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Research article

The measurement of intangible assets in the healthcare and public sectors: a scoping review of current knowledge

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Abstract: In recent times, economies have increasingly moved from the use and production of tangible assets to non-physical, intangible assets, such as data, software, and branding. Intangible assets are highly synergetic, scalable, less rivalrous, and appropriable than tangible assets and lead to knowledge spillovers, making them key drivers of productivity. Significant efforts have been devoted to measuring intangible assets in the private sector. However, the healthcare/public sectors have received comparably little attention, despite its importance in healthcare, as shown by the drive towards digitalisation in the recent 10-year health plan for the English National Health Service (NHS). This paper critically reviews the literature on the measurement of intangible assets in the healthcare and public sectors. It answers three questions: What methods are used to measure intangible assets in the healthcare and public sectors, what are the specific challenges of measuring intangible assets in the healthcare or public sector setting, and what would be the effect of including intangible assets in a measure of healthcare productivity? We identified 31 publications and two broad strands of literature: the intellectual capital literature, which uses indicator and survey-based methods to measure intangibles, and the Corrado, Hultens, and Sichel (CHS) framework literature, which uses national account style methods, namely the market purchase price and sum-of-costs approaches. We found that the survey and indicator-based measurements, taxonomy, and methods were not standardised, limiting the comparability of their estimates. The CHS methods were more standardised and comparable but relied on assumptions that may not hold in the public sector. The lack of market prices, market pressures, and the non-financial aims of the public sector make the measurement of intangibles challenging. The effects of these challenges on measurement were, however, generally underexplored except in the case of organisational capital. The effects of including intangible assets in healthcare productivity statistics were also underexplored.

Key words: intangible assets; intangible capital; intellectual capital; healthcare; public sector; measurement; valuation; national accounts; productivity

JEL Codes: O4, H4, EO1, C47, I1, M4

Abbreviations: AI: Artificial intelligence; CHS: Corrado, Hulten and Sichel (aka Corrado et al. 2005, 2009); GDP: Gross domestic product; GP: General Practitioner; IC: Intellectual capital; IP: Intellectual property; IT: Information technology; MFP: Multi-factor productivity; NA: National accounts [assets]; NHS: National health service [of the United Kingdom]; NNA: Non-national accounts [assets]; NPV: Net present value; OC: Organisational capital; ONS: Office for National Statistics; PIAAC: Programme for the International Assessment of Adult Competencies: PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses; PSP: Public Service Productivity; R&D: Research and Development; RQ: Research question; SNA: System of National Accounts; SPINTAN: Smart public intangibles project; SOC: Standard occupational classification; SRTP- Social rate of time preference

1. Introduction

1.1. Intangibles in the general economy and healthcare

Over recent decades, there has been an increasing transition from the "traditional" model of production of predominantly physical, tangible goods, such as buildings, vehicles, and machines, to a new model using intangible goods such as data, marketing strategies, and software (Corrado, 2024). Indeed, in the UK, intangible investment is roughly equal to investment in tangible assets (ONS 2024a, Martin, 2019). The same is increasingly true of the healthcare sector, with modern healthcare provision involving online appointments, online management, online health information, and use of healthcare data. A notable, but not unique, example of this is the recent NHS 10-year plan (UK government release, 2025). It emphasises the need to shift the NHS from "analogue to digital", as shown by the NHS federated data platform and the NHS App. As such, it is vital to properly measure intangible assets in the healthcare sector and the contribution they make in ensuring more financially sustainable, modern healthcare systems and public services.

Digitalisation is not the only way in which intangible assets are crucial to the future of the healthcare sector. Intangible assets are typically very scalable and less rivalrous than tangible assets, as well as associated with synergies with other assets and knowledge spillovers between sectors and organisations (Martin, 2024; Martin et al., 2024; Corrado et al., 2022; Corrado et al., 2017b). This is particularly relevant in the constrained budget environment of the wider public sector since the global financial crisis, with recent focus increasingly turning towards public sector productivity (BBC 2024; UK government 2024), and healthcare productivity remaining below its pre-Covid levels (Arabadzhyan et al., 2025; ONS, 2024a). In short, they are key drivers of productivity growth, and measuring their levels provides crucial insights into public sector organisation and reforms. There is also some evidence that both public and private hospitals with higher levels of intangible assets have better performance and are more efficient (Evans, 2015; Gastaldi, 2013; Scafarto et al., 2023), and that intangibles provide a competitive advantage (Rahman and Liu, 2023; Subramaniam and Youndt, 2005).

1.2. The measurement of intangible assets

Numerous methodologies have been created to measure intangible assets in the private sector, largely in the footsteps of Corrado, Hulten, and Sichel (2005, 2009) (hereafter CHS or the CHS framework), including INTANinvest, INNOdrive, and EUKLEMS. Existing literature provides comprehensive reviews of those methods (Martin et al., 2024; Osinski, 2017; Pastor et al., 2017; Van Criekingen et al., 2022). These include the income, sum-of-costs, market purchase price, and market value methods, plus various indicators that use metrics such as patents, content analysis, or surveys. Additionally, some national statistics agencies publish satellite account estimates of national accounts and non-national accounts' intangible assets, such as the Office for National Statistics (ONS) "Investment in intangible assets in the UK" (ONS, 2024a), including some intangibles for both private and public sectors.

And yet, despite significant scholarly work to determine the effects of intangible assets on private sector productivity (Bontadini et al., 2023; Corrado et al., 2009) and the inclusion of some intangible assets in national accounts, there has been relatively little attention directed towards intangibles in the public sector. The public sector is also one of the least researched areas in the intellectual capital (IC) literature; attempts to measure intangible assets in the public sector have either been one off (Bacchini et al., 2016) or refrained from disaggregating the public sector into separate sectors, such as healthcare or education (EUKLEMS). One reason for this is that intangible assets are very hard to measure. They are often "own-account", i.e., produced and used in-house, and thus have no observable market value (Corrado et al., 2005), are unique (Martin et al., 2024), and are often expensed rather than capitalised on balance sheets (Barker et al., 2022). It is also hard to isolate the benefits of a given asset and to estimate the service lives of intangibles, making their amortisation challenging.

However, these challenges exist in both the public and private sectors and so cannot explain the differences between the wealth of literature on intangible assets in the private sector and the paucity in the public sector. One public sector–specific challenge is that very few countries measure public service productivity (PSP). Even those who do, like ONS in the UK, do not disaggregate inputs into capital and labour, meaning there is less we can infer from a public sector measure of intangibles. Second, the lack of market prices for intangible assets is more marked in the public sector, which, by definition, does not provide services at a market price. Third, the lack of standardisation and measurement of intangible capital in the public sector itself makes further progress difficult.

This scoping review aims to map and synthesise existing approaches to the measurement and valuation of intangible assets in healthcare and public sector settings, to clarify current methodologies and highlight gaps for future research. Whilst we focus mostly on the healthcare sector, most of the methods and literature identified apply more broadly to the public sector as a whole. The intended outcome of this review is a structured overview of the frameworks applied, which can inform policy development and future empirical studies. In particular, we review the current literature to answer three research questions (RQs):

RQ 1: What methods are used to measure intangible assets in the healthcare and public sectors?

RQ 2: What are the specific challenges posed to the measurement of intangible assets by the healthcare or public sector setting?

RQ 3: What would be the effect of including intangible assets in a measure of healthcare productivity?

We identify 31 publications and two broad strands of literature: the intellectual capital literature, which uses indicator and survey-based methods to measure intangibles, and the CHS framework literature, which uses national accounts–style methods, namely the market purchase price and sum-of-costs approaches. We find that the survey and indicator-based measurements' taxonomy and methods were not standardised, limiting the comparability of their estimates. The CHS methods were more standardised and comparable but relied on assumptions that may not hold in the public sector. The lack of market prices, market pressures, and the non-financial aims of the public sector make the measurement of intangibles challenging. The effects of these challenges on measurement were, however, generally underexplored, except in the case of organisational capital. The effects of including intangible assets in healthcare productivity statistics were also underexplored.

2. Defining intangible assets

Intangible assets, sometimes known as knowledge capital, are typically categorised and defined as non-physical assets, following the seminal CHS framework (Corrado et al., 2009; 2005) (shown in Table 1). An asset is defined, in the System of National Accounts (SNA), as a durable store of value. That is, it provides identifiable economic value to its owner and lasts for more than one period (usually one year) (SNA 2025 11.10). Therefore, conceptually, there is no good reason to consider physical, tangible assets as capital but not intangible assets, purely because they are not physical.

From this framework, numerous measures of intangible assets in the private sector have emerged, such as INTANinvest, INNOdrive, and EUKLEMS. Indeed, many intangible assets are capitalised in national accounts. These are databases (expanded in SNA 2025 to include data itself), software and R&D, artistic originals, mineral exploration, purchased goodwill, contracts, and miscellaneous intellectual property products (Bavdaž et al., 2023; SNA, 2025). Some national statistical agencies also publish satellite account estimates of national accounts and non-national accounts' intangible assets, such as the ONS "Investment in intangible assets in the UK" series (ONS, 2024a).

Table 1. Different categories of public and private sector intangibles in CHS and SPINTAN.

Market sector Asset category	Asset	Public sector Asset category	Asset
Computerised information	Software	Information, scientific, and cultural assets	Software
	Databases		Databases, including open data
Innovative property	R&D		Basic and applied science research, industrial, and defence R&D
	Entertainment and artistic originals		Cultural and heritage, including design
	Design		Mineral exploration
	Mineral exploration	Societal competencies/social infrastructure	Brands
Economic competencies	Organisational capital (OC) (managerial and purchased)		Organisational capital (OC) (professional/managerial and purchased)
	Brands		Function-specific human capital
	Firm-specific human capital		Schooling-produced human capital

These methods and the CHS framework are aligned with national accounts principles, which allow for three ways to measure asset value. The market purchase price method defines an asset's value as its market price or a market price that can be imputed from numerous similar transactions; the sum-of-costs method values the asset as the sum of the deflated investment flows into it; and the income method values an asset as the net present value (NPV) of its expected future economic benefits accruing to its owner (Martin et al., 2024; Reilly, 2012a; 2012b; Reilly and Rabe, 1997; SNA, 2025).

A second categorisation comes from the management side of the literature and focuses on intellectual capital (IC). IC has a less settled definition, a problem that will be further explored later, but generally, it consists of human, relational, and structural capital (as shown in Table 2, which defines a typical taxonomy of intellectual capital) (Bontis, 1998; Mura et al., 2012; Stewart, 1997; Subramaniam, 2005; Yang, 1965; Youndt and Snell, 2004). Structural capital, which most commonly refers to institutionalised knowledge and organisational practices, sometimes includes IT systems but not always (Evans et al., 2015).

Table 2. Outline of intellectual capital definitions. Source: Own adaption of Evans et al. (2015).

Type of intellectual capital	Definition	Examples
Human capital	Knowledge, skills, and experiences owned and used by individuals (CHS methods would consider this as an asset of the individual, not a firm, and so part of labour quality, not capital)	Professional competencies and judgment, specialised skills, context-specific knowledge, leadership and managerial skills, and personal dispositions
Structural capital	Institutionalised knowledge and codified experience stored in databases, procedures, and the organisational culture	Vision, mission, values, strategic plan programs, tools, information systems, ways of working together, best practices, and routines
Relational capital	Knowledge available through networks of relationships, internal and external to the organisation	Patient/caregiver views and experiences, nature of internal clinical-managerial relations, contracts/agreements and partnerships with other service providers or with the government, research institutions, consultants, etc., brand, image, and reputation in the community

3. Methods

3.1. Purpose

This scoping review aims to map and synthesise existing approaches to the measurement and valuation of intangible assets in healthcare and public sector settings, to clarify current methodologies and highlight gaps for future research. The intended outcome of this review is a structured overview of the frameworks applied, which can inform policy development and future empirical studies. We discussed the intended review with stakeholders such as Sara Zella of the ONS Public Service Productivity team and Professor Jonathon Haskell of Imperial College London, who agreed with the usefulness of such a review.

3.2. Review methods

Our methodology is informed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses-Extension for Scoping Reviews (PRISMA-ScR) statement (Tricco et al., 2018) and the Arksey and O'Malley (2005) and Levac et al. (2010) scoping review methodologies.

To justify the need for this review, a search of the Cochrane Database of Systematic Reviews (CDSR) was conducted to identify if any reviews (existing or ongoing) about this topic already exist. None were found. Three similar papers were, however, identified during the review. Dumay et al. (2015), Evans (2015), and Paolini (2020) reviewed studies on intellectual capital (IC) in healthcare or public sector institutions. However, they all focused exclusively on IC, which is only part of the spectrum of intangible assets. Further, their focus was mainly on the management and importance of IC, and when they do consider measurement, they focus largely on relative measures and miss key literature such as the Smart Public Intangibles project (SPINTAN, 2016) (henceforth, SPINTAN). As such, there is a gap in the literature for this review.

3.3. Identifying relevant studies

Using controlled vocabulary terms, free text, and Boolean operators, search strategies were constructed with insights from the University of York's social science librarian. The strategy used key terms associated with intangible assets and public services, found from an extensive pre-reading of the private sector intangible literature and preliminary searches on SCOPUS, Web of Science, and PubMed. We then used these terms to search the titles and abstracts of English language papers on SCOPUS, Web of Science, and PubMed databases. While limiting the searches to three databases may result in omitting some studies, we believe that given the comprehensiveness of the selected databases, we were able to identify the vast majority of relevant existing literature. The period 2005–2025 was chosen to focus on papers at least influenced by Corrado et al. (2005); see Box 1 for the full list of inclusion and exclusion criteria.

Box 1: Inclusion and exclusion criteria.

Inclusion criteria:

1) The publication must be free to access and in English; 2) the publication must concern the measurement of intangible assets 3); the paper must concern healthcare or the public sector at large; 4) it must be from 2005, so it is at least influenced by the Corrado et al. (2005, 2009) (CHS) framework.

Exclusion criteria:

1) The publication was not accessible for free; 2) the paper was not in English; 3) the paper does not explicitly measure intangible assets; 4) the paper does not concern the public sector (including papers that focus on publicly owned corporations and government sponsored enterprises).

The search terms chosen can be categorised in three groups. The first included the term "intangible asset(s)" and its various synonyms. It also included the CHS categories and specific types

of assets. A wide range of terms was chosen, as there is no consensus on the taxonomy of intangible assets. The second group ensured that the publications concerned the healthcare sector or public sector at large.[1] It also included the term "non-market", as although not identical to the public sector, the principle of measuring intangible assets without market prices is relevant. Finally, the third group ensured that publications focussed on the measurement or valuation of intangible assets. We used these search terms to conduct a title and abstract search in SCOPUS, Web of Science, and PubMed (see sections A and B in the supplementary information for a full breakdown of the review protocol and search strategy). We chose two databases with a significant focus on economics and one with a significant focus on health care to achieve a balance. The initial search terms were from a wider reading of the general intangible assets literature and experimental database searches.

We found that terms such as "brand*", "software", and "design" led to the inclusion of many unrelated results. Further, assets like mineral exploration and artistic originals are not very relevant to the public sector. We therefore refined the search strategy (Box 2), which greatly increased feasibility at little cost to comprehensiveness. Once duplicates were removed, there were 650 papers to screen (Figure 1). We also performed a citation search from the papers identified in the search. Some of the grey literature was identified in this manner. Some, but not all, papers associated with projects such as SPINTAN and Globalinto were available on the searched databases and citation searching expanded these results to include all associated papers.

Box 2: Search terms used.

1) "intangible assets" OR "intangible capital" OR "public intangibles" OR" intellectual capital" OR "intellectual property products" OR "knowledge capital" OR "knowledge asset*" OR "computer* information" OR "economic competencies" OR "innovative property" OR "data assets" OR "digital assets" OR "organisational capital" OR "brand*" OR "Design" OR "software" OR "artistic originals" OR "mineral exploration"
Terms relating to intangible assets
AND
2) "healthcare" OR "human health activities" OR "health sector" OR "public sector" OR "public service" OR "non-market"
Terms relating to the health sector and the public sector at large
AND
3) "measure*" OR "value" OR "valuation" OR "assess*" OR "national account*" OR "productivity"

[1] Given that most healthcare in the UK is a public sector activity, both the wider public sector and healthcare share the main challenge of measuring intangible assets in the public sector: the lack of market prices. This means methods applied to the wider public sector are applicable to healthcare.

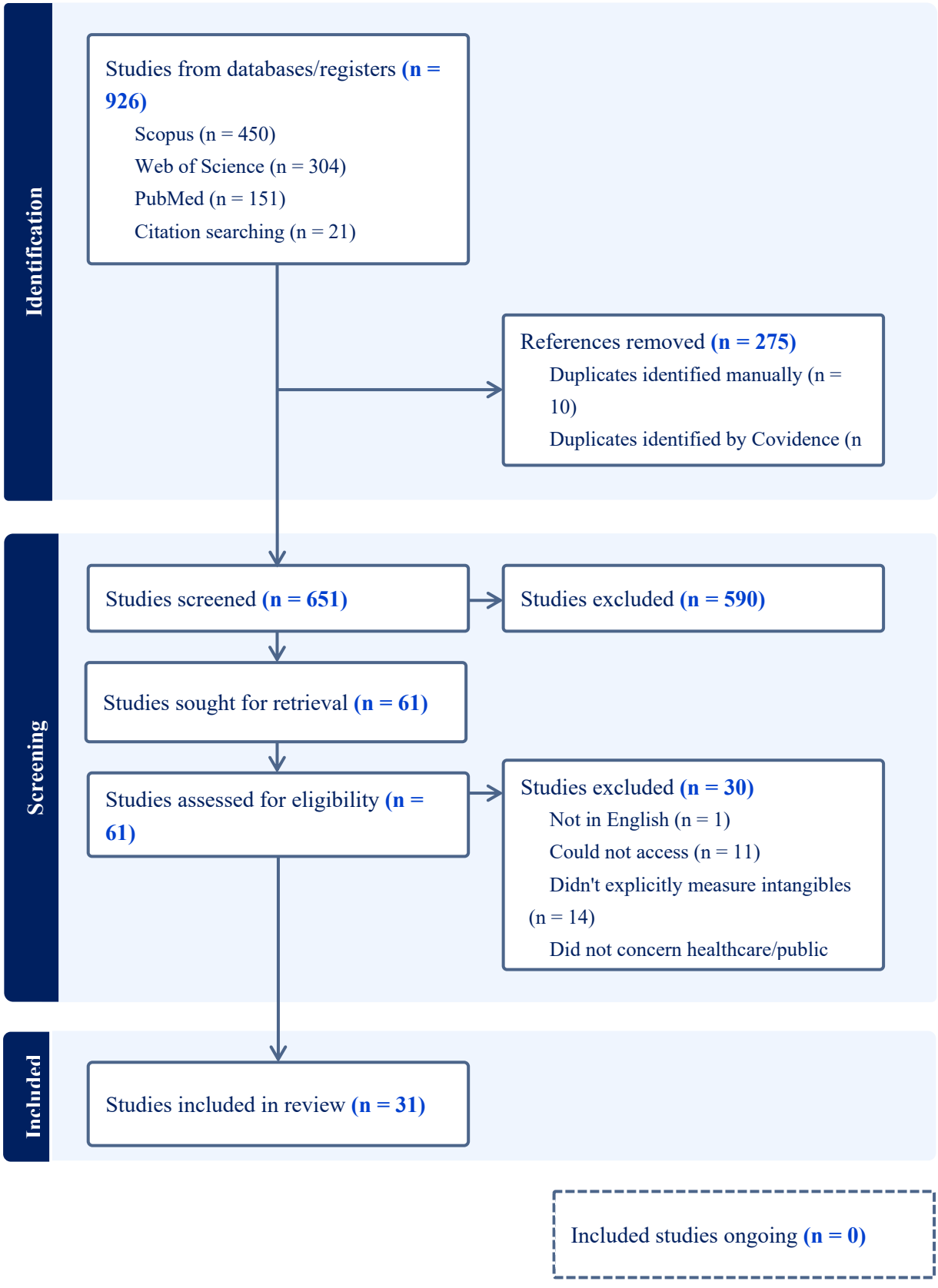

Figure 1. PRISMA diagram.

3.4. Screening

Two reviewers[2] independently screened the literature search results. To ensure consistency, a four-step procedure was used for study selection. Both reviewers screened titles and abstracts of the search results against the inclusion and exclusion criteria, and sorted them into three categories: "In", "Out", and "Undecided." Then, conflicts were resolved via discussion. Third, both reviewers independently screened the full texts to determine which should be included according to the inclusion criteria. All "Undecided" articles and disagreements were resolved through discussion. Finally, CW screened the references of the papers in the "Included" category for any further potentially relevant papers and added them to the screening stage, wherein they were subjected to the same procedure as the other papers. Numerous grey literature publications were identified, such as the SPINTAN and Globalinto projects.

3.5. Data extraction

A spreadsheet was created to chart the informational details extracted from the articles included in the review. CW extracted this information (see section C of the supplementary information for a full summary) and AC assessed it for accuracy and to ensure it covered appropriate information. Following this, we summarised the characteristics of included studies in a descriptive numerical form. We then conducted a qualitative thematic synthesis of the approaches to measuring intangible assets, to identify key patterns and conceptual frameworks. Finally, we considered the broader implications of these findings for future research.

4. Results

The search strategy identified 650 unique publications from the databases, with a further 20 added through citation searching. In total, 61 studies were considered for full text review and, of these, 14 were excluded because they did not contain a method of measuring one or more intangible assets, 1 was excluded because the full text was not in English, and 11 were excluded because we could not access them. Ultimately, 31 met the inclusion criteria and were included in the final review (a full summary of included papers can be found in section C of the supplementary information). Many key outputs in this field are published as project deliverables or working papers rather than journal articles, so these publications were treated as eligible grey literature, provided they met the inclusion criteria. Restricting the search to English language papers resulted in only the exclusion of only one paper, though this is likely due to the keywords used in the search being in English. The absence of non-English keywords in the search potentially means some relevant papers were excluded from the review, representing a possible weakness of the paper.

4.1. Overview of study characteristics

The full information can be found in section C of the supplementary information, but some key themes have been summarised in Box 3.

[2] The two reviewers are the main author (CW) and the second author (AC).

The included sources were largely published in the latter half of the period 2005–2025 and included an even mix of empirical studies (n = 15) and methodological proposals (n = 16). The methods of measurement used were also a mixture of survey-based (n = 7), indicator-based (n = 6), survey and indicator–based (n = 5), and CHS methods (n = 13) (Dumay et al. 2015, Elena 2020 and Evans et al. 2015). Belmonte et al. (2021) proved difficult to categorise given it constructed indicators from accounting data. Some of the studies came from grey literature projects; most significantly, SPINTAN provided eight papers. Although these pertained to the same project, and so contain similar methods, we decided to include them. Some followed the intellectual capital framework (n = 11) and others (n = 16) the CHS framework, which is analogous to national accounts methods. Others (n = 4) followed their own framework. Around 35% of the papers identified specifically focussed on healthcare, a similar percentage to that reported by Dumay et al. (2015) (40%). The research was predominantly based in European countries; however, the CHS-type articles aimed at creating internationally applicable methods. The review identified three broad types of measures: surveys, indicators, and national accounts measures (market purchase price and sum-of-costs). These are the same methods as those identified in private sector reviews of methods, the only difference being the absence of any income methods in the public sector (see Martin et al., 2024; Osinski, 2017; Pastor et al., 2017; Van Criekingen et al., 2022).

Box 3: A summary of the themes in the literature.

Method of measuring intangibles: Surveys = 7 Indicators = 6 Mix of surveys and indicators = 5	**Year of publication:** 2005–2025
Project SPINTAN = 8 Globalinto = 2 EUKLEMS = 1	**Empirical or methodological** Empirical = 15 Methodological = 16
Sector of measurement: Healthcare = 11 Whole public sector = 15 Local government = 2 Universities = 3	**Types of intangibles used:** Intellectual capital = 11 National accounts/CHS = 16

4.2. Methods to measure intangible assets in the healthcare and public sectors (Research question 1)

4.2.1. Intellectual capital vs. CHS intangibles

We identified two broad strands of literature; the intellectual capital (IC) framework literature, derived from the management literature, and the CHS framework literature, originating from the economics, national accounts literature. The IC literature tended to use survey and indicator methods, resulting in non-monetary measures. Dragomir (2024) noted that many elements of IC cannot be monetised. Dumay et al. (2015) noted that a significant proportion of the IC literature focuses on management over measurement, with a preference for cross-sectional over longitudinal measures, unlike the CHS literature.

The CHS literature uses national accounts–type measures, which do result in monetary measures. The boundaries of IC are inconsistent across publications; most papers broadly accept the tripartite division of IC into human, structural, and relational capital (Table 2). The CHS literature broadly follows the CHS and national accounts definitional framework. The SPINTAN project notably follows the CHS definitions (shown in Table C3 in the Appendix) but adds and redefines some categories. Saam et al. (2016), however, deviated from the SPINTAN categories. Dekkers et al. (2006), Erickson and Rothberg (2017), and Lytras and Ordonez de Pablos (2009) followed neither taxonomy, limiting their comparability.

4.2.2. Survey methods

Surveys typically involve asking respondents to rate either the relative importance of various subcategories of IC to their organisation (e.g., Wall, 2005) or to answer questions designed to illustrate the level of IC at their organisation. These rankings or answers are then collated into an index to give an overall level or importance of IC in an organisation.

About 39% of the identified studies used surveys to measure intangible assets (Basal et al., 2023; Chulski, 2023; Belmonte et al., 2021; Dekkers et al., 2006; Dumay et al., 2015; Fazlagić and Szczepankiewicz, 2018; Fleckenstein et al., 2023; Garlatti et al., 2015; Elena, 2020; Peng et al., 2007; Wall, 2005). Of the reviews, Evans et al. (2015) found that all but two of the quantitative studies used survey methods, the most common method they identified. Dumay et al. (2015) found nine studies[3] that used surveys, whilst Elena (2020) found 10 studies that used surveys or interviews. Likert scales are common (Chulski, 2023; Belmonte da Silva et al., 2021; Fazlagić and Szczepankiewicz, 2018), but there is no standard method of constructing questions or collating responses into a ranking.

4.2.3. Indicator methods

We use the term "indicator methods" to describe publications that use proxy data points (aka metrics) to indicate the level of a given intangible asset. Examples of indicator methods include using the rate of participation in research projects, R&D expenditure, and drop-out rate to measure the IC of public universities (Ramírez, 2017), or using the number and occupation of staff, exposure to the media,

[3] Note: None of the reviews focused specifically on the measurement of IC; they mostly focused on the definitions and roles of intangible assets.

and percentage of budget derived from external funds to proxy human, relational, and organisational capital, respectively, in the context of the healthcare sector (Lytras and Ordonez de Pablos, 2009). The level of an asset at a given organisation can thus be compared directly, for example, by comparing the R&D expenditure between organisations. Various indicators can also be collated into an index to give a broader measurement of intangible assets but, like with the survey method, there was no standardised method of indexation. Some identified literature also included elements aimed at capturing the quality as well as the quantity of an asset, most commonly by introducing survey questions into the indicator method.

About 35% of the publications identified in this review used indicators in some capacity (Dragomir, 2024; Dumay et al., 2015; Erickson and Rothberg, 2017; Evans et al., 2015; Fazlagić and Szczepankiewicz, 2018; Garlatti et al., 2015; Elena, 2020; Lytras and Ordonez de Pablos, 2009; Pirozzi and Ferulano, 2016; Ramírez, 2017; Ramírez, 2010). Of the reviews, Evans et al. (2015) found indicators and semi-structured interviews to be the second most common method of measurement. Neither Dumay et al. (2015) nor Elena (2020) stated explicitly how many of their included papers used indicator methods, but we identified at least 15 that used indicators in Dumay et al. (2015)[4] and 10 that used indicators in Elena (2020). The method in Dragomir (2024) was difficult to categorise, because it used indicators based on accounting data using national accounts methods. However, it was judged to be more similar to the indicator methods than the national accounts–type methods. It also used its own categorisation of assets, making it difficult to compare to others.

4.2.4. National accounting/CHS methods

In this subsection, we group the methods that follow the SNA and CHS framework (Bacchini et al., 2016; Berger, 2018; Corrado et al., 2017a; Corrado et al., 2016; Heiling, 2025; Le Mouel et al., 2016; O'Mahony et al., 2016; Piekkola et al., 2020; Redek et al., 2021; Saam et al., 2016; Schulz and Beckmann, 2016; Stehrer et al., 2019; Stokes et al., 2016). These measure intangible assets in monetary terms using the market purchase price or the sum-of-costs methods.

Around 42% of the studies reviewed used these methods, with papers published as part of the SPINTAN project (Bacchini et al., 2016; Corrado et al., 2017a; Corrado et al., 2016; Le Mouel et al., 2016; O'Mahony et al., 2016; Saam et al., 2016; Schulz and Beckmann, 2016; Stokes et al., 2016) being the most common. As shown in Appendix Table C3, the categories in SPINTAN are slightly different to the CHS framework, with schooling-produced human capital and cultural assets added as assets. The papers from the Globalinto project (Piekkola et al., 2020; Redek et al., 2021) covered IT (software), R&D, and organisational capital assets, whilst EUKLEMS (Stehrer et al., 2019) covered all CHS intangibles. At the time Dumay et al. (2015) and Evans et al. (2015) were published, no national accounts–style methods existed for the public sector[5], and Evans et al. (2015) noted that very few papers used "intellectual capital accounting". Elena (2020) also did not identify any such publications. Berger (2018) and Heiling (2025) focused on the International Public Sector Accounting Standards (IPSAS), a guideline for accounting in public sector entities, covering only assets already capitalised in the national accounts. The methods used in Bacchini et al. (2016), Berger (2018), Corrado et al. (2017a), Corrado et al. (2016), Heiling (2025), Le Mouel et al. (2016), O'Mahony et al.

[4] Mostly in the section "F. IC frameworks and models".

[5] These were published in the same year as SPINTAN.

(2016), Piekkola et al. (2020), Redek et al. (2021), Saam et al. (2016), Schulz and Beckmann (2016), Stehrer et al. (2019) and Stokes et al. (2016) essentially extend CHS to the public sector.

When assets are purchased from outside the organisation, they are valued using the market purchase price method. This means their value is taken as their market price, the price the organisation buys them for. For example, SPINTAN suggests using accounts data (on micro level) or input-output tables (on macro level) to retrieve information on purchased consultancy services to approximate the value of organisational capital[6]. The market purchase price method (Berger, 2018; Corrado et al., 2017a; Corrado et al., 2016; Heiling, 2025; Piekkola et al., 2020; Redek et al., 2021) also allows for measurement by imputation. That is, if an active market for an asset exists, we can impute a market price for a good even if the good itself has not been transacted. However, as public sector intangible assets are often unique and "own-account", this is very rarely practicable.

When they are produced and used in-house ("own-account"), they are measured using the sum-of-costs method. This means they are valued as the net present value of past investment in the asset, subject to depreciation. In practice, this implies identifying what occupation groups are responsible for the production of a given asset and summing their gross wage cost across a given sector, asset, or economy. Identifying what occupations are responsible for producing intangible assets is often a major challenge, and Corrado et al. (2017a), Piekkola et al. (2020), and Redek et al. (2021) addressed this extensively, providing a methodological guide for practitioners. For example, in the SPINTAN paper by O'Mahony et al. (2016), the authors calculated own-account investment in organisational capital in the English NHS as the number of employees in general manager, clinical manager, and consultant occupations from NHS Staff Census data multiplied by their wages, from NHS Staff Earnings data. They multiplied the number of consultants and other staff by a factor of 0.2, thereby assuming they spend 20% of their time on non-clinical activities. This is further multiplied by 0.2, assuming that 20% of non-clinical activity results in durable organisational capital. The estimates of 0.2 are assumptions taken from Corrado et al. (2005), reflecting the lack of appropriate evidence for them. The sum-of-costs method also requires the estimation of certain coefficients, or factors, which are applied to the wage costs. They account for the proportion of time a given occupational group spends producing a given asset (time factors), the non-labour costs used in production (uplift factors), and the fraction of these productive efforts that results in actual capital that is durable and provides economic benefit, rather than being day-to-day spending (capitalisation factors). The wage costs are adjusted by these factors and are summed to get the investment in an asset. When we are concerned with multiple periods of time (Bacchini et al., 2016; Berger, 2018; Corrado et al., 2017a; 2016; Piekkola et al., 2020; Redek et al., 2021; Stehrer et al., 2019; Stokes et al., 2016), these investment flows are converted into a capital stock (the value of the asset at a given time) using the perpetual inventory method, which can be summarised in equation 1 below. As such, the value of an asset at any given time is the sum of investment up to the present period, minus depreciation.

$$K_t = \sum_{j=0}^{T-1} d^j I_{t-j} + d^T K_{t-T} \text{ or more simply } K_t = K_{t-1}(1-d) + I_t \quad (1)$$

where K_t is the current capital value, I_{t-j} is investment, d is the depreciation rate, and j is the iteration index. Source: own adaptation of Martin et al. 2024.

[6] For a more detailed guide to practicing the CHS method, see the SPINTAN manual (Corrado et al. 2016).

4.3. Challenges posed by measuring intangible assets in the healthcare or public sectors (Research question 2)

Some common themes emerged about the effects of the healthcare or public sector setting on the measurement of intangible assets. In the IC literature, a broadly shared consensus was that it was under researched compared to the private sector (Dumay et al., 2015; Evans et al., 2015; Pirozzi and Ferulano, 2016; Ramírez, 2010; Stehrer et al., 2019), with more focus on understanding the taxonomy of intangibles than measurement, especially financial measurement (Dumay et al., 2015; Evans et al., 2015). Some argued financial measurement was not appropriate for the public sector as it could not adequately capture all elements of IC, especially in the absence of market prices (Dekkers et al., 2006; Evans et al., 2015). This view is not shared by Bacchini et al. (2016), Berger (2018), Corrado et al. (2017a), Corrado et al. (2016), Heiling (2025), Le Mouel et al. (2016), O'Mahony et al. (2016), Piekkola et al. (2020), Redek et al. (2021), Saam et al. (2016), Schulz and Beckmann (2016), Stehrer et al. (2019) or Stokes et al. (2016). There is also an agreement that IC in the healthcare sector is different because it is a knowledge-intensive industry (Peng et al., 2007; Pirozzi and Ferulano, 2016; Ramírez, 2010), is politicised, has more stakeholders and users, has a large amount of indirect payments, many staff are contractors and there are information asymmetries (Belmonte da Silva et al., 2021; Evans et al., 2015; Pirozzi and Ferulano, 2016; Stehrer et al., 2019). Further, Peng et al. (2007) suggested relational capital is particularly important for hospitals and implied that, as healthcare systems are often near monopsonies, market prices may not be reliable. Erickson and Rothberg (2017) found that brand equity, close customer relationships, and systematisation of processes are more developed in retail than in healthcare. In general, there was an agreement that the public sector has a larger degree of intangibility, for example in its aims and services provided, than the private sector, with Ramírez (2010) suggesting this makes it a good place to measure intangibles.

The CHS-type literature comments further on this question, with a broad agreement that the absence of market prices in the public sector makes measuring intangibles challenging. Corrado et al. (2017a) and Corrado et al. (2016) reclassified the CHS assets from "computerised information", "innovative property", and "economic competencies" to "information, scientific and cultural assets" and "societal competencies/social infrastructure" (Appendix Table C3). They noted that most assets, especially R&D, are the same in private and public sectors (and so can be measured in the same way). Whilst some assets, like branding, may not appear to translate well across sectors, in the papers we review, it is outlined how investments in branding for the public sector can be thought of as investments in export promotion, tourism promotion, and consumer product safety, i.e., investments in product reputation, the same concept as private sector branding. Within the SPINTAN project literature, data and organisational capital are treated differently to the CHS private sector framework, whilst cultural heritage and schooling-produced human capital are added as an asset.

4.4. What would be the effect of including intangible assets in a measure of healthcare productivity? (Research question 3)

Whilst the effect of capitalising intangible assets on productivity statistics is a focus of private sector literature (Bontadini et al., 2023; Corrado et al., 2009), it is rarely mentioned in the public sector literature, with only Corrado et al. (2017a; 2016) discussing it, despite a consensus that intangible assets positively affect productivity and performance (Bacchini et al., 2016; Chulski, 2023; Belmonte

da Silva et al., 2021; Erickson and Rothberg, 2017; O'Mahony et al., 2016; Pirozzi and Ferulano, 2016; Ramírez, 2010; Redek et al., 2021; Schulz and Beckmann, 2016; Stokes et al., 2016). Correspondingly, the public sector is not included in the ONS multi-factor productivity (MFP) statistics. This is because, as public sector services are not provided at fair market price, it is difficult to compare them to private sector outputs, which are measured using market prices. Corrado et al. (2017a; 2016) suggest imputing a return to public sector capital to surmount this problem and suggest the social rate of time preference (SRTP) as the best option. There is no discussion of intangibles' role in healthcare specific productivity measures, such as the ONS Public Service Productivity (PSP) measure.

5. Discussion

5.1. Discussion of the existing measurement methods

5.1.1. Intellectual capital vs. CHS intangibles

Overall, the definitions of intellectual capital were inconsistent, making these publications context-specific and limiting their comparability. Generally, the IC literature followed a tripartite division of assets into relational, human, and structural capital (Table 3), but this was not universally followed. The boundaries, particularly of structural capital, and even the broad concept of IC, were not conclusively defined (Evans et al., 2015; Peng et al., 2007; Pirozzi and Ferulano, 2016), and there was significant variation amongst studies. Most importantly, ICT assets were sometimes included in structural capital and sometimes not. This means there is little consistency in the IC literature, and different studies measured very different things, making it hard to compare them. Indeed, Evans et al. (2015) noted that about 40% of its included papers did not give a detailed definition for IC, making it challenging for them to be judged or interpreted appropriately.

Table 3. A summary of the types of intellectual capital[7].

Type of intellectual capital	Definition	Examples
Human capital	Knowledge, skills, and experiences owned and used by individuals *(CHS methods would consider this as an asset of the individual, not a firm, and so part of labour quality, not capital)*	Professional competencies, specialised skills context-specific knowledge, leadership, and managerial skills
Structural capital	Institutionalised knowledge and codified experience stored in databases, procedures, and the organisational culture	Vision, mission, values, strategic plan programs, tools and information systems, best practices, and routines
Relational capital	Knowledge available through networks of relationships internal and external to the organisation	Patient/caregiver experiences, internal clinical-managerial relations, contracts and partnerships with external organisations, brand/reputation

By contrast, the CHS literature generally more clearly defines its taxonomy of intangible assets, greatly increasing its comparability and external validity. This is because it broadly follows the seminal CHS paper by Corrado et al. (2005). Details of the 2005 and SPINTAN categorisation is shown in Table 4. In the CHS literature, public sector intangibles follow the SNA in its definitions of assets, into

[7] Source: Own adaptation of Evans (2015).

types such as software, data, organisational capital, etc. The categories were somewhat less clearly defined, with some not detailing categories and others, such as Corrado et al. (2016), slightly modifying categories compared to private sector alternatives (see Table 3 for details). As, however, assets are measured on a type, not category level, this made little practical difference to measurement.

Table 4. Comparison of the categories and types of assets in public and private sector intangible assets. Source: own adaptation of Corrado et al. (2016; 2005).

Market sector Asset category	Asset	Public sector Asset category	Asset
Computerised information	Software	Information, scientific, and cultural assets	Software
	Databases		Databases, including open data
Innovative property	R&D		Basic and applied science research, industrial, and defence R&D
	Entertainment and artistic originals		Cultural and heritage, including design
	Design		Mineral exploration
	Mineral exploration	Societal competencies/social infrastructure	Brands
Economic competencies	Organisational capital (OC) (managerial and purchased)		Organisational capital (OC) (professional/managerial and purchased)
	Brands		Function-specific human capital
	Firm-specific human capital		Schooling-produced human capital

5.1.2. Survey methods

The survey methods identified were often not comprehensively explained, particularly in how results were turned into an index (Chulski, 2023; Belmonte da Silva et al., 2021; Fazlagić and Szczepankiewicz, 2018; Fleckenstein et al., 2023; Garlatti et al., 2015; Wall, 2005), survey questions often used overly technical language (Dumay et al., 2015), whilst question form and content as well of the method of creating the index were not standardised. Even within asset types, this lack of standardisation continues. This assessment concurs with Dumay et al. (2015) and Evans et al. (2015), who highlighted inconsistency in the measurement of IC in the health and public sectors. Compared to the general IC literature, the literature on the healthcare and public sectors was less concerned with financial valuation; Dumay et al. (2015), published before SPINTAN, highlighted that there were no papers that used accounting-based measures to value public sector intangibles. The survey method itself is also limited. Whilst it can capture the quality of assets well, it lacks external validity. It produces relative measures, which, whilst sufficient to answer the studies question, are ordinal and highly contextual. This lack of a standard method and the flaws associated with the methods means it is not possible to compare results between studies or between assets, and any results of a survey-based method are only valid within the direct context of that study.

Additionally, it is questionable whether surveys are a valid method of measuring intangible assets, even in a relative sense. Martin (2024) and Bavdaž et al. (2023) highlighted the challenges of surveying businesses about intangibles, noting the difficulties people have in conceptualising and isolating them, given that they are often "own-account" and subject to spillovers and synergies. Therefore, even for the same asset in the same survey, we may not be able to compare results between different respondents.

Further, surveys are typically expensive and administratively challenging to run, making them difficult to repeat. Whilst, in the absence of depreciation rates or deflators, we may expect changing responses over time to provide an element of intertemporal comparison, the practical difficulties of this make it unlikely in reality. Overall, survey methods give results that lack external validity, are unreliable, and are hard to reproduce.

5.1.3. Indicator methods

Indicator methods tend to contain some objective measures, giving them an advantage in objectivity and comparability over survey methods. For example, a measure of data holdings per firm in gigabytes (GB) is an objective, comparable metric. However, they typically capture the quantity dimension of assets better than their quality dimension. Continuing the data example, the number of gigabytes a firm holds tells us nothing about the quality or value of this data, as one gigabyte of some data may be vastly more useful and valuable than a gigabyte of another kind of data. In other words, this does not necessarily mean results are more comparable than with survey methods. Some papers mitigate this by also including indicators to capture quality; however, these quality indicators introduce an element of subjectivity in measurements that reduces comparability and objectivity. This is particularly true when these indicators are based on survey information, like in Lytras and Ordonez de Pablos (2009). Indicator methods are also typically less costly than re-administering surveys, as they frequently use data already collected by organisations for a different purpose. As with the survey method, the lack of a standard method of indexing results or a standard set of indicators for a given asset reduces the external validity of results significantly.

Indicators also do not directly measure the asset, only proxy the level of an asset. For example, one identified indicator was raining expenditure per employee. This appears to be analogous to a measure of investment, but it does not account for what proportion of this spending results in the formation of durable capital. It also does not account for potential depreciation or discounting, as it has not intertemporal dimension. To summarise, the correlation between an asset and an indicator may not be high enough to truly capture the value of the asset. Further, efforts to address this by adding more indicators typically result in overly complex sets of indicators, such as in or Dekkers et al. (2006) or Lytras and Ordonez de Pablos (2009), producing results that are hard to interpret and more difficult to measure. Finally, similar to the survey methods, indicator methods do not measure assets in a comparable, standardised unit, such as money. It is not possible, under this method, to compare assets like data (measured in GB) to training expenditure per employee. Moreover, due to the absence of quality and intertemporal elements, even comparisons within assets, where units are shared, are limited in reliability, although they are more feasible than under survey methods.

Overall, the lack of agreed standard indicators for any one asset, the absence of quality and intertemporal elements, and units being different for different assets limit the comparability, quality, and usefulness of the results of indicator-based methods, especially for national accountants. They are however, in some dimensions, an improvement on survey-based methods.

5.1.4. National accounting/CHS methods

A key advantage of CHS methods is that they allow comparison of assets of different types in different settings intertemporally and between different publications as they use a common unit that

captures quality and quantity: the monetary unit. This gives it a considerable advantage over the other methods and makes it the only real choice from a national accounting perspective.

Further, if the assumptions underpinning the market purchase price and sum-of-costs methods are valid, these methods can be used for both the public and private sector, increasing comparability. These methods are also already used in the national accounts to capitalise certain intangible assets such as data and software (Corrado et al., 2017a; 2016). Therefore, data for these assets can be taken directly from the same sources used for the national accounts[8], making valuations easier to calculate for a researcher. Companies on an individual level also collect this data, making it possible to be used on a micro level and higher levels. It also means intangible assets not currently included in the national accounts could be integrated into them in the future. Finally, these methods are repeatable and reproducible. As stated, they are based on data that largely already exist in the UK (such as the Annual Survey of Hours and Earnings, Labour Force Survey, and Gross Fixed Capital Formation data[9]) and can be repeated yearly with greater ease and with no direct costs to researchers.

However, while the CHS methods provide good frameworks, they are limited by the absence of sufficient evidence on estimates of the time, uplift, and capitalisation factors for the public sector. These factors are used in the sum-of-costs methods to adjust labour costs for the proportion of time used by a given occupation on creating intangible assets (time factors), the use of other capital assets in the formation of intangible assets (uplift factors), and the proportion of investment that results in durable assets rather than day-to-day spending (capitalisation factors). Instead, estimates are often taken from private sector equivalents, which are of questionable relevance to the public sector. These private sector factors are often themselves based on limited evidence. For example, Stokes et al. (2016) created time and capitalisation factors for a specific project, but these could not be used more generally. Meanwhile, Berger (2018) provided a guideline for individual organisations, and therefore not an economy-wide method, which allows organisations to estimate their own factors. All this means these methods could result in significant misestimates of value and consequently misallocation of scarce public sector resources.

The perpetual inventory method, used within CHS methods, involves estimation of deflators to convert nominal costs into real costs, allowing intertemporal comparisons, and depreciation rates, which capture the decline in value of assets over time.[10] As intangible assets have not been recognised for very long and are often "own-account", often there is not sufficient price data to construct accurate deflators. These inaccuracies can lead to significant underestimates in value, especially for fast evolving technologies (Abdirahman et al., 2022), which could potentially lead to misallocation of healthcare resources. As regards depreciation, intangible assets are also subject to it despite their lack of physical wear and tear through economic obsolescence (Corrado et al., 2017a; Corrado et al., 2016; Piekkola et al., 2020; Redek et al., 2021). Similarly to the time, uplift, and capitalisation factors, depreciation rates for intangible assets are largely based on private sector measurements, except for

[8] Specifically, the gross fixed capital formation (GFCF) section.

[9] The Annual Survey of Hours and Earnings, Labour Force Survey, and Gross Fixed Capital formation, respectively.

[10] The geometric depreciation rates used in all these studies consist of an estimate of service life and a balance factor, which determines how "front-heavy" the depreciation is. This has an interesting implication that economic service life is shorter than the actual estimated service life.

the depreciation of organisational capital in Corrado et al. (2016)[11]. These are likely overestimates; the reasons for this are discussed further in 5.2. This reduces the accuracy of CHS-style measurements; there has been, to our knowledge, no efforts to estimate depreciation rates in the public sector beyond Corrado et al. (2016).

Additionally, both the market price method and the sum-of-costs method rely on certain assumptions that may not be appropriate for the public sector. The market price method relies on the existence of a competitive market, something that is obviously not the case in markets like the UK healthcare sector, where publicly owned organisations represent the vast majority of capital purchases. Similarly, whilst the sum-of-costs method is a standard accounting and national accounts methodology (Berger, 2018; Reilly, 2012; 2010; Reilly and Rabe, 1997; SNA, 2025), it relies on the overarching assumption that an entity would not invest more in an asset than it expects to benefit from it. It also relies on the assumption that returns to scale are constant, capital supply is sufficiently flexible to meet demand, and producers do not have monopoly power (Martin et al., 2024).

The main, overarching assumption is reasonable in the private sector, but less so in the public sector, where any benefits are non-monetary and, so, hard to observe or measure, and there are fewer market pressures that would enforce this principle. This is particularly relevant for intangible assets, whose benefits are hard to isolate from other assets. It is not clear if or how a public sector would observe the point where the retunes from a particular asset would be equal to what was spent on it, or even what those returns are in the absence of monetary returns or profits. Additionally, the flexible capital assumption certainly does not hold in many public sectors, which have been experiencing budget constraints since the global financial crisis. The idea that public sector entities do not have monopoly power in areas like education, defence, infrastructure, justice, or healthcare is also implausible in most public sectors. It is also questionable whether intangible assets, especially digital ones, display constant returns-to-scale. They tend to be less rivalrous and less appropriable than regular assets and display synergies and spillovers with other assets (Haskel and Westlake, 2017). When these assumptions are not met, particularly when returns-to-scale are increasing, there can be a disconnect between the sum-of-costs valuation and the true value.

To illustrate this point, consider a healthcare app owned by a public healthcare provider, for example, the NHS App in England. The scope of the healthcare app is to give benefits through a more quick and convenient management of appointments and/or prescriptions and through access to patient records. Through this, it provides value to its owner, the government. Imagine there are two versions of the App, A and B, identical in function, with both aiming to serve as many patients as possible. For some exogenous reason, A has many more users than B, provides more of its services and, therefore, offers more benefits. In a public service context, A is clearly more "valuable" than B. However, the sum-of-costs method would value them very similarly, given their similar development costs.[12] This illustrates the disconnect between true value and sum-of-costs valuations, particularly in modern intangible assets with increasing returns-to-scale.[13]

[11]O'Mahony et al. (2016), Saam et al. (2016), and Schulz and Beckmann (2016) are static estimates, so do not require depreciation rates or deflators.

[12] Perhaps the only difference would be that A may require larger, more costly servers.

[13] If this is difficult to imagine, picture the NHS app in period 1 and 2. In period 2, there are double the number of users than in period 1, so it provides double the benefit. Therefore, it is "worth" around double. We can also imagine the costs

Finally, the implementation of the sum-of-costs method as the way of measuring intangible capital could potentially create perverse incentives for strategic level policy makers that actually decrease productivity. Take "own-account" organisational capital in the healthcare as an example. It is calculated as a time factor share of the wage costs of managers and senior clinical staff, with managers having a higher weight. Increasing the number of managers increases the amount of own-account capital, by definition. However, there is no guarantee that an additional manager will produce capital at the margin, especially when, as in the public sector, time estimates are so poor and become out of date quickly. Therefore, such measurement could incentivise a misallocation of resources.

Table 5 shows a comparison between methods, and a more detailed quality assessment is discussed at the end of this section and in the appendix (Table C1). CHS methods are generally more standardised, comparable, account for time and depreciation, are more useful for national accountants, and require researchers to collect additional data. However, unlike indicator and survey methods, CHS methods require the estimation of certain additional factors like time, uplift, and capitalisation factors. They also rely on stricter assumptions than other methods, which researchers should take into account. Indicator methods struggle to capture quality as well as CHS and survey methods. It is also worth noting that, whilst they lack external validity, survey and indicator methods remain valid and useful tools for the assessment of intangible assets within narrower contexts. For example, the issue of the validity of comparing quantitative indicators in different context disappears when comparing them within the same, or very similar, organisations.

Table 5. Visual comparison of the three identified methods for measuring public sector intangible assets.

Comparator	Survey-based methods	Indicator methods	CHS methods
Are results in units that can be compared across asset types?	No	No	Yes
Are results in units that can be compared across studies (within asset types)?	No	Somewhat*	Yes
Does the method capture the quality of assets?	Yes	Somewhat**	Yes
Are methods standardised?	No	No	Yes
Does it give answers in monetary units?	No	No	Yes
Are methods accepted in the SNA?	No	No	Yes
Does the method rely on neo-classical assumptions?	No	No	Yes
Does the method require adjustment factors (for time, capitalisation, uplift, depreciation, and deflation)?	No	No	Yes
Does the method require collection of additional data by a researcher?	Yes	Yes	No

*Whilst indicator methods are often comparable objective indicators such as training expenditure per employee, their comparison is limited as £1 of training in one context is not equal to the same amount in a different context. In other words, as this method often fails to capture quality or does so in inconsistent ways, comparison is possible but limited.

**These methods sometimes attempt to capture quality and sometimes do not. Attempts are often limited in scope or effectiveness.

of ensuring the app can handle the extra users is less than double the initial cost of development, meaning the sum-of-costs approach underestimates the value.

5.2. The challenges posed by measuring intangible assets in the healthcare or public sectors (Research question 2)

In the IC literature, as noted earlier, there is a shared consensus that certain factors like politicisation, knowledge intensiveness, difference in relative importance of assets, and the generally higher degree of intangibility of aims and outcomes in the public sector make the measurement more default. The observation that financial measurement was not appropriate for the public sector as it could not adequately capture all elements of IC is a good one and is reflected in the choice of methods that do not result in monetary answers. It is also something that our critiques of CHS methods partially reflect. However, the failure to take their other observations, on politicisation and the level of intangibility, for example, further detail the ways in which they practically affect measurement with disappointing results. For example, it was not clear what, if any, differences these factors made to the choice of questions or indicators.

In the CHS literature, there was generally more comments on the differences between public and private sector intangible assets. Earlier, we noted that treatment of data and organisational capital was different. Datasets in the public sector are more often open access compared to the private sector. Open-access data are not often recorded in the SNA as no flows result from them, but it does allow for their capitalisation by the income method if "the owner still expects to obtain economic benefits" (SNA, 2025 11.102). In short, as open data, which are more common in the public sector, is harder to measure, it is often underestimated. This is particularly relevant to online health and prevention information. Weale (2025) offered a framework to potentially measure such information moving forward.

Organisational capital is considered particularly different in the healthcare sector. In the private sector, it is considered to be produced only by managers. In the healthcare sector, leadership is more distributed, with senior clinical staff also playing a significant role in creating organisational capital (O'Mahony et al., 2016; McKee et al., 2013). Therefore, when measuring organisational capital, we should also include the wages of senior clinical staff[14] in their costs (Corrado et al., 2017a; 2016; Le Mouel et al., 2016; O'Mahony et al., 2016). Despite the convincing case made by Corrado et al. (2016) and Le Mouel et al. (2016) for the inclusion of more than just management as creators of organisational capital, neither Bacchini et al. (2016) or the depreciation rate constructed for organisational capital[15] in Corrado et al. (2016) include non-managers.

The broad story of the CHS literature is that measurement is similar in public and private sectors. The identified methods, sum-of-costs and markets prices, are the same as those commonly used in the private sector. Whilst there are some differences in asset classification and purpose, these are relatively minor and do not affect the measurement. Whilst we note there is not sufficient exploration of differences in public sector depreciation rates and time, uplift, and capitalisation factors, these, again, are relatively minor differences that do not affect the methodology of the measurement.

This similarity makes for much easier implantation of these methods, as they use easily accessible data and are commonly understood and practiced. It also makes results much more comparable between private and public sector assets, gives valuations in comparable monetary units, and are methods sanctioned by the SNA. The main challenge with measuring intangible capital that this

[14] Or equivalent for non-healthcare settings.

[15] The depreciation rate is based on the quit rate of staff in the public sector, as when a staff member leaves, their contribution to organisational capital and their relationships with other staff are lost.

literature identifies is that intangible assets are more frequently both produced and used in-house without market prices. This challenge is common to both public and private sectors and is addressed using the sum-of-costs method.

However, there is a general lack of consideration for whether CHS methods are conceptually appropriate for the public sector. We discuss these critiques in more detail in section 5.1.4, namely that the neo-classical assumptions inherent in the sum-of-costs and market price methods do not hold for public sector intangible assets, but the lack of consideration of this is a weakness of the CHS literature. The concept of the link between spending on an asset and its value may break down in the public sector. Indeed, the lack of profit motive in the public sector suggests that we should instead focus on defining a public sector concept of value to measure assets. We should ask: What is the public sector aiming for in the purchase or production of an asset when the private sector aims at profit? Future research should seek to explore such questions and assess whether differences between public and private sector measurement should be bigger than the CHS literature suggests.

The role and estimation of deflators and depreciation rates was generally underexplored. The logic that informed the use of manager and clinician labour costs for investment in organisational capital for healthcare was not extended to the deflators used, which are based only on managerial turnover, potentially reducing the accuracy of estimates.

Regarding depreciation rates, Corrado et al. (2017a, 2016) noted how, despite not being subject to physical wear and tear, intangible assets still depreciate through economic obsolescence. As the public sector is subject to less competition and market pressures than the private sector, we would expect economic obsolescence to occur more slowly. This is evidenced by the public sector organisational capital depreciation rates in SPINTAN being lower than private sector alternatives in Corrado et al. (2005); however, this method was not universal. We found different studies using different approaches to account for depreciation of organisational capital. SPINTAN papers such as Corrado et al. (2017a, 2016), Le Mouel et al. (2016), O'Mahony et al. (2016), Schulz and Beckmann (2016), and Stokes et al. (2016) all used a depreciation rate for organisational capital that is significantly lower than the private sector's CHS depreciation rate[16]. However, Bacchini et al. (2016), Berger (2018), Corrado et al. (2017a, 2016)[17], Piekkola et al. (2020), Redek et al. (2021), Schulz and Beckmann (2016), and Stehrer et al. (2019) all used depreciation rates based on private sector estimates for assets, usually from the Corrado et al. (2005) or INNOdrive, which are probably overestimates. This difference should be resolved in future literature.

Despite these differences, the methods in the CHS framework broadly align with private sector methods. In fact, they generally adapt private sector methods to the public sector: SPINTAN is based on Corrado et al. (2005, 2009), Globalinto is based on INNOdrive, and EUKLEMS is itself a private sector method applied to the public sector. All these use market purchase price and sum-of-costs methodologies in alignment with the SNA, with the main differences between them being the assets covered. Globalinto and EUKLEMS only concern assets already included in the national accounts, whereas SPINTAN covers the whole spectrum of assets, even those not currently included in the SNA, such as organisational capital and branding. Moreover, Globalinto and EUKLEMS are efforts at measuring public sector intangibles in a given year, whereas SPINTAN functions more as an incredibly detailed methodological guide, with associated publications that practically apply the methodology,

[17] This paper uses private sector depreciation rates for all assets except organisational capital.

for example, Le Mouel et al. (2016) or O'Mahony et al. (2016). As such, SPINTAN is more useful to a practitioner who wishes to measure public sector intangibles.

5.3. What would be the effect of including intangible assets in a measure of healthcare productivity? (Research question 3)

In the private sector, the effect of capitalising intangibles not currently in the national accounts on productivity is, in short, an increase in gross output through increasing investment and decreasing intermediate consumption. [18] Therefore, productivity growth is higher than it would have been without capitalising intangible assets. Additionally, the sources of growth change as the share of growth attributed to capital increases relative to the shares attributed to labour and to MFP, the coveted "efficiency" portion of productivity, often described as the ability to do more with less[19] (Bontadini et al., 2023; Corrado et al., 2009; 2024).

However, as stated, in current MFP statistics, the public sector is not included, so capitalising intangibles would have a limited effect on productivity.[20] Capitalisation would theoretically have an effect on the sources of growth, but as the public sector is not included, these effects would not be visible. Imputing a return to public sector capital would solve this problem, as suggested in Corrado et al. (2017a, 2016); the effect of such an imputation would be that the public sector can be included in MFP productivity. However, as such an imputation would directly affect productivity and GDP estimates, we must be certain it is correct. At present, whilst the SRTP is the best option, there is not sufficient evidence to be confident. Whilst the public sector is technically included in labour productivity statistics, it is done under an "inputs equals outputs" convention, so conveys very little useful information.

In short, the main reason for the lack of focus on productivity identified in the literature is the difficulty associated with measuring public sector inputs and outputs, which is also the reason it is typically not covered in productivity statistics.

5.3.1. Intangible assets in public service productivity

The best candidate for analysing the effect of intangibles on productivity in the public sector is the ONS' PSP measure. This is an Atkinson (2005)-style measure of public service productivity that measures inputs in terms of costs and outputs as a cost-weighted activity. Incorporating intangible assets into an Atkinson (2005)-style healthcare-specific productivity measure, such as the ONS' PSP, would provide insights into not only the levels of intangible assets in the public sector but also how they affect productivity and how they have behaved during the budget constraints of the post-financial crisis world. The use of cost-weighted activity measures of output (ONS, 2025a; Atkinson, 2005), however, implies that the effect of capitalising currently uncapitalised intangible assets is ambiguous and mainly acts through inputs rather than outputs. It is also beyond the scope of this review.

The data to measure intangible assets in a PSP measure already exists within the national accounts, and doing so would provide great insight into their behaviour and productivity effects. We would

18 A full explanation of growth accounting is beyond the scope of this paper. For a more detailed explanation of growth accounting, see Bontadini et al. (2023).

19 See Lipsey and Carlaw (2000) for a deeper understanding.

20 This will be discussed in further detail when we consider the effect of capitalising intangibles on Public Service productivity.

expect growth in intangibles to positively affect productivity, due to their scalability, synergetic nature, and association with knowledge spillovers. It is also possible that by measuring them in this way, we could examine the effects of post-global financial crisis budget constraints on their level and determine whether this is a driver of the disappointing public sector productivity growth observed in countries like the UK (ONS, 2024b).

5.4. Quality assessment

In this section, we discuss the formal quality assessment. The full, formal quality assessment can be found in the Appendix in Table C1. Whilst due to the methodological and disparate nature of the papers included, it is not possible to adhere fully to a pre-existing quality assessment, the authors adapted the JBI analytical cross-sectional checklist to fit the methodological nature of the papers reviewed (Appendix Table C1).

Across the board, the papers clearly described their setting and, for the most part, defined the boundaries of their measured assets well, although as noted earlier, IC papers rarely shared common boundaries, unlike the CHS papers. Indicator and CHS method papers generally explained their methods clearly, whereas survey papers often did not, frequently failing to include the survey questions asked. CHS and survey papers mostly captured asset quality, whereas for indicator-based papers, the picture was more inconsistent. Survey papers did not use standardised, comparable units of measurement and could not be compared with other studies, whereas CHS papers did and could. Indicator methods featured a mixture of comparable units and non-comparable units, although it is also questionable to what extent indicators such as data holdings per firm can be used as comparators outside their immediate context, particularly considering they do not measure quality. As such, they were a mix of comparable and not. Neither indicator or survey-based papers, unlike CHS papers, accounted for time, and both required extra data beyond what is routinely collected by organisations, reducing their reproducibility.

Overall, CHS papers were judged to be of higher quality than the IC literature. Survey papers were generally superior to indicator papers in terms of accounting for quality but were weaker in appropriately explaining their methodology and in comparability.

6. Conclusions

This review summarised the current state of the measurement of intangible assets in the healthcare and public sectors. Although the healthcare sector was our primary focus, we included literature that studied other areas too. The methods used in healthcare and the wider public sector were mostly interchangeable. The one exception was that in healthcare, organisational capital can be generated by a wider range of staff than just managers, unlike other areas (Corrado et al., 2016; O'Mahony et al., 2016).

Thirty-one studies were identified following our literature search. Sixteen used the CHS framework of intangible assets, eleven used the IC framework, and the remainder used their own framework. There was no settled definition of IC, meaning the studies measured different things, and the IC literature usually did not take into consideration the technical definition of an asset. The CHS framework literature did not suffer from these issues. The CHS methods relied on standardised national accounts methods to value intangibles in monetary terms, whereas the IC literature relied on survey or indicator methods without a monetary value, limiting their external validity and comparability.

Survey method results were judged to be ordinal and highly contextual. Their indexing methods were often not outlined, and questions were not standardised. The non-monetary units used and the survey method itself inherently limit the comparability of a study. Indicators, especially when they were quantitative, were more objective, though they became less objective when the quality of an asset was included in the measurement. They also measure assets indirectly, so they only partly capture the true value of an asset. CHS framework methods were more standardised and measured assets in monetary units, so they were better equipped to capture quality than other methods and were more comparable between studies. They also largely used data that are already available. However, there is limited evidence estimating the time, capitalisation, and uplift factors necessitated by this method, limiting the accuracy of CHS methods. Additionally, it is not established whether the CHS methods are appropriate for assets with increasing returns-to-scale, such as software, or in the public sector, due to the absence of market prices and competition.

There was broad agreement that the healthcare and wider public sector setting made measurement more challenging, due to the relative absence of a competitive market, the intangibility of outputs, the aims in the public sector, and other factors, although this was underexplored. This was somewhat accounted for in the CHS literature, despite being broadly aligned with private sector methods, but not in the IC literature. Some CHS literature cited data and organisational capital as being different in the public sector and included schooling-produced human capital and cultural assets as assets, unlike private sector methods. This same literature also showed how depreciation for organisational capital was different in the public sector, but did not do the same for other assets. Very little of the literature considered the effect of capitalising non-national-accounts intangible assets on healthcare productivity measures, which is unsurprising given little attention is paid to public sector productivity compared to the private sector.

We conclude that research in the field of intangible assets and their measurement is underdeveloped and that there has been remarkably little progress since the SPINTAN project in 2016. This warrants further research into developing a universally accepted standardisation of IC methods, as well as a standard set of survey questions, elements a survey must capture, and indicators to measure assets. Future research should also produce better estimates of time, capital, and uplift factors within the CHS framework–based literature. One promising avenue in this regard is the forthcoming ONS "Time use in the public sector" survey. There should also be an exploration of alternatives to the sum-of-costs method within CHS methods and research into the role that intangible assets play in healthcare productivity. Additionally, future work should investigate whether the sum-of-costs approach to measuring "own-account" intangible assets is appropriate for the public sector and investigate the use of other methods of measurement permitted within the SNA (2025) to avoid the assumptions necessary in the sum-of-costs method.

Noting the key split between IC and CHS literature, a natural extension to the literature would appear to be integrating the two frameworks to improve overall measurement. However, we believe this pathway should be treated extremely cautiously, for several reasons. First, integrating survey and indicator elements into CHS methods risks obscuring the main benefits of this approach, namely the comparability of its results. By introducing subjective questions and indicators with units that do not lend themselves to effective comparison, any survey- or indicator-augmented CHS approach effectively inherits the problems of these approaches. Indeed, if the CHS methods are appropriately implemented and their assumptions are met, they capture all the facets the survey and indicator methods attempt to. Additionally, the taxonomy and categorisation of the CHS methods is clearer and

more consistent, and so, integrating the two frameworks would potentially not be beneficial. One pathway that could yield useful results is integrating the two methods on a micro scale, within organisations. The IC methods do provide useful information within the context of a specific organisation or setting, and the possibility of integrating this with the more organised, objective CHS methods in a scenario without the need for comparison offers an interesting future research strand.

A prescient future research area, and one that is particularly sensitive to our critique of the sum-of-costs method as unable to capture the value of digital assets with increasing returns to scale, is the measurement of AI assets. This, due to the novelty of AI assets, is an area that is also underdeveloped for the private sector. Some literature (Corrado et al., 2021) treats AI as a bundle of intangible assets including software, databases, and R&D and tangible assets such as computer hardware, which are measured using conventional CHS methods. Other literature (Theodorou and Theodorou, 2024) provides a framework for measuring the value added to companies through big data analytics (BDA) via a strategic alignment model that links BDA, strategy, and structure to a firm's risk-adjusted economic value added. Whether AI represents such a departure from previous software and R&D that it requires its own category is one important question, which Botadini et al. (2026) implicitly addressed by collecting survey data that specifically asks companies how much they spend on AI-related R&D. Perhaps more important is for future research to investigate whether it meets the necessary assumptions for the sum-of-costs method, in particular the constant returns to scale assumption. Based on the rapid advancement of AI technology and progress, this seems questionable. If this is the case, further research investigating alternative methods is required. Future empirical work implementing and testing methods such as those set out by Theodorou and Theodorou (2024) and Corrado et al. (2021) would represent a concrete and necessary next step.

Finally, this review did not cover hybrid measurement models, a promising new avenue of research. These methods use a mixture of historical costs (analogous to the sum-of-costs method), market value (analogous to the market price method), the depreciated replacement cost (the cost to replace an asset's remaining service potential adjusted for depreciation), and value in use (angles to the income method, or the net present value of expected future income from the asset) (Whittington, 2015; Barth, 2014). Evaluations obtained with alternative methods are then weighted based on each method's appropriateness in a given context. This method has the advantage of reducing any errors in any one method by aggregating them together. It is also perhaps more practicable in the public sector, where assets are more unique and can be assessed on a more individual basis. However, there are several issues that future literature should address before this can be used effectively in the public sector. First, by allowing the weighting of each method to change depending on which is most appropriate, it reduces comparability and consistency. Additionally, obtaining estimates via each of the methods is often difficult in certain contexts. For example, we noted earlier how the sum-of-costs method is typically used when market prices are absent, meaning the market purchase price method is not practicable. In this case, where one or few of the methods are feasible, it is not obvious what advantage hybrid models offer.

Although this scoping review is, to our knowledge, the first on this topic, it is subject to several limitations. First, it only searched three databases and only included papers in English. Second, based on the amount of grey literature, such as SPINTAN, found through citation searches rather than searching databases, it is possible that some literature was missed, as citation searching is less systematic than database searching. While the database searches captured several forms of grey literature, including SPINTAN, targeted searches of organisational websites (e.g., OECD, Eurostat,

ONS) were not undertaken. This may have resulted in the omission of non-indexed or unpublished material. Additionally, a formal quality assessment of included studies was not conducted, meaning the conclusions of this scoping review should be interpreted with caution, and no synthesis of results was possible due to the methodological focus of the review.

Author contributions

Christopher Warmington: conceptualisation, methodology, research, analysis, draft writing, administration

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Anastasia Arabdzhyan: validation, draft revising

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

The authors declare no conflict of interest.

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