
2 Methodology

This chapter outlines the methodology used to estimate the effect on multifactor productivity (MFP) of capitalising intangibles. A brief summary of related studies is provided, followed by the model and the classification of intangibles used in this paper.

2.1 Previous studies

There is an extensive literature on some elements of intangible investment/capital (for example, R&D capital), while other elements (for example, organisational capital) have received less attention.¹ This section provides a few examples of recent approaches to measuring intangibles in the economics literature.

Sichel (2008) identifies three broad approaches to measuring intangible capital in general — financial market valuation; other performance measures; and direct expenditure data.

The first approach, financial market valuation, infers the value of intangible capital as the difference between the market value of firms and the value of tangible assets.

- Brynjolfsson, Hitt and Yang used this approach in a number of papers examining the link between intangible investments and investment in computers in the United States (Brynjolfsson and Yang 1999, Brynjolfsson, Hitt and Yang 2000 and 2002). These papers used firm-level data and found that each dollar of installed computer capital in a firm was associated with between five and ten dollars of market value. They interpreted this difference as revealing the existence of a large stock of intangible assets that are complementary with computer investment. They also identified particular organisational practices at the firm level that represent at least part of these intangible assets (related to the types of decision making authority, use of self-managing teams and the breadth of job responsibilities).
- Webster (2000) used a similar approach with Australian data, assuming that any residual market value of the firm (stock market value plus liabilities) not explained by the balance sheet value of tangible assets must be due to intangible

¹ A review of this literature is beyond the scope of this paper.

assets. The results implied that the ratio of intangible to all enterprise capital rose by 1.25 per cent a year over the 50 years to 1998.

- World Bank (2006) measured intangible capital at the country rather than firm level. The value of intangible capital was derived as the residual after deducting natural capital and produced capital from total wealth (measured as the net present value of future sustainable consumption). For Australia this measure was US\$288 686 of intangible capital per person or around US\$5600 billion in total in 2000.

The second approach uses other performance measures, such as productivity or earnings, to estimate the value of intangible capital.

- McGrattan and Prescott (2005) inferred the value of intangible capital from corporate profits, the returns to tangible assets, and the assumption of equal after-tax returns to tangible and intangible assets. They estimated the value of intangible capital at 31 to 76 per cent of US GDP.
- Cummins (2005) defined intangible capital in terms of adjustment costs and estimated these costs econometrically from US firm-level panel data. His estimates were based on creating a proxy for the intrinsic value of the firm from discounted value of expected profits from analysts' forecasts (which he suggested reflect the analysts' valuation of intangibles) and estimating the return on each type of capital (tangible and intangible). He found no appreciable intangibles associated with R&D and advertising but sizable intangibles (organisational capital) created by IT.
- Webster (2000) measured growth in the rate of intangible investment using the proportion of the labour force in jobs that produce intangible capital. For Australia, growth in the ratio of intangible investment to all production was estimated to be around 2.8 per cent per year for the 25 years to 1996.
- Lev and Radhakrishnan (2005) developed a firm-specific measure of organisational capital, modelling the effect on sales of organisational capital (proxied by reported 'sales, general and administrative expenses', as this includes expenditures that generate organisational capital). They estimated the marginal productivity of organisational capital to be between 0.4 and 0.6, and mean organisational capital of 4 per cent of average sales of their sample of US firms.

It has been suggested that the first two approaches may be subject to considerable measurement error — for example, stock market values may reflect a mismeasurement to the extent that asset prices depart from their intrinsic values and analysts' measures of earnings can be subject to mistakes and biases (Cummins 2005).

The third approach uses expenditure data to develop more direct measures of intangible capital. This approach is not without measurement error and data limitations — including whether the list of measures of intangibles is comprehensive and able to capture changes in the nature of intangibles over time.

- Nakamura (1999, 2001) was the first to employ this approach. He measured gross investment in intangible assets using a range of measures including R&D expenditure, software, advertising and marketing expenditure, and wages and salaries of managers and creative professionals. He estimated that in 2000 US investment in intangibles was US\$1 trillion (roughly equal to that in non-residential tangible assets), with an intangible capital stock of at least US\$5 trillion.
- Corrado, Hulten and Sichel (CHS) (2005) expanded Nakamura's work to develop expenditure-based measures of a larger range of intangibles for the United States (see section 2.3). They estimated investment in intangibles averaged US\$1.1 trillion between 1998 and 2000 (1.2 times tangible capital investment) or 12 per cent of GDP.
- CHS (2006) built on this work to develop a methodology for explicitly identifying the contribution of intangibles in the national accounts and growth accounting. They estimated that previously unmeasured intangible capital contributed 0.24 of a percentage point (18 per cent) to conventionally-measured MFP growth in the United States between the mid-1990s and early 2000s. The CHS methodology has been applied in a number of other country studies — with estimates of the contribution of previously unmeasured intangible capital to MFP growth of 14 per cent (United Kingdom in Marrano, Haskel and Wallis 2007), 3 per cent (Finland in Jalava, Aulin-Ahmavaara and Alanen 2007) and 0 per cent (the Netherlands in van Rooijen-Horsten et al. 2008), over a similar period. Other country studies estimated only the contribution of *all* intangibles to MFP growth — -19 per cent in Japan (Fukao et al. 2008b), 19 per cent in France, 18 per cent in Germany, 9 per cent in Spain and 0 per cent in Italy (Hao, Manole and van Ark 2008).²
- Hulten and Hao (2008) applied a methodology similar to CHS to the financial data of a group of US R&D intensive companies to construct estimates of R&D and organisational capital. They found that this explained a significant portion of the difference between market value and book value.

² Belhocine (2008) estimated intangible investment for Canada but did not estimate the effect on MFP growth. The findings of all these studies are discussed in more detail, and compared with Australian estimates derived in this paper, in chapter 6.

Schreyer (2007, p. 79) notes that the CHS approach appears more practical for regular measurement of intangibles.

The Corrado-Hulten-Sichel approach does not require explicit econometric techniques and would appear more practical from the perspective of monitoring intangibles as part of a periodic measurement program carried out by a statistical office.

This quote highlights one of the reasons for the considerable ongoing debate about appropriate measures of intangibles in the broader literature — the desirability of a particular measure depends on the perspective taken and the use to which the measure is to be put. The literature on intangibles is from economic, accounting, legal and management perspectives (Bosworth and Webster 2006 provides a useful discussion of intangibles from each of these perspectives). One particular issue of debate is whether the measurement should be expenditure-based or value-based. The characteristics of a measure to be included in the accounts of an individual firm for accounting purposes may be different to those used for internal business management purposes (for example, past objective expenditures may be preferred for accounting purposes rather than estimates of future profits that may be useful for management purposes). An examination and assessment of this debate is beyond the scope of this paper and has been well canvassed elsewhere (see, for example, Lev 2001, Hunter, Webster and Wyatt 2005 and Bosworth and Webster 2006).

It is the CHS (expenditure-based) methodology that has been applied in this paper because it focuses on the examination of the relationship between intangibles and MFP growth and data for international comparisons are available. The CHS approach embeds intangibles in the standard growth accounting framework used to examine productivity growth, and it has already been applied to several OECD countries. This paper is an (exploratory) step in examining intangibles in Australia in an international context, using a method for which there are readily available international estimates on a comparable basis. (No previous applications of this methodology to Australian data have been identified). The remainder of this chapter focuses on the CHS methodology.

Justification for capitalisation of intangibles

The adjusted growth accounting in the expenditure-based approach to intangible measurement is based on capitalising intangibles.³ CHS (2006) suggest that the justification for capitalising intangibles from the standpoint of consumption is that any use of resources that reduces current consumption in order to increase it in the

³ ‘Capitalising’ refers to the treatment of expenditure as investment and the accumulation of a capital stock according to the perpetual inventory method.

future qualifies as an investment. And symmetry of all types of capital should therefore require that intangibles are treated in the same way as tangibles.⁴

However, from the production side, the principle of symmetrical treatment has been used as an argument against the capitalisation of intangibles. CHS (2006, pp. 10–4) list the characteristics that have been identified as disqualifying intangibles from being treated as capital and go on to counter these arguments. In brief, the characteristics and counter arguments are as follows.⁵

- *Lack of verifiability* of the quantity of intangibles not purchased through market transactions.
 - However, this does not automatically make intangibles intermediate inputs. Some tangibles lack verifiability (for example, internal construction projects) and some intangibles do not (for example, purchased management consulting services). CHS (2006) suggest that the economic character of the good not the ease of measurement should determine the classification of the good.
- *Lack of visibility* (or intangibility) after their acquisition, which complicates efforts to track past vintages. The lack of a physical embodiment means that in terms of national income methodology this creates difficulty in measuring depreciation rates and obtaining stocks.
 - Again, CHS (2006) suggest this measurement concern is not a valid conceptual reason for not capitalising intangibles.
- *Non-rivalness* (for example, knowledge being able to be employed by many users simultaneously without decreasing the quantity available to any single user) and *lack of appropriability of returns* from some intangibles (such as intellectual property).
 - CHS (2006, p. 13) argue that the capitalisation issue pivots on whether the provision of the intangible increases future output and consumption, not whether it is partly non-appropriable or non-rival. Therefore these two characteristics do not invalidate the need to capitalise intangibles that have these characteristics (and not all do).

⁴ The justification for capitalising intangibles is further explored in Webster and Jensen (2006). Also, van Rooijen-Horsten et al. (2008, pp. 5–9) provides a useful discussion of the extent to which different intangibles satisfy the definition of capital from the perspective of the 1993 System of National Accounts (which sets out the international statistical standards for the measurement of the market economy). These criteria include: having an economic and legal owner; providing possible economic benefits from being held or used; and being used repeatedly or continuously in production processes for more than one year.

⁵ These characteristics are also of concern to accountants. For a detailed discussion of the recognition and definition rules for intangibles, from an accounting perspective, see Wyatt (2006).

2.2 Model

CHS (2006) set out the effect on national account measures of treating intangibles expenditure as investment rather than as an intermediate input (see appendix B for a fuller derivation). Their model, outlined below, is based on three goods — a consumption good with real output volume in period t of C_t with price P_C ; a tangible investment good I_t with price P_I ; and an intangible good N_t with price P_{N_t} .

Intangibles treated as intermediate inputs

When intangibles are regarded as being intermediate inputs, labour L and tangible capital K are allocated to the production of all three goods, and N is an input to C and I . The production function and flow account for each of the three sectors is then

$$\text{Intangible sector} \quad N_t = F_N(L_{N_t}, K_{N_t}, t) \quad P_{N_t} N_t \equiv P_{L_t} L_{N_t} + P_{K_t} K_{N_t} \quad (2.1)$$

$$\text{Tangible sector} \quad I_t = F_I(L_{I_t}, K_{I_t}, N_{I_t}, t) \quad P_{I_t} I_t \equiv P_{L_t} L_{I_t} + P_{K_t} K_{I_t} + P_{N_t} N_{I_t} \quad (2.2)$$

$$\text{Consumption sector} \quad C_t = F_C(L_{C_t}, K_{C_t}, N_{C_t}, t) \quad P_{C_t} C_t \equiv P_{L_t} L_{C_t} + P_{K_t} K_{C_t} + P_{N_t} N_{C_t} \quad (2.3)$$

where tangible capital accumulates according to the perpetual inventory model $K_t \equiv I_t + (1 - \delta_k) K_{t-1}$ with depreciation rate δ_k . The production functions in each equation are linked to the accounting identities by the assumption that each input is paid the value of its marginal product. For intangibles, the left-hand side of equation (2.1) says that the output of intangibles is produced by labour and tangible capital in that sector. The right-hand side says that the value of the intangibles produced is identically equal to the returns to labour and tangible capital used in that sector (assuming factors are paid their marginal products).

The assumption in this model that intangibles $N_t (= N_{I_t} + N_{C_t})$ are an intermediate input means that, as both an output and an intermediate input to the production of the other products, intangibles net out in the aggregate.⁶ Intangibles therefore do not appear separately in the total output (Q'_t) identity

$$P_{Q'_t} Q'_t \equiv P_{C_t} C_t + P_{I_t} I_t \equiv P_{L_t} L_t + P_{K_t} K_t \quad (2.4)$$

where $L \equiv L_N + L_I + L_C$, and $K \equiv K_N + K_I + K_C$

⁶ CHS (2006) adopts the convention that intermediates used by the industry that produced them are netted out of final output. N_N is therefore omitted from the production function of the intangible sector.

Intangibles treated as capital

If intangibles are treated as capital, a different model applies. The intangible capital stock accumulates according to $R_t \equiv N_t + (1-\delta_R)R_{t-1}$, in the same way as tangible capital. The production function and flow account for each of the three sectors become

$$\text{Intangible sector} \quad N_t = F_N(L_{N_t}, K_{N_t}, R_{N_t}, t) \quad P_{N_t} N_t \equiv P_{L_t} L_{N_t} + P_{K_t} K_{N_t} + P_{R_t} R_{N_t} \quad (2.5)$$

$$\text{Tangible sector} \quad I_t = F_I(L_{I_t}, K_{I_t}, R_{I_t}, t) \quad P_{I_t} I_t \equiv P_{L_t} L_{I_t} + P_{K_t} K_{I_t} + P_{R_t} R_{I_t} \quad (2.6)$$

$$\text{Consumption sector} \quad C_t = F_C(L_{C_t}, K_{C_t}, R_{C_t}, t) \quad P_{C_t} C_t \equiv P_{L_t} L_{C_t} + P_{K_t} K_{C_t} + P_{R_t} R_{C_t} \quad (2.7)$$

where P_{R_t} is the rental price associated with the services of the intangible stock.⁷

Intangibles now appear on the left-hand side, in the production functions, as a cumulative stock (R_t) not as an intermediate input (N_t) as above. On the right-hand side payments to that stock ($P_{R_t} R_t$) appear rather than payment for the entire intermediate input ($P_{N_t} N_t$).

Again, the production functions in each equation are linked to the accounting identities by the assumption of marginal productivity pricing. The total output (Q_t) identity is expanded to include the value of output of the intangibles on the production side⁸ and the payments to the stock of intangibles on the income side:

$$P_{Q_t} Q_t \equiv P_{C_t} C_t + P_{I_t} I_t + P_{N_t} N_t \equiv P_{L_t} L_t + P_{K_t} K_t + P_{R_t} R_t \quad (2.8)$$

where $N \equiv N_N + N_I + N_C$ and $R \equiv R_N + R_I + R_C$

Comparing MFP growth under the two approaches

To see the implications for MFP growth, the following growth accounting equations can be derived from the production functions above (see appendix B).

⁷ The rental price of tangible capital (P_{K_t}) will also change when intangibles are capitalised because of the change in the equalising rate of return. However, the same notation ' P_{K_t} ' is maintained in both cases for simplicity (see appendix B).

⁸ This is the case whether intangibles are purchased intermediate inputs or own account production. When intangibles are produced on own account, some of the currently measured primary inputs of that industry are being used to create the additional intangible output. The expenditure-based approach values this additional output using the primary input costs (see chapter 3).

As an intermediate input, intangibles expenditure is netted out and does not appear in the MFP growth equation (\dot{x} denotes the growth rate of x)

$$\dot{\text{MFP}}' = \dot{Q}' - s'_L \dot{L} - s'_K \dot{K} \quad (2.9)$$

where $s'_L \equiv [P_L L]/[P_L L + P_K K]$ and $s'_K \equiv [P_K K]/[P_L L + P_K K]$

As capital, intangibles appear as an input in the MFP equation, which becomes

$$\dot{\text{MFP}} = \dot{Q} - s_L \dot{L} - s_K \dot{K} - s_R \dot{R} \quad (2.10)$$

where $s_L \equiv [P_L L]/[P_L L + P_K K + P_R R]$, $s_K \equiv [P_K K]/[P_L L + P_K K + P_R R]$ and $s_R \equiv [P_R R]/[P_L L + P_K K + P_R R]$.

Equation (2.10) differs from (2.9) in a number of ways.

- The level of aggregate output increases because it includes the value of output of the intangible goods. But whether output growth rises depends on whether the growth rate of real intangible investment is higher or lower than the growth rate of other output.
- The payment to an additional factor of production, the stock of intangibles, is also included.
- All the factor income shares are different because both output and the total payments to capital differ. Output has increased because of the inclusion of intangible output. And there is a corresponding increase in total factor payments. Income payments to the additional factor, intangible capital stock, increase total payments to capital. The labour income *share* therefore falls (the level of labour income is unchanged).
- The effect on MFP growth is ambiguous — it may rise or fall depending on the change in output growth relative to the change in input growth. For example, MFP growth will fall if the inclusion of intangibles raises the output growth rate by less than it raises the growth in inputs.

Implementation of the model

The methodology for explicitly identifying the contribution of intangible assets in growth accounting is discussed in detail in the following chapters, together with the results. Implementation requires a number of steps, many of which involve difficult measurement issues.

- Estimate investment in each intangible asset (see chapter 3)

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- find relevant data sources for expenditure on each intangible
 - compile a time series of nominal expenditure
 - determine the share of expenditure that is to be treated as investment
 - select appropriate deflator and deflate to get a real investment series.
 - Build a real capital stock for intangible assets (see chapter 4)
 - determine the appropriate rate of depreciation for each intangible asset
 - use the perpetual inventory method to construct a real capital stock from the real investment series and assumed depreciation rates.
 - Adjust output and income to include intangibles as per equation (2.8) (see chapter 5)
 - recalculate output (measured as market sector gross value added for Australia) to include intangibles output
 - adjust the operating surplus for market sector gross value added by adding intangibles investment.
 - Construct a volume index of capital services measures of all capital inputs (tangible and intangible) using capital stocks and rental prices (see chapters 4 and 5)
 - determine the appropriate rental price parameters for each intangible asset
 - rental prices for each asset (tangible and intangible) are derived from the adjusted operating surplus by solving for an equalising rate of return across all assets.
 - Undertake growth accounting as per equation (2.10) (see chapter 5)
 - using the data for intangibles estimated as outlined above, together with the published and unpublished Australian Bureau of Statistics (ABS) national accounts data used in standard growth accounting.

2.3 Classification of intangibles

As noted in chapter 1, CHS (2006) classify intangibles into three main categories — computerised information, innovative property and economic competencies. This classification is followed in this paper.

The three main categories of intangibles are made up of a variety of specific intangibles (as defined in CHS 2006).

- *Computerised information* is the knowledge embedded in computer programs and databases.

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- *Innovative property* includes the relatively familiar scientific R&D (reflecting scientific knowledge embedded in patents, licences and general know-how) but is much broader — including non-scientific R&D or creative property (innovative and artistic content in commercial copyrights, licences and designs).
 - *Economic competencies* include brand equity (for example, investment to retain or gain market share and investment in brand names), firm-specific human capital (employee skill building) and organisational capital (investments in strategic planning, adaptation and reorganisation).

Of these intangibles, organisational capital is perhaps the least well known. It is variously defined as:

- the body of knowledge in a firm enabling it to combine conventional factors of production in the production process (for example, business processes built around computer systems) (Brynjolfsson and Yang 1999)
- business processes, management structures and organisational systems specifically designed to maximise the value of output given available physical and human capital (quality management systems, supply chain management solutions and innovation processes for product development) (De and Dutta 2007)
- the organisational architecture and the systems for monitoring activity and communicating within the firm (Webster and Jensen 2006)
- the inherent values, relationships and practices of an organisation which contribute to performance (internal and external networks based on partnership and trust) (Healy 2005).

The individual types of intangible assets are discussed further in chapter 3 and appendix A.

Current treatment of intangible assets in Australian National Accounts

Intangibles are not easily measured and work has mainly focused on elements such as human capital and R&D. However, the identification of intangible assets in official national accounts, under the UN System of National Accounts (SNA), has been even more limited.⁹

⁹ The treatment of intangibles is, of course, only one of a number of national accounting issues under consideration. However, a discussion of these broader issues is beyond the scope of this paper.

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- The decision to capitalise software and databases, mineral exploration and entertainment, literary or artistic originals was taken under SNA93 and has been implemented in many countries.¹⁰
 - The decision to capitalise R&D was taken in 2007. According to Pilat (2007) there are no current plans for brand equity, firm-specific human capital and organisational capital to be capitalised in the SNA.¹¹

The ABS *Australian System of National Accounts*¹² includes the following intangibles in investment and capital stock series.

- computer software (purchase of software, and software developed in-house if expenditure is large, and large expenditures on the purchase, development or extension of databases)
- entertainment, literary or artistic originals (the originals of films, sound recordings, manuscripts, tapes etc on which drama performances, radio and television programming, musical performances, sporting events, literary and artistic output etc., are recorded or embodied)
- mineral and petroleum exploration (capitalised value of expenditures on exploration for petroleum, natural gas and mineral deposits).

The measurement of these ‘national accounts’ intangibles and the ‘new’ intangibles (the other intangibles in the CHS classification) is discussed in chapter 3.

¹⁰ Although this has been done in different ways, particularly for software, which affects international comparability (Aspden 2007).

¹¹ The OECD plans to release a handbook on measuring intellectual property to provide guidance on how to introduce various intangible fixed assets into national accounts (Pilat 2007).

¹² See ABS (2000, chapter 15) for details. Spectrum licences appear as experimental estimates in the national balance sheet but not the gross fixed capital formation or capital stock estimates (ABS 2000, para. 15.4).