



The 'F Words': Why Surveying Businesses About Intangibles is so Hard

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Abstract

The role of intangible assets in creating value in the modern economy is increasingly recognised, but measurement of their value and contribution are still in their infancy. This reflects a number of measurement challenges, which we characterise as 'the four F words'. First, data on intangibles are often not retained by businesses, as business accounting poses high hurdles for these assets to be recorded, and they usually cannot be used as debt collateral. As a result, businesses rarely have the information available to respond to business surveys, and often appear to give 'inconsistent responses' to survey questions: these intangible assets can be forgotten by businesses. Second, since surveys on intangible assets are often carried out under the auspices of 'research' or through surveys on 'innovation', rather than official investment surveys, businesses may be primed to respond in one way or another. Thus, the framing of surveys on intangibles might be especially important. Third, definitions of intangible assets vary from researcher to researcher, and can often overlap or be unclear. While those assets included in the National Accounts have precise definitions, those measured outside the boundary do not. These terms, for businesses and researchers, are fuzzy. Finally, unlike most investments, the creation of intangible assets can take a long time. Most tangible assets can be made and purchased reasonably quickly, and/or the purchase date is clear for the business. In the case of intangibles, especially own-account investment (which is especially common for intangibles) the production process can be gradual over many periods. Asking businesses to provide investments in any given period might thus cause problems; the frequency of surveys could therefore be key. We establish these characteristics and demonstrate their impact on the quality of data on intangibles collected through business surveys in the UK through a range of data sources and microdata linkage. We draw on this research to propose modifications to surveys on intangible investment that might yield superior data.

Keywords: intangible assets, capital, business surveys, data collection

JEL classification: E22, C83, C81

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The ‘F words’: why surveying businesses about intangibles is so hard

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Abstract

The role of intangible assets in creating value in the modern economy is increasingly recognised, but measurement of their value and contribution are still in their infancy. This reflects a number of measurement challenges, which we characterise as ‘the four F words’. First, data on intangibles are often not retained by businesses, as business accounting poses high hurdles for these assets to be recorded, and they usually cannot be used as debt collateral. As a result, businesses rarely have the information available to respond to business surveys, and often appear to give ‘inconsistent responses’ to survey questions: these intangible assets can be *forgotten* by businesses. Second, since surveys on intangible assets are often carried out under the auspices of ‘research’ or through surveys on ‘innovation’, rather than official investment surveys, businesses may be primed to respond in one way or another. Thus, the *framing* of surveys on intangibles might be especially important. Third, definitions of intangible assets vary from researcher to researcher, and can often overlap or be unclear. While those assets included in the National Accounts have precise definitions, those measured outside the boundary do not. These terms, for businesses and researchers, are *fuzzy*. Finally, unlike most investments, the creation of intangible assets can take a long time. Most tangible assets can be made and purchased reasonably quickly, and/or the purchase date is clear for the business. In the case of intangibles, especially own-account investment (which is especially common for intangibles) the production process can be gradual over many periods. Asking businesses to provide investments in any given period might thus cause problems; the *frequency* of surveys could therefore be key. We establish these characteristics and demonstrate their impact on the quality of data on intangibles collected through business surveys in the UK through a range of data sources and microdata linkage. We draw on this research to propose modifications to surveys on intangible investment that might yield superior data.

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1 Introduction

Intangible assets are increasingly recognised as important sources of business success and productivity growth. This is especially true given the transition to mainly service-based economies and the rise of digital forms of production. While some expenditures on intangibles are treated as capital investments in business and national accounting, many are not. Measurement of intangible assets is still largely in its infancy, following the seminal work of Corrado, Hulten and Sichel (2005) in the US, and development in the UK context by Goodridge, Haskel and Wallis (2014, 2016) amongst others.

One major challenge to the measurement of intangibles is the availability of good data on the topic. A variety of measurement approaches appear in the literature, which are frequently inconsistent. In particular, business surveys are relatively scarce and little understood. This is in contrast to many other topics in economic measurement which have well established approaches and yield consistent results across collection methods.

Capital assets – products that are used continuously or repeatedly as a factor of production over multiple years – can be either tangible or intangible. Tangible assets are widely recognised and understood, and business survey data are generally thought to be reliable. The opposite is true for intangible assets. Intangible assets have certain characteristics that make the collection of data on them through business surveys challenging, for respondents and collectors, but these challenges are under-researched.

Awano *et al.* (2010) report on a novel survey of businesses in the UK about intangible investments and asset benefit lives. They show that the results of this survey do not accord with other business surveys, or with ‘macro’ estimates produced at the time. A further survey in 2011 in the UK (Franklin and Field, 2012) produced similar results. Surveys have also been carried out in various European countries over the past decade, often with similar challenges. The results of these surveys are little explored.

We contribute to the literature on intangible assets in two ways: first, we document a range of business survey sources that can be used for microdata analysis of intangible assets in the UK; second, we establish the characteristics of intangibles from a measurement perspective which demonstrate the challenges in collecting data from business surveys.

The paper proceeds as follows: Section 2 outlines relevant business survey data sources for the UK; Section 3 details the characteristics of intangibles that make measurement difficult; Section 4 presents the results of microdata analysis, based largely on linked datasets, on the consistency of business responses to surveys on intangibles; Section 5 proposes some changes to business survey design for collection of data on intangible assets which we believe would yield higher quality data; and Section 6 concludes.

2 Data sources covering intangible assets in the UK

This section documents a range of business survey data that have questions relating to one or more intangible assets in the broader intangible assets framework as per Corrado, Hulten and Sichel (2005). We do not intend to be exhaustive here, and there are undoubtedly other smaller or private business surveys of which we are not aware, which include relevant questions. We do not cover surveys conducted outside the UK, or international research surveys which include the UK along with other countries. For a fuller account of surveys dedicated to intangible assets across Europe, see Bavdaž *et al.* (2021).

Rather, in this section we aim to briefly document the commonly used, large, or official business surveys in this area. All the sources used in current ONS estimates of intangible investment (e.g. ONS, 2021) are included. Many are not dedicated to intangible assets, but contain one or more relevant question. See also Martin (2019) for a summary of other surveys covering investment in training. Table 2 summarises all the survey sources detailed below.

2.1 Investment in Intangible Assets survey – first (2009/10) and second (2011)

The Investment in Intangible Assets survey (IIA) is arguably the most comprehensive intangible assets survey conducted in the UK to date. It asked firms to detail their in-house and purchased investments separately on six intangible asset categories: business process improvements (organisational capital), research and development, training, design, software and reputation and branding¹. Thus, it covered almost all the assets in the broader intangible assets framework – one of few surveys to do so.

As well as asking about investment, it also asked for asset benefit lives. These are important to determine if 1) the expenditures should indeed be considered investments, i.e. that they yield benefits for more than a year, and 2) what depreciation rate they have. All the surveyed assets had average benefit lives over a year, hence meeting the standard National Accounting criterion for their treatment as capital assets.

The survey was first conducted in 2009/10 with a relatively small sample of 2,004 firms. As it was a voluntary survey the response rate was relatively low (albeit typical for voluntary business surveys), at 42%, yielding 838 responses. The results of the first survey are documented in Awano *et al.* (2010).

The first survey followed a small scale scoping study in 2009, documented in Whittard *et al.* (2009). This covered just 40 firms to identify what sort of information would be possible to collect on this topic. The scoping study was framed around ‘scientific’ and ‘non-scientific’ research and development (R&D), a framing which was abandoned for the full-scale survey in 2009/10.

The survey was repeated with minor adjustments to question wording in 2011 with a slightly larger sample size of 2,540, and achieved a higher slightly response rate of 46%, thus yielding 1,180 responses. The results of this survey are documented in Franklin and Field (2012). Despite the larger sample size, the results on investment and benefit lives are very similar to the first survey.

2.2 UK Innovation Survey

The UK Innovation Survey (UKIS) is the main source of data on innovative activity, including spending on innovation, among businesses in the UK. It is the UK implementation of the Community Innovation Survey (CIS), conducted consistently across EU countries, making the findings on innovation internationally comparable. The definitions and concepts follow the Oslo Manual on innovation, and the survey is guided by international committee.

The survey has been conducted every two years since 2005, as well as in 2001 and 1997. It has a relatively large sample of around 32,000; however, because it is voluntary, it has a lower response rate than mandatory business surveys conducted by ONS. The survey is run by

¹ Exact question wordings, including inclusions and exclusions, are included in Annex A.

ONS on behalf of the Department for Business, Energy and Industrial Strategy (BEIS), who publish the results.

Among many qualitative questions on innovation, UKIS includes quantitative questions on investment in innovation. Businesses are asked for expenditure on six categories, covering most of the intangible assets in the broader framework. However, they are often worded differently to other surveys, and are in some cases broader or narrower than the intangible assets of interest. The questions, as in the 2019 survey, are detailed in Table 1.

Table 1 – Correspondence of UKIS questions on innovation investment and intangible assets

| Survey question | Corresponding intangible asset |
|--|---|
| internal Research and Development (R&D) | Own-account R&D |
| acquisitions of Research and Development (R&D) | Purchased R&D |
| acquisition of machinery and equipment, computer hardware or software | Purchased software [survey also includes tangible assets] |
| acquisitions of existing knowledge for the purposes of current or future innovation | Organisational capital [somewhat ambiguous] |
| training for innovative activities | Training [survey narrower than definitions in other surveys/research] |
| all forms of design activity, for the purposes of current or future innovation | Design [survey potentially narrower than definitions in other surveys/research] |
| market introduction of innovations (covering changes to product or service design, market research, changes to marketing methods, and advertising for a product or service launch) | Branding [survey narrower than definitions in other surveys/research] |

2.3 Annual Business Survey

The Annual Business Survey (ABS) is the main structural business survey conducted by the ONS. It is conducted annually and replaced the Annual Business Inquiry (ABI) part 2 in 2008. It is one of the main sources of data in the compilation of the National Accounts and as such has a large sample size of around 62,000 per year. In line with other mandatory ONS surveys, it typically has a response rate of around 80%, representing well over 80% of the turnover of sampled units, since more effort is made by ONS to chase responses by larger businesses.

The ABS covers the ‘non-financial business economy’, corresponding essentially to everything apart from the public sector, most of the financial and insurance industries, and most of the agricultural industries. Large firms (those with 250 or more employees, or very high turnover levels) in all covered industries are sampled with certainty, while smaller businesses are probability sampled. Most medium-sized businesses are sampled on a two-year rotation, staying in the sample for two consecutive years to provide some continuity in the sample before rotating out.

Long- and short-form versions of the survey are used for businesses of different size to reduce burden on smaller businesses. Different survey versions are also used for different industries, so that the questions on the product-breakdown of turnover and expenditure can be tailored to each industry.

Businesses on long-form surveys are asked for the amount spent on a variety of assets, including purchased and own-account software (since 2001). Since 2014 long-forms have also included questions for investment in intellectual property products (IPPs) excluding software and R&D, corresponding to mineral exploration and entertainment, literary and artistic originals in the intangible assets framework. The inclusions for this question also include “Plans, instructions and designs e.g. architectural/engineering plans” which may relate to the ‘other intellectual property products’ asset in international guidance (e.g. the European System of Accounts 2010) although it is unclear how businesses interpret this question. This could partially overlap with the ‘design’ asset in the broader intangible assets framework, although this is not treated as investment in the National Accounts. Short-form surveys only ask for total capital investment, with the notes detailing the inclusions. Full details are included in Annex A.

2.4 Quarterly acquisitions and disposals of Capital Asset Survey

The Quarterly acquisitions and disposals of Capital Assets Survey (QCAS) is one of the main data sources for calculating business investment in the UK. It is a quarterly survey and replaced the Quarterly Capital Expenditure Survey (QCES) in the first quarter of 2015. QCAS has a relatively large sample, with 24,500 firms sampled each quarter. As it is a mandatory survey it achieves a response rate of around 80%, but as for the ABS (see section 2.3) this is higher as a share of sampled turnover given focus on larger businesses.

QCAS asks firms to detail their investment each quarter for a variety of capital assets, as well as the value of sales (disposals) of some of those capital assets. For tangible assets, QCAS asks firms how much they invested in major improvements and construction work and various types of machinery and equipment. For intangible assets, firms are asked to detail their (purchased) investment in databases and purchased software. In all four quarters of 2015 and the first two quarters of 2016 firms were also asked to report their investment in own-account software development, ‘entertainment, literary and artistic originals’, and ‘other intellectual property products’ but these questions were removed in mid-2016.

2.5 Annual acquisitions and disposals of Capital Asset Survey

The Annual Acquisitions and Disposals of Capital Assets Survey (ACAS) is another survey that is used for capital investment statistics by the ONS. It asks firms to detail their investment in a wide range of capital assets as well as the value of any assets that are sold on. This helps to provide product-level breakdowns, to inform deflation and the construction of the Supply and Use tables. ACAS replaced and expanded upon the Business Spending on Capital Items survey in 2015 to bring it into line with the European System of Accounts (ESA) 2010 guidance. The survey is conducted annually and has a relatively small sample size of 2,500. As it is a mandatory survey, although a relatively long and complex one, the response rate is usually around 75%.

ACAS asks firms to report their investment in much greater detail than QCAS. For tangible assets investment categories on the survey include civil engineering projects, such as building

new roads and railways, and investment in office furniture. ACAS also asks firms their expenditure on intangible assets. Questions on intellectual property products include acquisitions and disposals of book and music publishing, films, and performances, as well as any protected or specialised knowledge, such as architectural plans. The survey also asks questions about expenditure on purchased and own-account computer software and databases. ACAS does include a question on purchased “scientific research and development services”, which likely only captures a narrow concept of R&D.

2.6 Business Expenditure on Research and Development Survey

The Business Enterprise Research and Development survey (BERD) is the source of data for UK research and development investment statistics and has been carried out annually since 1993. Firms that indicate intent to carry out research and development in ABS are added to the population of firms that could be sampled, which currently stands at approximately 60,000. Of these firms around 5,400 are sampled each year. BERD is a mandatory survey so achieves a relatively high response rate of around 80%.

Firms are chosen from the sample based on their size and, in the case of Northern Ireland, their location. The 400 largest firms based on research and development expenditure from the previous year complete a long version of the survey and are sampled every year because their contribution is so significant. An additional 3,600 smaller firms are selected at random to complete a short-form version of the survey. All firms in Northern Ireland who are known to undertake research and development are surveyed (approximately 1,400 each year).

BERD asks firms to breakdown their investment between in-house and purchased research and development. For in-house investment, firms are asked how much of their spending was on capital and non-capital expenditure. Non-capital expenditure includes spending on salaries and wages, materials needed to conduct research and development (such as chemicals) and services (for example, security for worksites). Capital expenditure includes land acquired by firms, construction and acquisition of buildings, machinery and equipment, and software. Purchased research and development is the expenditure by firms that is contracted out to other firms, both within and outside of the UK.

2.7 Annual Survey of Hours and Earnings

The Annual Survey of Hours and Earnings (ASHE) is a survey of employees run by the ONS, collecting a range of data on pay and hours worked. It uses a 1% sample of the working population, based on a random selection of active National Insurance numbers. The selection is the same every year, such that most respondents can be tracked over time. The sample is topped up annually with some additions from newly allocated National Insurance numbers, to compensate for departures when sampled people leave employment. ASHE has run every year since 2004, before which it was the New Earnings Survey, run in much the same way since the 1970s.

While ASHE samples employees, the survey respondents are the employers of those sampled employees. As a result, the data on earnings is thought to be of a higher quality than household surveys, but it also means that most demographic data cannot be collected on the survey, since employers typically don't know this. The industry information is taken from the Inter-Departmental Business Survey (IDBR), and the occupation is 'coded' to the Standard Occupational Classification (SOC) using automated and manual processes by ONS.

Its relevance for intangible assets is that it can be used to estimate own-account investment in intangibles via a 'sum of costs' approach. This approach is used to estimate own-account software investment in the national accounts, following international guidance. Occupations thought to contribute to creation of such assets for use within their businesses are identified, and a fraction of their wage treated as investment. Scaling factors for non-wage costs, including the use of (other) fixed capital, are added. This is the approach used in ONS (2021) to estimate own-account investment in design, branding, organisational capital, and financial product innovation.

The survey is mandatory, and like most ONS business surveys, achieves a response rate of around 70%, giving approximately 180k responses per year. It covers all employees with National Insurance numbers, so includes employees of the government, but excludes the self-employed. Industries that tend to use other forms of payment (e.g. cash in hand) will also be less well covered.

2.8 E-commerce survey

The e-commerce survey is run by ONS for the UK, as part of a cross-European survey that follows a broadly consistent approach across countries. It collects a range of data on the e-commerce and digital activities of businesses. ONS suspended the survey in 2021, and consulted on a new design to better measure the digital economy.

The survey has a sample of around 11,000 business, which is smaller than some other businesses surveys but still relatively large. The response rate is around the typical 80%, yielding c. 8,500 responses per year. It focuses on the non-financial business economy, excluding the public sector, agriculture, mining, finance, and some other service industries. Before 2014 only businesses with 10 or more employees were included, but the sample size was increased and smaller businesses added in 2014.

The survey covers some topics relevant to intangible assets, especially software and databases and organisational capital (especially the broader aspects of this asset, e.g. relating to supply chains). For instance, it includes questions on the use of various management software, including Customer Relationship Management (CRM) software, although it does not capture monetary values of investment spending..

2.9 Management and Expectations Survey

The Management and Expectations Survey (MES) is a research survey run by the ONS, in collaboration with the Economic Statistics Centre of Excellence (ESCoE) with funding from the Economic and Social Research Council (ESRC). It collects a range of qualitative data on management practices, which gives information on the stock of organisational capital in businesses. Note that management practices correspond only to part of the definition of the broader "organisational capital" asset in the intangible assets framework, as documented in Ardanaz-Badia, Martin, Morgan and Schneebacher (2022).

The MES ran in 2017 and 2020, following a pilot study in 2015. The pilot covered only manufacturing firms, whereas the later surveys covered most of the rest of the economy. The MES sample is partially sub-sampled from the ABS, and therefore largely mirrors its industrial coverage: excluding the public sector, financial services, and agriculture. It also excludes small firms – those with employment of less than 10, since the managerial questions apply less well in these cases.

2.10 Purchases Survey

The Annual Purchases Survey (APS) has run in its current format since 2016, having previously run in a slightly different guise up to 2006. It collects data from businesses on a detailed breakdown on spending on goods and services, known as intermediate consumption in the National Accounts. Intermediate consumption is the antonym to capital expenditure (gross fixed capital formation), as it covers products used up in the production process. However, following international national accounting rules, some spending that we might consider to be intangible investment is currently treated as intermediate consumption, hence this survey is useful for examining spending on these assets.

The APS covers the 'non-farm business economy', excluding government, non-profits and most of agriculture. It samples around 33,000 businesses annually, most of which overlap with the Annual Business Survey from that year to enable comparisons. The typical response rate for a compulsory ONS business survey of around 80% gives around 26,000 responses annually.

The intangibles covered by APS are most of those that are not treated as capital in the national accounts, namely design, organisational capital, and branding. Not all firms are explicitly asked about spending on each product, since the questionnaire is tailored to each industry for the sort of products they are expected to purchase. If not explicitly asked, the businesses can report it in a catch all question at the end of the survey.

Given its purpose, the survey asks businesses to exclude capital spending. But as above, since we are interested in spending on intangibles not treated as capital in the national accounts, that is not a problem for our purposes. If a business considered spending as an investment, they might not record it on the survey; however, this seems unlikely since such spending would not meet the requirements of business accounting to record it as capital spending in most cases. APS also excludes staff costs, so only captures purchased investments.

2.11 Employer Skills Survey

The Employer Skills Survey (ESS) is managed by the Department for Education, who in recent years have commissioned three private research agencies (IFF Research [lead contractor], BMG Research and Ipsos MORI) to run the survey. It surveys businesses with 2 or more employees across all industries. The sample is primarily drawn using commercial data, with a top-up from the IDBR. The IDBR is not the main source for the sample since it does not hold telephone numbers for many businesses, and ESS is a telephone survey.

The survey samples a large number of businesses, but given it is voluntary and quite long, achieves a relatively low response rate of around 15%. In 2019, of nearly 600,000 sampled businesses, around 80,000 interviews were achieved. The survey runs every other year on 'odd' years, e.g. 2017, 2019. Before 2011 it covered England only, which extended to the rest of the UK from 2011 until 2017, and then excluded Scotland in 2019. The survey is conducted in the 'odd' year, with data mostly relating to the time of the interview or 'the past year'. The 'Investment in Training' (IiT) survey module, used for estimates of training investment in ONS (2021) relate to the time of the survey.

As well as the monetary training investment data collected in the IiT module, ESS also collects non-monetary data on training and organisational capital, with questions on employment practices, training needs, skills, management, etc.

Table 2 – Summary of main surveys covering intangible assets in the UK

| Survey | Type of survey | Periods conducted | Sample size | Typical response rate | Intangible assets covered (unusual, imprecise, narrow, or broad definition denoted with *) | Industry coverage | Type of questions |
|--|---------------------|---|----------------|-----------------------|--|---|---|
| Investment in Intangible Assets (IIA) | Research; voluntary | Ad-hoc – 2009/10 and 2011 (calendar years) | 2,004 and 2500 | 44% | Organisational capital; R&D; training; design; software; branding | Excludes agriculture, finance, and public sector | Investment (own-account and purchased); benefit lives |
| UK Innovation Survey (UKIS) | Official; voluntary | Every two years since 2005, 2001, 1997 | 32,000 | 45% | Organisational capital*; R&D; training*; design*; purchased software*; branding* | Excludes public sector | Investment and related qualitative questions |
| Annual Business Survey (ABS) | Official; mandatory | Annually (ABI/2 before 2008) | 62,000 | 80% | Software (purchased and own-account); other IPPs* (since 2014) | Includes production, construction, distribution and some agriculture and service industries | Investment |
| Quarterly acquisitions and disposals of Capital Assets Survey (QCAS) | Official; mandatory | Quarterly (QCES before 2015) | 24,500 | 80% | Software (purchased and own-account); mineral exploration and evaluation | Excludes public sector and includes not-for-profit institutions | Investment |
| Annual acquisitions and disposals of Capital Assets Survey (ACAS) | Official; mandatory | Annually, since 2015 (Business Expenditure on Capital Items survey before 2015) | 2,500 | 75% | Software (purchased and own-account); mineral exploration and evaluation | Includes manufacturing, construction, other production, distribution services and some other services | Investment |
| Business Enterprise Research and Development survey (BERD) | Official; mandatory | Annually, since 1993 | 5,400 | 80% | R&D | Excludes public sector | Investment and related quantitative questions |

| | | | | | | | |
|--|---------------------|--|---------|-----|--|--|---|
| Annual Survey of Hours and Earnings (ASHE) | Official; mandatory | Annually (NES before 1999) | 300,000 | 70% | All* (own-account only) | All | Investment (partial) |
| E-commerce survey | Official; mandatory | Annually, since 2001 | 11,000 | 80% | Organisational capital* | Includes manufacturing, utilities, construction, wholesale, retail, transport and storage, accommodation and food services, IT, and other services | Qualitative questions |
| Management and Expectations Survey (MES) | Research; voluntary | One-off – 2017 and 2020 (calendar years) | 50,000 | 40% | Organisational capital* | Excludes agriculture, finance, and public sector | Qualitative questions |
| Annual Purchases Survey (APS) | Official; mandatory | Annually, since 2015 | 33,000 | 80% | Organisational capital*; training*; design*; branding* | All | Investment (purchased) |
| Employer Skills Survey (ESS) | Research; voluntary | Every two years, 1997 to 2021 | 600,000 | 15% | Training; organisational capital* | | Investment and related qualitative and quantitative questions |

3 Establishing the ‘F words’

3.1 What does good survey business survey design look like?

Given the importance of business surveys for National Statistical Institutes (NSIs), to collect the data to compile such important statistics as GDP and the National Accounts, there is surprisingly limited literature on how best to conduct such surveys. It seems likely that most lessons are learned within NSIs and embodied in practice, but not described in written form for external use. Indeed Moore *et al.* (2016) report that although NSIs “are leaders of business data collection”, they “typically publish little about how questionnaires are developed, especially in the context of establishment [business] surveys”.

Arguably the most authoritative work on this topic is Snijkers *et al.* (2013) which describes in detail the business survey collection process, including questionnaire design. We draw heavily on the guidance and frameworks developed in Snijkers *et al.* in this section and throughout this paper. Another important, if now somewhat outdated, text on business surveys is the Eurostat Handbook on Design and Implementation of Business Surveys (1998), edited by Willeboordse; we draw also from this work. It is clearly beyond the scope of this paper to give a full account of best practice in the conduct of business surveys, but we draw from the aforementioned works in the context of collecting data on intangibles through business surveys.

Broadly, the aforementioned texts recommend the following considerations for business survey design:

- Questions should ask for data that is available in businesses. If it is not, the respondent must guess, leading to low data quality, or else will leave the question blank. Businesses will only keep that data which it is required to keep (to complete mandatory official surveys, or for regulator purposes) or wants to keep (for operational or management purposes).
- The person responding to the survey needs to be aware of the existence of the data, know how to access it, and be able to access it. Even if the data exists in the business, if the respondent does not know this, or cannot access it, they cannot use it to respond.
- Instructions should be clear, understandable, and concise. They should also be specific (on reporting periods, definitions, inclusions and exclusions, etc.).
- Different types of respondent may give different answers to the same question. Large and small firms differ in the amount of data they hold, who in the business is likely to complete surveys, etc. Different industries may use different terminology.
- The framing, ordering, structure, and design of surveys is important – to motivate response and to support understanding.

3.2 The characteristics of intangibles

It is worth briefly describing the characteristics of intangible assets and intangible investment. This will make description of the problems in collecting data, described in the next section, more obvious. The concept of intangibles is described in more detail in much other literature, including Corrado, Hulten and Sichel (2005) and Haskel and Westlake (2017).

Corrado, Hulten and Sichel (2005) argue that any expenditure by businesses that increases future revenues or profits, at the expense of current consumption, should be treated as an investment. Thus, any spending by businesses on products with long-lasting returns, whether currently treated as capital expenditure by business or national accounting rules or not, should

qualify. These expenditures need not even be recognised by the business as an investment to qualify in the economic sense.

Haskel and Westlake (2017) describe four characteristics of intangibles:

- scalability – assets are ‘non-rival’: they can be used many times by many people without depriving another of its benefits, and thus can be used by businesses to grow quickly;
- spill-overs – the benefits of intangible often accrue to others, beyond the investor;
- sunk costs – it is difficult to retrieve the money invested to create them;
- synergies – intangibles work together to create value for businesses, somewhat at odds with the spill-overs they exhibit.

3.3 Establishing the ‘F words’

Intangibles are, by their nature, intangible. That is, they do not have a physical or financial embodiment. As such, they are not as easily counted in units, or physically measured, as tangible assets are. While you can count the number of cars, measure the floor space of buildings, or the weight of machines, you can rarely measure intangible assets in any of these ways.

While business surveys rarely ask respondents to actually count the number of machines they have, their physical presence may nonetheless help the business to conceptualise the assets when responding, and may reduce the risk of omission given their visibility and salience. The same is not true of intangibles – when software cannot be weighed, and research cannot be counted, and especially when these do not exist on asset registers, they may often be overlooked.

Intangible assets are often created by the business that intends to use them – so called “own-account investment”, or “output for own final use” in National Accounting jargon. This means that the business does not purchase the good or service on the market, and there is therefore no ‘transaction’ associated with the investment. While this can also be true for tangible assets, it is far more common for intangibles.

Take, for instance, the investment by a retail business in a new retail premise (a shop). The business could choose to build this itself – buying the necessary materials, hiring the necessary equipment, and employing the necessary individuals. However, it is likely not well-equipped to do this, and would likely (in most circumstances) purchase an existing building, or pay a construction company to build one for them. These are types of ‘purchased investment’ – transactions on the market for assets, or services leading to the creation of assets. The same usually goes for machinery and equipment (including transport equipment, ICT equipment, etc.) and other tangible assets.

While purchased investments are also a major source of intangible investments, businesses are much more likely to create such assets themselves. Data from the e-commerce survey (see Table 8) shows that 78% of large businesses in 2019 employed a software specialist (capable of creating a software asset for use by the business) – surely much higher than the equivalent figures for builders or machinery manufacturing occupations. Branding assets are readily created by in-house marketing departments, and although there is a significant industry that sells advertising services, Martin (2019) estimates that own-account investment in branding is some twice the value of purchased branding investments in the UK market sector.

Indeed, based on existing macro estimates of intangible investment (ONS, 2021) almost all types of intangibles are mostly created by the investing business.

As such, the measurement of investment in intangible assets is inherently the measurement of two distinct concepts: the purchase of intangible assets (akin to the purchase of tangible assets), and the creation of intangible assets in house. Own-account creation of tangible assets is generally an afterthought in business surveys: the Annual Business Survey (ABS) in the UK asks a single question of businesses covering “all work of a capital nature done by own-staff”, the total for which accounts for around 5% of total measured capital expenditure². While surveys about intangible investment do often make the distinction, the questions are often asked in the same way as for purchased investments, asking businesses to simply ‘state a value’ for the total value of the investments.

A further issue arising from the prevalence of own-account investment is that the creation (and investment) in intangible assets can take multiple periods (quarters, or years). The purchase of a machine or building on the market is easily dated as the date on which payment is made, or construction completed, or asset received (depending on the accounting system). By contrast, the iterative creation of a computer programme, film or prototype may take many months or even years to complete. The appropriate time to record this may be far less clear for a business.

The creation of some tangible assets, such as infrastructure projects or aircraft, can also span multiple periods. These can be subject to “progress payments” or “stage payments” where interim payments are made from producer to investor before the asset is completed. Following national accounting rules (e.g. ESA10) the investment is recorded when “the ownership of the fixed assets is transferred to the institutional unit that intends to use them in production” (ESA10, para 3.134, p.75). This might also cause problems for recording. However, a key difference is that for tangible assets this tends to be purchased investment, whereas for intangible assets this tends to be own-account investment. Purchased investment implies payments from one business to another, to finance the transaction. These payments are more likely to be recorded by the investing businesses, and thus reported on surveys.

By contrast, creation of intangibles in-house might not be recorded at all, and if it takes multiple periods then it seems even more likely that the full value would not be reflected. This problem may be even greater when the investment is made as part of normal business processes, as is often the case for branding and organisational capital, for instance. Allocating effort and expense to different accounting periods for such an ongoing process is likely to be extremely challenging for businesses.

This relates to the property of intangibles, described in Haskel and Westlake (2017), of ‘sunkness’. Intangibles can rarely be re-sold since they are often specific to the business and embodied within the business. The brand or organisational structure of a business cannot easily be sold on, and as such the investments, once made, are sunk costs. This contrasts with tangible assets, where the physical asset itself can often be re-sold or re-purposed. As a result, the recording of intangible assets on company ledgers and balance sheets (or even on internal records) is often poor. While international business accounting standards require a careful account of tangible assets, intangibles are rarely included. This is in part because intangible assets usually cannot be used as collateral in borrowing, given their inseparability

² The scope of the survey, driven by National Accounts rules, means that most intangible assets are excluded. Only software and databases, and mineral exploration and evaluation, are covered by the ABS; R&D is covered in a different survey; entertainment, literary and artistic originals is modelled separately; and intangibles not treated as assets in the National Accounts are covered only in current expenditure questions.

from the firm. The inability to re-sell many intangibles, and the lack of a requirement to record them in public accounts, leaves businesses with limited incentive to record their values.

So in sum, the relevant characteristics of intangible investment for business survey collection are:

- They cannot be counted or similarly measured in a physical sense, such that they may be overlooked, and businesses may find it difficult to conceptualise them.
- They are often the result of 'own-account investment' which means there is no transaction associated with the investment, which may further lead to the assets being overlooked. The likelihood of data being held on own-account investment is far lower than for 'purchased investment', and the approach to collecting data might therefore need to be different.
- Own-account investments in intangibles may take place over multiple periods, or iteratively over many periods. As such, the allocation of an investment to an accounting period may be more challenging than for purchased investments.
- Since most intangibles are not recognised in business accounting rules, and since they cannot readily be re-sold or used as collateral, businesses may not retain information on these assets.

3.4 Forgotten, fuzzy, frequency, framing

Drawing on these characteristics, we can summarise the challenges in surveying businesses about intangible investment with four "F" words:

- **Forgotten** – intangible investments may appear to be "forgotten" by businesses, given the lower chance of data on these being retained by the business, in part due to the inability use intangible assets for financing.
- **Fuzzy** – the measured concept of intangibles is not always clear to researchers, let alone businesses, causing confusion with respondents, and likely leading businesses not to respond or respond to a low quality.
- **Frequency** – given the iterative nature of investment, allocating intangible investment to set time periods might be challenging; the frequency of surveys may therefore be important.
- **Framing** – with precise data on intangible investment rarely recorded and retrievable by businesses, their responses might often be 'best guesses' or estimates; as such, the framing of the survey and question might steer the respondent towards an answer (either and over- or under-estimate, depending on the framing).

While we believe these characteristics will hold true for many businesses and data collections, there will inevitably be variation in the degree to which they apply and they may not all act in equivalent ways. If intangible investments are forgotten, then businesses are likely to under-report investment in surveys. Since definitions are fuzzy, this could lead to under- or over-reporting, but is likely to add noise to any estimates. We have no strong priors on how frequency might affect reporting on own-account investment, and could see arguments for it being over- or under-reported at quarterly frequency relative to annual frequency, for instance. Similarly, the framing of the survey might act in either direction, depending on the specific type of framing. Take together, this range of effects on responses is likely to lead to uncertain under-estimates, but this is unlikely to be universally true.

Firms that are more familiar with intangible assets, perhaps because they are more important to their operations, may be able to respond more consistently and easily than others. As such,

we might expect higher quality survey responses for businesses and industries that do more intangible investment on average. Industries that do most intangible investment (both in absolute terms and relative to their size) are ICT services (section J of SIC 2007), finance and insurance (section K), profession, scientific and technical services (section M), and manufacturing (section C).³

4 Testing the ‘F words’

In this section, we test these ‘F words’ by examining the congruence of responses to relevant surveys, both in the aggregate and with a limited industry breakdown (limited by sample sizes). Since it is possible that industries that invest more in intangible assets will report more consistently (see section 3.4 for discussion), we partition industries roughly according to their intangible-intensity. However, given the limited sample sizes in most cases when working with linked datasets, we use relatively high-level industry groupings: manufacturing (section C of SIC2007), non-manufacturing production and construction (sections A, B, and D to F), intangible-intensive services, consisting of ICT services, finance, and profession services (sections J, K and M) and other services (sections G to I, L, and N, to S).

4.1 Forgotten

Investment in intangible assets may be less memorable than tangible assets because they are more difficult to measure and not easily countable. As such, firms that have invested in intangible assets may report different values for the same period if asked at different times.

Awano *et al.* (2010) linked respondents to the first Investment in Intangible Assets survey (IIA) with the latest available UK Innovation Survey (UKIS) at the time, that was conducted in 2007. IIA largely collected data for the 2008 calendar year, while UKIS 2007 collected expenditure data for the 2006 calendar year. Table 3 is a reproduction of Table 16 from Awano *et al.* (2010) and shows the number of overlapping businesses giving an inconsistent response between surveys. Here, consistency simply requires a non-zero investment response in each survey, or a zero response in each survey – the magnitude of a positive response is not considered. Of 81 overlapping respondents, a large proportion are unable to even record a consistently zero or non-zero investment across the two surveys. The inconsistency is highest for ‘business process improvement’ (organisational capital), and lowest for R&D – this might reflect the familiarity of these terms to respondents, or the consistency in survey question wording across the two surveys.

Awano *et al.* (2010) speculate that the inconsistency is in part due to the different timing of the sources, since IIA mostly covered the 2008 calendar year, and UKIS 2007 covered the 2006 calendar year. We update this analysis by matching IIA with UKIS 2009, which collected data for the 2008 calendar year, thus giving a more contemporaneous match. The results, in Table 4, are little better than those in Table 3. While the number of matched businesses is a little higher at 126, the inconsistency rate is little changed. We also amended the assets on which the inconsistency is assessed, based on a review of the UKIS questions (see Section 2.2) – this does little to improve matters.

³ See ONS (2021) and Martin (2021) for data on this.

Table 3 – Inconsistency between respondents to the Investment in Intangible Assets survey and UK Innovation Survey 2007

| Asset category | Discrepancy between IIA and UKIS 2007 (number of firms) | Matched firms (number of firms) |
|--|--|--|
| In-house R&D expenditure | 30 | 81 |
| Purchased R&D expenditure | 19 | 81 |
| Software expenditure | 34 | 81 |
| Business process improvement expenditure | 45 | 81 |

Source: reproduction of Table 16 from Awano et al. (2010).

Table 4 – Inconsistency between respondents to the Investment in Intangible Assets survey and UK Innovation Survey 2009

| Asset category | Proportion of firms inconsistent between IIA and UKIS 2009 (n = 126) | Proportion of firms inconsistent between IIA and UKIS 2009 (contingent on positive response in either survey) | Number of matched firms with positive response in either survey |
|------------------------------|---|--|--|
| Total R&D | 29% | 64% | 58 |
| Branding | 36% | 79% | 57 |
| Training | 59% | 78% | 95 |
| Business process improvement | 25% | 86% | 36 |
| Design | 18% | 74% | 31 |

Source: this paper, using data from Investment in Intangible Assets survey and UK Innovation Survey 2009.

Notes: The assets compared are different to those in Awano et al. (2010) following a review of the question wordings in each survey. Total number of matched firms between IIA and UKIS 2009 is 126 – this is the denominator for the figures in column 1. “Contingent on positive response in either survey” means that only matched pairs for which non-zero investment is reported in either survey, or both, are included.

We repeat this analysis for the second Investment in Intangible Assets survey (IIA2) and the subsequent UKIS (run in 2011), both broadly collecting data for the 2010 calendar year. This gives 1,042 matched firms – far higher than before. Table 5 shows the rates of inconsistency, which appear lower than previously. However, this is due almost entirely to a far larger number of matched businesses reporting no investment in either survey. While this is ‘consistent’, it does not reveal much about the consistency of reported intangible investment; rather, the consistency of the lack of such investment. If we restrict the inconsistency test just to businesses reporting positive spending on either survey, then the inconsistency rate is much higher at over 70% for each asset, and in line with the previous survey (Table 4).

The relatively small number of linked firms make industry breakdowns for this analysis difficult, likely unreliable, and often disclosive. However, other dataset links offer larger sample sizes and can be reported. Table 6 shows average discrepancy rates (not contingent on positive response) across multiple survey vintages, for various dataset linkages and assets. This provides tentative evidence that investment in software (both purchased and own-account) is less likely to be forgotten in intangible-intensive industries, supporting speculation in section

3.4 that industries which do more intangible investment might provide more consistent survey responses.

Table 5 – Inconsistency between respondents to the second Investment in Intangible Assets survey and UK Innovation Survey 2011

| Asset category | Proportion of firms inconsistent between IIA2 and UKIS 2011 (n = 1,024) | Proportion of firms inconsistent between IIA2 and UKIS 2011 (contingent on positive response in either survey) | Number of matched firms with positive response in either survey |
|------------------------------|--|---|--|
| Total R&D | 8% | 72% | 109 |
| Branding | 14% | 83% | 173 |
| Training | 21% | 82% | 264 |
| Business process improvement | 7% | 91% | 80 |
| Design | 10% | 97% | 115 |

Source: this paper, using data from the second Investment in Intangible Assets survey and UK Innovation Survey 2011.

Notes: Total number of matched firms between IIA2 and UKIS 2011 is 1024 – this is the denominator for the figures in column 1. “Contingent on positive response in either survey” means that only matched pairs for which non-zero investment is reported in either survey, or both, are included.

Table 6 – Average inconsistency rates across various survey linkages, by industries, various years

| | Manufacturing | Non-manufacturing production and construction | Intangible-intensive services | Other services |
|--|----------------------|--|--------------------------------------|-----------------------|
| UKIS-BERD (2004-2014, every other year) | | | | |
| In-house R&D | 62% | 48% | 63% | 62% |
| Purchased R&D | 45% | 35% | 49% | 46% |
| | | | | |
| ABS-QCAS (2008-2019) | | | | |
| Purchased software | 31% | 33% | 29% | 33% |
| | | | | |
| ABS-IIA (2008, 2010) | | | | |
| Purchased advertising | 2% | 6% | 15% | 11% |
| Purchased software | 37% | 34% | 30% | 33% |
| Own-account software | 34% | 47% | 25% | 30% |
| | | | | |
| QCAS-IIA (2008, 2010) | | | | |
| Purchased software | 33% | 31% | 10% | 34% |

Source: this paper, various survey sources.

Notes: many sample sizes are small, so results should be interpreted with caution. Averages are simple averages across years, unweighted for sample size in each year. QCAS-IIA in 2010 for manufacturing, and UKIS-BERD in 2008 for non-manufacturing production and construction are disclosive and omitted from averages.

4.2 Fuzzy

Unfamiliar concepts may result in firms reporting differently across surveys, even if they do report investment on each survey. Intangible assets like software and research and development are capitalised in the National Accounts, meaning these assets are well-defined and have been included in surveys for many years. As such, it might be easier for firms to know what spending to include for these assets.

Table 7 shows that responses are generally reasonably consistent across surveys, contingent on a positive response in each. Correlation coefficients for investment in R&D, software, branding and design between IIA and various other surveys are generally upwards of 0.9. These are not much different, and often higher, than consistency in reporting of tangible assets. However, the comparison of tangible assets is between a quarterly and an annual survey, which we discuss further in section 4.4.

Table 7 – Correlation coefficients (contingent on non-zero reported investment in both surveys) between sources

| Asset | IIA2-UKIS (2010) | IIA2-ABS (2010) | IIA2-BERD (2010) | BERD-UKIS (2004-2014, every other year) | IIA2-QCES (2010) | ABS-QCAS (2015-2019) |
|--------------------------------|------------------|-----------------|------------------|---|------------------|----------------------|
| Intangible assets | | | | | | |
| Total R&D | 0.93 | | 0.97 | 0.7 (0.29-0.91) | | |
| Purchased R&D | | | | 0.69 (0.19-0.98) | | |
| Internal R&D | 0.97 | | 0.96 | 0.64 (0.3-0.81) | | |
| Purchased software | | 0.99 | | | 0.85 | 0.75 (0.42-0.88) |
| Own-account software | | | | | | 0.95 |
| Training | 0.36 | | | | | |
| Branding | | 0.97 | | | | |
| Design | 0.96 | | | | | |
| Tangible assets | | | | | | |
| Other buildings and structures | | | | | | 0.93 (0.89-0.96) |
| Machinery and equipment | | | | | | 0.84 (0.51-0.97) |

Source: this paper, various survey sources.

Notes: data show correlation coefficients between reported investment in each asset between each survey. In the case of multiple years, averages and ranges of the yearly correlation coefficients are given. Own-account software in ABS-QCAS is for 2015 only. “Contingent on positive response in either survey” means that only matched pairs for which non-zero investment is reported in either survey, or both, are included.

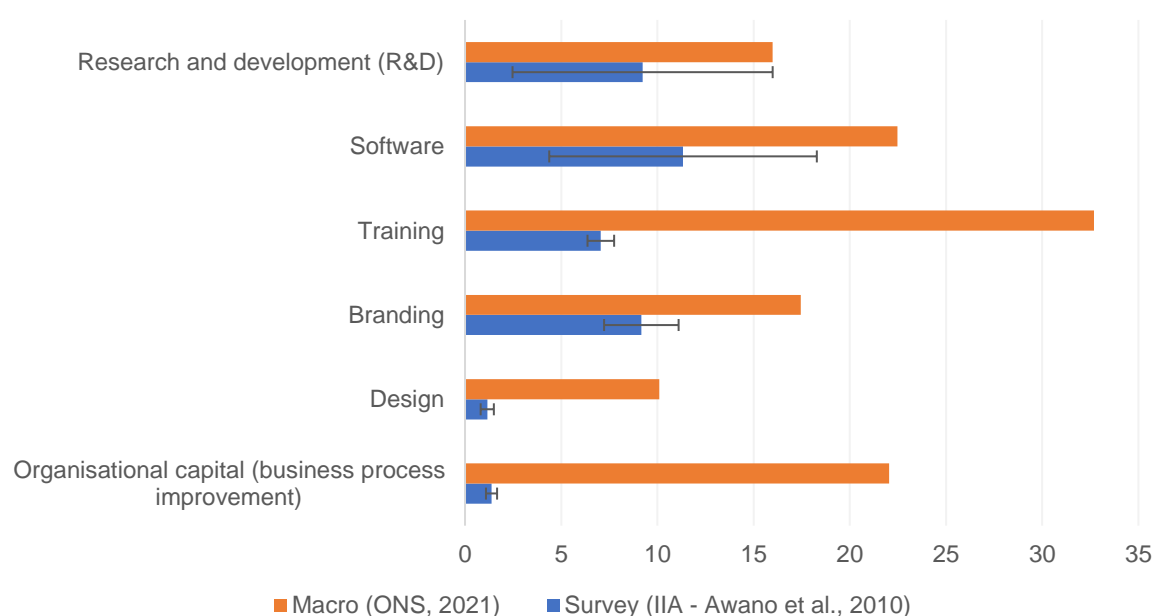
The lowest correlations are for training (which are quite different concepts in IIA2 and UKIS) and comparisons of BERD and UKIS (likely due to the very different survey design of the two, which we discuss further in section 4.3).

Industry breakdowns for this analysis are again difficult due to small number of matched firms, which are made further still by the necessity to restrict to non-zero responses in both sources. This makes results for most industries, in both source-pairs, disclosive. Analysis of limited results, not presented in this paper, offers no clear industry variations.

The differences between survey responses may also be a result of unclear instructions as to what should be included as investment. Unfamiliar concepts may not be a barrier to consistent responses provided there is a clear and consistent definition used across surveys. Some surveys, such as IIA, are specific about what to include and exclude (see Annex A for details), whereas others rely heavily on respondents' judgements, such as UKIS which provides only one sentence worth of guidance (see Table 1 and Annex A). For assets that firms are familiar reporting on, such as R&D, this may not present a problem, but for some intangible assets, such as training, a lack of detail may cause confusion as to what costs to include.

The result of this *fuzziness* is that survey-based estimates and macro-estimates of intangible investment differ substantially. Figure 1 compares the estimates of investment in intangible assets for the UK market sector from IIA with the latest macro intangible investment estimates for the UK (ONS, 2021). Both survey and macro estimates cover the UK market sector and are for the same year (2008). The differences, especially for the uncapitalised intangibles, could not be starker. This suggests differences between definitions of these assets as understood by businesses through survey collection, and definitions used in macro estimates, or else between researchers.

Figure 1 – Comparison of survey-based and macro estimates for investment by asset for the UK market sector, 2008, £ billions



Source: Awano et al. (2010) and ONS (2021).

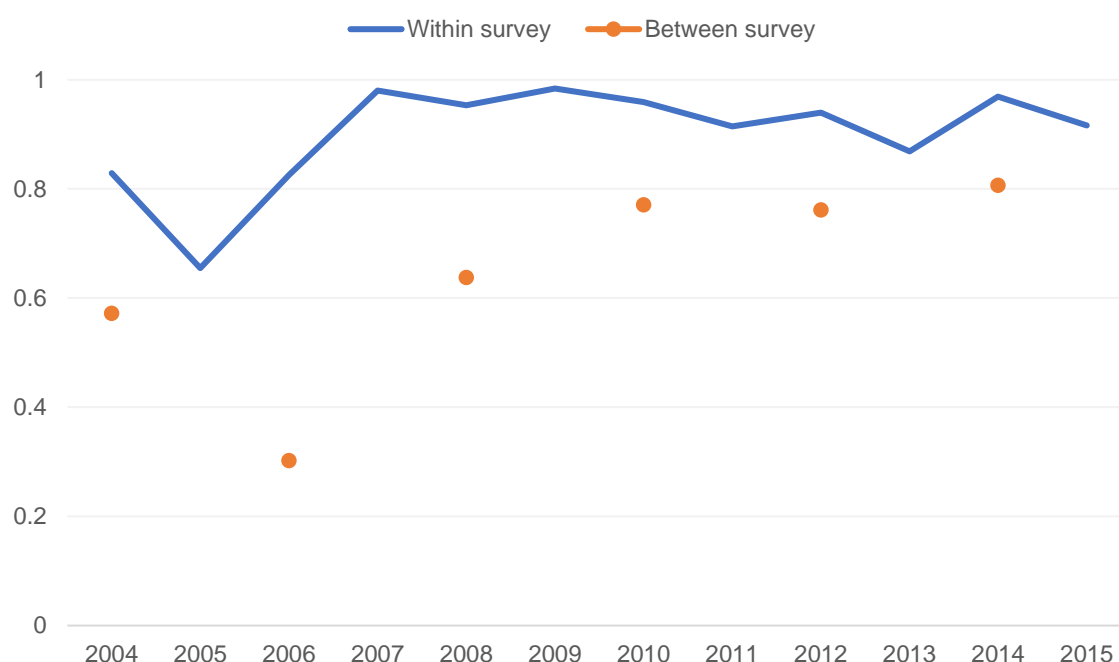
Notes: confidence intervals from Awano et al. (2010). This is similar to Table 10 from Awano et al. (2010) but with updated macro estimates.

4.3 Framing

Inconsistencies in the values firms report across surveys might also result from differences in the *framing* of the survey questions. BERD and UKIS both ask firms to report their expenditure on research and development but in very different ways. BERD is extremely detailed, asking for breakdowns of expenditure by type of cost (e.g. staff, materials, capital) and by product type; this follows international guidance set out in the Frascati Manual (OECD, 2015). By contrast, UKIS gives no instruction but simply asks businesses to report a value for “internal R&D” and “external R&D”. It thus relies heavily on respondent understanding and interpretation.

Figure 2 shows correlation coefficients for R&D investment reported by matched firms between two consecutive years of the same survey (for BERD), and between firms in both surveys (BERD and UKIS) in the same year. Since the within-survey correlations are consistently higher than the between-survey correlations, this suggests that within-survey consistency is substantially higher than between-survey consistency for R&D. Between years of BERD, responses are highly correlated. It seems respondents get familiar with a survey, and report consistently over time. Some may even set up reporting systems in their business to produce the appropriate information each year, ensuring within-survey consistency. By contrast, between-survey consistency is low, even for data relating to the same year. This is likely to be at least in part due to differences in *framing* between the surveys.

Figure 2 – Correlation coefficients for intramural R&D, within (BERD) and between (BERD-UKIS) surveys



Source: this paper, using data from Business Enterprise Research and Development survey (BERD) and UK Innovation Survey (UKIS).

Notes: BERD is an annual survey, whereas UKIS is every other year only.

Reporting different values in surveys may not be incorrect if the surveys ask firms to report on different concepts. As Table 7 shows, there is a low correlation for training expenditure

between firms that reported in both IIA2 and UKIS in 2010. IIA2 asks firms to report all training undertaken, whereas UKIS asks for “training for innovative activities” only. As “all training” will include “training for innovative activities”, it is expected the figures reported in UKIS will be the lower bound of the possible answers reported in IIA2. Therefore, firms may not be reporting inconsistently, if they are in fact reporting investment on different concepts. This in part reflects *fuzziness*, but also the *framing* of the question – we cannot expect businesses to give consistent answers if researchers ask inconsistent questions.

4.4 Frequency

The *frequency* with which firms are surveyed could affect the amount of investment reported, as it may be difficult to allocate the costs of investments to time periods, if it takes multiple periods to produce. Table 8 shows that respondents consistently report less investment in buildings and structures in an annual survey (ABS) relative to a quarterly survey (QCAS, aggregated to an annual figure). Own-account software, only asked on QCAS in all four calendar quarters in 2015, appears to follow the same pattern. In contrast, firms consistently report higher purchased software investments in ABS than in QCAS (aggregated to an annual figure) and this is also true, to a lesser extent, for machinery and equipment.

Allocating investment in machinery and equipment to years or quarters should be relatively simple as these are usually purchased on the market, and hence there is a market transaction associated with the investment which respondents can refer to. This should give a date and value that can readily be used. On the other hand, investment in buildings and structures and own-account software may be more difficult to allocate to a specific period because of the protracted nature of their production. It seems that in this case, businesses tend to overestimate investment in quarterly surveys, and revise down when reporting for the year as a whole.

Purchased software seems to have the opposite problem to own-account software, with significantly higher estimates in the annual survey than the quarterly (aggregated to an annual figure). Purchased software represents both ‘off the shelf’ investment in software, and ‘customised software’ which may take several periods to complete, like construction work.

Table 8 – Differences in average reported investment levels between ABS (annual) and QCAS (quarterly) for selected assets

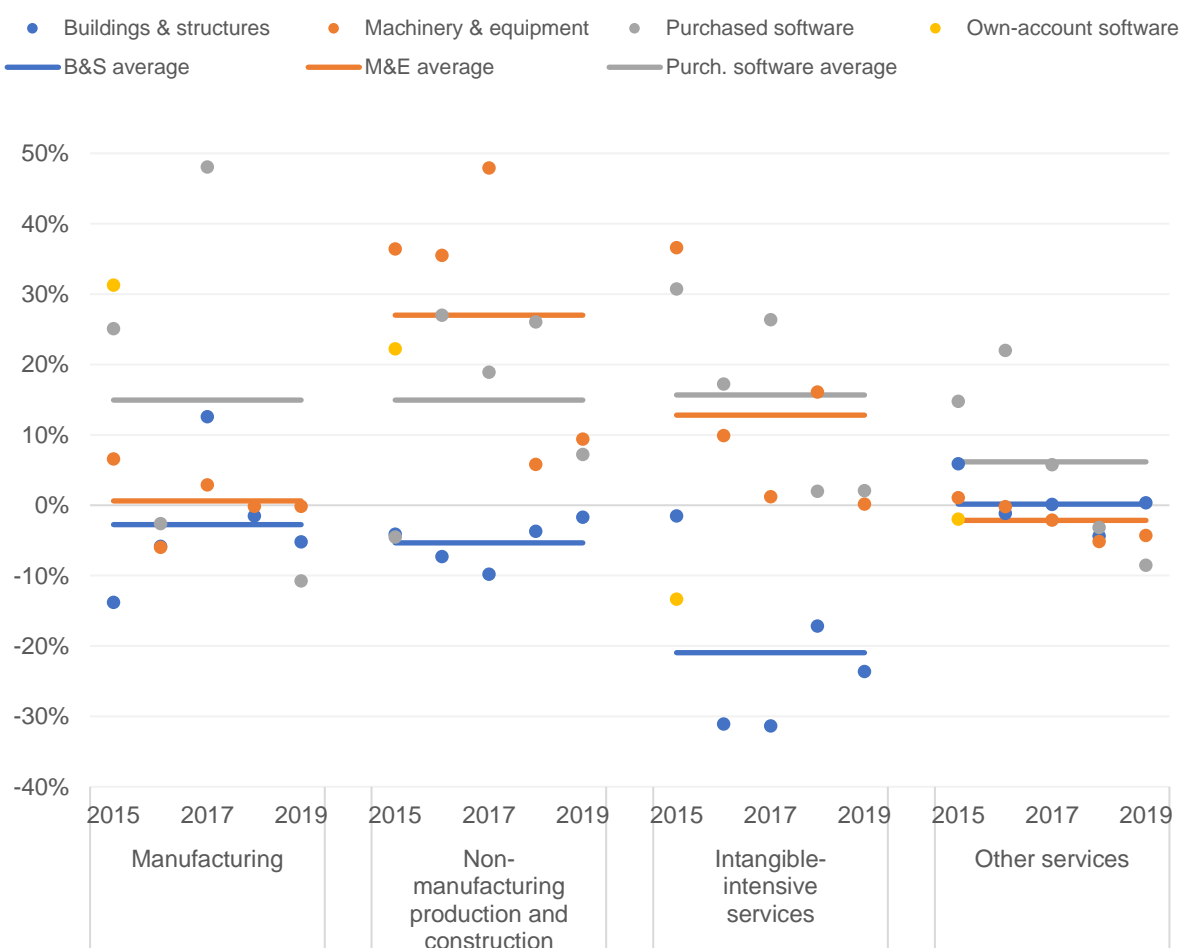
| | Buildings and structures | Machinery and equipment | Purchased software | Own-account software |
|------|---------------------------------|--------------------------------|---------------------------|-----------------------------|
| 2015 | -1.3% | 9.5% | 18.6% | -5.9% |
| 2016 | -7.6% | 2.9% | 17.9% | |
| 2017 | -7.0% | 4.4% | 16.2% | |
| 2018 | -4.7% | 0.3% | 21.2% | |
| 2019 | -2.2% | -1.8% | -4.3% | |

Source: this paper, using data from matched businesses in the Quarterly acquisitions and disposals of Capital Assets survey and the Annual Business Survey.

Note: only those firms that reported on QCAS in all four quarters have been included, see Annex B for robustness based on other restrictions. Negative values show ABS is lower than QCAS. Own-account software was only asked in QCAS in all four calendar quarters in 2015.

Equivalent data broken out by industry is shown in Figure 3, where dots represent years and lines show averages across years by industry and asset. Some interesting trends emerge. First, the “other services” grouping reports reasonably consistently for all assets on average, but this likely reflects a much larger sample size than the other industries, and hide important variation for more detailed industry breakdowns. Second, consistency by industry generally follows our expectation that industries doing more of such an investment would report more consistently – for instance, manufacturing and other services for machinery and equipment (which includes transport equipment and office equipment used widely in services industries), and buildings and structures in all industries other than the intangible-intensive industries. Third, own-account software is more likely to be over-reported on the quarterly survey relative to the annual (as in Table 8 for the aggregate) for services industries, but under-reported for the manufacturing and production industries. This demonstrates the potential for the ‘F words’ to act differently in different industries, and the potential benefit of designing surveys differently for different industries (see section 5).

Figure 3 – Differences in average reported investment levels between ABS and QCAS for selected assets, by industry group

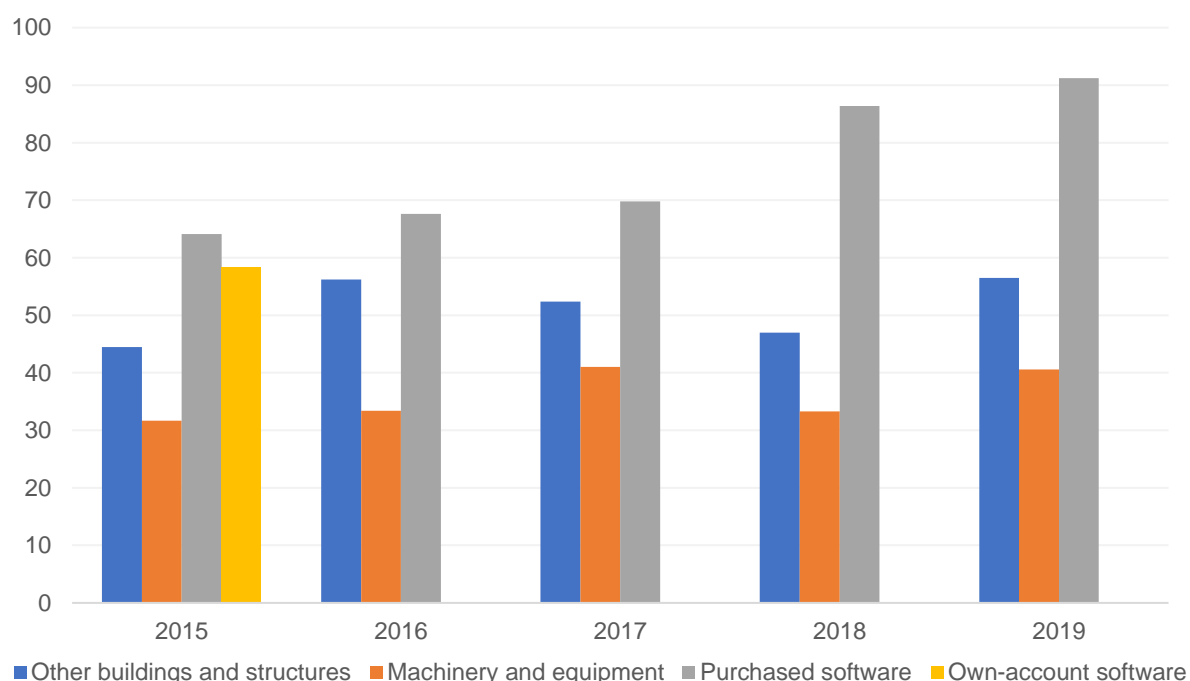


Source: this paper, using data from matched businesses in the Quarterly acquisitions and disposals of Capital Assets survey and the Annual Business Survey.

Note: only those firms that reported on QCAS in all four quarters, and with consistent industry coding across sources, have been included. Negative values show ABS is lower than QCAS. Own-account software was only asked in QCAS in all four calendar quarters in 2015. Purchased software in manufacturing in 2018 excluded as an outlier (value of 222%).

Irrespective of the direction of difference, respondents are generally less consistent between annual and quarterly surveys when reporting on own-account and purchased software than machinery and equipment and buildings. Figure 4 shows the Standardised Total Percentage Error (STPE) between the annual and quarterly surveys (aggregated to an annual figure), for these four assets. Purchased software (and own-account software for the one year that was asked in QCAS) have much higher STPE than the two tangible assets. Similarly, a larger fraction of businesses are inconsistent (as defined in section 4.1) between the annual and quarterly survey for the intangible assets than the tangible assets (see Annex B for details).

Figure 4 – Standardised Total Percentage Error between investment in various assets on ABS and QCAS



Source: this paper, based on data from the Annual Business Survey and Quarterly acquisitions and disposals of Capital Assets Survey.

Notes: Standardised Total Percentage Error (STPE) is the sum of the absolute difference between the responses on each survey, divided by the value reported on the ABS, averaged across firms. Own-account software was only asked in QCAS in all four quarters in 2015. Only those firms that reported on QCAS in all four quarters have been included; see Annex B for robustness based on other restrictions.

There is some evidence to suggest firms underreport investment in own-account software across both annual and quarterly surveys (Table 9). The proportion of firms reporting investment in own-account software in 2015 was 15% on QCAS (any quarter) and 18% on the ABS. By contrast, nearly half of all medium-sized businesses and over three-quarters of large businesses employ ICT specialists, suggesting a much larger fraction of businesses do some investment in own-account software than what is reported on investment surveys. This could be partially due to firms struggling to estimate investment in own-account software, or else that investment being ‘forgotten’.

Table 9 – Evidence of firms underreporting own-account software investment

| | | |
|-------------------------------------|-------------------|-----|
| % reporting own-account software in | quarterly survey | 15% |
| | annual survey | 18% |
| % employing ICT specialists in | small businesses | 16% |
| | medium businesses | 49% |
| | large businesses | 78% |

Source: e-commerce survey, Annual Business Survey and Quarterly acquisitions and disposals of Capital Assets Survey; data for 2015.

5 Designing a better intangibles survey

The two ONS intangible asset surveys (IIA and IIA2) each follow a similar design: there is a section for each asset, which appear sequentially over the course of the 6 page paper survey. In each section, the business is asked whether they did any investment in the given asset in the last year (yes or no) – if yes, they are asked to report the expenditure on the asset purchased from other organisations; the value of the investment in the asset carried out by own staff; and the estimated service life of the asset. The exception is training, which also asks for number of days training each staff member received on average in the period.

This structure is very different to that used in the pilot survey, as reported in Whittard *et al.* (2009). In the pilot, the questionnaire was split into “technical R&D” and “non-technical R&D”, and many detailed questions were asked in each section. In total, the pilot questionnaire contained 14 detailed questions, including the use of several data tables, but treated all “non-technical R&D” together for some questions. By contrast, IIA and IIA2 contained 26 short questions (with no data tables) and separated the types of “non-technical R&D” into sections.

Whittard *et al.* (2009) make clear that different people in the business would be needed to complete different parts of the pilot survey: specifically, “R&D managers” (technical staff) are appropriate for the section on “technical R&D” and “finance managers” or “directors” are appropriate for the section on “non-technical R&D”.

IIA and IIA2 allow for this delineation by combining all questions relating to each type of intangible spending into a single section, as described above. Hence, it would allow the paper survey to be passed between individuals or departments within the business, with each responding to the relevant set of questions, independently of the other. For instance, the first section in IIA is on training, so a HR representative might complete that, before passing to the IT department for the section on software, and so forth.

While this makes some intuitive sense, it runs counter to the recommendations in Snijkers *et al.* (2013), since the data required in each section is very different. Take the software section: the IT department may be the best location for data on own-account software, since it is where the software professionals who create own-account software work; but the purchases of software (through licenses) may be handled by (and, crucially, recorded by) the finance department. Further, the service lives of software might well be answered by the IT department, or a more senior manager with oversight of the business more broadly.

It could well be that 3 different people in the business are most suitable for the 3 questions in each section of IIA. As such, the arrangement by asset type may be counter-productive. Following Snijkers *et al.* (2013), an arrangement by ‘location of data in the business’ might be more fruitful – for instance, grouping all questions on purchased investment together (to be

answered by the finance department) and then all staff/time based questions (to be answered by HR, or function-specialist departments).

An alternative approach would be to give far greater guidance, and perhaps visual aids, to indicate the likely location of the necessary data within the business. The grouping by asset type could be retained, but with each question indicating explicitly who in the business should respond, with a consistent colour formatting across the survey to aid quick recognition of the relevant questions. Information on who the best contact in the business is for each question would require further research, but could draw from Whittard *et al.* (2009) and other similar studies. It might be sensible to have this vary by industry and/or sizeband, since the appropriate person in a business may vary across those dimensions (as highlighted in Snijkers *et al.* (2013)).

This does, however, assume that the required data is available in the business somewhere. In practice, this is unlikely to be the case. Snijkers *et al.* (2013) notes that businesses will only keep data if they use it to help manage their business operations, or because they have to legally (for reporting requirements etc). Expenditure data may well be kept, but only to the degree needed, which is unlikely to include a detailed breakdown by type of spend.

This is difficult for a National Statistical Institute to overcome. However, the economics profession and NSIs could work together to lobby for the retention of this information by promoting the benefits of this data for official statistics and economic analysis, and for business operations. Additionally, by frequently asking about these topics in official investment surveys, businesses might be encouraged to keep the data so as better to respond to the surveys in future.

Questions on own-account investment are even harder – these figures likely have never existed in the business, and would require a large computational effort on the part of the respondent to estimate. Instead, breaking the request into “manageable data chunks” (Snijkers *et al.*, 2013) may improve response, even if this adds to the number of questions. A respondent may be much better able to report the number of software developers, the fraction of their time spend developing new software assets for internal use, and any direct non-labour costs associated with that activity, than estimate (through a complex sum-of-costs method) own-account investment in software. The computation can be carried out by the NSI, drawing on other available data as required to apply scaling and adjustment factors to fit the data collected to the required concept and valuation. While this requires further steps on the part of the NSI, and may introduce some uncertainty through the use of other data, it is not clear that this is any worse than the assumptions and estimations made (out of sight) by the non-expert respondent. Drawing on Snijkers *et al.* (2013), it seems likely to the authors that this approach would yield superior results.

Based on the challenges measuring intangibles outlined in Section 3, some novel approaches to future intangible asset survey design might therefore include:

- Giving respondents choice over the time period they respond about, for each question. This could allow the question to best match the data available in the firm, and the data collector (i.e. the NSI) could adjust or scale as appropriate.
- Giving guidance on where in the business the data for each question is likely to exist. This would require significant testing and research, but may avoid the problem of a lack of data knowledge by the respondent given the diverse range of information required. This guidance could vary by industry and/or firm size.

- Grouping questions that are likely to require data from the same person or part of the respondent business. This could also be achieved through visual aids such as colour formatting, or individual logins in an online survey.
- Making clear that estimates are acceptable (if indeed they are) if the respondent does not have data available. This would avoid null-responses due to lack of data existence.
- Asking for estimates of own-account investment by asking for the component parts of the estimation process, rather than an overall estimate of the investment value. For instance, asking for numbers of different types (occupations) of workers, what fraction of their time each occupation group spends investing in the relevant intangible asset, and their average wages. The data collector could then manipulate, adjust, and compute investment estimates, potentially improving data quality and making the estimation process more transparent. This is similar to the way R&D investment estimates are compiled using data from the BERD survey.

6 Conclusion

We have demonstrated that past intangible investment surveys in the UK, especially the two Investment in Intangible Asset surveys, produced results that were inconsistent with prevailing macro estimates of intangible investment, and inconsistent at the firm-level with similar data collected on other surveys. This issue persists after updating past analysis to use more contemporaneous matches, and when expanding the analysis to other surveys.

To characterise the challenges collecting data on intangible assets, we suggest the use of four 'F words' – *forgotten*, *fuzzy*, *framing* and *frequency*. We have established these theoretically, by appealing to the characteristics of intangible assets, and in practice, using linked microdata analysis. The depth of these inconsistencies varies in the various comparisons we made, and not all of them are necessarily due to 'misreporting' by businesses. Indeed, many of the survey questions relate to different concepts, or are worded differently across surveys. We do not look to put 'blame' at the feet of businesses, and feel that data collectors could do substantially more to improve the quality of the collected data in this area.

Looking ahead, we have reflected on the survey design literature and respondent process to suggest changes to the design of intangible assets survey that may yield better (and more consistent) results. These would need testing with businesses, something that is beyond the scope of this paper. We hope this research, and these suggestions, are useful for future practitioners in this area.

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Annex A – survey questions

Investment in Intangible Assets (first)

Training

During the year, what was this business's expenditure on training provided by other organisations?

Include:

- training provided by external suppliers, whether provided on-site or elsewhere
- levy payments for training organisations, e.g. Sector Skills Council

During the year, what was this business's spending on staff training carried out by its own staff?

Include:

- staff costs of trainers, including development and delivery of training
- travel and subsistence payments
- associated costs, including providing facilities, overheads and materials but not capital items.

Exclude:

- the cost of staff time whilst being trained and therefore absent from work
- on-the-job training
- capital items

Software

During the year, what was this business's expenditure on software bought from other organisations?

Include:

- off-the-shelf software
- software licenses and license renewals
- generic and bespoke software.

Exclude:

- software embedded in other items of current or capital expenditure, e.g. software pre-installed on IT hardware

During the year, what was this business's spending on software development carried out by its own staff?

Include:

- staff costs of all staff involved, excluding contractors
- associated costs, including office facilities, overheads and materials but not capital items.

Note: Estimates based on proportions of staff time are acceptable

On average, how long does the business expect to benefit from a typical investment in software?

Reputation and branding

During the year, what was this business's expenditure on activities undertaken by other organisations to enhance reputation or brand values?

Include:

- external costs of advertising and marketing campaigns to agencies, media organisations, trade fairs, suppliers of marketing databases, etc

During the year, what was this business's spending on activities carried out by its own staff to enhance reputation or brand values?

Include:

- staff costs of all staff involved, e.g. product managers, sales and marketing personnel
- associated costs, including office facilities, overheads and materials but not capital items.

Note: Estimates based on proportions of staff time are acceptable

On average, how long does the business expect to benefit from a typical investment intended to enhance reputation and branding?

Research and development

During the year, what was this business's expenditure on R&D undertaken by other organisations?

Include costs of bought-in R&D services

During the year, what was this businesses' spending on R&D conducted by its own staff?

Include:

- staff costs of all staff involved
- associated costs, including facilities, overheads and materials but not capital items.

Note: Estimates based on proportions of staff time are acceptable

On average, how long does the business expect to benefit from a typical investment in R&D?

Design

During the year, what was this business's expenditure on activities by other organisations to design new or improved products or services?

Include costs of bought-in design services.

Exclude costs of design embedded in other items of current or capital expenditure

During the year, what was this business's spending on work carried out by its own staff to design new or improved products or services?

Include:

- staff costs of all staff involved, e.g. graphic designers, product designers, architects, design engineers, etc.
- associated costs, including office facilities, overheads and materials but not capital costs.

Note: Estimates based on proportions of staff time are acceptable

On average, how long does the business expect to benefit from a typical investment in designing new or improved products or services?

Organisation or Business Process Improvement

During the year, what was this business's expenditure on organisation or business process improvement undertaken by other organisations?

Include costs of bought-in management consultancy services

During the year, what was this business's spending on organisation or business process improvement conducted by its own staff?

Include:

- staff costs, including those who do this as part of their everyday jobs, e.g. managers working to improve general business processes
- associated costs, including office facilities and overheads for staff involved but not capital items.

Note: Estimates based on proportions of staff time are acceptable

On average, how long does the business expect to benefit from a typical investment in organisation or business process improvement?

Investment in Intangible Assets (second)

Training

During the reporting period, what was your business's expenditure on training provided by other organisations?

Include:

- training provided by external suppliers, whether provided on-site or elsewhere
- levy payments for training organisations, e.g. Sector Skills Council

During the reporting period, what was your business's expenditure on staff training carried out by its own staff?

Include:

- staff costs of trainers, including development and delivery of training, both on and off the job
- travel and subsistence payments
- associated costs, including providing facilities, overheads and materials.

Exclude:

- the cost of staff time whilst being trained and therefore absent from work
- capital items.

Note: Estimates based on proportions of staff time are acceptable

Software

During the reporting period, what was your business's expenditure on software bought from other organisations?

Include:

- off-the-shelf software
- databases
- software licences and licence renewals
- generic and bespoke software.

Exclude:

- software embedded in other items of current or capital expenditure, e.g. software pre-installed on IT hardware

During the reporting period, what was your business's expenditure on software development carried out by its own staff?

Include:

- staff costs of all staff involved, excluding contractors
- associated costs, including office facilities, overheads and materials but not capital items.

Note: Estimates based on proportions of staff time are acceptable

How long would your business expect to benefit from a typical expenditure on software?

Reputation and branding

During the reporting period what was your business's expenditure on activities undertaken by other organisations to enhance reputation or brand values?

Include:

- external costs of advertising and marketing campaigns to agencies, media organisations, trade fairs, suppliers of marketing databases, etc

During the reporting period, what was your business's expenditure on activities carried out by its own staff to enhance reputation or brand values?

Include:

- staff costs of all staff involved, e.g. product managers, sales and marketing personnel
- associated costs, including office facilities, overheads and materials but not capital items

Note: Estimates based on proportions of staff time are acceptable

How long would your business expect to benefit from a typical expenditure intended to enhance reputation and branding?

Research and development

During the reporting period, what was your business's expenditure on R&D undertaken by other organisations?

Include costs of bought-in R&D services, purchase of patents or long-term licences

During the reporting period, what was your business's expenditure on R&D conducted by its own staff?

Include:

- staff costs of all staff involved
- associated costs, including facilities, overheads and materials but not capital items.

Note: Estimates based on proportions of staff time are acceptable

How long would your business expect to benefit from a typical expenditure on R&D?

Design

During the reporting period, what was your business's expenditure on design activities by other organisations?

Include costs of bought-in design services.

Exclude costs of design embedded in other items of current or capital expenditure

During the reporting period, what was your business's expenditure on design work carried out by its own staff?

Include:

- staff costs of all staff involved, e.g. graphic designers, product designers, architects, design engineers, etc.
- associated costs, including office facilities, overheads and materials but not capital costs.

Note: Estimates based on proportions of staff time are acceptable

How long would your business expect to benefit from a typical expenditure on design?

Organisation or Business process improvement

During the reporting period, what was your business's expenditure on organisation or business process improvement undertaken by other organisations?

Include costs of bought-in management consultancy services

During the reporting period, what was your business's expenditure on organisation or business process improvement conducted by its own staff?

Include:

- staff costs, including those who do this as part of their everyday jobs, e.g. managers working to improve general business processes
- associated costs, including office facilities and overheads for staff involved but not capital items.

Note: Estimates based on proportions of staff time are acceptable

How long would your business expect to benefit from a typical expenditure on organisation or business process improvement?

Annual Business Survey (since 2014)

Computer software programs and databases

Include:

- Program descriptions, extensions, supporting materials for systems and applications

Exclude:

- Hardware. Report this at 9 (e)
- Cost of ongoing management

i) developed by own staff for business use

ii) purchased or developed externally (bespoke)

Other non-produced assets

Include:

- Goodwill, patents, licences, concessions, contracts (excluding sports contracts), trade dress, mastheads, domain names, collective and certification marks, etc

Of which:

- i) Goodwill

Intellectual property assets

This refers to new protected information and specialised knowledge that are used to facilitate production.

Include:

- Recordings, films and performances
- Manuscripts and publications
- Plans, instructions and designs e.g. architectural/engineering plans

Exclude:

- Research and development
- Patents, licences, and assets for marketing and publicity. Report this at 9 (g)
- Works of art e.g. paintings, even if acquired or disposed of by dealers, galleries or museums

Quarterly Acquisitions and Disposals of Capital Assets Survey

Transport assets and equipment

Include: new and used motor vehicles, special purpose vehicles, trailers, ships, boats, aircraft and railway rolling stock, motor cycles, bicycles, invalid carriages, parts, accessories, major repairs, etc

Exclude: lifting and handling machinery and special purpose machinery.

Computer software programs

Include: program descriptions, extensions and supporting materials for systems and applications.

- i) developed by own staff for business use?
- ii) purchased or developed externally (bespoke)?

Other machinery or equipment, used in any business or industry

Include:

- Electrical / electronic equipment.
- General / special purpose equipment.
- Small tools.
- Furniture.
- Office equipment.
- Fabricated products

Annual Acquisitions and Disposals of Capital Assets Survey

Computer software programs

Include: program descriptions, extensions and supporting materials for systems and applications.

- i) developed by own staff for business use?
- ii) purchased or developed externally (bespoke)?

UK Innovation Survey

During the 3 year period 1 January 2014 to 31 December 2016, did this business invest in any of the following, for the purposes of current or future innovation?

- a. Internal Research and Development
Creative work undertaken within your business that increases knowledge for developing new and improved goods or services and processes
- b. Acquisition of Research and Development
Same activities as above, performed by companies, including other businesses within your group, or by public or private research organisations and purchased by your business
- c. Acquisition of advanced machinery, equipment and software for innovation
 - Advanced machinery and equipment
 - Computer hardware
 - Computer software
- d. Acquisition of existing knowledge
Purchase or licensing of patents and non-patented inventions, know-how and other types of knowledge from other businesses or organisations
- e. Training for innovative activities
Internal or external training for your personnel, specifically for the development and / or introduction of innovations
- f. All forms of design

Engagement in all design activities, including strategic, for the development or implementation of new or improved goods, services and processes.

- g. Market introduction of innovations
 - Changes to product or service design
 - Market research
 - Changes to marketing methods
 - Launch advertising

For each of the main innovation related investments in question 4, please ESTIMATE the amount of expenditure for the YEAR 2016 ONLY. Include both internal costs and purchases from outside the business

Please round to the nearest £ thousand

- a. Internal Research and Development
- b. Acquisition of Research and Development
- c. Acquisition of advanced machinery, equipment and software
- d. Acquisition of existing knowledge
- e. Training for innovative activities
- f. All forms of design
- g. Market introduction of innovations

Business Expenditure on Research and Development Survey

In-house R&D: Non Capital Expenditure

The total cost of non-capital expenditure carried out by your business in the UK, regardless of the source of funds or their treatment within your business' accounts. All expenditure should be reported as gross unless otherwise stated.

4. During the 12 month reporting period, what was your gross non capital expenditure on salaries and wages for R&D?

Include overtime, bonuses, redundancies, commissions, holiday pay and employers' contributions to national insurance and pension schemes

5. During the 12 month reporting period, what was your non capital expenditure on all R&D materials, supplies, equipment and services?

Include expenditure on on-site consultants and overseas purchases.

Exclude VAT.

Of your figure reported in question 5, how much was spent on:

The sum of answers to questions 5a and 5b should equal your answer to question 5. Please provide estimates if actual data is not available.

5a. purchase of materials for R&D?

Include water, fuel, materials for labs (for example, chemicals), reference materials (for example, books).

Exclude VAT

5b. purchase of services for R&D?

Include expenditure for on-site consultants, prototypes/models made outside the organisation, indirect services hired/purchased (for example, security, storage, repair/maintenance of buildings/equipment, computer services, printing, subscriptions to libraries/scientific societies, all administration, insurance, post and telecommunications)

Exclude VAT

6. During the 12 month reporting period, what was your total in-house non capital expenditure on R&D?

This is the sum of questions 4 and 5

In-house R&D: Capital Expenditure

8a. During the 12 month reporting period, what was your gross capital expenditure on land acquired for R&D?

8b. During the 12 month reporting period, what was your gross capital expenditure on buildings acquired/constructed for R&D?

Include major improvements, modifications, new builds and repairs

9a. During the 12 month reporting period, what was your gross capital expenditure on equipment and machinery for R&D?

Include computer software that has been developed in-house specifically for R&D.

Exclude routine computer software.

9b. Of your figure reported in question 9(a), how much was spent on computer software for R&D?

10. During the 12 month reporting period, what was your total in-house capital expenditure for R&D?

This is the sum of questions 8a, 8b and 9a

Annex B – Additional results on ABS-QCAS matching

QCAS-ABS discrepancies – all matched firms

| | 2015 | | 2016 | | 2017 | | 2018 | | 2019 | |
|--------------------------------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|
| <u>Asset</u> | % discrepancy | n | % discrepancy | n | % discrepancy | n | % discrepancy | n | % discrepancy | n |
| Other buildings and structures | 47.8% | 10,059 | 53.2% | 14,091 | 48.0% | 12,795 | 45.8% | 12,585 | 42.8% | 10,891 |
| Machinery and equipment | 13.1% | 10,059 | 15.5% | 14,091 | 12.4% | 12,795 | 11.4% | 12,585 | 10.2% | 10,891 |
| Purchased software | 84.7% | 10,059 | 84.6% | 14,091 | 55.6% | 12,795 | 53.9% | 12,585 | 53.9% | 10,891 |
| Own-account software | 51.8% | 10,059 | 60.4% | 14,091 | | | | | | |

QCAS-ABS discrepancies – matched firms with responses to QCAS in all 4 quarters of the year

| | 2015 | | 2016 | | 2017 | | 2018 | | 2019 | |
|--------------------------------|---|-------|---|-------|---|--------|---|--------|---|-------|
| <u>Asset</u> | % discrepancy (all 4 quarters in QCAS) | n | % discrepancy (all 4 quarters in QCAS) | n | % discrepancy (all 4 quarters in QCAS) | n | % discrepancy (all 4 quarters in QCAS) | n | % discrepancy (all 4 quarters in QCAS) | n |
| Other buildings and structures | 39.9% | 7,548 | 44.1% | 9,167 | 44.2% | 10,583 | 41.9% | 10,636 | 39.9% | 9,479 |
| Machinery and equipment | 7.9% | 7,548 | 9.3% | 9,167 | 9.5% | 10,583 | 9.0% | 10,636 | 8.5% | 9,479 |
| Purchased software | 81.0% | 7,548 | 51.1% | 9,167 | 51.9% | 10,583 | 50.4% | 10,636 | 50.9% | 9,479 |
| Own-account software | 43.6% | 7,548 | | | | | | | | |

QCAS-ABS discrepancies – matched firms with responses to QCAS in all 4 quarters of the year, contingent on positive response in either survey

| | 2015 | | 2016 | | 2017 | | 2018 | | 2019 | |
|-----------------------------------|--|-------|--|-------|--|--------|--|--------|--|-------|
| <u>Asset</u> | % discrepancy (contingent on either positive) (all 4 quarters in QCAS) | n | % discrepancy (contingent on either positive) (all 4 quarters in QCAS) | n | % discrepancy (contingent on either positive) (all 4 quarters in QCAS) | n | % discrepancy (contingent on either positive) (all 4 quarters in QCAS) | n | % discrepancy (contingent on either positive) (all 4 quarters in QCAS) | n |
| Other buildings and structures | 48.0% | 6,280 | 51.7% | 7,822 | 52.0% | 9,001 | 49.8% | 8,955 | 47.7% | 7,926 |
| Machinery and equipment | 8.2% | 7,333 | 9.6% | 8,922 | 9.8% | 10,259 | 9.2% | 10,321 | 8.7% | 9,197 |
| Purchased software | 92.2% | 6,634 | 58.5% | 8,005 | 59.6% | 9,210 | 58.5% | 9,161 | 59.5% | 8,114 |
| Own-account software | 51.7% | 6,361 | | | | | | | | |

QCAS-ABS positive spending correlation – matched firms, contingent on positive response in both surveys

| | 2015 | | 2016 | | 2017 | | 2018 | | 2019 | |
|-----------------------------------|--|-------|--|--------|--|--------|--|--------|--|-------|
| <u>Asset</u> | Correlation coefficient (contingent on both positive) | n | Correlation coefficient (contingent on both positive) | n | Correlation coefficient (contingent on both positive) | n | Correlation coefficient (contingent on both positive) | n | Correlation coefficient (contingent on both positive) | n |
| Other buildings and structures | 0.9176 | 3,788 | 0.8924 | 4,865 | 0.921 | 4,884 | 0.9607 | 4,970 | 0.9638 | 4,532 |
| Machinery and equipment | 0.9272 | 8,443 | 0.509 | 11,488 | 0.8497 | 10,797 | 0.9671 | 10,767 | 0.9414 | 9,441 |
| Purchased software | 0.8841 | 3,499 | 0.7988 | 4,168 | 0.8119 | 4,150 | 0.4157 | 4,195 | 0.8324 | 3,566 |
| Own-account software | 0.9476 | 559 | 0.8356 | 369 | | | | | | |

QCAS-ABS positive spending correlation – matched firms with responses to QCAS in all 4 quarters of the year, contingent on positive response in either survey

| | 2015 | | 2016 | | 2017 | | 2018 | | 2019 | |
|--------------------------------|--|-------|--|-------|--|-------|--|-------|--|-------|
| <u>Asset</u> | Correlation coefficient (contingent on both positive) (all 4 quarters in QCAS) | n | Correlation coefficient (contingent on both positive) (all 4 quarters in QCAS) | n | Correlation coefficient (contingent on both positive) (all 4 quarters in QCAS) | n | Correlation coefficient (contingent on both positive) (all 4 quarters in QCAS) | n | Correlation coefficient (contingent on both positive) (all 4 quarters in QCAS) | n |
| Other buildings and structures | 0.9188 | 3,267 | 0.8922 | 3,776 | 0.9214 | 4,319 | 0.9606 | 4,495 | 0.9652 | 4,143 |
| Machinery and equipment | 0.9265 | 6,733 | 0.9551 | 8,068 | 0.8496 | 9,252 | 0.9673 | 9,369 | 0.9504 | 8,396 |
| Purchased software | 0.8843 | 3,070 | 0.8238 | 3,323 | 0.8154 | 3,718 | 0.4156 | 3,801 | 0.8336 | 3,288 |
| Own-account software | 0.9475 | 517 | | | | | | | | |

Standardised Total Percentage Error (STPE) – matched firms with responses to QCAS in all 4 quarters of the year, contingent on positive response in either survey

| | 2015 | | 2016 | | 2017 | | 2018 | | 2019 | |
|--------------------------------|--|--------|--|--------|--|--------|--|--------|--|--------|
| <u>Asset</u> | Standardised Total Percentage Error (STPE) | n | Standardised Total Percentage Error (STPE) | n | Standardised Total Percentage Error (STPE) | n | Standardised Total Percentage Error (STPE) | n | Standardised Total Percentage Error (STPE) | n |
| Other buildings and structures | 46.7 | 10,059 | 60.8 | 14,091 | 54.2 | 12,795 | 47.7 | 12,585 | 57.6 | 10,891 |
| Machinery and equipment | 32.8 | 10,059 | 44.9 | 14,091 | 41.8 | 12,795 | 34.6 | 12,585 | 43.7 | 10,891 |
| Purchased software | 64.9 | 10,059 | 71.4 | 14,091 | 71.6 | 12,795 | 86.5 | 12,585 | 93.0 | 10,891 |
| Own-account software | 58.9 | 10,059 | | | | | | | | |

Average level of investment in Annual Business Survey and Quarterly acquisitions and disposals of Capital Assets survey – matched firms, contingent on positive response in either survey

[illegible]

Average level of investment in Annual Business Survey and Quarterly acquisitions and disposals of Capital Assets survey – matched firms with responses to QCAS in all 4 quarters of the year, contingent on positive response in either survey

[illegible]