while overeducated employees get higher wages, albeit below the average expected given their higher educational level. Consequently, educational mismatch imposes a cost on both individuals and the economy as a whole, in that it implies the inefficient allocation of resources.

The empirical evidence supporting these conclusions is extensive and several examples can be found from different countries (see for example Hartog and Oosterbeek (1988) for the Netherlands; Korpi and Tåhlin (2009) for Sweden; Daly et al. (2000) for USA and Germany; Cohn and Khan (1995), Tsai (2010) and Abel and Deitz (2016) for USA; Cohn and Ng (2000) for Hong Kong; Ren and Miller (2011) for China; Kiker et al. (1997) for Portugal; Di Pietro and Urwin (2006) for Italy; Groot (1996), Dolton and Silles (2008) and Walker and Zhu (2011) for the UK; or Alba-Ramírez (1993), Budría and Moro-Egido (2008) and Murillo et al. (2012) for the Spanish case). Further evidence is also found for developing countries (see Mehta et al., 2011). The authors discover evidence of overeducation in unskilled jobs in the Philippines, mild evidence in Mexico, and little evidence in India and Thailand.

Apart from this general evidence on returns to overeducation, additional findings can be found for related topics. For instance, a growing empirical literature pays attention to gender differences in returns. Mixed results can be obtained from the literature. On the one hand, some studies suggest that the negative effects of educational mismatch on workers' earnings are greater in the case of men (Daly et al., 2000, for Germany; Dolton and Vignoles, 2000 and McGuinness and Sloane, 2011, for the UK; Ren and Miller, 2011, for China), whereas, on the other, different studies point to the opposite, with

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women being more penalised by educational mismatch than men (Cohn and Ng, 2000, for Hong Kong; Budría and Moro-Egido, 2009 and Salinas et al., 2013 for the Spanish case). We also find evidence concluding that the mismatch does not account for the gender wage gap; rather the gender wage differential is entrenched in the fundamentals of pay determination (Voon and Miller, 2005).

Another topic of interest in this literature refers to location, size of the labour market and mobility, and the effect of this on the risk of being overeducated (for example, Büchel and van Ham, 2003; Ianmmarino and Marinelli, 2015; Jauhiainen, 2011). The literature concludes by saying that the probability of overeducation depends on the region, and that living in a large regional labour market decreases the probability of being overeducated. A further point explored in the literature is the link between family background and overqualification. The empirical analysis shows that graduates from high status families are found to be less likely to be overqualified (Erdsiek, 2016).

Lastly, there is growing interest in the literature on the presence of unobserved heterogeneity in studies of overeducation. Quantile regression has been employed with the aim of investigating how the returns to required and surplus education vary across the distribution (Budría and Moro-Egido, 2014; Johnes, 2016 and McGuinness and Bennett, 2007). The evidence on this is mixed.

Some studies have been criticised for failing to take two important econometric problems into account: omitted variable bias and measurement error. In some cases, the omitted variable bias appears to be substantial and possibly explains the difference between returns on required schooling and overschooling (Leuven and Oosterbeek, 2011). Moreover, measurement error may generate attenuation bias in the estimation of returns on education. So far, few empirical studies have considered these two problems (Boll et al., 2016; Iammarino and Marinelli, 2015; Iriondo and Pérez-Amaral, 2016), therefore, additional research is needed.

Meanwhile, as emphasised by McMahon (2010) and Hermannsson et al. (2016) additional social benefits can be linked to education, including improved political systems, innovation infrastructure, health outcomes, social trust, volunteering and civil order. It is important to note that these benefits may accrue even if the private returns to education are exhausted – so what appears, on a narrow, economic, metric to be overeducation may nonetheless be desirable from a societal perspective (Green and Henseke, 2016).

Further research is needed to shed more light on this field of study, in particular putting emphasis on the education system itself and the analysis of factors that cause the depreciation of skills. In particular, as the speed of technological change makes lifelong learning increasingly necessary, the effectiveness of continuous learning in mitigating the depreciation of human capital and, ultimately, in improving worker-firm matches (reducing under and overeducation), should be monitored.

## 6. ENDOGENEITY ISSUES

Endogeneity bias occurs when there is correlation between an explanatory variable and the error term in a regression. It is often caused by omitted variables, or by two-way causality between the dependent and explanatory variables. In the case of an earnings function, both of these causes can be relevant. Innate ability may reasonably be consid-

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ered to be a determinant of earnings, but analysts rarely have data that allow this to be directly measured. And individuals' choices about how much education to undertake are often influenced by their perception of future earnings opportunities (conditional on that education) – something that in itself is likely determined by innate ability. Highly educated people have invested a lot in their education precisely because they expect high earnings as a result.

All of this means that establishing a line of causality from educational investments to earnings is not as straightforward as is implied by the use of ordinary least squares regression. Several methods have been introduced that allow correction to be made for endogeneity. Many of these rely on instrumental variables. These include: college proximity (Card, 1995); quarter of birth (Angrist and Krueger, 1991; Staiger and Stock, 1997); raising of the minimum school leaving age (Harmon and Walker, 1995; Meghir and Palme, 1999) and other educational reforms (Brunello and Miniaci, 1999); differences in educational attainment due to war (Ichino and Winter-Ebmer, 2004; Angrist and Krueger, 1995). Typically these studies have yielded estimates of the coefficient on schooling that are at least as high as those obtained by ordinary least squares. While endogeneity bias might be expected to lower the coefficient – with the contribution of schooling being separated out from that of innate ability – this effect seems either to be small or to be cancelled out by some countervailing effect. It is often suggested that the countervailing effect might be due to measurement error (Griliches, 1977). This has led some researchers to use partner's education as an instrument for respondents' education (Ginsburgh and Prieto-Rodriguez, 2011). All this said, however, there is evidence to suggest that choice of instrument is not innocuous, and that different instruments can lead to different results (Harmon and Walker, 1999).

Most recent work that addresses the endogeneity issue in earnings functions focuses on the use of a toolkit that is reliant on some sort of discontinuity. The tools include propensity score matching (Rosenbaum and Rubin, 1983), difference-in-difference estimation, and regression discontinuity design (Thistlethwaite and Campbell, 1960).[16] In each case there is an exogenous shock to schooling that differs across the groups of respondents being compared, and the response of earnings to this shock provides a measure of the return. In the remainder of this section, we consider an example of each of these methods of analysis, applied to the evaluation of the wage returns to schooling.

Blundell et al. (2005) use matching to investigate the returns associated with undertaking higher education in the UK. They use cohort data from the National Child Development Survey, which follows a group of respondents born in 1958 through their life cycle. The technique allows respondents with higher education each to be compared with a matched respondent without, where the matching is done by reference to ethnicity, region, gender, prior test performance, school characteristics and family characteristics. The average treatment of the treated (ATT) effect indicates that the higher educated enjoy a wage premium of around 27 per cent, while the average treatment of the non-treated (ATNT) suggests that those not educated at higher level would, had they been more highly educated, have gained a premium of some 33 per cent. The distinction between these two treatment effects is instructive, and we shall examine the heterogeneity of returns in more

[16] Difference-in-difference estimation has a long history (Lechner, 2010) that can be traced back to the nineteenth century. An early modern application is that of Ashenfelter (1978).

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detail in the next section. Note meanwhile that the large figures reported here are wage premia associated with undertaking a whole course of higher education; they should not therefore be directly compared with rates of return associated with undertaking an additional year of schooling.

A difference-in-difference approach is used by Cellini and Chaudhary (2014) to evaluate the returns to attendance at a for-profit college of higher education. Using US panel data from the National Longitudinal Study of Youth (NLSY97), they find an earnings premium of around 10 per cent for those attending a for-profit college, relative to those who do not enter college at all. Given the length of a typical college associate degree programme, this implies a rate of return of around 4 per cent.

Oreopoulos (2006) uses a regression discontinuity design approach to examine the effect that the raising of the minimum school leaving age from 14 to 15 had on earnings in Great Britain and Northern Ireland. He finds a clear discontinuity implying a return to the extra year of around 8 per cent in Great Britain and 11 per cent in Northern Ireland.

An important caveat attaches to the use of the difference-in-difference estimator in this context, however (Ashenfelter and Card, 1985) – the underpinning assumptions of the models require that nothing other than the treatment changes for one group but not the other. Where the treatment is contaminated, inference about its effect can be hazardous. It is for this reason that considerable effort has been made in recent decades to ensure that treatments are as clean as possible. This has meant that difference-in-difference exercises in particular have tended to be confined mainly to short duration training interventions rather than lengthier episodes of full-time education.

The broad consistency in the results obtained by these studies is encouraging. While it is clear that allowing for endogeneity can have an impact on estimates of the rate of return to schooling, and that the method used and instruments chosen can be material, it is equally the case that studies generally report estimates of the rate of return that are significantly positive, that compare favourably with rates of return obtainable from other investments, and that suggest that endogeneity bias does not result in substantial upward bias in the estimation of returns.

## 7. HETEROGENEITY ISSUES

In addition to endogeneity, heterogeneity has been an issue of concern to researchers. Many studies have concentrated on estimating the rate of return to the average respondent; in essence the regression approach, by fitting a line through the scatter of observations, focuses attention on the relationship between the dependent and explanatory variables for the average respondent. But decisions are made at the margin (Ashworth, 1998). The question of whether the optimal amount of resource is being invested in education involves evaluation of the rate of return, not for an average student but for a prospective student who is at the margin.

At a minimum, one might expect the rate of return to vary across different groups of (prospective) students. Using US data from the Census and the American Community Survey, Henderson et al. (2011) show, for example, that ethnic minorities typically have higher rates of return than others, natives have higher returns than immigrants, and younger generations have higher returns than older workers. These results are clearly

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instructive, but while there is clearly variation across groups, it is likely that there is variation at the individual level too.

An estimation method that permits rates of return to vary by group is quantile regression (see Koenker and Hallock, 2001). Specifically, quantile regression allows a regression line to be separately estimated at different points of the distribution of the dependent variable rather than, as in least squares regression, just at the mean. Comparison of the results at different quantiles allows us to assess the extent to which the impact of the explanatory variables on the dependent variable might vary across the distribution. The idea of evaluating parameters at points other than the mean has a long history, but because the methods are computationally burdensome it is only recently that quantile regression has come to be commonly used.

The earliest rigorous attempt to evaluate returns at the margin, using quantile regression methods, is that of Buchinsky (1994). This study analyses patterns in the rate of return to various levels of education over a quarter of a century. While there is evidence of rates of return being different at different quantiles, the pattern that emerges is not one in which returns uniformly rise or uniformly fall as one moves up the quantiles. Buchinsky concludes that 'although the returns at the . . . quantiles are different, the patterns of change are similar across all quantiles for almost all skill groups'.

Another early study, providing useful evidence of rates of return in the context of a country with a particularly complex labour market, is that of Mwabu and Schultz (1996) who use a quantile regression approach to study the labour market effects of education in South Africa. Using 1993 data from the Project for Statistics on Living Standards and Development survey, these authors evaluate separately for white and African respondents the returns to education at various quantiles of the wage distribution, separately for primary, secondary and higher education. Within each category, returns are typically fairly stable across the distribution. There is one major exception – whites whose highest level of education is secondary. For this group, returns are around 20 per cent at the bottom end of the distribution, but negligible at the top. Indeed for no group is there any marked tendency for returns to rise as we move to the right of the distribution, and so there is no evidence that the omission of ability from the regressions is biasing the central estimate of the rate of return upwards.

The first study to allow for endogeneity biases in a quantile regression setting is that of Arias et al. (2001). They use twins data, with sibling schooling employed as an instrument for education. They find that, if anything, rates of return are higher for higher quantiles of the distribution, though there is little evidence that this rising pattern is statistically significant. They attribute the pattern to a tendency for abler individuals to access more education owing to lower costs.

A more recent study that considers heterogeneity alongside endogeneity is that of Balestra and Backes-Gellner (2017), who use Swiss data and tackle endogeneity using canton-level compulsory education laws as instrument. They find, in their instrumental variable quantile regression estimates, that the rate of return to education is highest at the lowest deciles of the distribution.

To study further the broad issue of heterogeneity, consider the estimates reported in Table 1.2. These show, for a large number of countries, the Mincerian rates of return – that is, the coefficient on years of education obtained by regressing (log) hourly wages against education and a number of control variables. The ordinary least squares (OLS) estimate

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*Table 1.2 Coefficient on years of education in (log) wage equation: OLS and quantile regressions, ISSP data pooled 2012–14, various countries*

| Country | OLS | Lowest decile | Lower quartile | Median | Upper quartile | Highest decile | Number of observations |
|---|---|---|---|---|---|---|---|
| Taiwan | 0.0925 | 0.0890 | 0.0854 | 0.0858 | 0.0930 | 0.0965 | 3250 |
| | (27.91) | (12.53) | (20.87) | (26.24) | (24.60) | (15.80) | |
| Croatia | 0.0859 | 0.0564 | 0.0901 | 0.0910 | 0.1012 | 0.1041 | 1078 |
| | (17.57) | (5.42) | (13.02) | (16.16) | (16.54) | (12.33) | |
| Czech | 0.0620 | 0.0451 | 0.0543 | 0.0620 | 0.0677 | 0.0815 | 2173 |
| | (16.89) | (6.21) | (12.63) | (15.02) | (16.65) | (14.14) | |
| Denmark | 0.0300 | 0.0269 | 0.0384 | 0.0354 | 0.0282 | 0.0247 | 3668 |
| | (12.05) | (4.38) | (9.76) | (14.49) | (10.80) | (6.82) | |
| Finland | 0.0431 | 0.0311 | 0.0363 | 0.0481 | 0.0481 | 0.0528 | 1972 |
| | (9.99) | (6.21) | (9.74) | (15.91) | (12.85) | (5.48) | |
| France | 0.0531 | 0.0361 | 0.0494 | 0.0545 | 0.0663 | 0.0567 | 2401 |
| | (12.12) | (8.48) | (15.34) | (18.18) | (14.17) | (4.19) | |
| Iceland | 0.0296 | 0.0317 | 0.0314 | 0.0374 | 0.0325 | 0.0254 | 2102 |
| | (10.47) | (6.09) | (9.07) | (12.99) | (9.75) | (4.85) | |
| India | 0.0636 | 0.0643 | 0.0519 | 0.0606 | 0.0730 | 0.0280 | 1185 |
| | (6.30) | (4.81) | (6.14) | (5.22) | (3.56) | (1.16) | |
| Japan | 0.0720 | 0.0659 | 0.0719 | 0.0741 | 0.0723 | 0.0561 | 1929 |
| | (10.28) | (6.19) | (7.79) | (9.79) | (8.71) | (5.33) | |
| Korea | 0.0827 | 0.0756 | 0.0884 | 0.0935 | 0.0863 | 0.0736 | 2000 |
| | (15.21) | (9.01) | (13.76) | (17.43) | (12.25) | (4.61) | |
| Lithuania | 0.0700 | 0.0640 | 0.0679 | 0.0705 | 0.0721 | 0.0807 | 1185 |
| | (11.15) | (7.12) | (10.15) | (11.01) | (10.52) | (6.65) | |
| Norway | 0.0309 | 0.0356 | 0.0359 | 0.0316 | 0.0293 | 0.0315 | 2819 |
| | (6.99) | (6.78) | (12.71) | (13.65) | (7.05) | (1.27) | |
| Philippines | 0.1350 | 0.1241 | 0.1344 | 0.1323 | 0.1186 | 0.1304 | 1392 |
| | (13.87) | (8.49) | (11.71) | (9.42) | (11.59) | (9.19) | |
| Russia | 0.0623 | 0.0586 | 0.0588 | 0.0653 | 0.0652 | 0.0736 | 1604 |
| | (9.69) | (5.43) | (7.76) | (8.75) | (6.82) | (5.76) | |
| Slovakia | 0.0683 | 0.0486 | 0.0547 | 0.0704 | 0.0762 | 0.0900 | 1461 |
| | (14.52) | (4.61) | (11.95) | (14.09) | (14.27) | (7.11) | |
| Slovenia | 0.0678 | 0.0551 | 0.0667 | 0.0703 | 0.0734 | 0.0633 | 940 |
| | (15.81) | (7.70) | (14.44) | (16.49) | (17.18) | (9.80) | |
| South Africa | 0.1717 | 0.1549 | 0.1854 | 0.1864 | 0.1658 | 0.1742 | 1627 |
| | (23.59) | (12.72) | (20.80) | (21.70) | (16.09) | (12.89) | |
| Spain | 0.0402 | 0.0369 | 0.0368 | 0.0411 | 0.0385 | 0.0433 | 1756 |
| | (14.02) | (6.36) | (9.83) | (13.91) | (13.43) | (7.21) | |
| Sweden | 0.0411 | 0.0255 | 0.0303 | 0.0394 | 0.0502 | 0.0589 | 1763 |
| | (13.32) | (4.61) | (10.67) | (14.47) | (13.35) | (8.53) | |
| Switzerland | 0.0468 | 0.0542 | 0.0512 | 0.0463 | 0.0338 | 0.0251 | 2122 |
| | (12.00) | (5.43) | (8.62) | (13.23) | (9.83) | (4.06) | |
| Turkey | 0.0618 | 0.0394 | 0.0566 | 0.0718 | 0.0705 | 0.0694 | 697 |
| | (7.68) | (2.67) | (6.52) | (8.61) | (8.17) | (4.31) | |
| United States | 0.1170 | 0.1159 | 0.1168 | 0.1109 | 0.1129 | 0.1050 | 1922 |
| | (16.80) | (6.29) | (13.02) | (16.12) | (20.29) | (12.11) | |

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*Table 1.2* (continued)

| Country | OLS | Lowest decile | Lower quartile | Median | Upper quartile | Highest decile | Number of observations |
|---|---|---|---|---|---|---|---|
| Germany | 0.0463 | 0.0324 | 0.0468 | 0.0470 | 0.0476 | 0.0546 | 1823 |
| | (14.04) | (5.31) | (12.42) | (13.82) | (13.92) | (10.25) | |
| Great Britain | 0.0614 | 0.0657 | 0.0620 | 0.0612 | 0.0644 | 0.0719 | 1548 |
| | (11.82) | (6.40) | (9.19) | (10.47) | (9.08) | (8.18) | |
| Israel | 0.0870 | 0.0697 | 0.0886 | 0.0951 | 0.0946 | 0.0835 | 1078 |
| | (14.34) | (4.90) | (10.91) | (14.61) | (11.77) | (9.14) | |

*Note:* t statistics are in parentheses. In addition to the years of education, control variables include linear and quadratic terms in age, a gender dummy and year dummies.

is reported in the first column, and the remaining columns report the corresponding estimate from a series of quantile regressions at the lowest and highest deciles, the lower and upper quartiles, and at the median.

The data come from the International Social Survey Programme (http://www.issp.org/), and cover all 25 countries for which data are available in each of the three years 2012–14; the data for these years are pooled (and year dummies are included in the vector of control variables). Unfortunately, owing to the nature of the data, we are unable to correct for endogeneity bias in this analysis. For most countries, the personal income variable in the ISSP data is grouped. However, the bins are narrow, and using hours worked data to convert this into an hourly wage yields a dependent variable that is more or less continuous; the hourly wage data are therefore suitable for use in quantile regressions. The controls include linear and quadratic terms in age, and a gender dummy.

The Mincerian rate of return to schooling obtained from OLS regression ranges from close to 3 per cent in Iceland, Denmark and Norway to around 17 per cent in South Africa. The pattern of variation in rates of return across countries has been well established in the literature and noted by, for example, Montenegro and Patrinos (2013). The Nordic countries typically have relatively flat income distributions with low Gini coefficients (see http://bit.ly/1g6dwIV) so that the premium associated with education is relatively low. Iceland, Denmark and Norway all have Gini coefficients well below 30 per cent. South Africa, in contrast, has a Gini coefficient of 62.5 per cent. It is not surprising therefore to observe that the premium associated with education is very much higher in this country than in economies characterised by greater equality.

The remaining columns of Table 1.2 report the corresponding Mincerian rates of return at various quantiles of the distribution. For the most part, there appears to be little variation across the distribution. Returns to education appear to be broadly similar across individuals within each country. That said, returns are lowest at the bottom decile in 13 of the 25 countries (albeit in many only just so). This may be suggestive of a relatively low potential for education to improve earnings amongst the very least advantaged in the economy, but the effect is very weak. Indeed, only in a very few countries (Croatia, Slovakia) is there evidence of a strong pattern in the returns to education across the distribution, with those at the higher end of the distribution earning higher returns. In sum, there is little compelling evidence here of any marked heterogeneity in the rate of return

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to education. Note that (despite our inability to instrument for education) our results for Switzerland are qualitatively similar to those obtained by Balestra and Backes-Gellner (2017) in that the highest returns are observed for those in the lowest deciles.

## 8. CONCLUSIONS

The focus of this chapter has been on the evaluation of the returns to education. That there is a private benefit associated with schooling is beyond dispute. More controversial, however, is the assertion that society as a whole benefits from investment in education – at least to the full extent suggested by estimated rates of return. Signalling and screening hypotheses suggest that schooling might merely serve as an indicator of innate ability, and that it is differences in ability rather than differences in human capital accumulation resulting from education that explains the earnings premium gained by educated workers. While a definitive resolution of the debate between advocates of human capital theory and those of signalling and screening is elusive, the results obtained in analyses that exploit the presence of discontinuities strongly suggest that human capital is enhanced by education.

Looking to the future, labour markets are likely to change dramatically as technology develops. In Chapter 6 of this volume, Steve McIntosh documents the polarisation that has occurred in the labour market as a consequence of automation. New generations of robots that can interact with their environment in enhanced ways using cameras and visual recognition in real time are likely to transform the nature of work. It is difficult to anticipate what this means for the future evolution of the returns to education, at least with a broad brush. Many occupations currently in being will cease to exist or will morph beyond recognition (Arntz et al., 2016; Frey and Osborne, 2017). The returns to creativity are likely to be enhanced, while the returns to learning that are programmable will decline. The pace of change will mean that education will need to become a truly lifelong activity; the return to education at the start of life might decline, but this might be compensated for by high value investments at a later stage of the life cycle. To respond to these changes, we will need to develop models of human capital investment that capture the new dynamics. A summary statistic – *the* rate of return – may no longer be sufficient.

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