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Understanding sectoral absorptive capacity in the UK – a new analysis

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Understanding sectoral absorptive capacity in the UK – a new analysis

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Stephen Roper

Enterprise Research Centre
Warwick Business School
Stephen.roper@wbs.ac.uk

Rita Nana-Cheraa

Enterprise Research Centre
the Productivity Institute, Warwick Business School
Rita.Nana-Cheraa.1@wbs.ac.uk

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EXECUTIVE SUMMARY

Absorptive capacity has been defined as an organisation's ability to recognize the value of innovation and information, assimilate it, and then apply it when making decisions. Sectors in which firms exhibit high levels of absorptive capacity are likely to be able to diffuse new technologies and innovations most rapidly. Supporting R&D and innovation in these sectors is likely to maximise the societal value of publicly supported innovation.

This report provides an overview and comparison of absorptive capacity in 60 UK sectors based on a range of indicators compiled from firm level data sources including the Business Structures Database, ONS Intangible Investment data, the UK Innovation Survey, and the Employer Skills Survey.

Which UK sectors have the highest absorptive capacity?

A range of business and professional services have the highest levels of sectoral ACAP. Scientific research and development services top the ranking covered closely by the Activities of membership organizations (which includes standards setting bodies) and Computer programming and information services. Other professional, scientific, and veterinary activities, Publishing activities, Financial Services and Telecommunications comprise a second group of service sectors also with high levels of ACAP. Among the manufacturing sectors, pharmaceuticals and computer and electronic products have the highest overall levels of ACAP. Some of the lowest levels of sectoral ACAP are recorded in extractive sectors, and a range of basic manufacturing activities (See below).

Sectors with highest ACAP in rank order

Rank	SIC2007	Sector Name
1	72	Scientific research and development
2	94	Activities of membership organizations
3	62_63	Computer programming and information services
4	74_75	Other professional, scientific, and veterinary activities
5	58	Publishing activities
6	64	Financial services
7	61	Telecommunications
8	69_70	Legal and accounting services
9	05_06_07_08_09	Mining and support services
10	93	Sports activities and amusement and recreation
11	73	Advertising and market research
12	21	Manufacture of basic pharmaceutical products
13	33	Repair and installation of machinery and equipment
14	71	Architectural and engineering activities
15	59_60	Film, television programming and broadcasting
16	26	Manufacture of computer, electronics, and optical products
17	79	Travel insurance, tour operator
18	28	Manufacture of machinery and equipment n.e.c.
19	66	Activities auxiliary to financial services
20	77	Rental and leasing activities

What determines sectoral absorptive capacity?

Econometric analysis of the diffusion of innovations across sectors in the UK provides some evidence on those factors which have the strongest influence on sectoral ACAP. The key results are:

- Collaboration between firms in innovation proves a powerful influence on adoption. A one per cent increase in collaboration increases innovation adoption by 0.879 per cent in the short term and by 1.201 per cent in the longer-term.
- Investments in R&D and organisational capital¹ also have significant and positive impacts on adoption in both the short and longer term. A one per cent increase in R&D spending increases adoption by 0.136 per cent in the short term and 0.185 per cent in the longer term.

Other aspects of investment (computer software, design), training etc. have statistically insignificant effects on adoption as do skills gaps. These may be particularly important in some sectors but do not prove significant across the whole range of sectors. Note also that we observe significant persistence in sectoral absorptive capacity. This persistence may reflect other factors not captured elsewhere in our set of explanatory variables.

Defining and measuring sectoral ACAP

While the concept of absorptive capacity (ACAP) has been widely used there is little or no agreement or established convention about how it should be measured either at firm, regional or sectoral level. Studies using single measures or indicators co-exist alongside studies using multi-dimensional quantitative and qualitative indicators. These are reviewed in detail in Section 1.

Individual ACAP metrics - such as R&D intensity - are not relevant in every sector or indeed to all firms. Adopting a multi-indicator approach therefore seems helpful in both avoiding any bias caused by individual measures and capturing the different dimensions of ACAP. Metrics used here include:

- Measures of intangible investment such as R&D as well as other aspects of intangibles such as design and software.
- Measures of human capital or skills provide an indication of the quality of the labour force in any sector.
- Measures of connectivity or collaboration which might provide the basis for knowledge sharing and exchange.
- Indicators of organisational sophistication or management quality.

¹Investment in organisational capital consists of investment into the structures and managerial practices of the organisation aimed at increasing productivity and efficiency.

Here we combine a range of ten sectoral ACAP metrics representing sectors' knowledge investments, skills, management capabilities and inter-firm linkages to suggest a sectoral ranking of ACAP.

Indicators

Intangible investments represent investments in the knowledge capital of a business and so provide an indication of how knowledge rich or knowledge poor firms are in any given sector.

Pharmaceutical products have by far the highest level of R&D spending relative to sales followed by a range of other manufacturing sectors. Services sectors tend to rank lower on this indicator due to the concentration of R&D activity in manufacturing. Design spending also tends to be concentrated in manufacturing sectors with some more basic services towards the foot of the table. Conversely software purchases are highest in a range of knowledge intensive service activities with manufacturing activities mainly mid-table and basic services again towards the foot of the table.

Skills are a standard measure of ACAP at firm level. Here we use three skill-related measures which reflect the proportion of firms whose action is restricted by skill shortages. Sectors facing the fewest restrictions to their performance due to skills gaps tend to be professional and business services sectors, with some higher technology manufacturing sectors facing more intensive skill barriers to growth and productivity.

Connectivity - another important element of sectoral ACAP is the level of connectivity or collaboration between firms in the sector which provides an indication of the scope for inter-firm knowledge transfer. Some of the highest levels of collaboration activity are observed in high-tech manufacturing and services sectors, with lower levels of collaborative activity in low-tech and personal services.

Managerial capability - we also include two indicators derived from the Employer Skills Survey which provide an indication of the managerial sophistication and resources of enterprises within each sector – use of a business plan and training budget. Pharmaceutical manufacture and a range of professional service sectors are most likely to have a business plan and score well on this metric. Lower ranked sectors relate to several basic services sectors.

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SECTION 1: DEFINING AND MEASURING ABSORPTIVE CAPACITY (ACAP)

1.1 Introduction

The notion of absorptive capacity has attracted significant academic attention over recent years as governments have sought to spread the benefits of R&D and innovation across firms. Absorptive capacity is a prerequisite for high levels of diffusion of new technologies or management techniques across firms with their attendant benefits for productivity and growth. This prior research on absorptive capacity (or ACAP) has made substantial progress in conceptual terms with broad agreement on the key capabilities which work together to enable firms to absorb and effectively utilise external knowledge. These studies are reviewed in Section 1.2. Fewer studies have considered ACAP at a sectoral level and these are discussed in Section 1.3. Adopting a sectoral approach highlights not only firm level factors but also the potential for knowledge sharing between firms within the given sector.

Later sections deal with the more contentious issue of measurement with the variety of studies and approaches suggesting little current agreement on how to measure ACAP. Some studies adopt a single indicator – typically related to R&D or skill levels – while most of the research recognises that ACAP is a multi-dimensional concept requiring a basket of indicators or measures. Measurement is the focus of Section 1.4. Section 1.5 provides a brief overview of lessons from prior studies.

1.2 ACAP defined

Absorptive capacity has been defined as an organization's ability to recognize the value of innovation and information, assimilate it, and then apply it when making decisions. (Ashoor et al., 2021) suggest that absorptive capacity comprises the following four mechanisms:

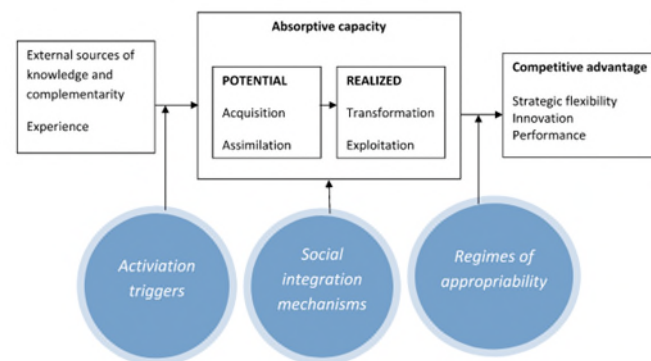
- Knowledge acquisition or knowledge search defined as the capability “to identify and acquire externally generated knowledge that is critical to its operations.” (Zahra & George, 2002, p.189).
- Knowledge assimilation – “routines and processes that allow it to analyse, process, interpret and understand the information obtained from external sources.” (Zahra & George, 2002, p.189)

- Knowledge transformation: “to develop and refine the routines that facilitate combining existing knowledge and the newly acquired and assimilated knowledge.” (Zahra & George, 2002, p.190)
- Knowledge application - the capability “to refine, extend and leverage existing competencies or to create new ones by incorporating acquired and transformed knowledge into its operations.” (Zahra & George, 2002, p.190).

As such absorptive capacity recognises the need for innovating firms to draw on and use external knowledge as well as have strong internal learning capabilities. This suggests the close association between absorptive capacity and open or collaborative innovation (Bhadauria & Singh, 2022). It also stresses the importance of firms’ internal learning capabilities and agility in assimilating and applying new knowledge (Cordero & Ferreira, 2019) and the role of inter-organisational linkages in facilitating firms’ access to external knowledge (Agramunt et al., 2020).

Following (Zahra & George, 2002) some studies make a distinction between ‘potential’ and ‘realised’. (Thomas & Wood, 2014), for example consider the relationship between potential and realised ACAP and firms’ external environment (see Figure 1).

Figure 1: ACAP, potential ACAP and realised ACAP



Source: Thomas and Wood, 2014, page 14.

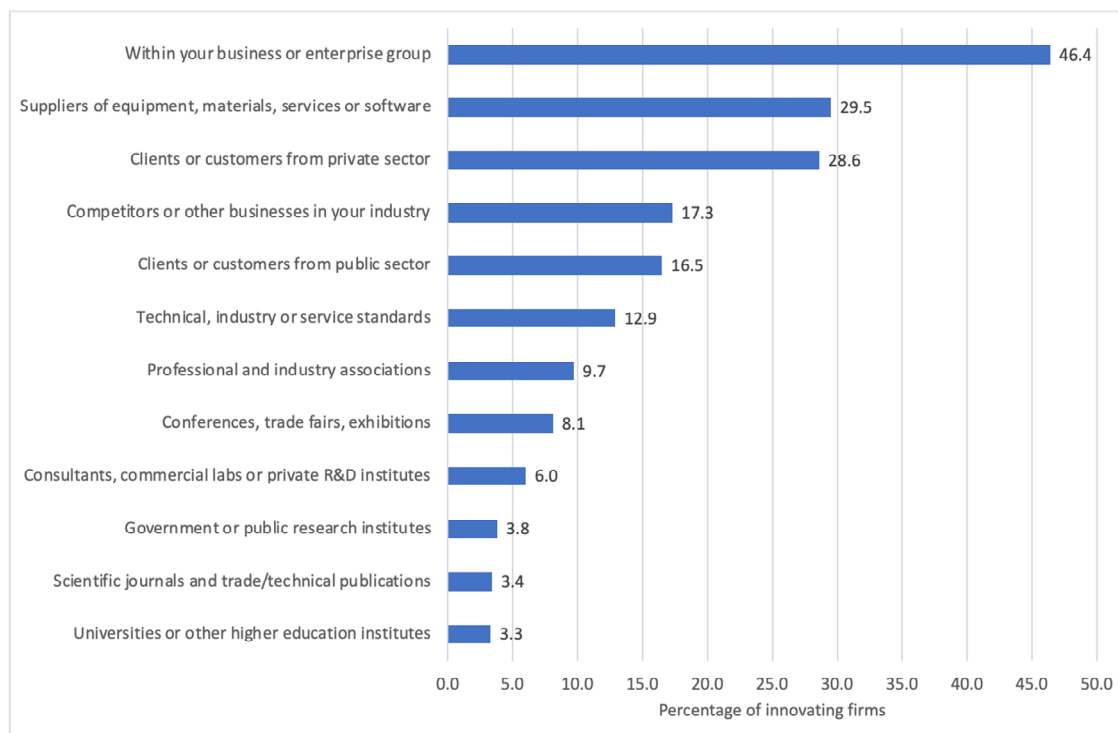
1.3 ACAP and technology diffusion in sectors

ACAP is typically conceived as a capability of individual organisations. Notions of sectoral ACAP – the ability of a related group of companies to recognize the value of innovation and information, assimilate it, and then apply it – have received less attention in the research literature. Here, however, several research literatures provide insights into the

inherently social process of sectoral innovation based on knowledge exchange between individuals and R&D teams and benefitting from network linkages (Roper and Love 2018).

It is worth noting at the outset the diversity of knowledge flows which can shape business innovation. The UK Innovation Survey identifies the sources of knowledge which firms regard as 'highly important' for their innovation (Figure 2). Key here are internally generated knowledge and that flowing from supply chain partners in the private and public sectors. Standards and networking events and groups also play a significant role as do intermediary organisations such as professional or industry associations. Only 3.3 per cent of UK firms regarded universities or higher education institutes as 'highly important' for their innovation. A similar proportion (3.4 per cent) regarded scientific journals or publications as significant in terms of their innovation activity.

Figure 2: Importance of knowledge sources for business innovation: 2016-18



Source: UK Innovation Survey 2019, Statistical Annex, Table 9.

The implication of Figure 2 is that for most firms in the economy the networks and knowledge flows which shape innovation are linked to their internal knowledge creation activities and/or supply chains. This may reflect notions of cognitive proximity between firms within a given supply chain (Dooley et al. 2016). Relationships and knowledge exchange between firms can occur through various routes, however. For example, firms

may form deliberate, purposive relationships with other firms or organisations as a means of acquiring or accessing new knowledge. This type of relationship is characterised by strategic intent and mutual engagement of both parties and may be characterised as a form of interactive learning (Glückler 2013). Collaborative R&D with universities would be a good example of this type of relationship which might focus on more radical innovation. This type of relationship is also central to notions of open or collaborative innovation (van de Vrande et al. 2009; Perkmann and Walsh 2007; Chesbrough 2003).

Firms may also acquire knowledge deliberately but without the direct engagement of another party. Examples of this type of mechanism include imitation, reverse engineering or participation in network or knowledge dissemination events. Here, there is a clear knowledge-gathering intent on the part of the firm but no mutuality in the knowledge flows. This can be characterised as non-interactive learning.

Finally, firms may acquire knowledge vicariously and unintentionally through informal spillover mechanisms such as social contacts between employees and those in other firms, media publicity or demonstration effects, or through the mobility of labour between enterprises. These pure knowledge spillovers represent un-priced gains to the firm, effectively increasing the social returns to knowledge. This type of knowledge spillover plays a central role in thinking about industrial districts (Belussi and Sedita 2012), clusters (Wolfe 2009) and, more recently, innovation districts (Clark, Huang, and Walsh 2010).

OECD research sets this discussion of diffusion in the context of Frontier firms which are larger and often engaged with international markets and smaller non-Frontier or Laggard firms which often have a focus on domestic markets². There is convincing evidence of an increased divergence in innovation and productivity between Frontier and Laggard firms (Andrews et al., 2016; Berlingieri et al., 2017b) accompanied by suggestions that it is the failure for technologies to diffuse rapidly from Frontier to Laggard firms which is part of the explanation. Recent studies also emphasise the diversity of firms within the Laggard group and suggest the importance of investments in intangible ICT (Berlingieri et al 2020) and internal leadership and managerial competencies in such firms in driving technology adoption and productivity growth (Jibril et al. 2020). This suggests the potential for different factors to be shaping diffusion in different industries and national contexts. For instance,

² <https://www.oecd.org/sti/ind/laggard-firms-and-technology-diffusion.pdf>.

Bartelsman et. al. (2008) examines the relative importance of global and national frontier firms in facilitating technology diffusion to laggard firms. For the UK, they find that national frontier firms are much more important for technology diffusion, and that diffusion from the global frontier reduces with technological distance whereas technological distance has no effect on diffusion from the national frontier.

One other aspect of the diffusion of innovations which has received some attention is the location or more generally the proximity of the collaborating partners. Proximity defines the 'distance' between those sharing knowledge and can be geographic, cognitive, cultural, or organisational (Boschma 2005). In each case greater distance may make knowledge sharing more difficult and/or costly. Conversely, more 'distant' knowledge sources may provide knowledge which is more distinctive (e.g., Inter-disciplinary or multi-disciplinary collaborations or international linkages) allowing access to very specific expertise not available locally. Proximity can determine both the ease of collaboration but also the extent of knowledge spillovers. For example, there is widespread evidence of beneficial knowledge spillovers from universities, with recent evidence for China suggesting strong university spillover effects on patenting, effects which decay with distance (Li, Li, and Wu 2020). This reflects a range of similar evidence internationally which also suggests it may be more difficult for smaller firms to capture spillover benefits perhaps due to their lower levels of absorptive capacity. Evidence for the UK is more limited although one recent study does support both the significance and concentration of spillover effects noted internationally (Davies et al. 2021).

Proximity effects on diffusion may be reinforced by clusters and dense networks. In both cases these effects depend on the pool of knowledge available locally. As He and Wong (2012) suggest: 'local knowledge is ... a semi-public good that is spatially bounded, and access to which requires nothing more than cluster membership. Next, local knowledge exchange is prompt or spontaneous because local firms are assumed to be more willing to share knowledge and exchange ideas with other local actors because of shared norms, values, and other formal and informal institutions that hold down misunderstanding and opportunism' (He and Wong, 2012, p. 542). Localised knowledge may also have other spatially distinct characteristics, reflecting the presence of specific institutions (typically universities, research labs), clusters of industrial activity, and/or concentrations of specific types of human capital. Universities with areas of research strength may intensify local knowledge in particular disciplines or technologies promoting cluster development and sustainability (Calzonetti, Miller, and Reid 2012). Alternatively, the presence of large-scale

scientific research facilities – such as those linked to nuclear activity, biotechnology, or particle acceleration - may create very specific local knowledge conditions and stimulate cluster formation. Labour mobility within clusters may also act as a key mechanism for knowledge sharing (Almeida and Kogut 1999; Breschi and Lissoni 2009).

1.4 Measuring ACAP

Despite the degree of interest in absorptive capacity and ‘significant advances in conceptualizing it, there has been no clear consensus on how to measure it’ (Martinez-Senra et al., 2015) p.208. In firm level studies two main approaches have been adopted, however, broadly reflecting a distinction between the economics (and innovation studies) and management literatures. In the economics and innovation studies literature firms’ ACAP is often measured using unidimensional measures such as R&D intensity or R&D continuity sometimes augmented by measures of labour quality (Table 1) (Harris & Yan, 2019; Harris and Le 2019). In general terms, these studies find these measures important both in terms of their direct impact on innovation but also as a (positive) moderator of other influences on innovation such as external collaboration. (Thomas & Wood, 2014) provide a thoughtful commentary on this type of approach, however, stressing both conceptual and empirical weaknesses. In conceptual terms they suggest that unidimensional measures of ACAP are inadequate for capturing the complexity of the concept, particularly when there is any interest in the separate aspects of potential and realised ACAP. Second, they suggest that R&D-based measures of ACAP may be less relevant in services where innovation is more organisational and less technologically dependent. Human capital measures such as those adopted in some economics studies of ACAP may have wider relevance across sectors. Balancing these issues are the objective nature of such measures of ACAP and therefore the ability to use similar measures in different contexts (Harris and Le 2019).

The contribution of human resources (skills) to absorptive capacity also motivated a recent report by the Royal Society (2022) examining skill differentials in different UK regions. Although not providing any direct evidence of the contribution of different skill groups to ACAP the report does emphasise the significant differences in occupational structure and levels of human capital available in different UK regions and localities.

Management researchers have generally taken a different multi-dimensional approach to measuring ACAP, often combining a range of item-based scales to provide separate indicators of each dimension of ACAP (Table 2). As with the more economic studies, however, there is little consistency between the various indicators used across studies, although the framework developed by Flatten et al. (2011) is perhaps used most widely. For the most part, these studies provide evidence of construct reliability and as in the economic studies emphasise the importance of ACAP as an element of firms' innovation activity.

Harris and Yan (2019) and Harris and Le (2019) also adopt a multi-item approach to measuring ACAP in firms in the UK and New Zealand respectively. Harris and Yan (2019) base their analysis on the UK innovation survey while Harris and Le (2019) use very similar data from the Business Operation Survey for New Zealand. In each case they use factor analysis to define elements of firms' external connectivity for innovation based on data on linkages and sources of information for innovation. Their factor analysis suggests a series of five factors which they denote as: external knowledge, national cooperation with business, links with national researchers, international business cooperation and international cooperation with business (Table A.1). This approach overcomes some of the disadvantages of single item scales suggested by Thomas and Wood (2014) and is related to literatures on open and collaborative innovation and sectoral spillovers. Its links to the conceptualisation of ACAP suggested in management studies is less clear.

1.5 Summary

While the concept of absorptive capacity has been widely used there is little or no agreement or established convention about how it should be measured either at firm, region, or sectoral level. Previous studies suggest four implications for any sectoral analysis.

First, what metrics should be used? Studies using single measures or indicators co-exist alongside studies using multi-dimensional quantitative (Harris and Le 2019) and qualitative indicators (Soo et al., 2017). As Thomas & Wood (2014) suggest, however, individual measures such as R&D intensity are not relevant in every sector or indeed to all firms. Adopting a multi-indicator approach therefore seems helpful in both avoiding any bias caused by individual measures and capturing the different dimensions of ACAP. This should probably include:

- Measures of R&D intensity and or continuity as well as other aspects of intangible investment such as training for innovation or investments in intangible knowledge.
- Measures of human capital or skills to provide an indication of the quality of the labour force in any sector (Royal Society, 2022).
- Measures of connectivity or collaboration which might provide the basis for knowledge sharing and exchange. Following Harris and Le (2019) this might separate out national and international collaborations and the types of partners.
- Existing knowledge stocks may also provide the basis for continued organisational learning such as that envisaged in ACAP Belderbos et al., 2016; Xia and Roper, 2016).

Second, previous studies raise the question of the appropriate metrics? As discussion of Frontier and non-Frontier firms suggest, and as Harris and Yan (2019) and Harris and Le (2019) demonstrate, ACAP can differ significantly between firms within an industry or sector and so aggregate industry measures may tell only part of the story. Instead, distributional measures are likely to be required to profile the ability of a sector to widely distribute innovation. This might simply be a distinction between Frontier and non-Frontier firms but might also reflect other distributional measures?

Third, proximity matters for diffusion and knowledge exchange. A key aspect of this is geographical proximity – knowledge exchange in clusters is likely to be stronger than that in more dispersed networks. Considering the geographical concentration of firms in a particular sector may therefore be important.

Fourth, previous studies emphasise the potential importance of spillovers, which although not directly observable may be identifiable in multi-variate analyses.

Table 1: Overview of ACAP studies using quantitative metrics

Study	Country	Unit of Analysis	ACAP metrics	Key Findings
Roper & Love, 2006	EU	Regional	% with tertiary education % participating in life-long learning % employment in high-tech manufacturing % employment in high-tech services	Human capital factors are more important than labour market structure. Inter-regional knowledge flows are significant.
Ahlin et al., 2014	USA, Slovenia	Small firms	Realised absorptive capacity following Kotabe et al (2011)	Innovation is related to entrepreneur's networks, an effect positively moderated by absorptive capacity
Martinez-Senra et al., 2015	Spain	Innovating firms	Importance of external knowledge sources (suppliers, customers, competitors, consultants, universities, public research bodies, technology centres, conferences, scientific journals, and business associations)	Basic research enhances the innovation effects of absorptive capacity, although only in the relatively short term.
Belderbos et al., 2016	EU, US, Japan	Pharma firms	The number of scientific publications on which the firm or its subsidiaries are listed as the affiliations of one of the authors	Strong 'scientific absorptive capacity' was associated with a stronger link between university collaboration and innovation
Lucena & Roper, 2016	Spain	Firms	R&D expenditure Continuity in R&D Training for R&D personnel Employee skills	ACAP mediates the relationship between technology alliance diversity and innovation
Xia & Roper, 2016	US, Europe	Bio-pharma firms	PACAP: R&D intensity, Related prior knowledge, Employee skills RACAP: Patent stock	Growth benefits of external knowledge are conditional on ACAP. Continuity in R&D is a key element of ACAP.
Badillo & Moreno, 2018	Spain	Firms (10+ employees)	Internal R&D intensity	Firms that have high absorptive capacity are more efficient at translating external knowledge into innovation.
Kobarg et al., 2018	Germany	Firms	R&D intensity Continuity of R&D Percentage of labour cost invested in training Share of graduate employees	R&D based dimensions of ACAP negatively moderate the innovation effects of university collaboration. HR aspects of ACAP are only important for radical innovation.
Martinez-Sanchez et al., 2020	Spain	Manufacturing firms	The evaluation of alternative technologies by firms, The evaluation of technological change, the contracting of outside consultants as a mechanism for obtaining information about technology, The existence of a firm's technology management or committee The preparation of a plan The measurement of results obtained in this management process.	HR flexibility complements the ACAP to innovation and R&D to innovation relationship

Table 2: Overview of studies using multi-dimensional ACAP indicators

Study	Acquisition	Assimilation	Transformation	Exploitation
Camisón & Forés (2010)	Knowledge of the competition Openness towards the environment R&D cooperation Internal development of technological competences Assimilation of technology	Assimilation of technology Human resources Industrial benchmarking Involvement in spreading the knowledge Attendance at training courses and professional events Knowledge management	Transmission of IT-based knowledge Renewal capability Adaptation capacity Exchange of scientific and technological information Integration of R&D	New knowledge exploitation Application of experience Development of patents Technological proactiveness
Delmas, Hoffmann & Kuss, (2011)	Business units and functional groups strongly interact with upper levels to acquire new knowledge Different departments strongly interact with each other to acquire new knowledge The company collects industry information through informal means The company regularly organizes special meetings with third parties	We quickly recognize shifts in our market (e.g., competition, regulation, demography) New opportunities to serve our clients are quickly understood. Consequences of technological progress are quickly understood.	The company regularly considers the impact of changing market demands for the portfolio of products and services The meetings held regarding new operations and products are highly effective Newly acquired knowledge is documented and shared within the whole company. The applicability of new knowledge to existing knowledge is quickly recognized.	The processes (e.g., procedures, and so on) for all kinds of activities are clearly known (e.g., face-gate-process, standard operating procedures, and so on). We experience difficulties in implementing client requests (e.g., product modifications, and so on) We constantly consider how to better exploit knowledge (e.g., lessons learned processes).
Jimenez-Barrionuevo, Garcia-Morales, Molina (2011)	There is close personal interaction between the two organizations. The relation between the two organizations is characterized by mutual trust. The relation between the two organizations is characterized by mutual respect. The relationship with this organization is one of personal friendship. The relationship between the two organizations is characterized by a high level of reciprocity	The members of the two organizations share their own common language. There is high complementarity between the resources and capabilities of the two organizations. The main capabilities of the two organizations are very similar/overlap. The organizational cultures of the two organizations are compatible. The operating and management styles of the two organizations are compatible.	There are many informal conversations in the organization that involve commercial activity. Interdepartmental meetings are organized to discuss the development and tendencies of the organization. The different units publish informative documents periodically The important data are transmitted regularly to all units. When something important occurs, all units are informed within a short time. The organization has the capabilities or abilities necessary to ensure that knowledge flows within the organization and is shared between the different units.	There is a clear division of functions and responsibilities regarding use of information and knowledge obtained from outside. There are capabilities and abilities needed to exploit the information and knowledge obtained from the outside.

Flatten, Engelen, Zahra, A& Brettel (2011)	The search for relevant information concerning our industry is every-day business in our company. Our management motivates the employees to use information sources within our industry. Our management expects that the employees deal with information beyond our industry	In our company ideas and concepts are communicated cross-departmental. Our management emphasizes cross-departmental support to solve problems. In our company there is a quick information flow. Our management demands periodical cross-departmental meetings to interchange new developments, problems, and achievements	Our employees can structure and to use collected knowledge. Our employees are used to absorb new knowledge as well as to prepare it for further purposes and to make it available. Our employees successfully link existing knowledge with new insights. Our employees can apply new knowledge in their practical work	Our management supports the development of prototypes. Our company regularly reconsiders technologies and adapts them accordant to new knowledge. Our company can work more effective by adopting new technologies
Soo et al., 2017	We regularly collect industry information through informal means (e.g., lunch with industry friends, talks with trade partners) We regularly scan the external environment for new information, knowledge, or technologies It is common for our employees to approach customers, suppliers, or third parties (i.e., consultants, financial advisors, etc.) to acquire new knowledge The search for relevant information concerning our industry is everyday business in our organization We keep ourselves constantly updated with the latest technologies or state-of-the-art knowledge related to our organization's business	Our employees quickly recognize and understand the usefulness of new external knowledge We quickly analyse and interpret the impact of changing market demands on our products and/or services New opportunities to serve our customers are quickly understood We are slow to recognize and interpret shifts in our market In our organization, new external information or knowledge is quickly communicated across all business units or departments Our management demands periodical cross-departmental meetings to exchange and analyse new knowledge or technological developments from the external environment	Our employees record and store newly acquired knowledge for future reference Our employees have the ability to successfully link existing knowledge with new knowledge or insights Our employees regularly meet to discuss how to utilize new knowledge to improve our current products, services, or internal processes Our employees are able to apply new knowledge in their practical work In this organization, we regularly consider the consequences of changing market demands in terms of new (or improved) products and/or services In this organization, we periodically meet to discuss consequences of market trends and new product development	Our management supports the development of prototypes, new products, services, or processes Our organization regularly reconsiders our current products, services, or processes and adapts them in accordance with new knowledge or technologies Our organization has the ability to work more effectively by adopting new technologies or knowledge We regularly implement new technologies to develop new products, services, or processes In this organization, we are proficient in transforming new knowledge into new (or improved) products, services, or processes We regularly consider how to better exploit knowledge and/or technologies. Our organization has difficulty implementing new products and services

SECTION 2: PROFILING SECTORAL ABSORPTIVE CAPACITY

2.1 Introduction

In this Section we draw on data from several UK data sources to profile the absorptive capacity of a group of 63 UK sectors. The aim is to identify those sectors where absorptive capacity is stronger and weaker and how aspects of ACAP vary between sectors.

As the discussion of the previous Section suggested there is no single or specific measure of absorptive capacity and so we draw on a range of indicators to capture different aspects of sectoral absorptive capacity (Table 2.1). First, we use a series of measures of intangible investment to capture the scale and nature of firms' investments in knowledge within each sector. These intangibles indicators are derived primarily from recent ONS publications on sectoral intangible investment³. Second, we include a range of indicators relating to skills gaps – potential limitations on absorptive capacity - and business capabilities derived from the Employer Skills Survey. Finally, to reflect the inter-connected nature of firms and the potential for inter-organisational knowledge transfer we also include a measure of within-industry collaboration derived from the UK Innovation Survey (Table 2.1). Detailed definitions of the individual variables are included in Table A2.2 and the sectoral definitions are included in Table A2.2.

³ Table 2 details the original data source as indicated on the ONS website.

Table 2.1: ACAP variable classification

Knowledge (intangible investment)	Skills and Capabilities	Intra-industry Linkages
R&D/sales	Impact of skills gap: performance	Collaboration with other businesses within own industry
Design/sales	Impact of skills gap: Delay new product and services development	
Software /sales	Impact of skills gap: Have difficulty introducing new working practices	
Organisation capital/sales	Business plan	
	Training budget	

Table 2.2: Variable definitions

Variable	Data source
Intangible investment	
Industry investment in Research and Development as a percentage of sales	Business Investment Data (ONS), Business Structure Database (ONS) 2021
Industry investment in Computer Software and Databases as a percentage of sales	Business Investment Data (ONS), Business Structure Database (ONS) 2021
Industry investment in Design as a percentage of sales	Business Investment Data (ONS), Business Structure Database (ONS) 2021
Industry investment in Organisational Capital ⁴ as a percentage of sales	Business Investment Data (ONS), Business Structure Database (ONS) 2021
Skills and capabilities	
Industry skills gap impact: Reducing performance (% firms)	Employer Skills Survey 2017
Industry skills gap impact: Delay in new product and services development (% firms)	Employer Skills Survey 2017
Industry skills gap impact: Difficulty in introducing new working practices (% firms)	Employer Skills Survey 2017
Business plan (% firms)	Employer Skills Survey 2017
Training budget (% firms)	Employer Skills Survey 2017
Collaboration	
Intra-industry collaborations (% firms)	UK innovation Survey 2021

⁴ Investment in organisational capital consists of investment into the structures and managerial practices of the organisation aimed at increasing productivity and efficiency.

2.2 ACAP indicators

2.2.1 *Intangible investment*

Intangible investments (purchased or own production) represent investments in the knowledge capital of a business and so provide an indication of how knowledge rich or knowledge poor firms are in any given sector. They also provide an indication of the level of understanding firms' staff may have of different technology areas. For example, firms investing in R&D are likely to have dedicated staff which may conduct R&D but may also be key receptors of external knowledge. We therefore anticipate that sectors with higher levels of intangible investment (relative to sales) are likely to have higher levels of sectoral absorptive capacity.

Each of these indicators is summarised in Tables 2.3-2.6. For each sector we report three items: the actual value of the indicator itself, a rank across sectors and a simple green/orange/red indicator of the overall rank of the sector. Green indicates a sector is in the top quartile for the indicator, orange in the second quartile and red in the lower two quartiles of the distribution of sectors. Green sectors are those with the highest levels of absorptive capacity.

Pharmaceutical products have by far the highest level of R&D spending relative to sales (Table 2.3) followed by a range of other manufacturing sectors. Services sectors tend to rank lower on this indicator due to the concentration of R&D activity in manufacturing. Design spending also tends to be concentrated in manufacturing sectors with some more basic services towards the foot of the table (Table 2.4). Conversely software purchases are highest in a range of knowledge intensive service activities (Table 2.5) with manufacturing activities mainly mid-table and basic services again towards the foot of the table. An essentially similar pattern is observable in terms of organisational capital spending (Table 2.6).

2.2.2 *Skills and capabilities*

Skills are a standard measure of ACAP at firm level. Here we use three skill-related measures derived from the Employer Skills Survey (2017) which reflect the proportion of firms whose action is restricted by skill shortages. In each case we anticipate that the larger proportion of firms whose actions are constrained by skill shortages *the lower* is sectoral absorptive capacity. These indicators are therefore negatively related to absorptive capacity.



We also include two indicators derived from the Employer Skills Survey which provide an indication of the managerial sophistication and resources of enterprises within each sector – use of a business plan and training budget. Each of these we anticipate will be positively related to absorptive capacity.

Sectors facing fewest restrictions to their performance due to skills gaps tend to be a range of professional and business services sectors (Table 2.7), with some higher technology manufacturing sectors facing more intensive skill barriers to growth and productivity. Skill gaps restricting new product development activity are also least pressing in a range of service and some basic manufacturing sectors (Table 2.8). Again, skill gaps are most restrictive for new product development in a range of high technology and medium technology manufacturing sectors (Table 2.8). An essentially similar pattern is evident for the impact of skills gaps on the adoption of new working practices (Table 2.9).

Two indicators are also included relating to managerial capabilities – business plan use and whether firms have a training budget (Tables 2.10 and 2.11). Pharmaceutical manufacture and a range of professional service sectors are most likely to have a business plan and score well on this metric. Lower ranked sectors relate to several basic services sectors (Table 2.10). A similar group of sectors perform well on the training budget metric (Table 2.11), although some of the lowest scores on this metric are observed in low and medium-tech manufacturing firms.

2.2.3 Collaboration within the sector

Another important element of sectoral ACAP is the level of connectivity or collaboration between firms in the sector which provides an indication of the scope for inter-firm knowledge transfer. Our final indicator of sectoral ACAP, derived from the UK Innovation Survey, is intended to capture this factor, and represents the proportion of firms in each sector collaborating with other firms in the sector (within the UK) for innovation. Some of the highest levels of collaboration activity are observed in high-tech manufacturing and services sectors (Table 2.12) with lower levels of collaborative activity in low-tech and personal services. Note that for this metric we are unable to report values for several sectors due either to a very small number of collaborating firms (and therefore data could not be released) or as these sectors are excluded from the UK Innovation Survey.

Table 2.3: Intangible investment: R&D as a % of sales

SIC2007	Sector Name	R&D %	Rank	
21	Manufacture of basic pharmaceutical products	15.6	1.0	
29	Manufacture of motor vehicles, trailers, and semi-trailers	6.2	2.0	
72	Scientific research and development	5.5	3.0	
26	Manufacture of computer, electronics, and optical products	5.0	4.0	
30	Manufacture of other transport equipment	4.2	5.0	
27	Manufacture of electrical equipment	2.3	6.0	
28	Manufacture of machinery and equipment n.e.c.	2.2	7.0	
20	Manufacture of chemicals and chemical products	1.6	8.0	
93	Sports activities and amusement and recreation	1.6	9.0	
62_63	Computer programming and information services	1.6	10.0	
61	Telecommunications	1.5	11.0	
31_32	Manufacture of furniture and other manufacturing	1.3	12.0	
25	Manufacture of fabricated metal products	1.1	13.0	
33	Repair and installation of machinery and equipment	0.9	14.0	
58	Publishing activities	0.8	15.0	
23	Manufacture of other non-metallic mineral products	0.7	16.0	
69_70	Legal and accounting services	0.6	17.0	
71	Architectural and engineering activities	0.6	18.0	
59_60	Film, television programming and broadcasting	0.6	19.0	
73	Advertising and market research	0.5	20.0	
22	Manufacture of rubber and plastic products	0.5	21.0	
74_75	Other professional, scientific, and veterinary activities	0.4	22.0	
24	Manufacture of basic metals	0.4	23.0	
10_11_12	Manufacture of food, drink, and tobacco	0.3	24.0	
47	Retail trade, except motor vehicle and motorcycle	0.2	25.0	
05_06_07_08_09	Mining and support services	0.2	26.0	
77	Rental and leasing activities	0.1	27.0	
41_42_43	Construction	0.1	28.0	
80_81_82	Security services and office support	0.1	29.0	
45	Wholesale and retail trade motor vehicles	0.1	30.0	
46	Wholesale trade, except of motor vehicle and motorcycle	0.1	31.0	
35	Electricity, gas, steam, and air conditioning supply	0.0	32.0	
64	Financial services	0.0	32.0	
84	Public administration and defence; social security	0.0	32.0	
87_88	Residential and other social care	0.0	32.0	
68	Real estate activities	0.0	32.0	
85	Education	0.0	32.0	
86	Human health activities	0.0	32.0	
1	Crop and animal production, hunting	0.0	32.0	
2	Forestry and logging	0.0	32.0	
3	Fishing and aquaculture	0.0	32.0	
13_14_15	Manufacture of textiles, wearing apparel, leather products	0.0	32.0	
16	Manufacture of wood, and of products of wood and cork	0.0	32.0	
17	Manufacture of paper and paper products	0.0	32.0	
18	Printing and reproduction of recorded media	0.0	32.0	
19	Manufacture of coke and refined petroleum products	0.0	32.0	
36	Water collection, treatment, and supply	0.0	32.0	
37_38_39	Sewerage, waste collection and remediation	0.0	32.0	
49	Land transport and transport vis pipeline	0.0	32.0	
50	Water transport	0.0	32.0	
51	Air transport	0.0	32.0	
52	Warehouse and support activities for transportation	0.0	32.0	
53	Postal and courier activities	0.0	32.0	
55_56	Accommodation and food & beverage services	0.0	32.0	
65	Insurance, reinsurance, and pension funding	0.0	32.0	
66	Activities auxiliary to financial services	0.0	32.0	
78	Employment activities	0.0	32.0	
79	Travel insurance, tour operator	0.0	32.0	
90_91_92	Art, entertainment, libraries, museums, gambling	0.0	32.0	
94	Activities of membership organizations	0.0	32.0	
95	Repair of computers and personal goods	0.0	32.0	
96	other personal services activities	0.0	32.0	

Table 2.4: Intangible investment: Design as a % of sales

SIC2007	Sector Name	Design %		
30	Manufacture of other transport equipment	1.5	1.0	
05_06_07_08_09	Mining and support services	1.4	2.0	
26	Manufacture of computer, electronics, and optical products	1.2	3.0	
41_42_43	Construction	0.9	4.0	
23	Manufacture of other non-metallic mineral products	0.8	5.0	
28	Manufacture of machinery and equipment N.E.C.	0.7	6.0	
25	Manufacture of fabricated metal products	0.7	7.0	
36	Water collection, treatment, and supply	0.7	8.0	
18	Printing and reproduction of recorded media	0.6	9.0	
27	Manufacture of electrical equipment	0.5	10.0	
21	Manufacture of basic pharmaceutical products	0.5	11.0	
24	Manufacture of basic metals	0.5	12.0	
20	Manufacture of chemicals and chemical products	0.5	13.0	
31_32	Manufacture of furniture and other manufacturing	0.4	14.0	
37_38_39	Sewerage, waste collection and remediation	0.4	15.0	
33	Repair and installation of machinery and equipment	0.4	16.0	
35	Electricity, gas, steam, and air conditioning supply	0.3	17.0	
58	Publishing activities	0.3	18.0	
62_63	Computer programming and information services	0.2	19.0	
95	Repair of computers and personal goods	0.2	20.0	
22	Manufacture of rubber and plastic products	0.2	21.0	
13_14_15	Manufacture of textiles, wearing apparel, leather products	0.2	22.0	
59_60	Film, television programming and broadcasting	0.2	23.0	
93	Sports activities and amusement and recreation	0.2	24.0	
61	Telecommunications	0.2	25.0	
73	Advertising and market research	0.2	26.0	
79	Travel insurance, tour operator	0.2	27.0	
94	Activities of membership organizations	0.2	28.0	
17	Manufacture of paper and paper products	0.1	29.0	
3	Fishing and aquaculture	0.1	30.0	
29	Manufacture of motor vehicles, trailers, and semi-trailers	0.1	31.0	
45	Wholesale and retail trade motor vehicles	0.1	32.0	
16	Manufacture of wood, and of products of wood and cork	0.1	33.0	
10_11_12	Manufacture of food, drink, and tobacco	0.1	34.0	
80_81_82	Security services and office support	0.1	35.0	
65	Insurance, reinsurance, and pension funding	0.1	36.0	
71	Architectural and engineering activities	0.1	37.0	
52	Warehouse and support activities for transportation	0.1	38.0	
90_91_92	Art, entertainment, libraries, museums, gambling	0.1	39.0	
74_75	Other professional, scientific, and veterinary activities	0.1	40.0	
77	Rental and leasing activities	0.1	41.0	
72	Scientific research and development	0.1	42.0	
64	Financial services	0.1	43.0	
19	Manufacture of coke and refined petroleum products	0.1	44.0	
47	Retail trade, except motor vehicle and motorcycle	0.1	45.0	
1	Crop and animal production, hunting	0.1	46.0	
96	other personal services activities	0.1	47.0	
50	Water transport	0.1	48.0	
46	Wholesale trade, except of motor vehicle and motorcycle	0.1	49.0	
55_56	Accommodation and food & beverage services	0.0	50.0	
69_70	Legal and accounting services	0.0	50.0	
49	Land transport and transport vis pipeline	0.0	50.0	
66	Activities auxiliary to financial services	0.0	50.0	
51	Air transport	0.0	50.0	
78	Employment activities	0.0	50.0	
84	Public administration and defence; social security	0.0	50.0	
87_88	Residential and other social care	0.0	50.0	
68	Real estate activities	0.0	50.0	
85	Education	0.0	50.0	
86	Human health activities	0.0	50.0	
2	Forestry and logging	0.0	50.0	
53	Postal and courier activities	0.0	50.0	

Table 2.5: Intangible investment: Software as a % of sales

SIC2007	Sector Name	Software %		
95	Repair of computers and personal goods	4.6	1.0	
72	Scientific research and development	4.4	2.0	
58	Publishing activities	3.7	3.0	
61	Telecommunications	3.4	4.0	
36	Water collection, treatment, and supply	2.5	5.0	
94	Activities of membership organizations	2.3	6.0	
74_75	Other professional, scientific, and veterinary activities	2.0	7.0	
62_63	Computer programming and information services	2.0	8.0	
73	Advertising and market research	1.8	9.0	
71	Architectural and engineering activities	1.8	10.0	
59_60	Film, television programming and broadcasting	1.7	11.0	
69_70	Legal and accounting services	1.7	12.0	
18	Printing and reproduction of recorded media	1.3	13.0	
30	Manufacture of other transport equipment	1.2	14.0	
33	Repair and installation of machinery and equipment	0.9	15.0	
93	Sports activities and amusement and recreation	0.8	16.0	
80_81_82	Security services and office support	0.8	17.0	
28	Manufacture of machinery and equipment N.E.C.	0.8	18.0	
52	Warehouse and support activities for transportation	0.8	19.0	
79	Travel insurance, tour operator	0.8	20.0	
2	Forestry and logging	0.8	21.0	
53	Postal and courier activities	0.8	22.0	
25	Manufacture of fabricated metal products	0.7	23.0	
51	Air transport	0.7	24.0	
77	Rental and leasing activities	0.7	25.0	
31_32	Manufacture of furniture and other manufacturing	0.6	26.0	
37_38_39	Sewerage, waste collection and remediation	0.6	27.0	
16	Manufacture of wood, and of products of wood and cork	0.6	28.0	
21	Manufacture of basic pharmaceutical products	0.6	29.0	
35	Electricity, gas, steam, and air conditioning supply	0.6	30.0	
49	Land transport and transport vis pipeline	0.5	31.0	
66	Activities auxiliary to financial services	0.5	32.0	
78	Employment activities	0.5	33.0	
24	Manufacture of basic metals	0.5	34.0	
90_91_92	Art, entertainment, libraries, museums, gambling	0.5	35.0	
20	Manufacture of chemicals and chemical products	0.5	36.0	
96	other personal services activities	0.5	37.0	
27	Manufacture of electrical equipment	0.5	38.0	
13_14_15	Manufacture of textiles, wearing apparel, leather products	0.4	39.0	
47	Retail trade, except motor vehicle and motorcycle	0.4	40.0	
50	Water transport	0.4	41.0	
23	Manufacture of other non-metallic mineral products	0.4	42.0	
10_11_12	Manufacture of food, drink, and tobacco	0.4	43.0	
17	Manufacture of paper and paper products	0.4	44.0	
22	Manufacture of rubber and plastic products	0.4	45.0	
26	Manufacture of computer, electronics, and optical products	0.3	46.0	
29	Manufacture of motor vehicles, trailers, and semi-trailers	0.3	47.0	
55_56	Accommodation and food & beverage services	0.3	48.0	
05_06_07_08_09	Mining and support services	0.3	49.0	
46	Wholesale trade, except of motor vehicle and motorcycle	0.3	50.0	
64	Financial services	0.2	51.0	
41_42_43	Construction	0.2	52.0	
45	Wholesale and retail trade motor vehicles	0.1	53.0	
65	Insurance, reinsurance, and pension funding	0.1	54.0	
19	Manufacture of coke and refined petroleum products	0.0	55.0	
84	Public administration and defence; social security	0.0	55.0	
1	Crop and animal production, hunting	0.0	55.0	
87_88	Residential and other social care	0.0	55.0	
68	Real estate activities	0.0	55.0	
85	Education	0.0	55.0	
86	Human health activities	0.0	55.0	
3	Fishing and aquaculture	0.0	55.0	

Table 2.6: Intangible investment: Organisational capital as a % of sales

SIC2007	Sector Name	OrgCap %		
72	Scientific research and development	2.3	1.0	
94	Activities of membership organizations	1.4	2.0	
74_75	Other professional, scientific, and veterinary activities	1.3	3.0	
71	Architectural and engineering activities	1.3	4.0	
69_70	Legal and accounting services	1.2	5.0	
58	Publishing activities	1.2	6.0	
18	Printing and reproduction of recorded media	1.2	7.0	
26	Manufacture of computer, electronics, and optical products	1.2	8.0	
62_63	Computer programming and information services	1.2	9.0	
2	Forestry and logging	1.2	10.0	
93	Sports activities and amusement and recreation	1.1	11.0	
61	Telecommunications	1.1	12.0	
17	Manufacture of paper and paper products	1.0	13.0	
25	Manufacture of fabricated metal products	1.0	14.0	
73	Advertising and market research	1.0	15.0	
22	Manufacture of rubber and plastic products	1.0	16.0	
3	Fishing and aquaculture	1.0	17.0	
96	other personal services activities	0.9	18.0	
23	Manufacture of other non-metallic mineral products	0.9	19.0	
31_32	Manufacture of furniture and other manufacturing	0.9	20.0	
55_56	Accommodation and food & beverage services	0.8	21.0	
33	Repair and installation of machinery and equipment	0.8	22.0	
90_91_92	Art, entertainment, libraries, museums, gambling	0.8	23.0	
95	Repair of computers and personal goods	0.8	24.0	
20	Manufacture of chemicals and chemical products	0.7	25.0	
16	Manufacture of wood, and of products of wood and cork	0.7	26.0	
27	Manufacture of electrical equipment	0.7	27.0	
80_81_82	Security services and office support	0.7	28.0	
49	Land transport and transport via pipeline	0.7	29.0	
77	Rental and leasing activities	0.7	30.0	
53	Postal and courier activities	0.7	31.0	
28	Manufacture of machinery and equipment N.E.C.	0.6	32.0	
47	Retail trade, except motor vehicle and motorcycle	0.6	33.0	
21	Manufacture of basic pharmaceutical products	0.6	34.0	
64	Financial services	0.6	35.0	
41_42_43	Construction	0.6	36.0	
30	Manufacture of other transport equipment	0.6	37.0	
52	Warehouse and support activities for transportation	0.6	38.0	
78	Employment activities	0.5	39.0	
13_14_15	Manufacture of textiles, wearing apparel, leather products	0.5	40.0	
79	Travel insurance, tour operator	0.5	41.0	
59_60	Film, television programming and broadcasting	0.5	42.0	
10_11_12	Manufacture of food, drink, and tobacco	0.5	43.0	
05_06_07_08_09	Mining and support services	0.4	44.0	
35	Electricity, gas, steam, and air conditioning supply	0.4	45.0	
29	Manufacture of motor vehicles, trailers, and semi-trailers	0.4	46.0	
36	Water collection, treatment, and supply	0.4	47.0	
24	Manufacture of basic metals	0.4	48.0	
1	Crop and animal production, hunting	0.3	49.0	
46	Wholesale trade, except of motor vehicle and motorcycle	0.3	50.0	
66	Activities auxiliary to financial services	0.3	51.0	
50	Water transport	0.3	52.0	
51	Air transport	0.2	53.0	
65	Insurance, reinsurance, and pension funding	0.2	54.0	
45	Wholesale and retail trade motor vehicles	0.2	55.0	
37_38_39	Sewerage, waste collection and remediation	0.1	56.0	
19	Manufacture of coke and refined petroleum products	0.0	57.0	
84	Public administration and defence; social security	0.0	57.0	
87_88	Residential and other social care	0.0	57.0	
68	Real estate activities	0.0	57.0	
85	Education	0.0	57.0	
86	Human health activities	0.0	57.0	

Table 2.7: Skills gaps: % firms in which restricting performance

SIC2007	Sector Name	Skills: Perf.		
95	Repair of computers and personal goods	8.1	1.0	
05_06_07_08_09	Mining and support services	9.2	2.0	
96	other personal services activities	9.3	3.0	
68	Real estate activities	9.3	4.0	
1	Crop and animal production, hunting	9.3	5.0	
74_75	Other professional, scientific, and veterinary activities	9.8	6.0	
64	Financial services	10.3	7.0	
59_60	Film, television programming and broadcasting	10.5	8.0	
53	Postal and courier activities	10.7	9.0	
94	Activities of membership organizations	10.7	10.0	
79	Travel insurance, tour operator	10.8	11.0	
41_42_43	Construction	11.0	12.0	
87_88	Residential and other social care	11.2	13.0	
77	Rental and leasing activities	11.3	14.0	
58	Publishing activities	11.3	15.0	
13_14_15	Manufacture of textiles, wearing apparel, leather products	11.6	16.0	
52	Warehouse and support activities for transportation	11.7	17.0	
69_70	Legal and accounting services	11.8	18.0	
49	Land transport and transport vis pipeline	11.8	19.0	
66	Activities auxiliary to financial services	11.8	20.0	
61	Telecommunications	12.1	21.0	
37_38_39	Sewerage, waste collection and remediation	12.4	22.0	
86	Human health activities	12.5	23.0	
62_63	Computer programming and information services	12.6	24.0	
50	Water transport	12.8	25.0	
22	Manufacture of rubber and plastic products	13.6	26.0	
21	Manufacture of basic pharmaceutical products	13.9	27.0	
84	Public administration and defence; social security	14.0	28.0	
3	Fishing and aquaculture	14.1	29.0	
90_91_92	Art, entertainment, libraries, museums, gambling	14.2	30.0	
65	Insurance, reinsurance, and pension funding	14.2	31.0	
33	Repair and installation of machinery and equipment	14.3	32.0	
71	Architectural and engineering activities	14.4	33.0	
18	Printing and reproduction of recorded media	14.7	34.0	
36	Water collection, treatment, and supply	14.8	35.0	
72	Scientific research and development	14.8	36.0	
93	Sports activities and amusement and recreation	14.8	37.0	
73	Advertising and market research	14.9	38.0	
85	Education	14.9	39.0	
80_81_82	Security services and office support	15.7	40.0	
35	Electricity, gas, steam, and air conditioning supply	15.8	41.0	
27	Manufacture of electrical equipment	16.4	42.0	
46	Wholesale trade, except of motor vehicle and motorcycle	16.4	43.0	
25	Manufacture of fabricated metal products	16.4	44.0	
45	Wholesale and retail trade motor vehicles	16.5	45.0	
19	Manufacture of coke and refined petroleum products	16.7	46.0	
29	Manufacture of motor vehicles, trailers, and semi-trailers	16.8	47.0	
20	Manufacture of chemicals and chemical products	17.4	48.0	
26	Manufacture of computer, electronics, and optical products	17.5	49.0	
31_32	Manufacture of furniture and other manufacturing	17.5	50.0	
16	Manufacture of wood, and of products of wood and cork	17.5	51.0	
2	Forestry and logging	17.6	52.0	
23	Manufacture of other non-metallic mineral products	17.8	53.0	
51	Air transport	18.5	54.0	
47	Retail trade, except motor vehicle and motorcycle	18.5	55.0	
28	Manufacture of machinery and equipment N.E.C.	18.8	56.0	
78	Employment activities	20.0	57.0	
24	Manufacture of basic metals	20.3	58.0	
10_11_12	Manufacture of food, drink, and tobacco	21.7	59.0	
55_56	Accommodation and food & beverage services	21.9	60.0	
17	Manufacture of paper and paper products	24.0	61.0	
30	Manufacture of other transport equipment	25.6	62.0	

Table 2.8: Skills gaps: % firms in which restricting new product development

SIC2007	Sector Name	Skills: NPD		
1	Crop and animal production, hunting	1.7	1.0	
23	Manufacture of other non-metallic mineral products	1.9	2.0	
33	Repair and installation of machinery and equipment	1.9	3.0	
22	Manufacture of rubber and plastic products	1.9	4.0	
96	other personal services activities	1.9	5.0	
53	Postal and courier activities	2.1	6.0	
64	Financial services	2.2	7.0	
72	Scientific research and development	2.2	8.0	
84	Public administration and defence; social security	2.3	9.0	
52	Warehouse and support activities for transportation	2.3	10.0	
41_42_43	Construction	2.3	11.0	
68	Real estate activities	2.4	12.0	
66	Activities auxiliary to financial services	2.4	13.0	
77	Rental and leasing activities	2.5	14.0	
87_88	Residential and other social care	2.5	15.0	
16	Manufacture of wood, and of products of wood and cork	2.6	16.0	
05_06_07_08_09	Mining and support services	2.7	17.0	
69_70	Legal and accounting services	2.8	18.0	
49	Land transport and transport via pipeline	2.8	19.0	
59_60	Film, television programming and broadcasting	2.9	20.0	
2	Forestry and logging	2.9	21.0	
85	Education	2.9	22.0	
86	Human health activities	3.0	23.0	
37_38_39	Sewerage, waste collection and remediation	3.0	24.0	
90_91_92	Art, entertainment, libraries, museums, gambling	3.1	25.0	
74_75	Other professional, scientific, and veterinary activities	3.2	26.0	
47	Retail trade, except motor vehicle and motorcycle	3.4	27.0	
46	Wholesale trade, except of motor vehicle and motorcycle	3.4	28.0	
45	Wholesale and retail trade motor vehicles	3.4	29.0	
94	Activities of membership organizations	3.5	30.0	
93	Sports activities and amusement and recreation	3.6	31.0	
79	Travel insurance, tour operator	3.6	32.0	
58	Publishing activities	3.7	33.0	
61	Telecommunications	3.7	34.0	
24	Manufacture of basic metals	3.8	35.0	
95	Repair of computers and personal goods	4.0	36.0	
17	Manufacture of paper and paper products	4.1	37.0	
65	Insurance, reinsurance, and pension funding	4.2	38.0	
36	Water collection, treatment, and supply	4.3	39.0	
71	Architectural and engineering activities	4.5	40.0	
13_14_15	Manufacture of textiles, wearing apparel, leather products	4.5	41.0	
80_81_82	Security services and office support	4.6	42.0	
73	Advertising and market research	4.7	43.0	
18	Printing and reproduction of recorded media	5.0	44.0	
25	Manufacture of fabricated metal products	5.0	45.0	
78	Employment activities	5.0	46.0	
28	Manufacture of machinery and equipment N.E.C.	5.1	47.0	
27	Manufacture of electrical equipment	5.1	48.0	
55_56	Accommodation and food & beverage services	5.3	49.0	
35	Electricity, gas, steam, and air conditioning supply	5.3	50.0	
31_32	Manufacture of furniture and other manufacturing	5.7	51.0	
62_63	Computer programming and information services	5.9	52.0	
20	Manufacture of chemicals and chemical products	6.8	53.0	
10_11_12	Manufacture of food, drink, and tobacco	6.8	54.0	
26	Manufacture of computer, electronics, and optical products	7.0	55.0	
3	Fishing and aquaculture	7.0	56.0	
29	Manufacture of motor vehicles, trailers, and semi-trailers	8.4	57.0	
30	Manufacture of other transport equipment	11.6	58.0	
50	Water transport	12.8	59.0	
21	Manufacture of basic pharmaceutical products	13.9	60.0	
19	Manufacture of coke and refined petroleum products	16.7	61.0	
51	Air transport	18.5	62.0	

Table 2.9: Skills gaps: % firms in which restricting adoption of new working practices

SIC2007	Sector Name	Skills:WP		
64	Financial services	2.3	1.0	
05_06_07_08_09	Mining and support services	2.7	2.0	
96	other personal services activities	3.0	3.0	
79	Travel insurance, tour operator	3.0	4.0	
68	Real estate activities	3.2	5.0	
77	Rental and leasing activities	3.2	6.0	
58	Publishing activities	3.3	7.0	
41_42_43	Construction	3.4	8.0	
1	Crop and animal production, hunting	3.5	9.0	
29	Manufacture of motor vehicles, trailers, and semi-trailers	3.5	10.0	
66	Activities auxiliary to financial services	3.5	11.0	
62_63	Computer programming and information services	3.8	12.0	
24	Manufacture of basic metals	3.8	13.0	
33	Repair and installation of machinery and equipment	3.8	14.0	
52	Warehouse and support activities for transportation	3.8	15.0	
13_14_15	Manufacture of textiles, wearing apparel, leather products	3.9	16.0	
69_70	Legal and accounting services	3.9	17.0	
95	Repair of computers and personal goods	4.0	18.0	
59_60	Film, television programming and broadcasting	4.1	19.0	
65	Insurance, reinsurance, and pension funding	4.2	20.0	
61	Telecommunications	4.2	21.0	
53	Postal and courier activities	4.3	22.0	
74_75	Other professional, scientific, and veterinary activities	4.3	23.0	
36	Water collection, treatment, and supply	4.3	24.0	
49	Land transport and transport via pipeline	4.4	25.0	
94	Activities of membership organizations	4.4	26.0	
22	Manufacture of rubber and plastic products	4.5	27.0	
71	Architectural and engineering activities	4.7	28.0	
73	Advertising and market research	4.7	29.0	
37_38_39	Sewerage, waste collection and remediation	5.1	30.0	
45	Wholesale and retail trade motor vehicles	5.1	31.0	
84	Public administration and defence; social security	5.2	32.0	
26	Manufacture of computer, electronics, and optical products	5.2	33.0	
35	Electricity, gas, steam, and air conditioning supply	5.3	34.0	
46	Wholesale trade, except of motor vehicle and motorcycle	5.3	35.0	
87_88	Residential and other social care	5.3	36.0	
86	Human health activities	5.5	37.0	
23	Manufacture of other non-metallic mineral products	5.6	38.0	
78	Employment activities	5.6	39.0	
27	Manufacture of electrical equipment	5.6	40.0	
72	Scientific research and development	5.7	41.0	
90_91_92	Art, entertainment, libraries, museums, gambling	5.7	42.0	
28	Manufacture of machinery and equipment N.E.C.	5.8	43.0	
30	Manufacture of other transport equipment	5.8	44.0	
93	Sports activities and amusement and recreation	6.1	45.0	
80_81_82	Security services and office support	6.1	46.0	
18	Printing and reproduction of recorded media	6.1	47.0	
20	Manufacture of chemicals and chemical products	6.1	48.0	
25	Manufacture of fabricated metal products	6.1	49.0	
16	Manufacture of wood, and of products of wood and cork	6.1	50.0	
47	Retail trade, except motor vehicle and motorcycle	6.4	51.0	
31_32	Manufacture of furniture and other manufacturing	6.4	52.0	
85	Education	6.8	53.0	
3	Fishing and aquaculture	7.0	54.0	
2	Forestry and logging	7.1	55.0	
17	Manufacture of paper and paper products	7.5	56.0	
55_56	Accommodation and food & beverage services	8.2	57.0	
10_11_12	Manufacture of food, drink, and tobacco	9.6	58.0	
50	Water transport	12.8	59.0	
21	Manufacture of basic pharmaceutical products	13.9	60.0	
19	Manufacture of coke and refined petroleum products	16.7	61.0	
51	Air transport	18.5	62.0	

Table 2.10: Capabilities: % firms with a business plan

SIC2007	Sector Name	Business Plan		
21	Manufacture of basic pharmaceutical products	86.1	1.0	
85	Education	85.3	2.0	
64	Financial services	85.1	3.0	
78	Employment activities	82.2	4.0	
72	Scientific research and development	81.3	5.0	
90_91_92	Art, entertainment, libraries, museums, gambling	80.6	6.0	
87_88	Residential and other social care	80.6	7.0	
19	Manufacture of coke and refined petroleum products	80.0	8.0	
65	Insurance, reinsurance, and pension funding	79.2	9.0	
66	Activities auxiliary to financial services	78.2	10.0	
73	Advertising and market research	76.7	11.0	
94	Activities of membership organizations	75.5	12.0	
84	Public administration and defence; social security	75.3	13.0	
86	Human health activities	74.5	14.0	
80_81_82	Security services and office support	72.7	15.0	
05_06_07_08_09	Mining and support services	71.4	16.0	
28	Manufacture of machinery and equipment N.E.C.	71.1	17.0	
93	Sports activities and amusement and recreation	70.9	18.0	
26	Manufacture of computer, electronics, and optical products	70.8	19.0	
62_63	Computer programming and information services	70.7	20.0	
51	Air transport	70.4	21.0	
10_11_12	Manufacture of food, drink, and tobacco	69.9	22.0	
30	Manufacture of other transport equipment	69.8	23.0	
50	Water transport	69.2	24.0	
79	Travel insurance, tour operator	69.0	25.0	
29	Manufacture of motor vehicles, trailers, and semi-trailers	68.5	26.0	
47	Retail trade, except motor vehicle and motorcycle	68.1	27.0	
35	Electricity, gas, steam, and air conditioning supply	67.4	28.0	
68	Real estate activities	67.2	29.0	
27	Manufacture of electrical equipment	67.0	30.0	
69_70	Legal and accounting services	66.6	31.0	
20	Manufacture of chemicals and chemical products	66.2	32.0	
59_60	Film, television programming and broadcasting	65.6	33.0	
46	Wholesale trade, except of motor vehicle and motorcycle	65.2	34.0	
71	Architectural and engineering activities	64.0	35.0	
17	Manufacture of paper and paper products	63.7	36.0	
55_56	Accommodation and food & beverage services	62.9	37.0	
61	Telecommunications	62.7	38.0	
36	Water collection, treatment, and supply	62.6	39.0	
3	Fishing and aquaculture	62.0	40.0	
58	Publishing activities	61.9	41.0	
77	Rental and leasing activities	61.6	42.0	
74_75	Other professional, scientific, and veterinary activities	61.0	43.0	
37_38_39	Sewerage, waste collection and remediation	60.8	44.0	
31_32	Manufacture of furniture and other manufacturing	60.4	45.0	
24	Manufacture of basic metals	60.2	46.0	
22	Manufacture of rubber and plastic products	59.6	47.0	
45	Wholesale and retail trade motor vehicles	58.6	48.0	
23	Manufacture of other non-metallic mineral products	58.1	49.0	
52	Warehouse and support activities for transportation	56.9	50.0	
33	Repair and installation of machinery and equipment	55.6	51.0	
13_14_15	Manufacture of textiles, wearing apparel, leather products	55.1	52.0	
18	Printing and reproduction of recorded media	52.2	53.0	
49	Land transport and transport vis pipeline	50.9	54.0	
25	Manufacture of fabricated metal products	49.5	55.0	
2	Forestry and logging	49.4	56.0	
1	Crop and animal production, hunting	49.3	57.0	
96	other personal services activities	48.8	58.0	
95	Repair of computers and personal goods	47.6	59.0	
41_42_43	Construction	45.2	60.0	
53	Postal and courier activities	42.1	61.0	
16	Manufacture of wood, and of products of wood and cork	36.8	62.0	

Table 2.11: Capabilities: % firms with a training budget

SIC2007	Sector Name	Train Budget		
85	Education	83.8	1.0	
84	Public administration and defence; social security	78.7	2.0	
87_88	Residential and other social care	74.0	3.0	
21	Manufacture of basic pharmaceutical products	69.4	4.0	
94	Activities of membership organizations	65.7	5.0	
86	Human health activities	62.2	6.0	
72	Scientific research and development	62.2	7.0	
19	Manufacture of coke and refined petroleum products	60.0	8.0	
65	Insurance, reinsurance, and pension funding	60.0	9.0	
50	Water transport	59.0	10.0	
78	Employment activities	58.6	11.0	
69_70	Legal and accounting services	57.6	12.0	
35	Electricity, gas, steam, and air conditioning supply	54.7	13.0	
90_91_92	Art, entertainment, libraries, museums, gambling	54.3	14.0	
93	Sports activities and amusement and recreation	54.1	15.0	
80_81_82	Security services and office support	52.6	16.0	
51	Air transport	51.9	17.0	
74_75	Other professional, scientific, and veterinary activities	51.0	18.0	
05_06_07_08_09	Mining and support services	49.7	19.0	
68	Real estate activities	49.2	20.0	
10_11_12	Manufacture of food, drink, and tobacco	49.0	21.0	
73	Advertising and market research	48.0	22.0	
2	Forestry and logging	47.6	23.0	
66	Activities auxiliary to financial services	47.6	24.0	
64	Financial services	46.9	25.0	
45	Wholesale and retail trade motor vehicles	46.9	26.0	
20	Manufacture of chemicals and chemical products	45.7	27.0	
71	Architectural and engineering activities	45.5	28.0	
55_56	Accommodation and food & beverage services	45.4	29.0	
37_38_39	Sewerage, waste collection and remediation	45.1	30.0	
62_63	Computer programming and information services	44.8	31.0	
29	Manufacture of motor vehicles, trailers, and semi-trailers	44.1	32.0	
52	Warehouse and support activities for transportation	43.5	33.0	
28	Manufacture of machinery and equipment N.E.C.	42.3	34.0	
26	Manufacture of computer, electronics, and optical products	42.0	35.0	
17	Manufacture of paper and paper products	41.8	36.0	
77	Rental and leasing activities	41.3	37.0	
47	Retail trade, except motor vehicle and motorcycle	41.2	38.0	
49	Land transport and transport vis pipeline	41.0	39.0	
46	Wholesale trade, except of motor vehicle and motorcycle	40.9	40.0	
36	Water collection, treatment, and supply	40.9	41.0	
61	Telecommunications	40.7	42.0	
96	other personal services activities	40.4	43.0	
79	Travel insurance, tour operator	40.4	44.0	
27	Manufacture of electrical equipment	40.2	45.0	
33	Repair and installation of machinery and equipment	39.8	46.0	
59_60	Film, television programming and broadcasting	38.8	47.0	
24	Manufacture of basic metals	37.6	48.0	
58	Publishing activities	36.9	49.0	
23	Manufacture of other non-metallic mineral products	36.3	50.0	
31_32	Manufacture of furniture and other manufacturing	35.3	51.0	
3	Fishing and aquaculture	35.2	52.0	
41_42_43	Construction	35.1	53.0	
22	Manufacture of rubber and plastic products	34.3	54.0	
25	Manufacture of fabricated metal products	32.7	55.0	
30	Manufacture of other transport equipment	29.1	56.0	
95	Repair of computers and personal goods	29.0	57.0	
16	Manufacture of wood, and of products of wood and cork	27.2	58.0	
1	Crop and animal production, hunting	24.0	59.0	
13_14_15	Manufacture of textiles, wearing apparel, leather products	22.9	60.0	
18	Printing and reproduction of recorded media	22.1	61.0	
53	Postal and courier activities	19.2	62.0	

Table 2.12: Collaboration: % firms collaborating within the sector

SIC2007	Sector Name	Collab (%)		
26	Manufacture of computer, electronics, and optical products	55.4	1.0	
28	Manufacture of machinery and equipment N.E.C.	52.4	2.0	
36	Water collection, treatment, and supply	50.0	3.0	
72	Scientific research and development	48.4	4.0	
30	Manufacture of other transport equipment	46.7	5.0	
62_63	Computer programming and information services	46.2	6.0	
50	Water transport	45.5	7.0	
22	Manufacture of rubber and plastic products	40.4	8.0	
61	Telecommunications	39.8	9.0	
64	Financial services	39.7	10.0	
65	Insurance, reinsurance, and pension funding	38.7	11.0	
10_11_12	Manufacture of food, drink, and tobacco	37.9	12.0	
27	Manufacture of electrical equipment	37.9	13.0	
31_32	Manufacture of furniture and other manufacturing	37.7	14.0	
21	Manufacture of basic pharmaceutical products	36.7	15.0	
71	Architectural and engineering activities	35.2	16.0	
20	Manufacture of chemicals and chemical products	34.7	17.0	
17	Manufacture of paper and paper products	34.2	18.0	
13_14_15	Manufacture of textiles, wearing apparel, leather products	34.2	19.0	
29	Manufacture of motor vehicles, trailers, and semi-trailers	34.0	20.0	
74_75	Other professional, scientific, and veterinary activities	33.5	21.0	
23	Manufacture of other non-metallic mineral products	33.3	22.0	
73	Advertising and market research	33.3	23.0	
66	Activities auxiliary to financial services	32.0	24.0	
58	Publishing activities	31.5	25.0	
24	Manufacture of basic metals	30.3	26.0	
18	Printing and reproduction of recorded media	30.0	27.0	
59_60	Film, television programming and broadcasting	29.9	28.0	
25	Manufacture of fabricated metal products	29.5	29.0	
33	Repair and installation of machinery and equipment	29.1	30.0	
77	Rental and leasing activities	28.9	31.0	
46	Wholesale trade, except of motor vehicle and motorcycle	28.8	32.0	
49	Land transport and transport vis pipeline	28.8	33.0	
52	Warehouse and support activities for transportation	28.8	34.0	
51	Air transport	26.3	35.0	
16	Manufacture of wood, and of products of wood and cork	26.1	36.0	
78	Employment activities	25.9	37.0	
37_38_39	Sewerage, waste collection and remediation	25.8	38.0	
80_81_82	Security services and office support	25.5	39.0	
47	Retail trade, except motor vehicle and motorcycle	25.4	40.0	
69_70	Legal and accounting services	24.3	41.0	
41_42_43	Construction	24.2	42.0	
55_56	Accommodation and food & beverage services	23.9	43.0	
68	Real estate activities	23.8	44.0	
45	Wholesale and retail trade motor vehicles	23.7	45.0	
53	Postal and courier activities	23.6	46.0	
05_06_07_08_09	Mining and support services	22.3	47.0	
35	Electricity, gas, steam, and air conditioning supply	20.9	48.0	
1	Crop and animal production, hunting	na	na	
2	Forestry and logging	na	na	
3	Fishing and aquaculture	na	na	
19	Manufacture of coke and refined petroleum products	na	na	
79	Travel insurance, tour operator	na	na	
84	Public administration and defence; social security	na	na	
85	Education	na	na	
86	Human health activities	na	na	
87_88	Residential and other social care	na	na	
90_91_92	Art, entertainment, libraries, museums, gambling	na	na	
93	Sports activities and amusement and recreation	na	na	
94	Activities of membership organizations	na	na	
95	Repair of computers and personal goods	na	na	
96	Other personal services activities	na	na	

2.3 Sectoral ACAP – an integrated view

There is no single accepted route for integrating a range of ACAP indicators with different sectors having rather different profiles as indicated earlier. There may for example be sectoral variations in the importance of different indicators suggesting different weights should be applied in each different sector⁵.

A neutral approach seems to be to rank sectors according to each indicator and then compare sectors based on this ranking: sectors with consistently low rankings across indicators are then likely to have the highest sectoral levels of ACAP. This approach is adopted in Table 2.13 which summarises the rank data for each sector and uses the same colour coding as previously. Again, green indicates those sectors which perform in the top quartile on each ACAP indicator. In the table sectors are ranked based on their average ranking across the ten ACAP measures. This suggests a ranking of sectors in terms of ACAP overall, but also suggests (based on the colours) the consistency of this assessment across the different dimensions of knowledge investment, skills, capabilities, and collaboration.

Judged in this way a range of business and professional services have the highest levels of sectoral ACAP. Scientific research and development tops the ranking covered closely by the Activities of membership organizations and Computer programming and information services (Table 2.13). Other professional, scientific, and veterinary activities, Publishing activities, Financial services and Telecommunications comprise a second group of service sectors also with high levels of ACAP. Among the manufacturing sectors, pharmaceuticals and computer and electronic products have the highest overall levels of ACAP.

2.4 Summary

Combining a range of ten sectoral ACAP metrics representing sectors' knowledge investments, skills, management capabilities and inter-firm linkages suggests a sectoral ranking of ACAP. A range of business and professional services have the highest levels of sectoral ACAP. Scientific research and development tops the ranking covered closely by the Activities of membership organizations and Computer programming and information

⁵ Later in this report (Section 3) we use regression models to explore which ACAP indicators are most significant across sectors.

services (Table 2.13). Other professional, scientific and veterinary activities, Publishing activities, Financial services and Telecommunications comprise a second group of service sectors also with high levels of ACAP. Among the manufacturing sectors, pharmaceuticals and computer and electronic products have the highest overall levels of ACAP. Some of the lowest levels of sectoral ACAP are recorded in extractive sectors, and a range of basic manufacturing activities.

Table 2.13: ACAP across sectors – integrated view

	Sectoral rankings on ACAP specific indicators											
Sector Name	SIC2007	R&D as % Sales	Design as % sales	Software as % sales	OrgCap as % sales	Collaboration - % firms	Performance skill gaps (% firms)	NPD skill gaps (% firms)	Working Practices skill gaps (% firms)	Business Plan - % firms	Training Budget - % firms	Mean rank
Scientific research and development	72	3	42	2	1	4	36	8	41	5	7	15
Activities of membership organizations	94	32	28	6	2	na	10	30	26	12	5	17
Computer programming and information services	62-63	10	19	8	9	6	24	52	12	20	31	19
Other professional, scientific, and veterinary activities	74-75	22	40	7	3	21	6	26	23	43	18	21
Publishing activities	58	15	18	3	6	25	15	33	7	41	49	21
Financial services	64	32	43	51	35	10	7	7	1	3	25	21
Telecommunications	61	11	25	4	12	9	21	34	21	38	42	22
Legal and accounting services	69-70	17	50	12	5	41	18	18	17	31	12	22
Mining and support services	05-09	26	2	49	45	47	2	17	2	16	19	23
Sports activities and amusement and recreation	93	9	24	16	11	na	37	31	45	18	15	23
Advertising and market research	73	20	26	9	15	23	38	43	29	11	22	24
Manufacture of basic pharmaceutical products	21	1	11	29	34	15	27	60	60	1	4	24
Repair and installation of machinery and equipment	33	14	16	15	22	30	32	3	14	51	46	24
Architectural and engineering activities	71	18	37	10	4	16	33	40	28	35	28	25
Film, television programming and broadcasting	59-60	19	23	11	43	28	8	20	19	33	47	25
Manufacture of computer, electronics, and optical products	26	4	3	46	8	1	49	55	33	19	35	25
Travel insurance, tour operator	79	32	27	20	42	na	11	32	4	25	44	26
Manufacture of machinery and equipment N.E.C.	28	7	6	18	32	2	56	47	43	17	34	26
Activities auxiliary to financial services	66	32	50	32	52	24	20	13	11	10	24	27

Rental and leasing activities	77	27	41	25	30	31	14	14	6	42	37	27
Manufacture of rubber and plastic products	22	21	21	45	16	8	26	4	27	47	54	27
Water collection, treatment, and supply	36	32	8	5	48	3	35	39	24	39	41	27
other personal services activities	96	32	47	37	18	na	3	5	3	58	43	27
Art, entertainment, libraries, museums, gambling	90-92	32	39	35	23	na	30	25	42	6	14	27
Repair of computers and personal goods	95	32	20	1	24	na	1	36	18	59	57	28
Warehouse and support activities for transportation	52	32	38	19	38	34	17	10	15	50	33	29
Insurance, reinsurance, and pension funding	65	32	36	54	55	11	31	38	20	9	9	30
Manufacture of other non-metallic mineral products	23	16	5	42	19	22	53	2	38	49	50	30
Residential and other social care	87-88	32	50	55	58	na	13	15	36	7	3	30
Manufacture of textiles, wearing apparel, leather products	13-15	32	22	39	40	19	16	41	16	52	60	34
Manufacture of electrical equipment	27	6	10	38	27	13	42	48	40	30	45	30
Manufacture of other transport equipment	30	5	1	14	37	5	62	58	44	23	56	31
Construction	41-43	28	4	52	36	42	12	11	8	60	53	31
Manufacture of chemicals and chemical products	20	8	13	36	25	17	48	53	48	32	27	31
Real estate activities	68	32	50	55	58	44	4	12	5	29	20	31
Security services and office support	80-82	29	35	17	28	39	40	42	46	15	16	31
Public administration and defence; social security	84	32	50	55	58	na	28	9	32	13	2	31
Manufacture of motor vehicles, trailers, and semi-trailers	29	2	31	47	47	20	47	57	10	26	32	32
Sewerage, waste collection and remediation	37-39	32	15	27	57	38	22	24	30	44	30	32
Printing and reproduction of recorded media	18	32	9	13	7	27	34	44	47	53	61	33
Human health activities	86	32	50	55	58	na	23	23	37	14	6	33
Land transport and transport via pipeline	49	32	50	31	31	33	19	19	25	54	39	33
Manufacture of fabricated metal products	25	13	7	23	14	29	44	45	49	55	55	33
Manufacture of furniture and other manufacturing	31-32	12	14	26	20	14	50	51	52	45	51	34
Electricity, gas, steam, and air conditioning supply	35	32	17	30	46	48	41	50	34	28	13	34
Postal and courier activities	53	32	50	22	31	46	9	6	22	61	62	34

Manufacture of basic metals	24	23	12	34	49	26	58	35	13	46	48	34
Education	85	32	50	55	58	na	39	22	53	2	1	35
Crop and animal production, hunting	1	32	46	55	50	na	5	1	9	57	59	35
Employment activities	78	32	50	33	41	37	57	46	39	4	11	35
Forestry and logging	2	32	50	21	10	na	52	21	55	56	23	36
Water transport	50	32	48	41	53	7	25	59	59	24	10	36
Manufacture of paper and paper products	17	32	29	44	13	18	61	37	56	36	36	36
Manufacture of food, drink, and tobacco	10-11-12	24	34	43	44	12	59	54	58	22	21	37
Retail trade, except motor vehicle and motorcycle	47	25	45	40	33	40	55	27	51	27	38	38
Wholesale trade, except of motor vehicle and motorcycle	46	31	49	50	51	32	43	28	35	34	40	39
Manufacture of wood, and of products of wood and cork	16	32	33	28	26	36	51	16	50	62	58	39
Wholesale and retail trade motor vehicles	45	30	32	53	56	45	45	29	31	48	26	40
Fishing and aquaculture	3	32	30	55	17	na	29	56	54	40	52	41
Air transport	51	32	50	24	54	35	54	62	62	21	17	41
Manufacture of coke and refined petroleum products	19	32	44	55	58	na	46	61	61	8	8	41
Accommodation and food & beverage services	55-56	32	50	48	21	43	60	49	57	37	29	43

SECTION 3: MODELLING THE SECTORAL DIFFUSION OF INNOVATION

3.1 Introduction

In this section we integrate the variables examined in earlier sections using econometric approaches. The overall aim is to test the relative importance of the variables considered earlier in determining the diffusion of innovation across sectors.

Our dependent variable here is the proportion of firms in each sector adopting new to the firm innovations in each three-year period. Derived from the UK Innovation Survey, this is a measure of the extent of adoption of new innovations across firms in each sector. We then explore which of the factors considered in the previous section have most power in explaining the levels of sectoral adoption. To do this we include the ACAP measures – skills, investments, and collaboration – as explanatory variables in the models.

A number of statistical and econometric issues arise in the estimation of this type of dynamic panel model and these are discussed in Section 3.2. Section 3.3 summarises the key results.

3.2 Dynamic panels estimation

One of the main challenges of estimating a dynamic panel model of sectoral ACAP is the problem of endogeneity, as most of the explanatory variables may not truly be exogenous. Standard panel estimation methods, such as the least square dummy variable (LSDV) estimator that uses mean-cantered variables, produces unbiased but inefficient parameter estimates and biased estimates of the standard errors. Nickell (1981) also shows that for short panels, the standard panel estimator yields bias coefficient estimates (although this bias tends to zero as t approaches infinity). One way of resolving this problem is the use of instruments for the explanatory variables. However, finding proper macroeconomic or sectoral variables as instruments for the explanatory variables can pose a challenge.

In addressing this problem, the generalized method of moments (GMM) estimator by Arellano and Bond (1991) has been the most common estimator used in the literature. There are two variants of the GMM estimator: the difference-GMM and the system-GMM. Consistency of the GMM estimator requires the absence of second order serial correlation in the residuals of the differenced or system equations specification. The Hansen/Sargan

test of over identifying restrictions is used to test the overall validity of instruments (see Arellano and Bond, 1991; Hansen 1982).

Blundell and Bond (1998) criticized the difference-GMM estimator and argued that the system-GMM should be preferred because in situations of strong persistent data and dominant cross-sectional variability, the lagged levels observations that are used as instruments in the difference-GMM estimation are likely to be poor instruments. The authors show that for an AR(1) model, the finite sample bias of the difference-GMM estimator can be reduced dramatically with the system-GMM.

In this current model, we therefore employ the system-GMM (Arellano and Bond, 1991; Blundell and Bond, 1998), taking into consideration different estimation options as permitted by the `xtabond2` command in Stata (Roodman, 2009). The baseline dynamic panel model of sectoral adoption in our study is:

$$\ln NTF_{i,t} = \phi \ln NTF_{i,t-1} + \beta \ln X_{it} + \mu_i + \varepsilon_t + \omega_{it} \quad i = 1, \dots, N; t = 1, \dots, T$$

Where $\ln NTF_{i,t}$ is the natural log of new-to-firm innovation, $\ln X_{it}$ is the natural log of all the ten explanatory variables measuring ACAP. μ_i is an unobserved sector-specific effect, ε_t is time-specific effect and ω_{it} is the error term (usually assumed IID). Variable definitions are included in Table 3.1.

Table 3.1: Description of variables

Variable name	Variable definition
New-to-firm innovation (NTF) (log)	Natural logarithm of the ratio number of firms in the industry with NTF as a proportion of industry total sales
Collaboration (log)	Ratio number firms that collaborate as a proportion of industry total sales
Intangible investments	
R&D (log)	Ratio of total R&D investment in the industry as a proportion of industry total sales
Organisational capital (log)	Ratio of total industry investment in organisational capital as a proportion of industry total sales
Computer software (log)	Ratio of total industry investment in computer software as a proportion of industry total sales
design (log)	Ratio of total industry investment in design as a proportion of industry total sales
Skills gap affects:	
Performance (log)	Ratio of firms with skills gap affecting performance as a proportion of industry total sales
New product development (log)	Ratio of firms with skills gap affecting new product development as a proportion of industry total sales
	Ratio firms with skills gap affecting the development of new work practice as a proportion of industry total sales
New work practice development (log)	
Management sophistication	
Training budget (log)	Ratio number of firms in the industry with a training budget as a proportion of industry total sales
Training plan (log)	Ratio number of firms in the industry with a training plan as a proportion of industry total sales

3.3 Estimation results

We experimented with a range of estimation options, documented in Tables 3.3 and 3.4. These included both one step and two-step GMM estimators and alternative strategies for identifying instrumental variables. The results in all models are broadly similar and provide consistent evidence on those factors which are most important in terms of shaping sectoral absorptive capacity. Our preferred model is reported in Table 3.2, and we focus discussion in the remainder of this section on this model.

Note first that all variables in the model are expressed in logs, meaning that estimated coefficients can be interpreted as elasticities. For example, the coefficient on collaboration has a value of 0.879 meaning a 1 per cent increase in collaboration in the sector increases the diffusion of new-to-the-firm innovation by 0.879 per cent in the short-term (Table 3.2). The longer-term effect is larger at 1.201 per cent. Statistically significant (or robust) relationships in the model are denoted by “*”s following the usual convention. Key results from the preferred model are as follows:

- There is significant persistence in sectoral absorptive capacity suggested by the lagged dependent variable. This persistence may reflect other factors not captured elsewhere in our set of explanatory variables.
- Intra-industry collaboration between firms in innovation proves a powerful influence on adoption. A one per cent increase in collaboration increases adoption by 0.879 per cent in the short term and by 1.201 per cent in the longer-term.
- Investments in R&D and organisational capital also have significant and positive impacts on adoption in both the short and longer term. A one per cent increase in R&D spending increases adoption by 0.136 per cent in the short term and 0.185 per cent in the longer term.
- Other aspects of investment (computer software, design), training etc. have statistically insignificant effects on adoption as do skills gaps. These may be particularly important in some sectors but do not prove significant across the whole range of sectors. Detailed firm level analysis may shed light in this regard and permit a multi-level analysis (i.e., firms within sectors).

Table 3.2: Preferred model of sectoral innovation adoption– 2 Step GMM estimator with level equation instruments excluded

Variables	GMM short run (std. Er)	GMM log Run (std. Er)
NTF_1, log	0.268* (0.136)	
Constant	-0.108 (0.611)	
Collaboration, log	0.879*** (0.108)	1.201*** (0.187)
Intangible investments		
R&D, log	0.136** (0.056)	0.185*** (0.063)
Organisational capital, log	0.039* (0.021)	0.053** (0.026)
Computer software, log	-0.094 (0.075)	
Design, log	-0.155 (0.115)	
Skills gap effects		
Performance, log	-0.088 (0.155)	
New product development, log	-0.009 (0.101)	
New work practice development, log	0.107 (0.072)	
Management sophistication		
Training budget, log	-0.154 (0.114)	
Training plan, log	0.067 (0.147)	
Year dummies	yes	
No. of Observations	129	
No. of groups	36	
No. of instruments	18	
F Statistics	6751.73	
AR (1) p-value	0.074	
AR (2) p-value	0.262	
Hansen p-value	0.283	

Notes: Time effects are not reported. Robust standard errors are in parentheses.

*** (**, *) imply significance level at 1% (5%, 10%)

In Table 3.2 we report several robustness tests which provide an indication of the validity of our estimation approach and the specification of the preferred model. Roodman (2009) developed the `xtabond2` command in Stata for difference and system GMM estimation but noted that the Sargan/Hansen test is prone to weakness. Particularly where the number of instruments is large models can overfit the endogenous variables and fail to expunge their endogenous component, weakening the Hansen test to the point where it generates implausibly good (low) p-values. This suggests that conventional values (below 0.10) should be treated with caution. In our preferred model, the Hansen test of over-identifying restriction produced a p-value of 0.283, well above the conventional limit, and confirming the overall validity of the instruments used in our model (Hansen 1982). The test of second-order autocorrelation (AR2) also produced a p-values between 0.186 and 0.435. We therefore fail to reject the null of no-second-order serial correlation in the first-differenced error term, giving support to the correct specification of our instruments.

Table 3.3: One-Step system GMM Results (Dependant variable: log NTF innovation)

Variables	level equation instruments included		level equation instruments excluded		level equation instruments included (+ collapse option)		level equation instruments excluded (+ Collapse option)	
	GMM (std. Er)	log Run (std. Er)	GMM (std. Er)	log Run (std. Er)	GMM (std. Er)	log Run (std. Er)	GMM (std. Er)	log Run (std. Er)
NTF_1, log	0.245** (0.102)		0.229** (0.107)		0.212 (0.128)		0.190 (0.136)	
Constant	0.121 (0.539)		0.131 (0.561)		116 (0.552)		0.164 (0.593)	
Collaboration, log	0.862*** (0.117)	1.142*** (0.127)	0.831*** (0.115)	1.079*** (0.141)	0.890*** (0.119)	1.129*** (0.133)	0.856*** (0.106)	1.057*** (0.159)
Intangible investments								
R&D, log	0.123*** (0.044)	0.163*** (0.057)	0.140*** (0.045)	0.182*** (0.055)	0.126** (0.048)	0.159*** (0.056)	0.147** (0.054)	0.181*** (0.053)
Organisational capital, log	0.030 (0.019)		0.038* (0.022)	0.050* (0.027)	0.039* (0.020)		0.039* (0.019)	0.049** (0.022)
Computer software, log	-0.101 (0.060)		-0.094 (0.068)		-0.102 (0.061)		-0.093 (0.070)	
Design, log	-0.141 (0.115)		-0.084 (0.119)		-0.132 (0.113)		-0.076 (0.118)	
Skills gap effects								
Performance, log	-0.039 (0.136)		0.018 (0.153)		-0.039 (0.136)		0.015 (0.151)	
New product development, log	-0.005 (0.101)		-0.038 (0.105)		0.008 (0.010)		-0.023 (.100)	
New work practice development, log	0.115** (0.056)	0.153** (0.077)	0.094* (0.055)	0.122 (0.075)	0.113* (0.060)	0.144* (0.074)	0.091 (0.059)	
Management sophistication								
Training budget, log	-0.145 (0.103)		-0.091 (0.108)		-0.158 (0.106)		0.107 (0.112)	
Training plan, log	-0.010 (0.142)		-0.047 (0.147)		0.002 (0.145)		0.036 (0.152)	
Year dummies	yes		yes		yes		yes	
No. of Observations	129		129		129		129	
No. of groups	36		36		36		36	
No. of instruments	23		23		18		18	
F Statistics	10109.2		7367.49		9724.3		6748.35	
AR (1) p-value	0.102		0.099		0.092		0.085	
AR (2) p-value	0.337		0.253		0.316		0.241	
Hansen p-value	0.346		0.471		0.313		0.283	

Notes: Time effects are not reported. Robust standard errors are in parentheses. *** (**, *) imply significance level at 1% (5%, 10%)

Table 3.4: Two-Step system GMM Results (Dependant var. log NTF innovation)

Variables	level equation instruments included		level equation instruments excluded		level equation instruments included (+ collapse option)		level equation instruments excluded (+ Collapse option)	
	GMM (std. Er)	log Run (std. Er)	GMM (std. Er)	log Run (std. Er)	GMM (std. Er)	log Run (std. Er)	GMM (std. Er)	log Run (std. Er)
NTF_1, log	0.218* (0.109)		0.177 (0.117)		0.294 ** (0.123)		0.268* (0.136)	
Constant	-0.026 (0.594)		-0.088 (0.612)		0.023 (0.554)		-0.108 (0.611)	
Collaboration, log	0.909*** (0.140)	1.163*** (0.126)	0.907*** (0.135)	1.103*** (0.121)	0.865*** (0.117)	1.225*** (0.149)	0.879*** (0.108)	1.201*** (0.187)
Intangible investments								
R&D, log	0.115* (0.059)	0.147** (0.070)	0.136** (0.062)	0.165** (0.067)	0.122** (0.048)	0.174*** (0.063)	0.136** (0.056)	0.185*** (0.063)
Organisational capital, log	0.030 (0.020)		0.043* (0.022)	0.053** (0.024)	0.028 (0.019)		0.039* (0.021)	0.053** (0.026)
Computer software, log	-0.082 (0.069)		-0.075 (0.078)		-0.110* (0.065)	-0.156 (0.096)	-0.094 (0.075)	
Design, log	-0.144 (0.119)		-0.092 (0.113)		-0.198* (0.106)	-0.280* (0.159)	-0.155 (0.115)	
Skills gap effects								
Performance, log	-0.144 (0.154)		-0.056 (0.158)		-0.120 (0.134)		-0.088 (0.155)	
New product development, log	0.046 (0.107)		0.017 (0.105)		0.015 (0.100)		-0.009 (0.101)	
New work practice development, log	0.156* (0.080)	0.200* (0.105)	0.130 (0.082)		0.119* (0.066)	0.169* (0.088)	0.107 (0.072)	
Management sophistication								
Training budget, log	-0.199 (0.132)		-0.156 (0.134)		-0.168 (0.108)		-0.154 (0.114)	
Training plan, log	0.097 (0.183)		0.058 (0.176)		0.052 (0.145)		0.067 (0.147)	
Year dummies	yes		yes		yes		yes	
No. of Observations	129		129		129		129	
No. of groups	36		36		36		36	
No. of instruments	23		23		18		18	
F Statistics	14224.96		10186.32		10481.03		6751.73	
AR (1) p-value	0.125		0.141		0.066		0.072	
AR (2) p-value	0.435		0.366		0.313		0.262	
Hansen p-value	0.346		0.471		0.313		0.283	

Notes: Time effects are not reported. Robust standard errors are in parentheses. *** (**, *) imply significance level at 1% (5%, 10%)

SECTION 4: DISCUSSION AND CONCLUSIONS

4.1 Key findings

4.1.1 Which sectors have the highest levels of ACAP?

In considering our findings it is important to acknowledge that there is no single agreed measure of absorptive capacity. This is true both at the level of the individual firm and, as here, by sector. Based on a range of indicators relating to firms' knowledge investments, connectivity, skills, and managerial capabilities, our analysis suggests a hierarchy of absorptive capacity across around 60 UK sectors. Overall, the picture suggests that absorptive capacity may be strongest in a range of professional service sectors in the UK, with some R&D intensive manufacturing sectors also suggesting relatively high levels of absorptive capacity. Other manufacturing sectors, particularly those reflecting low technology industries, appear to have lower levels of absorptive capacity. It is important to acknowledge that these are sectoral rather than firm level indicators and that within those sectors where levels of absorptive capacity appear low, individual companies may have high levels of absorptive capacity and the ability to absorb external knowledge effectively.

The role of business and professional services sectors in the economy is a dual one. First, these sectors provide services directly to individual businesses and innovation in these services may support productivity growth and business development in the sectors which they serve. Secondly, business and professional services act as carriers of knowledge transferring expertise from one assignment to another and thereby sharing knowledge through the economy. Our results suggest that this second channel as carriers of knowledge may be working particularly effectively in these sectors given their high levels of absorptive capacity.

4.1.2 What factors have the strongest effect on sectoral ACAP?

Econometric analysis of the diffusion of innovations across sectors in the UK provides some evidence on those factors which have the strongest influence on sectoral ACAP. The key results are:

- Intra-industry collaboration between firms in innovation proves a powerful influence on adoption. A one per cent increase in collaboration increases adoption by 0.879 per cent in the short term and by 1.201 per cent in the longer-term.

- Investments in R&D and organisational capital also have significant and positive impacts on adoption in both the short and longer term. A one per cent increase in R&D spending increases adoption by 0.136 per cent in the short term and 0.185 per cent in the longer term.

Other aspects of investment (computer software, design), training etc. have statistically insignificant effects on adoption as do skills gaps. These may be particularly important in some sectors but do not prove significant across the whole range of sectors. Note also that we observe significant persistence in sectoral absorptive capacity. This persistence may reflect other factors not captured elsewhere in our set of explanatory variables.

4.2 Implications

These initial results provide some insight into: (a) how investments supported by innovate UK may result in wider spillovers, and (b) how Innovate UK can help to support sectoral absorptive capacity.

In terms of those sectors where ACAP is strongest and therefore where wider spillovers are most likely to emerge, spillovers seem strongest among potential projects supported either in or involving business and professional services sectors. This suggests a dual strategy. Projects may: (a) be supported directly in these sectors with the confidence that results will diffuse rapidly through the sectors, or (b) projects may involve firms from these sectors as partners in consortia to support onward diffusion of knowledge. For example, in a research project involving university-business or supply-chain collaboration it may also be useful to involve an industry group or scientific society as a knowledge transfer or knowledge exchange partner with an explicit task to share project knowledge or findings more widely among potential users. Maximising social value might suggest this type of engagement is a required (and funded) element of larger projects.

Secondly, our results emphasise the strong contributions of inter-organisational collaboration and knowledge investments (in R&D and corporate capability) to sectoral ACAP. Evidence on the crowding-in effects of R&D and innovation grants is significant and reflected in recent evidence reviews (Zuniga-Vicente et al. 2014). There is also evidence on the positive effect of R&D subsidies on firms' collaboration (Radas et al. 2015; Chapman et al. 2018), with one recent study of Korean grant recipients suggesting that 'R&D subsidies stimulate firms to choose partners more adventurously, by going outside the traditional value chains and regional boundaries' (Ahn et al. 2020). Reflecting the potential contribution of collaboration to spillovers and sectoral ACAP, the same authors conclude

that 'policy makers must implement a complementary policy tool (in addition to R&D subsidy) to incentivise a firm's collaborative behaviour. In this respect, various policy experiments (e.g., innovation voucher leading open innovation, the proliferation of non-disclosure agreement (NDA) or the use of blockchain technology to alleviate mistrust between organisations) and the evaluation for these attempts must be made in the near future' (p. 12). The importance of collaboration in raising sectoral ACAP reinforces this appeal and suggests the value of policy designs which can support and encourage higher levels of innovation collaboration. These might prioritise collaborative R&D projects or align knowledge sharing initiatives with publicly supported R&D projects.

4.3 Next steps

Our analysis here suggests two further areas of research. First, the high level of absorptive capacity of organisations classified in SIC 94 Activities of Membership organisations, which includes industry associations and a range of scientific societies, suggests the potential value of looking in more detail at the potential knowledge sharing potential of organisations in this sector which might be either encouraged to join projects as knowledge sharing partners or more directly supported in their knowledge sharing activities. Future research could investigate the extent to which these organisations are currently engaged with IUK or more broadly UKRI grant schemes and whether this link could usefully be developed.

A second theme could look more closely at firm-level ACAP with a particular focus on identifying the firm-level factors which might influence adoption. Interest here might focus on the nature and range of firms' collaborative activity, an element of firms' activities rarely considered in analyses of firm-level ACAP. This analysis can also provide more detail on how the determinants of firm-level ACAP vary between sectors and between groups of firms, e.g., by sizeband, frontier v non-frontier status etc.

ANNEX 1: DEFINITIONS OF SECTORS

Table A2.2: Standard Industrial Classification (SIC2007) Division codes and descriptions

Division Code	Description
01	Crop and animal production, hunting and related service activities
02	Forestry and logging
03	Fishing and aquaculture
05,06,07,08,09	Mining and support services
10,11,12	Manufacture of food, drink, and tobacco
13,14,15	Manufacture of textiles, wearing apparel, leather, and leather products
16	Manufacture of wood and of products of wood and cork
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment N.E.C.
29	Manufacture of motor vehicles, trailers, and semi-trailers
30	Manufacture of other transport equipment
31,32	Manufacture of furniture and other manufacturing
33	Repair and installation of machinery and equipment
35	Electricity, gas, steam, and air conditioning supply
36	Water collection, treatment, and supply
37,38,39	Sewerage, waste collection and remediation
41,42,43	Construction
45	Wholesale and retail trade and repair of motor vehicles and motorcycles
46	Wholesale trade, except of motor vehicles and motorcycles
47	Retail trade, except of motor vehicles and motorcycles
49	Land transport and transport via pipelines
50	Water transport
51	Air transport
52	Warehousing and support activities for transportation
53	Postal and courier activities
55,56	Accommodation and food & beverage services
58	Publishing activities
59, 60	Film, television programming and broadcasting

61	Telecommunications
62, 63	Computer programming and information service activities
64	Financial service activities, except insurance and pension funding
65	Insurance, reinsurance, and pension funding, except compulsory social security
66	Activities auxiliary to financial services and insurance activities
68	Real estate activities
69, 70	Legal and accounting services and activities of head offices
71	Architectural and engineering activities; technical testing and analysis
72	Scientific research and development
73	Advertising and market research
74, 75	Other professional, scientific, and veterinary activities
77	Rental and leasing activities
78	Employment activities
79	Travel agency, tour operator and other reservation service and related activities
80,81,82	Security services and office support
84	Public administration and defence; compulsory social security
85	Education
86	Human health activities
87,88	Residential and other social care
90,91,92	Arts, entertainment, libraries, museums, gambling, and betting activities
93	Sports activities and amusement and recreation activities
94	Activities of membership organisations
95	Repair of computers and personal and household goods
96	Other personal service activities
97, 98	Activities of households

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Centre Manager
Enterprise Research Centre
Warwick Business School
Coventry, CV4 7AL
CentreManager@enterpriseresearch.ac.uk

Centre Manager
Enterprise Research Centre
Aston Business School
Birmingham, B1 7ET
CentreManager@enterpriseresearch.ac.uk

