A review of how economists thinking about human capital has evolved and the current state of research on human capital in Australia

Jeff Borland* and Michael Smedes**

Paper prepared for 2024 ABS/RBA Joint Conference on Human Capital, June 11-12, 2024

*Department of Economics, University of Melbourne
**Australian Bureau of Statistics

1] Introduction

The concept of human capital captures two main ideas. First, that talents and skills, which are the basis of labour's input to the production of output, are embodied in humans. Second, that those talents and skills are a stock, which provide a flow of inputs to production in current and future time periods, and where the stock is capable of being increased by investment, but can also depreciate over time (Rosen, 1989, p.136).

Human capital is central to modern economics; 'deep in the bones' of the discipline as Goldin and Katz (2023, p.2) put it. In so many fields it is nowadays part of the core tool kit for analysis: labour, development, education, health, macroeconomics, economic geography, and economic history. The list of research topics where human capital is an essential part of the story has a similar span, including identifying the determinants of individual earnings, understanding causes of national output and productivity, and the role and design of education and training systems.

In this paper, we briefly review developments in thinking about human capital, and the state of research on human capital in Australia. Given the vastness of the literature, the review is necessarily impressionistic. As well, we draw almost exclusively from the economics literature, and use the well-known Mincer earnings function to delineate the scope of our review. Section 2 describes evolution of concept of human capital and its measurement, beginning with Becker-Mincer seminal contributions. Section 3 reviews Australian research motivated by or based around the concept of human capital. Section 4 overviews how this economic literature has been reflected in official statistical measurement, with specific reference to estimation of the aggregate value of human capital.

2] The evolution of the concept of human capital and how it is measured

a] The beginnings

The first use of the precise term 'human capital' is credited to Irving Fisher in 1897 (Goldin and Katz, 2023, p.2). Recognition of the general idea goes back even further, at least as far as Adam Smith. It was not until the 1960s, however, that the concept of human capital took off. Interestingly, the original motivation was a macroeconomic puzzle: 'the impetus was to understand the residual in growth accounting' (Goldin and Katz, 2023, p.1). Applications of the Solow growth framework found that growth in capital per capita could explain only a small fraction of growth in income per capita, thus 'focusing attention on less tangible resources, like knowledge possessed' (Becker, 1962, p.9).

When human capital did come to the fore, the seminal theoretical contribution was made by Gary Becker (1962, 1964, 1967). As Rosen (1989, p.138) writes: 'The fundamental conceptual framework of analysis for virtually all subsequent work in this area was provided by Gary Becker, who not only organized the emerging empirical observations but also provided a systematic method for seeking new results and implications of the theory.'

Becker's contributions in his set of works in the 1960s were multiple (and frankly, amazing). First, he characterised optimal investment in human capital, based on the principle that a rational agent will pursue an investment up to the point where the marginal rate of return equals the marginal cost of funds. Differences in levels of investment in human capital between individuals can then be regarded as deriving from differences in abilities (difference in rate of return) and differences in family background and capacity to invest (difference in marginal cost of funds). Second, he established the concepts of general and firm-specific human capital, and showed the importance of that distinction for thinking about who would pay for worker training – and in doing so, also brought into play the idea of higher wages for higher levels of schooling and training as an equalising difference in wage-setting. Third, he showed how the combination of the time path of investment in human capital and who paid for that investment would determine the shape of a worker's age-earnings profile. If that wasn't enough, his 1962 *Journal of Political Economy* article is brimming with ideas that point forward to what would become major research topics – the determinants of quits and layoffs, the nexus between firm-specific capital and firm monopsony power, health as a key dimension of human capital (and the efficiency wage-like idea that good health might be promoted by paying higher wages), the role of long-term contracts, and the importance of a worker's motivation in determining their productivity.

Other important early theoretical work on the nature and optimal accumulation of human capital was done by Schultz (1961), Becker and Chiswick (1966) and Ben-Porath (1967). Ben-Porath (1967) presented a fully worked out formal model of optimal investment in human capital and demonstrated the relation between that investment and the life cycle earnings profile.

Initial empirical analysis using the human capital framework focused on estimation of the relation between a worker's earnings and schooling. Here the seminal work was by Mincer (1974), in which he originated what has become known as the 'Mincer earnings function':

$$lnw_i = \alpha + \beta S_i + \gamma E_i + \delta(E_i)^2 + \epsilon$$

Where w_i = wage of worker i, S_i = years of schooling and E_i = years of post-school experience (on-the-job training).

The earnings function is derived using a model which: (i) splits investment between schooling and post-schooling (on-the-job training); and (ii) assumes that the fraction of time devoted to investment in creating human capital declines linearly over a worker's career. (For a summary and discussion of advantages of the Mincer earnings function, see Chiswick, 2023, pp.15-16.)

Estimating the Mincer earnings function to identify a causal impact of education on earnings became major topic of research from the 1970s to 1990s - seeking to deal with potential biases from omitted variables (for example, family background, likely to be separately correlated with earnings and years of schooling), selection effects (for example, unobserved ability directly affecting both wages and years of schooling), and measurement error in the schooling variable. Griliches (1977) provided an early summary of this literature, and Card (1999) a later review. Important contributions to this literature include the application of IV methods (for example, using compulsory schooling laws as an instrument; see Angrist and Krueger, 1991) and use of data on twins to seek to control for genetic and family background effects (Ashenfelter and Krueger, 1994).

Another major application of the Mincer earnings function was to use the model as a benchmark to establish non-competitive determinants of wages. The equalising difference theory of wages implies that differences in wages between individual workers in a competitive labour market should reflect only differences in the opportunity cost of work (Willis, 1986; Rosen, 1986). Differences in the opportunity cost of work could be the costs of acquiring the skills necessary to do a job (schooling and on-the-job training) or the disutility associated with a job (such as working conditions). The Mincer earnings function, including other explanatory variables to proxy for disutility of work, can then be

regarded as an 'exact' representation of the equalising differences theory. To the extent that variables apart from those capturing the opportunity cost of acquiring human capital or the disutility of work have explanatory power for wages, the labour market is then interpreted to be influenced by non-competitive forces.

Of course, none of this is straightforward. The above statement of the equalising differences theory relies on strong assumptions. And it is usually difficult to argue conclusively whether an explanatory variable for wages is proxying for human capital/compensating differentials or for non-competitive influences.

Nevertheless, the approach of testing for non-competitive influences in the labour market by adding extra explanatory variables to the Mincer earnings function, intended to proxy for those influences, has been used extensively. Key examples of how Mincer earnings equation has been applied in this way is in studies of impact of discrimination in wage-setting (for example, Oaxaca, 1973); and influences such as imperfect competition and efficiency wages (for example, Krueger and Summers, 1988).

The other major area of early empirical research on human capital was estimation of an internal rate of return (IRR) associated with schooling and training, an approach also pioneered by Gary Becker (1962). The IRR method calculates the discount rate that sets to zero the net present value of benefits minus costs from an investment in human capital. Comparison of the IRR to an individual's discount rate establishes whether the investment is profitable. The IRR approach built on earlier work that sought to estimate the net present value of training (see, for example, Friedman and Kuznets, 1945), and was initially the predominant empirical method for valuing human capital. Although still sometimes used, it was quickly superseded by the Mincer earnings function.

b] What came next?

Subsequent years have added substantially (an under-statement!) to both the depth and breadth of the research agenda on human capital. Here, we highlight several main themes of that development.

<u>i] The demand-side value/transferability of human capital</u>

The value of a worker's human capital, the value they can add (per unit of time) to production of output, will generally vary depending on 'where' they are working. Becker (1962) distinguished between general human capital, a worker's skills that were fully transferable between jobs and firms, and hence valued equally throughout the labour market, and firm-specific human capital, skills that were valuable only at the specific firm

where a worker was currently employed. Empirical studies have shown this to be a meaningful distinction (for example, Altonji and Shakotko, 1987; Topel, 1991). Interest in firm-specific human capital has again recently come to the fore, with growing attention to firm-level wage differences and the implications of labour being traded in imperfectly competitive markets (Deming, 2023).

Becker himself (1962, p.24), however, acknowledged that the distinction between general and firm-specific human capital was a simplification of the dimensions on which demand-side variation in the value of a worker's human capital would be likely to exist. Research which has found evidence of industry-specific human capital (Carrington, 1993; Neal, 1995) and occupation-specific human capital (Shaw, 1984) has confirmed that conjecture. The emergence of the 'task' as the foundational building block in theoretical analysis of the labour market (Acemoglu and Autor, 2011), has also been supported by studies which find that the value of a worker's human capital varies at task-level (for example, Gathmann and Schonberg, 2010; Taber and Vejlin, 2020).

ii] The supply-side: Multi-dimensional human capital

That human capital is multi-dimensional – consisting of an array of abilities and skills – was implicit in the earliest models. For example, multi-dimensional human capital is a necessary condition for the same worker to possess both general and firm-specific skills. What has changed in recent times is that multi-dimensionality has become central in applications of human capital theory.

Classification of the dimensions of human capital has been done in a variety of ways. A simple framework divides skills between cognitive and non-cognitive (for example, Heckman et al., 2006). Cognitive skills have been cast as encompassing aspects such as information processing ability (Welch, 1970, Schultz, 1975); decision-making skills (Deming, 2021); and cognitive endurance (Brown et al., 2022). Non-cognitive skills can be divided between manual and interpersonal skills (for example, Lise and Postel-Vinay, 2020). Recent work by Deming (2017) recasts interpersonal skills into social skills, with the growing importance of teamwork motivating an increased demand for those skills.

iii] Putting together the demand and supply sides

Where each worker possesses a unique bundle of skills that make up their human capital (supply-side), and the value of those skills varies across jobs (demand-side), it follows that a worker's productivity will differ across available jobs. That job-level productivity has usually been represented as the aggregation of a vector of skills with weights that vary across industries/occupations (see for example, Welch, 1969; Rosen, 1983; Lazear, 2007).

The implication of heterogeneity in worker productivity across jobs is that workers will seek to select into jobs where they have a comparative advantage (Roy, 1951).

In a world where workers' skills remain fixed over time, and with perfect information, heterogeneity in skills would imply a permanent pattern of matching of workers to jobs. Instead, of course, we observe mobility of workers between jobs. Recent studies explain those dynamics as the result of search frictions. Workers begin with imperfect information about available job opportunities and hence are likely to begin in jobs where their productivity is less than potential. But, with search and learning over time, they are able progressively to sort into jobs in which their productivity is higher. Models of occupational sorting based on multi-dimension human capital are developed by Guvenen et al. (2022) and Lise and Postel-Vinay (2020).

It is possible to add to this framework the idea that a worker's productivity changes over time. That might happen as a worker's amount of human capital changes – by them acquiring new skills or experiencing atrophy in their existing skills. The value of their human capital might also change due to production becoming more intensive in the skills they possess, or due to their skills becoming obsolescent with the development of new knowledge and changes to production processes (Deming, 2023).

iv] Inside the black boxes of schooling and on-the-job training

Part of the natural progression of research on human capital has been more detailed study of determinants of the quantity and quality of schooling and on-the-job training. Just a small sample of topics examined includes the determinants of education attainment (for example, Bjorklund and Salvanes, 2011), impact of teacher quality (for example, Bacher-Hicks and Koedel, 2023), classroom interventions to improve student learning (for example, Alan and Mumcu, 2024), and a variety of issues related to firm training (for example, Black et al., 2023).

v] How the years before formal schooling matter

That human capital began to be formed prior to formal schooling was well understood by those undertaking the initial wave of research (for example, Becker and Lewis, 1974, on the trade-off between quantity and quality of children). But an increasing awareness of just how important is that phase of development has made this an area of major research activity. This has been a multi-disciplinary enterprise, with economists arriving well after other disciplines.

Economists have contributed in two main ways. First, to research describing inequality in development outcomes during the early years and to analysis of the determinants of development, including investigating the technology underlying skill production (for reviews, see Almond and Currie, 2011; Almond et al., 2018; Cunha and Heckman, 2007). Second, to analysis of the impact of government policies on development – including the direct impact of early years education and childcare and targeted interventions on development outcomes (Cannon et al. 2017; Duncan et al., 2022); and indirect impact from, for example, financial assistance from government to low-income families (for example, Hoynes and Whitman Schanzenbach, 2018).

vi] Macroeconomics of human capital

The impetus for development of human capital theory had been to better understand the sources of national economic growth. A natural extension of empirical application of the theory was therefore to estimate country-level stocks of human capital, with the objective to test its role in explaining changes in material living standards, over time within a country, and between countries. This has led to a variety of approaches to estimation of the stock of human capital (see section 4), and as a consequence an evolving understanding of the impact of human capital on economic growth (for recent important contributions, see Jones, 2014 and Angrist et al., 2021).

3] Review of main themes from research in Australia about human capital

a] Returns to schooling and skills

Initial Australian research using the Mincer earnings function was mainly directed to estimating the impact of education on earnings. That research began with Chapman and Miller (1983), which used 1976 Census data to compare the role of human capital in earnings determination in Australia and Japan. As with international research, a primary concern was with using methods to identify a causal impact of schooling.

Various approaches (addressing various potential sources of bias) have been applied: including explanatory variables for ability and family background in the Mincer earnings regression model (for example, Karmel, 1995; Barrett, 2012); application of selection correction methods (Vella and Gregory, 1996); using samples of twins to control for family and genetic background (Miller et al. 1995); using actual years of experience instead of the proxy of age minus years of schooling (Rummery, 1992); controlling for changing composition of education attainment categories (Coelli and Wilkins, 2009); separately estimating the returns to foreign and Australian education (Tani et al., 2013); and

including controls to estimate the impact of quality of education (Carroll et al., 2019). Other research sought to evaluate the extent to which returns to education should be regarded as due to increased human capital or signalling (Ryan, 2001).

Earnings differentials by level of education attainment have been used as the basis for calculating private and social rates of return to higher education (Borland et al., 2000; Daly et al., 2015). And the evolution of earnings differentials by education attainment from the early 1980s to the present (especially to university-level qualifications) have been tracked, with changes over time interpreted using a demand/supply framework following the approach of Katz and Murphy (1992) (Borland, 1996; Borland and Coelli, 2016). Preston (1997) provides a comprehensive review of empirical research using the Mincer earnings function for Australia.

c] Human capital (competitive) model as a benchmark to establish non-competitive determinants of wages:

Econometric modelling of the determinants of individual wages in Australia was initiated by Haig (1980, 1982), using ABS data collected in 1973 for the Henderson Poverty Inquiry, to estimate wage discrimination by gender and country of birth. The common (Blinder-Oaxaca) approach has been to estimate a Mincer earnings equation that allows for returns to schooling and experience to differ, for example in the case of testing for wage discrimination by gender, between females and males. The difference between average male and female wages is then decomposed, treating differences in the quantities of education and experience as a source of 'justified' wage differences, and differences in wages due to differences in the return to education and experience as 'unjustified', or representing discrimination. Borland (1999a) and Borland and Coelli (2016) review the literature. Gregory et al. (1986) apply the framework using a cross-country comparison to study the impact of the 1969/1972 Australian equal pay case decisions.

An alternative approach taken to examine non-competitive influences on wage-setting has been via inter-industry wage differentials (Borland and Suen, 1990; Gregory and Daly, 1990). More recent work on the impact of imperfect competition on wages has used firm-level data (for example, Andrews et al., 2019; Hambur, 2023).

c] Multi-dimensional skills

Interest in a multi-dimensional representation of skills has come from recent changes in the occupational composition of jobs in Australia, which has been interpreted as shifting the relative demand for different dimensions of skills – towards analytical and inter-personal skills and away from manual skills (Heath, 2016, 2020). Thus far, there has been

little detailed work on the returns to alternative dimensions of human capital in Australia. Exceptions are studies of returns to cognitive skills (Barrett, 2012; Ackermann et al., 2023).

d*] Inside the black box of schooling and on-the-job training*

Economists have – especially in recent years – made contributions to understanding of the quality of education, although obviously that work is a drop in the ocean against the overall body of education research. Topics covered include (i) the impact of type of school (for example, government versus independent – Cobbold, 2015; the impact of select entry schools – Houng and Ryan, 2018); (ii) the influence of teachers and principals (for example, Leigh and Ryan, 2008; Leigh, 2010; Helal and Coelli, 2016); and (iii) practices to improve learning outcomes (for example, Hunter et al., 2023, 2024).

The literature on training is vast. A large set of research work derived from the Australian Workplace Industrial Relations Survey in the 1980s and 1990s. The National Centre for Vocational Education Research has been an on-going source of studies on topics including apprenticeship, VET, determinants of quality of training and student outcomes etc. More recently, Jobs and Skills Australia (previously the National Skills Commission) is providing research on a variety of aspects of demand for skills and design of the training system.

e] Early acquisition of human capital

Recognition of inequality in development during the early years and its long-term consequences is receiving increased attention from economists in Australia (for example, Bradbury et al., 2011; Biddle et al., 2017; Schurer et al., 2017). Attention is also being paid to the role of early years education and school starting age on that development (for example, Tseng et al., 2022; Jha, 2015; Beatton et al., 2023), as well as to the impact of government income support policies (for example, de Gendre et al., 2021; Cobb-Clark et al., 2021).

f] Human capital model as framework for investigating sources of earnings inequality

The Mincer earnings function has been used as a framework for understanding the sources of changes in earnings inequality in Australia, following international research (Juhn et al., 1993). Using this framework, potential sources of changes to inequality are identified as changes in the distribution of education attainment and work experience, changes in the returns to those characteristics, and 'unobservable' characteristics. Examples are Borland (1999b); Borland and Coelli (2016); and Chatterjee at al. (2016).

g] Contribution of education to productivity growth

Findings from Mincer-type earnings models have been used to calculate the total value of human capital in Australia (Wei, 2008). Measures of human capital can then be used in analysis of the sources of aggregate productivity growth in Australia (for example, Chou, 2003; Banerjee and Wilson, 2016).

4] Developments in the measurement of official statistics

Developments in economic statistics have closely tracked those in economic research - embedding new findings in the measurement standards and supporting research through the provision of new data sources.

Three broad approaches have been taken to measuring investments human capital: the indicator approach, the income approach, and the cost approach (Abraham and Mallet, 2022). The first approach, regularly applied by the World Bank, constructs index numbers using a range of indicators (years of schooling, test scores, child and adult survival rates etc). The second and third approaches more closely follow the economic literature, calculating monetary values for human capital based on expected lifetime earnings (following the work of Mincer and later Jorgenson and Fraumeni, 1989), and on input costs for capital formation (following Kenrick, 1976). These latter two approaches, which have been more widely applied by national statistical offices, will be the focus of this section of the paper.

The System of National Accounts

Human capital is not included in the National Accounts asset boundary despite the original architects of the accounts acknowledging its importance. Kuznets (1961) wrote: '[F]or many purposes—particularly the study of economic growth over long periods and among widely different societies—the concept of capital and capital formation should be broadened to include investment in the health, education, and training of the population itself, that is, investment in human beings.'

Kuznets defended its omission on two practical grounds: one, that measuring human capital investments would be difficult; and two, that it would be hard to distinguish activities undertaken for the purpose of adding to productive capacity from those undertaken for enjoyment (Jorgenson, 2010).

Capital formation measurement was at the time in its infancy, lacking the necessary concepts, methods and data sources and contributing to the adoption of a very narrow asset boundary in the early national accounts. Today, the work of the Canberra II group, part of the United Nations 2008 System of National Accounts, has been instrumental in developing a workable approach to the application of capital theory to national accounting issues. The results are summarized OECD Manual: Measuring Capital (2009). This development has supported the asset boundary expanding to include an ever-larger set of intangible assets - mineral exploration, marketing assets, research and development, software, and soon data.

However human capital continues to be explicitly omitted from the core accounts on the basis that it is not the consumption of education and training services that forms human capital assets, but rather it's the assembly of these inputs by the persons consuming them into productive knowledge, skills, competencies, and attributes (European Commission et al 2008). As such, the resulting human capital can only be generated by individual application - its acquisition cannot be undertaken by anyone else, and ownership cannot be transferred to a third party—and these assets are therefore not considered to be 'produced'.

This exclusion from the core accounts has not stopped the research and development of methodological and conceptual advice for compiling human capital estimates in satellite (or supplementary) accounts. This material has been developed in a range of manuals, particularly by the UN Economic Commission for Europe.

These measures show that human capital, were it to be included, would be by far the most important component of total capital stock (Greaker et al., 2008). Worryingly, despite considerable research and the development of extensive guidance, the two approaches to calculating monetary values of capital stock (input costs and lifetime earnings) provide vastly different results. Gu and Wong (2010) compiled results for the Canadian economy which showed:

- when the cost-based approach is used to estimate human capital, GDP would increase by 10 per cent and capital formation by 76 per cent, while total final consumption would decline by seven per cent; and
- when the income-based approach is used, GDP would increase by 30 per cent, and capital formation by 150 per cent, while final consumption would decline by seven per cent.

Research for other countries have shown human capital estimates using the lifetime income approach providing an estimate 4 to 8 times higher than the cost approach (UNECE 2012).

The ABS calculated estimates of human capital stock for each Census year between 1981 and 2001 using the lifetime earnings approach (estimates were not compiled using the cost approach). These estimates showed a human capital stock of $5,576 billion in 2001 (Hei 2004). If this estimate were included in the nations balance sheet, Australia's capital stock would have increased by 149%.

It is likely that the cost approach provides a lower bound for the estimate of human capital as it is typically limited solely to education costs, overlooking the importance on the job training as well as a range of other activities, for example health expenditures and unpaid household activity. Estimates based on the cost approach also overlook the impacts of immigration and emigration. Conversely the lifetime income approach allocates all earnings income as a return to human capital, overlooking the importance of other factors. Both measures are also extremely sensitive to a range of assumptions, such as discount rates, depreciation rates, and future earnings growth.

Growth Accounting and Productivity Measurement

Stymied by the practical challenges in accurately measuring the stock of human capital many statistical agencies, including the ABS, turned to producing quality adjusted measures of labour input. These measures adjust the quantity of labour inputs (hours worked) with measures of labour quality (for example years of education or level of educational attainment) to provide a proxy measure of the services provided by the stock of human capital, and an additional explanatory variable for economic growth.

Since quality adjusted labour inputs capture the ongoing improvements in the labour quality of the workforce, the rate of growth of labour input measured is generally higher than the growth measured by hours worked. Consequently, measured productivity will grow at a slower rate when measured on a quality adjusted basis compared to a hours worked basis (ABS 2022). ABS estimates show the quality adjusted labour inputs series grew 20.5% more from 1994-95 to 2021-22 than the corresponding hours worked series. As a result, multifactor productivity on an hours worked basis grew 9.5% more than on a quality adjusted basis (ABS 2022).

The 2025 System of National Accounts

An updated System of National Accounts (the 2025 SNA) is under development and scheduled for ratification at the UN Statistical Commission in 2025. This 2025 version of the SNA does not extend the asset boundary to include human capital, however it does include new guidance on the compilation of several accounts which will provide the

economic flows critical to calculating the stock of human capital, using either the cost or income approach (Smedes et al., 2021).

Labour Accounts (produced by the ABS since 2018) will be included in the SNA manual for the first time, and importantly the manual will provide guidance on extending these accounts to include the dimensions of age, gender and occupation which are vital inputs to the income approach for measuring human capital. This will be the first time the SNA recommends disaggregating an account by these household characteristics.

The 2025 SNA will also provide guidance for compiling a range of supplementary tables which will serve as inputs into the cost approach calculations: education and training account; health care account; and household services (unpaid labour) account. These tables would support compiling human capital estimates based on a range of input costs, depending on the desired scope of the measure.

New Data Sources

Notwithstanding the ongoing challenges in designing (and agreeing) appropriate concepts and methods for measuring human capital, there are now a range of new data sources which provide a substantially improved evidence base from that previously available.

The development of unit level integrated data assets such as the Person Level Integrated Data Environment (PLIDA) and the Business Longitudinal Analytical Data Environment (BLADE) provide several benefits for researching and measuring human capital:

- comprehensive and regular coverage of the Australian population means that studies which were only previously able to be conducted with Census data every five years (for example ABS capital stock estimates or quality adjusted labour factors) could now be undertaken far more frequently (e.g. annually)
- detailed characteristics - data integration provides access to a range of characteristic information which researchers previously struggled to obtain. This has enabled important studies of specific population groups for example First Nations people, those living with disability, and migrants.
- the ability to link inputs and outputs - the measurement of human capital has been confounded by the challenge of understanding the links between the formation of capital and the application of the capital in the production process. Integrated data assets like the VET National Data Asset which link vocational education to employment outcomes enable research into the link between inputs into capital formation and the services provided by that capital.

- linking employees and employers - thru linking PLIDA and BLADE based on the employment relationship it is possible to undertake research into job matching, facilitating research into efficiency of labour market and the application of human capital into the production process.

References

Abraham, Katherine and Mallat, Justine (2022), 'Measuring Human Capital', *Journal of Economic Perspectives*, 36(3): 103-130

Abraham, Katharine G., and Justine Mallatt. "Replication data for: Measuring Human Capital." American Economic Association [publisher], Inter-university Consortium for Political and Social Research [distributor].

Acemoglu, Daron and David Autor (2011), 'Skills, tasks and technologies: Implications for employment and earnings', chapter 12 in Orley Ashenfelter and David Card (eds.) *Handbook of Labor Economics Volume 4B* (Elsevier).

Acemoglu, Daron and Jorn-Steffen Pischke (1998), 'Why do firms train? Theory and evidence', *Quarterly Journal of Economics*, 113(1): 79-119.

Ackermann, Klaus, Sefa Awaworyi Churchill and Russell Smyth (2023), 'Broadband internet and cognitive functioning', *Economic Recor*d, 99(327): 536-63.

Alan, Sule and Ipek Mumcu (2024), 'Nurturing childhood curiosity to enhance learning: Evidence from a randomized pedagogical intervention', *American Economic Review*, 114(4): 1173-1210.

Almond, Douglas and Janet Currie (2011), 'Human capital development before age five', pages 1315-1486 in Orley Ashenfelter and David Card (eds) *Handbook of Labor Economics Volume 4B* (Elsevier).

Almond, Douglas, Janet Currie and Valentina Duque (2018), 'Childhood circumstances and adult outcomes: Act II', *Journal of Economic Literature*, 56(4): 1360-1446.

Altonji, Joseph and Robert Shakotko (1987), 'Do wages rise with job seniority?', *Review of Economic Studies*, 54(3): 437-59.

Andrews, Dan, Nathan Deutscher, Jonathan Hambur and David Hansell (2019), 'Wage growth in Australia: Lessons from longitudinal data', Treasury Working Paper 2019-04.

Angrist, Noam, Simeon Djankov, Pinelopi Goldberg and Harry Patrinos (2021), 'Measuring human capital using global learning data', *Nature*, 10 March.

Angrist, Joshua and Alan Krueger (1991), 'Does compulsory school attendance affect schooling and earnings?', *Quarterly Journal of Economics*, 106(?): 979-1014.

Ashenfelter, Orley and Alan Krueger (1994), 'Estimates of the economic return to schooling for a new sample of twins', *American Economic Review*, 84(??): 1157-73.

Australian Bureau of Statistics (2022), 'Understanding labour quality and its contribution to productivity measurement', published 13 December 2022, ABS Website

Bacher-Hicks, Andrew and Cory Koedel (2023), 'Estimation and interpretation of teacher value added in research applications', pages 93-134 in Erik Hanushek, Stephen Machin and Ludger Woessman (eds) *Handbook of Economics of Education Volume 6* (Elsevier).

Banerjee, Rajabrata and John Wilson (2016), 'Roles of education in productivity growth in Australia, 1860-1939', *Economic Record*, 92(216): 47-66.

Barrett, Garry (2012), 'The return to cognitive skills in the Australian labour market', *Economic Record*, 88(280): 1-17.

Beatton, Tony, Michael Kidd, Anthony Niu and Francis Vella (2023), 'Age of starting school, academic performance, and the impact of non-compliance: An experiment within an experiment, evidence from Australia', *Economic Record*, 99(325): 175-206.

Becker, Gary (1962), 'Investment in human capital: A theoretical analysis', *Journal of Political Economy*, 70(5, Part 2): 9-49.

Becker, Gary (1964), *Human Capital: A Theoretical and Empirical Analysis, With Special Reference to Education* (New York: National Bureau of Economic Research).

Becker, Gary (1967), 'Human capital and the personal distribution of income', W.S. Woytinsky Lecture no.1, University of Michigan.

Becker, Gary and Barry Chiswick (1966), 'Education and the distribution of earnings', *American Economic Review Papers and Proceedings*, 56(1/2): 358-69.

Becker, Gary and H. Gregg Lewis (1974), 'Interaction between the quantity and quality of children' pages 81-90 in Theodore Schultz (ed.) *Economics of the Family: Marriage, Children and Human Capital* (University of Chicago Press: Chicago).

Ben-Porath, Yoram (1967), 'The production of human capital and the life-cycle of earnings', *Journal of Political Economy*, 74(4, Part 1): 352-65.

Biddle, Nicholas, Heather Crawford, & Robin Seth-Purdie (2017), 'Risk burden, participation in early childhood education and care, and child outcomes', *Australasian Journal of Early Childhood*, 42(1): 49-59.

Bjorklund, and Kjell Salvanes (2011), 'Education and family background: Mechanisms and policies', pages 201-47 in in Erik Hanushek, Stephen Machin and Ludger Woessman (eds) *Handbook of the Economics of Education Volume 3* (Elsevier).

Black, Dan, Lars Skipper and Jeffrey Smith (2023), 'Firm training', pages 287-468 in Erik Hanushek, Stephen Machin and Ludger Woessman (eds) *Handbook of the Economics of Education Volume 7* (Elsevier).

Borland, Jeff (1996), 'Education and the structure of earnings in Australia', *Economic Record*, 72(219): 370-80.

Borland, Jeff (1999a), 'The Equal Pay Case – 30 Years On", *Australian Economic Review*, 32(3): 265-272.

Borland, Jeff (1999b), 'Earnings inequality in Australia: Changes, causes and consequences', *Economic Record*, 75(229): 177-202.

Borland, Jeff and Michael Coelli (2016), 'Labour market inequality in Australia', *Economic Record*, 92(299): 517-47.

Borland, Jeff, Peter Dawkins, David Johnson and Ross Williams (2000), 'Returns to investment in higher education', Melbourne Economics of Higher Education Research Program Report no.1, University of Melbourne.

Borland, Jeff and Anthony Suen (1990), 'The determinants of individual wages in Australia: Competitive and non-competitive influences', *Australian Economic Review*, 23(4): 33-42.

Bradbury, Bruce, Miles Corak, Jane Waldfogel and Elizabeth Washbrook (2011), 'Inequality during the early years: Child outcomes and readiness to learn in Australia, Canada, United Kingdom and the United States', IZA Discussion Papers no.6120.

Brown, Christina, Supreet Kaur, Geeta Kingdon and Heather Schofield (2022), 'Cognitive endurance as human capital', National Bureau of Economic Research, Working paper no.30133.

Cannon, Jill, M. Rebecca Kilburn, Lynn Karoly, Teryn Mattox, Ashley Muchow and Maya Buenaventura (2017), *Investing Early: Taking Stock of Outcomes and Economic Returns from Early Childhood Programs* (Rand Corporation).

Card, David (1999), 'The causal effect of education on earnings', chapter 30 in Orley Ashenfelter and David Card (eds) *Handbook of Labor Economics Volume 3A* (Elsevier).

Carrington, William (1993), 'Wage losses for displaced workers: Is it really the firm that matters?', *Journal of Human Resources*, 28(3): 435-62.

Carroll, David, Chris Heaton and Massimiliano Tani (2019), 'Does it pay to graduate from an 'elite' university in Australia?', *Economic Record*, 95(310): 343-57.

Chapman, Bruce and Paul Miller (1983), 'Determination of earnings in Australia: An analysis of the 1976 Census' in K. Hancock, Y. Sano, B. Chapman and P. Fayle (eds) *Japanese and Australian Labour Markets: A Comparative Study* (Australia-Japan Research Centre).

Chatterjee, Arpita, Aarti Singh and Tahlee Stone (2016), 'Understanding wage inequality in Australia', *Economic Record*, 92(298): 348-60.

Chiswick, Barry (2023), 'Estimating returns to schooling and experience: A history of thought', GLO Discussion paper no.1365, Global Labor Organization.

Chou, Yuan (2003), 'The Australian growth experience, 1960-2000: Human capital, R&D, or steady-state growth?', *Australian Economic Review*, 36(4): 397-414.

Cobb-Clark, Deborah, Nathan Kettlewell, Stefanie Schurer and Sven Silburn (2023), 'The effect of quarantining welfare on school attendance in Indigenous communities', *Journal of Human Resources*, 58(6): 2072-2110.

Cobbold, Trevor (2015), 'A review of academic studies of private and public school outcomes in Australia', mimeo, Save Our Schools.

Coelli, Michael and Roger Wilkins (2009), 'Credential changes and education earnings premia in Australia', *Economic Record*, 85(270): 239-59.

Cunha, Flavio and James J. Heckman (2007), 'The technology of skill formation', *American Economic Review*, 97(2), 31-47.

Daly, Anne, Phil Lewis and Tiffany Heaslip (2015), 'The private rate of return to a university degree in Australia', *Australian Journal of Education*, 59(1): 97-112.

Deming, David (2017), 'The growing importance of social skills in the labor market', *Quarterly Journal of Economics*, 132(4): 1593-1640.

Deming, David (2021), 'The growing importance of decision-making on the job', National Bureau of Economic Research, Working paper no.28733.

Deming, David (2022), 'Four facts about human capital', *Journal of Economic Perspectives*, 36(3): 75-102.

Deming, David (2023), 'Multidimensional human capital and the wage structure', National Bureau of Economic Research, Working Paper no.31001.

Duncan, Greg, Ariel Kalil, Magne Mogstad and Mari Rege (2022), 'Investing in early childhood development in preschool and at home', National Bureau of Economic Research Working Paper no. 29985.

European Commission, International Monetary Fund, Organisation for Economic Cooperation and Development, United Nations, and World Bank. 2009. System of National Accounts 2008. New York: United Nations.

Fraumeni, Barbara M., and Michael S. Christian (2019), 'Accumulation of Human Capital in the United States, 1975–2012: An Analysis by Gender', National Bureau of Economic Research, Working Paper 25864.

Friedman, Milton and Simon Kuznets (1945), *Income from Independent Professional Practice* (National Bureau of Economic Research: New York).

Gathmann, Christina and Uta Schonberg (2010), 'How general is human capital?: A task based approach', *Journal of Labor Economics*, 28(1): 1-49.

Gu, Wulong, and Ambrose Wong (2015), 'Productivity and economic output of the education sector', *Journal of Productivity Analysis* 43 (2): 165–82.

De Gendre, Alexandra, Stefanie Schurer and Angela Zhang (2021), 'Two decades of welfare reforms in Australia: How did they affect single mothers and their children?', IZA Discussion Paper no.14752.

Goldin, Claudia and Lawrence Katz (2023), 'The incubator of human capital: The NBER and the rise of the human capital paradigm', National Bureau of Economic Research, Working paper no.26909.

Greaker, Mads, and Liu, Gang (2008), 'Measuring the stock of human capital for Norway – A lifetime labour income approach', Paper presented at the OECD workshop on The Measurement of Human Capital in Turin, Italy, 3-4 November.

Gregory, Robert, Anne Daly and V. Ho (1986), 'A tale of two countries: Equal pay for women in Australia and Britain', Australian National University, Centre for Economic Policy Research, Discussion paper no.147.

Griliches, Zvi (1977), 'Estimating the returns to schooling: some economic problems', *Econometrica*, 45(1): 1-22.

Gu, Wulong, and Ambrose Wong (2009), 'Human Development and its Contribution to the Wealth Accounts in Canada.' Paper presented at the Canadian Economic Association Annual Conference, 29 May.

Gu, Wulong, and Wong, Ambrose (2010), 'Estimates of Human Capital in Canada: The Lifetime Income Approach.' Statistics Canada Catalogue no. 11F0027M. Economic Analysis Research Paper Series. No. 62.

Guvenen, Faith, Burhan Kuruscu, Satoshi Tanaka and David Wiczer (2020), 'Multidimensional skill mismatch', *American Economic Journal: Macreconomics*, 12(1): 210-44.

Haig, Bryan (1980), 'Earnings of migrants in Australia', *Journal of Industrial Relations*, 22(3): 264-74.

Haig, Bryan (1982), 'Sex discrimination in the reward for skills and experience in the Australian labour force', *Economic Record*, 58(1): 1-10.

Hambur, Jonathan (2023), 'Did labour market concentration lower wages growth pre-COVID?', Reserve Bank of Australia, Research Discussion Paper 2023-02.

Heath, Alex (2016), 'The changing nature of the Australian workforce', Speech to CEDA Conference on Future Skills: The Education and Training Pipeline, September 21.

Heath, Alex (2020), 'Skills, technology and the future of work', Address to the Career Education Association of Victoria and Victorian Commercial Teachers Association Work Futures Conference, March 16.

Heckman, James J., Jorg Stixrud and Sergio Urzua (2006), 'The effect of cognitive and noncognitive abilities on labor market outcomes and social behavior', *Journal of Labor Economics*, 24(3): 411-82.

Helal, Mike and Michael Coelli (2016), 'How principals affect schools', Melbourne Institute Working Paper no.18/16.

Houng, Brendan and Chris Ryan (2018), 'Achievement gains from attendance at high school', Melbourne Institute Working Paper no.08/18.

Hoynes, Hilary and Diana Whitman Schanzenbach (2018), 'Safety net investments in children', *Brookings Papers on Economic Activity*, Spring, 89-132.

Hunter, Jordana and Amy Haywood (2023), *How to Implement a Whole-School Curriculum Approach: Grattan Guide* (Grattan Institute).

Hunter, Jordana, Anika Stobart and Amy Haywood (2024), *The Reading Guarantee: How to Give Every Child the Best Chance of Success* (Grattan Institute).

Jha, Nikhil (2015), 'Late start with extra schooling: The effect of increase in school entry age and preschool provision', Economic Record, 91(Special issue): 54-77.

Jones, Benjamin (2014), "The human capital Stock: A generalized approach", *American Economic Review* 104(11): 3752-3777.

Jorgenson, Dale W., and Fraumeni, Barbara M (1989), 'The Accumulation of Human and Nonhuman Capital, 1948–84', In *The Measurement of Saving, Investment, and Wealth*, edited by Robert E. Lipsey and Helen Stone Tice, 227–86.

Jorgenson, Dale W., and Fraumeni, Barbara M (1992), 'Investment in Education and U.S. Economic Growth', *Scandinavian Journal of Economics* 94 (Supplement): S51–70.

Juhn, Chinhui, Brooks Pierce and Kevin M. Murphy (1993), 'Wage inequality and the rise in returns to skill', *Journal of Political Economy*, 101(1): 35-78.

Karmel, Tom (1995), The Impact of Increasing Education Levels on the Australian Workforce, Unpublished PhD dissertation, Australian National University.

Krueger, Alan and Lawrence Summers (1988), 'Efficiency wages and the inter-industry wage structure', *Econometrica*, 56(2): 259-93.

Kuznets, Simon (1961), *Capital in the American Economy: Its Formation and Financing*. (Princeton NJ: Princeton University Press).

Lazear, Ed (2009), 'Firm-specific human capital: A skills-weight approach', *Journal of Political Economy*, 117(5): 914-40.

Leigh, Andrew (2010), 'Estimating teacher effectiveness from two-year changes in students' test scores', *Economics of Education Review*, 29: 480-88.

Leigh, Andrew and Chris Ryan (2008), 'How and why has teacher quality changed in Australia?', *Australian Economic Review*, 41(2): 141-59.

Lise, Jeremy and Fabian Postel-Vinay (2020), 'Multidimensional skills, sorting and human capital accumulation', *American Economic Review*, 110(8): 2328-76.

Miller, Paul, Charles Mulvey and Nick Martin (1995), 'What do twins studies reveal about the economic returns to education? A comparison of Australian and U.S. findings', *American Economic Review*, 85(??): 586-99.

Mincer, Jacob (1974), *Schooling, Experience and Earnings* (New York: National Bureau of Economic Research).

Neal, Derek (1995), 'Industry-specific human capital: Evidence from displaced workers', *Journal of Labor Economics*, 13(4): 653-77.

Oaxaca, Ronald (1973), 'Male-female wage differentials in urban labor markets', *International Economic Review*, 14: 693-709.

Polidano, Cain and Chris Ryan (2017), 'What happens to students with low reading proficiency at 15? Evidence from Australia', *Economic Record*, 93(303): 600-14.

Preston, Alison (1997), 'Where are we now with human capital theory in Australia?', *Economic Record*, 73(220): 51-78.

Rosen, Sherwin (1983), 'A note on aggregation of skills and labor quality', *Journal of Human Resources*, 18(3): 425-31.

Rosen, Sherwin (1986), 'The theory of equalising differences', pages 641-92 in Orley Ashenfelter and Richard Layard (eds) Handbook of Labor Economics Volume 1 (Elsevier).

Rosen, Sherwin (1989) 'Human capital' pages 136-55 in Jonathen Eatwell, Murray Milgate and Peter Newman (eds) *Social Economics* (Palgrave Macmillan, London).

Roy, A.D. (1951), 'Some thoughts on the distribution of earnings', *Oxford Economic Papers*, 3(2): 135-46.

Ryan, Christopher (2001), Education: Tests of whether it enhances productivity or merely conveys information on individual productivity in the labour market', Unpublished PhD thesis, University of Melbourne.

Rummery, Sarah (1992), 'The contribution of intermittent labour force participation to the gender wage differential', *Economic Record*, 68(202): 351-64.

Sanders, Carl and Christopher Taber (2012), 'Life-cycle wage growth and heterogeneous human capital', *Annual Review of Economics*, 4: 399-425.

Schultz, Theodore (1961), 'Investment in human capital', *American Economic Review*, 51(1): 1-17.

Schultz, Theodore (1975), 'The value of the ability to deal with disequilibria', *Journal of Economic Literature*, 13(3): 827-46.

Schurer, Stefanie, Kristian Trajkovski and Tara Hanrihan (2019), 'Understanding the mechanisms through which adverse childhood experiences affect lifetime economic outcomes', *Labour Economics*, 61 (101743).

Shaw, Kathryn (1984), 'A formulation of the earnings function using the concept of occupational investment', *Journal of Human Resources*, 19(3): 319-340.

Smedes, Michael, Fraumeni, Barbara, Gu, Wulong (2021), 'Labour Accounts, Education and Human Capital), 15th Meeting of the Advisory Expert Group on National Accounts, 6-8 April 2021, United Nations Statistical Division

Taber, Christopher and Rune Vejlin (2020), 'Estimation of a roy/search/compensating differential model of the labor market', *Econometrica*, 88(3): 1031-69.

Tani, Massimiliano, Christopher Heaton and Gavin Chan (2013), 'The wage premium of foreign education: Evidence for Australia', *Australian Economic Review*, 46(4): 395-404.

Topel, Robert (1991), 'Wages rise with job seniority', *Quarterly Journal of Economics*, 99(1): 145-76.

Tseng, Yi-Ping, Brigid Jordan, Jeff Borland, Megan Clark, Nichola Coombs, Kate Cotter, Mael Guillou, Alice Hill, Anne Kennedy and Jane Sheehan (2022), *Changing the Life Trajectories of Australia's Most Vulnerable Children – Report no.5: 36 months in the Early Years Education Program: An assessment of the impact on children and their primary caregivers*.

United Nations Economic Commission for Europe (UNECE) (2016), 'Guide on Measuring Human Capital' Geneva, Switzerland: United Nations.

United Nations Economic Commission for Europe (UNECE). 2020. Satellite Account for Education and Training: Compilation Guide. Geneva, Switzerland: United Nations.

Vella, Francis and Robert Gregory (1996), 'Selection bias and human capital investment: Estimating the rate of return to education for young males', *Labour Economics*, 3(??): 197-219.

Wei, Hui (2008), 'Measuring human capital flows for Australia: A lifetime labour income approach', ABS Research Paper, 1351.0.55.023, ABS website

Welch, Finis (1969), 'Linear synthesis of skill distribution', *Journal of Human Resources*, 4(Summer): 311-27.

Welch, Finis (1970), 'Education in production', *Journal of Political Economy*, 78(1): 35-59.

Willis, Robert (1986) 'Wage determinants: A survey and reinterpretation of human capital earnings functions', pages 525-602 in Orley Ashenfelter and Richard Layard (eds) *Handbook of Labor Economics Volume 1* (Elsevier).

World Bank (2020), 'The Human Capital Index 2020 Update: Human Capital in the Time of COVID-19'. Washington, DC: World Bank Group.