The Economic Contribution of Standards to the UK Economy

June 2015

Cebr

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Authorship and acknowledgements

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Foreword

It is well-understood that standards play a vital and often invisible role in supporting economic growth through their role in boosting productivity and innovation. However, the impacts of standards within businesses and their supply chains are less well understood.

This report, prepared by my colleagues at Cebr, represents the most comprehensive study of the economic benefits of standards to UK businesses to date. The original research published in 2005 during my tenure as Director General and Chief Economist at DTI established the economic value of standards in the UK and raised the profile of standard use within industry.

This study adds to that important work by updating the estimates for the impact of consensus standards on productivity at the national level, using a similar methodology and covering the period from 1921 to today. These updated estimates indicate that business standards have had a larger impact on UK productivity over this longer period than previously recognised. On our calculations, standards appear to have contributed towards 37.4% of annual productivity growth. As an illustration, in 2013, that would translate to an extra £8.2 billion of GDP emanating from the proper use of standards. Caution should be taken when interpreting these estimates given that standards have a complementary and interdependent role in driving productivity along with patents, and other forms of knowledge. Nevertheless it is clear that standards are a vital element of the growth and strength of UK industry, facilitating trade and innovation and adding to the impact generated by the machinery and equipment used in production and the people employed in those industries.

More importantly, this study gives us for the first time empirical evidence of the ways that standards are benefiting individual companies in the UK. The research showcases the extent to which standards provide multiple benefits to companies including enhancing the quality of products and the efficiency of processes; facilitating the efficient distribution of technical information and processes; supporting the effective functioning of supply chains; and catalysing innovation within businesses. Using a survey, it was also possible to build a picture of the financial benefits of standards at the sector level in terms of turnover and GVA.

At the time of writing, the UK economy continues to recover from the most severe recession since the 1930s depression. The recovery will only be sustainable if it is accompanied by an internal and external rebalancing of our economy: in other words a higher savings rate, more business investment, and rising net exports. Boosting productivity is essential to this. The research presented here shows that standards are most intensively used by the UK's most productive sectors such as the aerospace and defence sector where labour productivity (output per worker) in manufacturing between Q1 2005 and Q3 2014 has increased by 20.1% compared to 4.9% for the UK economy as a whole.

The impact of standards on exports is of particular interest in the current policy context, given the necessity to address the UK's trade deficit. Standards are important for opening up new markets, linking UK companies into global supply chains and reducing technical barriers to trade. Exporting firms tend to be the most productive. The evidence shows that standards have been hugely influential in boosting the sales of UK products and services abroad, with reported impacts averaging 3.2%, equivalent to £6.1 billion per year in additional exports.

The benefits of standards in the growth of the UK economy so far are clear and is reemphasised by the findings in this report. What the UK now needs is to capitalise on its strong position and continue

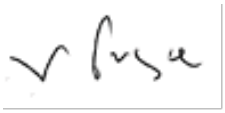
moving up the value chain so it can cement its role as the world leader in the industries where we have comparative advantage.

Over the past 110 years, the UK has led the world at each stage of the evolution of voluntary consensus standards for industry. The UK was one of the first countries to develop technical product standards and later, the first to develop process standards for quality management (BS ISO 9001), environmental management (BS ISO 14001) and information security management (BS ISO 27001).

Today, in a third phase of development, the UK is leading the codification of good practices aimed at releasing the full potential of businesses, through a new focus on people – through leadership, governance and risk. Good examples of this are standards covering the principles of organisational governance (BS 13500), anti-bribery (BS 10500) or corporate social responsibility (BS ISO 26000). By taking a lead in using UK experts to create standards for good practice in all areas of business practice, the UK can remain one step ahead of the game.

The policy context of this report is also important. It is often forgotten that standardization represents a useful and often superior policy alternative to regulation, with legitimacy of the voluntary standard achieved within industry through the consensus process.

Considering this policy function and the importance of standardization for the future competitiveness of the UK economy, it is vital that it should continue to figure highly in Government industrial policy for many years to come.



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Executive Summary

This report provides a comprehensive examination of how standards – in their important role as diffusers of technology and promoters of efficiency in businesses – have impacted UK economic growth. The report and underlying study were commissioned by the British Standards Institution (BSI).

The report examines the economic contribution of standards from two angles: **an empirical analysis of the macroeconomic impact of standards on the UK economy**, updating a previous study published by the DTI in 2005, and **a micro-level analysis on how the use of standards and participation in the standards development process produce financial and other benefits for individual companies**. The micro-level analysis combines a survey of 527 UK companies (referred to in this report as the BSI Standards in Industry Survey), in-depth interviews and case studies covering seven key sectors to provide evidence on how standards benefit companies. The key findings of the study are presented here:

- It is widely accepted that **standards play a vital and often invisible role in supporting economic growth** – by promoting productivity and efficiency in companies, through their role in supporting international trade and by acting as a catalyst for innovation within companies and sectors.
- Taking into account these multiple important roles that standards play, it is possible to envision that standards might have a sizeable effect on productivity in the UK economy. To measure this empirically at the national (macro) level, an econometric analysis was carried out to determine the relationship that standards have with productivity and to quantify the value of standard's contribution.

Financial benefits of standards

- The analysis found a positive and significant contribution of standards to productivity – **supporting 37.4% of annual labour productivity growth** in the UK economy over the period 1921 to 2013, which translates into **approximately 28.4% of annual GDP growth** – a similar finding to that of other recent national level studies in France and Germany. However standards do not boost productivity growth exclusively. Instead standards have a **symbiotic and complementary role in driving productivity** along with other factors such as improvements to education and advancements in technology. Standards support productivity growth through a variety of mechanisms such as by **enhancing organisational efficiency, boosting trade and facilitating innovation.**
- For the purposes of putting the findings in monetary terms, and if you accepted that such a contribution was broadly constant over time, standardization at a national level would be associated with approximately **£8.2 billion of the £29.0 billion of GDP growth recorded in 2013** (2014 prices).
- Results from the micro-level analysis provide evidence to support these macro-level findings. **Close to half (48%) of companies surveyed reported a net benefit from standards**, and this finding was consistent across industries ranging from 40% in the automotive sector to 54% in food and drink manufacturing with larger businesses more likely to report a net benefit relative to SMEs.

The results show that **at the sector level, impacts on annual turnover range from 1.7% (aerospace and defence) to 5.3% (food and drink manufacturing),** closely mirroring findings from a series of ISO company case studies which found impacts ranging from 0.15% to 5% of annual turnover[1] .

This translates into substantial financial benefits for the seven sectors surveyed, amounting to **annual impacts on turnover totalling £33.3 billion (2014 prices) and £6.9 billion (2014 prices) in GVA terms.** Food and drink manufacturing reported the largest revenue impact (£10.2 billion per year) while the ICT sector had the largest impact in GVA terms (£2.1 billion per year).

How using standards generates benefits for companies

- A further objective of the study – beyond quantifying the financial contribution of standards at the micro and macro level – was to understand how the use of standards generated benefits for companies. The academic literature shows that standards fulfil four important economic functions that help solve fundamental problems of firms and industries, which can impede companies from maximising their productive potential. These four economic functions were explored in the survey. The findings for each are listed below:

  1 *Standards help businesses to enhance the quality of their products and the efficiency of their processes* – **More than a third (36%) of companies reported that they had experienced an increase in productivity** as a result of using standards. These findings were highest in the ICT sector, where 48% of companies reported a boost to productivity. In terms of the effect of standards on quality, **70% of respondents stated that standards had contributed to improving their supply chain by improving the quality of supplier products and services.**

  2 *Standards efficiently reduce the variety of goods and services to an optimal level for minimising cost* – **63% of firms stated that standards have homogenised products to the extent that price competition has increased.**

  3 *Standards facilitate inter-operability of products and processes* – In sectors highly reliant on technical standards; the survey confirms the importance of standards in interoperability – **41% of companies in the ICT sector agreed that standards have increased inter-operability of products and systems.**

  4 *Standards efficiently make available technical information to all firms allowing an effective and less costly inter-firm exchange of information.* - **More than half** (**54%) of companies reported that information was made more accessible through the dissemination of technology** through standards and this was highest in the ICT sector (60%).

The benefits of standards to trade

- One of the most important economic roles of standards is in promoting and supporting international trade. Using a similar approach to the estimation of turnover impacts, the survey results show that **impacts on exports attributed to standards ranged from 0.3% in the energy sector to 9.9% in the food and drink manufacturing sector.** Translating these estimates into monetary values, it was found that the combined **impact of standards on exports in the sectors surveyed amounted to £6.1 billion per year (2014 prices).**
- The survey results highlight the important role of standards in ensuring compatibility of British products in international markets, reducing transaction costs and providing a signal of quality to

[1] International Organization for Standardization, 2014, 'Economic Benefits of Standards', ISO.

customers, thus boosting the export performance and prestige of British companies. On average, **76% of companies disagreed with the concept that standardization had contributed to higher barriers of trade**. Given this supportive role, it is of no surprise that **survey respondents (all of which use standards) were twice as likely to export relative to the average firm of the same size in the whole economy[2].**

The role of standards as a catalyst for innovation

- The academic literature highlights another important economic role of standards – as **a catalyst of innovative activity**. Standards facilitate innovation by reducing the time to market for new products, promoting the diffusion of innovative products, levelling the innovation playing field between big and small companies, and facilitating inter-operability in network industries thus creating the environment for the development of new products. The survey provides evidence to support this catalytic role of standards in innovation – **50% of firms stated that standards encouraged innovation through the diffusion of new knowledge.**
- The survey shows that standards enhance the supply chain of industries by promoting compatibility between products and processes and boosting confidence between suppliers and clients. On average, **over half (51%) of all firms surveyed confirmed that standardization had improved their client-supplier relationship through improved confidence**.

Benefits of participation in the standards development process

- The survey highlighted the existing capacity of businesses to become more involved in the standards development process. **Over two-thirds (68%) of businesses surveyed were not involved in the standards development process.** The survey evidence shows that participating in developing standards makes it more likely that a company experiences benefits from using standards – **those that reported they are highly involved in the standards development process are the most likely to report that they experience a net benefit from standards**.
- The most important **benefits of participation in the standards development process** are:
    - **Being able to anticipate future market rules and emerging themes in their industry** (88% of participant companies),
    - **Promoting the industry's interests at a national level** (75% of participant companies);
    - **Having prior access to information that would not normally be received** (71% of participant companies).

Other important roles of standards

A further important role of standards relates to non-monetary issues such as protecting the environment, and the health and safety of employees. The survey results show that **73% of companies found that standards allow greater control over environmental problems** and **89% of companies stated that standards contributed to the optimisation of compliance with regulations such as health and safety legislation.**

[2] This refers to all firms in the UK non-financial business economy as defined in the Annual Business Survey 2013. The finding does not indicate the direction of causality between standards and exporting activity in firms. There is likely to be bi-directional causality between standards and trade, given their mutually supportive roles.

Conclusions

- The macro-level analysis confirms the important role that standards play in boosting UK productivity. In addition, the findings emphasise that the impact of standards on productivity accrues only in the long-run, implying that businesses should consider the use and implementation of standards as an investment that pays back over a number of years, in the same way that businesses invest in new machinery and equipment.
- The micro-level analysis reveals the perceptions of businesses regarding standards and the channels through which standards impact firms. The sector analysis illustrates the extent to which standards are essential to the functioning of UK businesses, sector supply chains and markets. The survey results also provide evidence to support the theory in the academic literature on the role of standards in the economy.
- The study shows that being involved in the standards development process produces surprisingly large benefits for participants, and it raises the questions as to why there is not more widespread involvement among UK companies. In some countries where demand to participate is high, companies pay for the right to sit on technical committees whereas in the UK this is not the case. This may be a result of UK companies simply not being aware of the specific benefits that accrue to companies that get involved in standards development.
- Evidence from the survey and in-depth interviews with industry experts show that standards are an integral part of the functioning of businesses in many of the sectors. In some cases, if standards were not widely used in the sector, companies simply would not be able to operate the same way they currently do, or it would become uneconomical to do so. For example the business model of large aircraft manufacturers (OEMs) has evolved to outsource the production of a vast array of components, and to focus on the design and assembly of aircraft. This allows for substantial cost savings to be achieved. Without standards to allow easier verification of quality and to distribute technical information, manufacturers would need to revert to a more traditional vertically-integrated model of business structure, which may reduce the capacity of the industry to produce aircraft in sufficient volumes and would likely increase costs of production, to the detriment of customers and the economy.
- The evidence from the sectors covered in this report shows that standards have been hugely influential in boosting the sales of UK products and services abroad, with reported impacts averaging 3.2% of annual exports, equivalent to £6.1 billion per year in additional exports. Given the current Government emphasis on re-balancing the economy towards export-led growth, this highlights the importance and benefits of further promoting standardization throughout the UK economy.

Integrating the macro-level results with findings from the British Standards Institution (BSI) Standards in Industry survey provides insight into how standards benefit businesses and the mechanisms through which these benefits translate into national-level impacts.

- The micro-level analysis targeted sectors that were identified as the most standard-intensive in the UK economy. These sectors, which represent 25% of the UK non-financial business economy are also sectors that have experienced the strongest productivity growth over the past ten years – productivity in manufacturing grew by 19.7% between Q1 2005 and Q3 2014 compared to just 4.9% growth for all sectors over the same time period[3].

[3] Productivity statistics obtained from the Office of National Statistics Labour Productivity Q3 2014 Dataset

- The macro-level estimate for the impact of standardization is based on average productivity growth for the whole economy, incorporating both high and low productivity growth sectors. If only high productivity growth sectors were covered - as was the case in the sector-level analysis - then estimated impacts would likely have been larger.

There are several conclusions that can be drawn from this:

- Standards which enable high productivity growth industries to be more productive may have helped to offset low and even negative productivity growth in some sectors during the recession.
- If high productivity growth industries tend to be intensive users of standards, then it follows that standards are likely to have played a role in sustaining overall productivity growth during the recession and in the economy generally.
- If standards were more widely employed across businesses and sectors, average productivity across the whole economy could rise. This suggests that if such a study of national economy impacts of standard were repeated in the future, and standard use also increased over that period, then we could expect that the estimated impacts of standards would be even larger.

1 Introduction

This report provides a comprehensive examination of how voluntary consensus standards – in their role as an important diffuser of good business practices and catalyst of innovation – have impacted on UK economic growth. The report was commissioned by the British Standards Institution (BSI) using funding provided by the UK's Department for Business, Innovation & Skills (BIS).

There are several inter-related objectives of this report and the study underlying it. They are to:

- Quantify the macroeconomic impact of standards on the UK economy;
- Determine how standards affect the financial and export performance of UK companies;
- Determine how standards impact industry supply chains in the UK;
- Present the value of participation in the development of standards.

This study was composed of two parts:

Part 1 involved an analysis of the ***macroeconomic*** impact of standards and represents an update of the 2005 study *'The Economic Contribution of Standards in the UK'* published by the Department for Trade and Industry (now part of the Department for Business, Innovation & Skills). Cebr has endeavoured to replicate the methodology employed in that study but inevitably, given advances in knowledge and in the availability of new and better data, there are some differences. The underlying framework has not changed though and has also been employed in national-level studies in Germany, France and Canada. Sections 1 to 4 of this report document the methodological approach and findings of Part 1 of the study.

Part 2 sought to understand the ***microeconomic*** effects of standardization – how the adoption of standards and participation in the standards development process benefits individual companies. The research concentrates on the role of standards in seven key sectors: automotive, energy, aerospace and defence, food and drink manufacturing, ICT, construction and life sciences. The report on this part of the study combines the evidence from a survey of 527 UK companies (BSI Standards in Industry survey) and in-depth interviews with executives of companies that use standards, which were used to produce case studies demonstrating how standards benefit companies in each sector. Part 2 of the study is reflected in Sections 5 and 6 of this report.

Together, both parts of the study achieve a comprehensive examination of the macro and micro economic effects of standards and builds upon and extends the existing understanding of the important role standards play in driving the UK economy.

What makes this study unique is the examination of the role of standards in the UK economy at the microeconomic level. The objective of the research was to understand the qualitative and where possible quantitative benefits of standards on UK companies, how standards are used by companies, the value of participating in the standards development process and the impact of standards on the supply chains of the UK's largest sectors. While research on standards of this kind has been carried out in other countries, this is, as far as we are aware, the first of its kind in the UK.

2 How standards contribute to economic growth

Voluntary consensus business standards have long been associated with making an important contribution to economic growth and productivity, although few studies sought to examine this question in detail until the late 1990s. Since then, a large body of research has developed to explain the mechanisms through which standards have an impact on economic growth and productivity.

In this section, we present an overview of the main channels identified by the academic literature through which business standards contribute to economic growth – supporting productivity and efficiency within companies, facilitating trade and acting as a catalyst for innovative activity.

2.1 A brief history of standards and BSI

Standards-making has progressed in three distinct phases. In the first phase, at the turn of the twentieth century, it was recognised by industry that getting agreement amongst experts on the technical specifications of products, such as the dimensional criteria or test methods, would open up new markets and allow competition on the basis of quality and service. Today this would be described as enabling the inter-operability of components. The first national standard in the UK, BS1, was published in February 1903 and tabulated the standard dimensions of steel angle sections, essential for structural engineers in sourcing from different manufacturers.

Following WWII and the work of Edward Deming in Japan, industry experts began to recognise that the quality of a product was a function not only of the technical specification but also of the quality of the process which made it, and that the manufacturing process was common to many different products. So assuring the quality of the manufacturing process could go a long way to assuring the quality of the products. The UK is widely regarded as a thought leader in the development of standards for management systems and BSI in its role as the UK national standards body acting on behalf of the UK manages the secretariats for most of the world's most famous management system standards. Many of the UK's successes will be instantly familiar to many:

- ISO 9001, quality management systems, started life as BS 5750,
- ISO 14001, environmental management systems, started life as BS 7750,
- ISO 27001, information management, started life as BS 7799,
- ISO 22301, the business continuity management standard, started life as BS 25999.

In the last few years, a third phase in the role of best practice in delivering business potential has begun to be recognised. This third phase of the evolution of business standards is concerned primarily with the business principles that underpin high performance, rather than the business processes or product specifications. The third phase of business standards development is about improving organisational performance by codifying best practice principles in the areas of behaviour: leadership, governance and risk. This is based on the consensus that there are good practices in how to improve the innovation capacity of an organisation, as well as how to motivate and improve the productivity of the workforce. Recent standards in this area include the principles of organisational governance (BS 13500), anti-bribery management (BS 10500, to be BS ISO 37001) and organizational risk management (BS 31500, now BS ISO 31000). In the area of smart (future) cities, new UK developed standards address the principles of decision making (BSI PAS 181) and planning guidelines, (BSI PD 8101) as a pre-requisite for building investor confidence and supply chain procurement.

2.2 What is a standard?

Simply put, a standard is an agreed way of doing, thinking about or managing something. The International Organization for Standardization (ISO), on the Council of which the UK has a permanent seat and for which BSI pays the national dues, defines a standard as a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose. Standards can relate to anything, including definitions and classifications, manufacturing, process management or service delivery.

All countries around the world that are signatories to the World Trade Organisation (WTO) Technical Barriers to Trade (TBT) chapter have a national standards body which is responsible for developing national standards, participating in the development and adoption of new international standards and the publication of standards in their country. In the UK, the British Standards Institution (BSI) is appointed by the UK government (HMG) as the sole organisation responsible for developing and publishing British Standards. BSI supports and coordinates UK expertise in making standards, including participation in the development of European and international standards, the majority of which are also adopted as British Standards.

This study focuses on voluntary standards[4] developed and published by BSI, which facilitates collaboration between industry experts, government bodies, companies, academia, trade associations and consumer groups. As a result of this cooperation, each standard is developed to represent an industry-wide consensus on best practice.

The relationship between standards and regulations is frequently confused. Standards can assist companies to comply with legislation but in almost all cases in the EU and EFTA countries are not a legal obligation[5]. While standards provide a straight forward way to demonstrate conformity, with very few exceptions their use is voluntary – it is up to the individual company to decide whether to try and meet the requirements of the legislation themselves or to adopt the standard. Some standards may become a market requirement, as has happened in the case of EU construction products regulation[6].

Standards cover a wide variety of activities undertaken by businesses in the production of their products or services and in supplying their customers. A summary of the main types of standards is provided in Table 1.

Table 1: Summary table of the main types of standards

Standard type	Description	Example
Quality management	Help companies achieve cost effective and quality assurance methods through a system of continual improvement	ISO 9001 quality management system (QMS) ISO 13485 QMS for medical device industry ISO 16949 QMS for automotive industry
Health & safety	Set out systems for health and safety management and the minimisation of operational risk	OHSAS 18001 Occupational health & safety BS ISO 31000 Risk management BS 5839 Fire detection and fire alarm systems for buildings

[4] While proprietary technology (normally covered by patents) represent an important part of the stock of technological knowledge, this does not fall into the scope of this study.

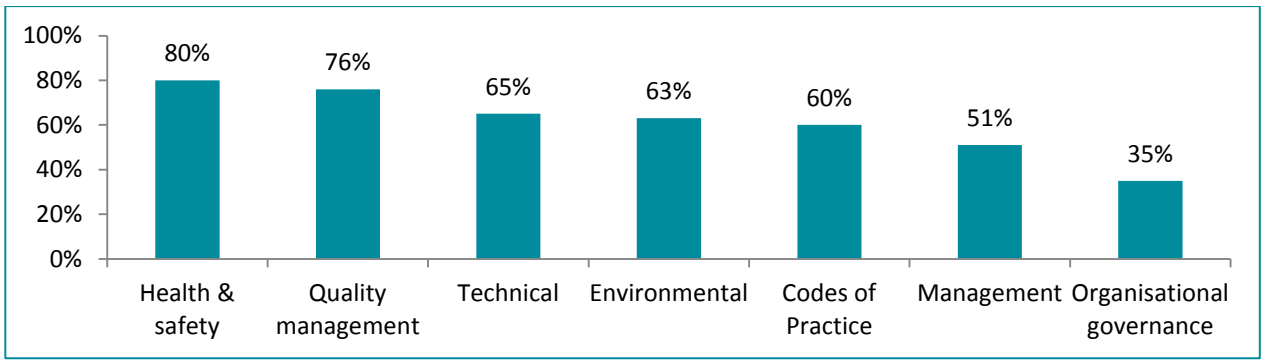
[5] In the EU, the voluntary 'New Approach' system of technical harmonisation introduced in 1985 specifies standards as one means of conformity with the 'essential requirements' of European directives. Where another technology/method is used to meet the essential requirements, or in the absence of standards, the burden of proof that the product meets the essential requirements rests on the producer or importer of the product.

[6] A rare example where standards are mandatory is in the construction products industry, where the 2011 EU Construction Products Regulation has made it a mandatory requirement that products are manufactured to a common European technical specification (EN standards).

Standard type	Description	Example
Technical	Set out the technical characteristics of a product or a production process, allowing efficient application and replication	BS 7671 Requirements for electrical installations BS EN 1090 Execution of steel structures and aluminium structures
Environment	Enable companies to identify and control their environmental impact and improve their environmental performance	ISO 14001 Environmental management systems
Code of practice	Provide best practice guidelines in the implementation of a process or procedure	BS 5266 Code of practice for the emergency escape lighting of premises
Management	Provide systems for the effective management of specific functions within organisations	ISO/IEC 27001 Information Security Management
Organisational governance	Provide guidance on effective structures and practices for the governance of organisations	BS 13500 Code of practice for delivering effective governance

The BSI Standards in Industry survey – covering 527 companies within seven sectors - reveals that health and safety standards are the most commonly used standards across all UK businesses, with 80% of companies surveyed reporting their use in their organisation (see Figure 1). Quality management standards such as ISO 9001 have become an essential certification for many UK companies. The survey shows that 75% of companies surveyed – and 98% of large companies (>250 employees) – use quality management standards in their organisation.

Figure 1: Adoption of standards, all sectors, % utilisation by standard type



Source: BSI Standards in Industry Survey, Cebr analysis

2.3 How standards contribute to productivity and efficiency

The development of standards is driven by a demand from industry. Standards help to solve fundamental process, organisational and technical problems, which if left unresolved, could result in inefficient market functioning and poor economic outcomes. Lessons from the introduction of the first standards in the UK are instructive on the economic role that standards play. One of the first to be introduced in the UK – the standardization of the number of tram gauge specifications from 75 to 5 in 1903 (standard BS 2) – was put in place to ensure quality of manufacture while removing the unnecessary variety that existed in the tram rail market, which restricted the interoperability of tram networks and resulted in longer lead times

for tram rails. The reduction in variety reduced the purchase costs for tram companies and allowed tram rail manufacturers to expand their markets (Dow, 2014).

The same principles of standardization apply to today's industries – standards help industries overcome a multitude of problems that would otherwise result in a less optimal outcome for businesses. A common classification of standards in the literature (Swann, 2000) relates to the economic issues they solve. This classification generally show that standards play a direct or indirect role in the productivity and efficiency of companies – through reducing the cost of producing goods and services, increasing revenue by opening up new markets, or boosting the efficiency with which goods and services are produced. Standards can serve many purposes and therefore solve multiple issues. Here we provide a brief discussion of the different types of standards and their role.

Facilitating inter-operability of products and processes

Some standards are designed to assist in the inter-operability between products and systems. The literature (for example, Farrell & Klemperer, 2007) describes two economic phenomena that inter-operability standards affect: switching costs and network effects.

Switching costs arise when a customer chooses to change supplier. This often 'locks in' the customer to purchasing from a single firm because it is costly to switch or purchase from multiple suppliers. These barriers to switching have the effect of limiting competition in the market. Interoperability was a key aspect of the reforms of the regulated network industries in the 80s and 90s, largely with a view to reducing switching costs and therefore facilitating competition. Standards help to reduce switching costs by making it easier for customers to move between suppliers, thus improving choice and lowering the overall cost of investment for the customer.

Network effects (also known as network externalities) are generated when the adoption of a given technology, product or service produces benefits that increase with the number of users, i.e. creating a 'network of users'. The oldest example of a good that produces network externalities is probably the telephone (De Vries, 2006). Specifically, there is zero economic benefit if only one person owns a telephone and is connected to the network. As more and more people are connected, the benefits increase exponentially because every user experiences the benefit of being able to call more and more people. Social networks operate in much the same way – the more people are connected to Facebook, for instance, the more attractive it becomes to be a part of the network for people who have not done so already.

With interoperability between telecommunications networks, for example, these network effects are even greater because anyone connected to one network can call anyone connected to other networks, including fixed-to-mobile for instance. This increases the attractiveness of being connected to at least one of them because it means being able to call anybody on one's own network and on any other network. With network externalities making it so attractive to be connected, it is in the interest of communications providers to ensure interoperability between their networks, as it increases the size of the total market, allowing them to achieve a higher turnover. But interoperability is also good for competition and ensuring value-for-money to the consumer.

One downside of strong network effects is the lock-in of customers to older or less functional technologies (Swann, 2000). Highly specialised computer software systems such as those used in engineering, design or finance sectors can often lock firms in by requiring specialised training for their use. As competing packages will have different methods that require different skill-sets, firms are locked

in from switching to other systems by disruption to business and re-training costs. This can result in firms using the same software for many years even if other more recent software might be more efficient.

Efficient reduction in the variety of goods and services

Markets require standards in order to efficiently align the expectations of buyers and sellers. If different versions of products need to be produced for each market, costs are likely to be higher for both consumers and producers. For example, the size of freight containers used for transporting cargo need to be standardized across global markets so that they can be stacked onto ships, trucks, and trains as efficiently as possible. If containers were not standardized then it would be difficult to load, unload and move goods seamlessly between modes of transport, leading to higher costs for the producer and consequently higher costs of goods for consumers. Therefore it is efficient to standardize the sizes of containers to ensure that as many goods as possible can be transported at one time.

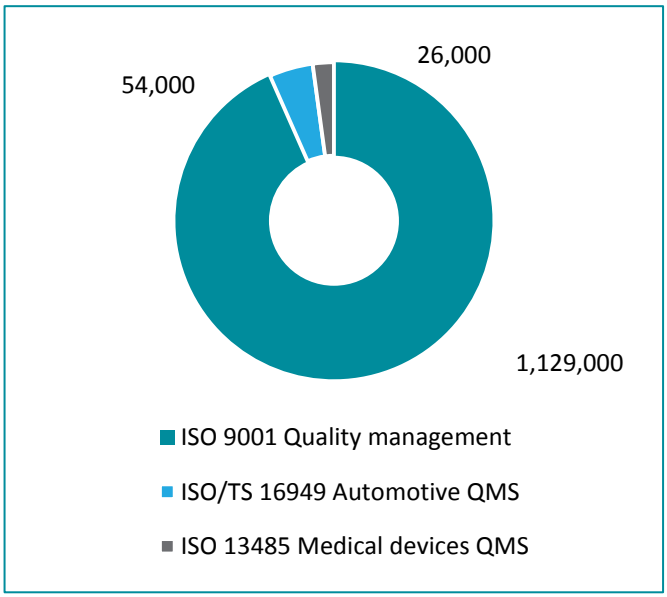
A more recent example of a standardized product is the USB connector, which was introduced by industry to provide a standardized way to supply power to cameras, mobile phones and other handheld devices and to allow such devices to communicate with each other.

Ensuring quality and promoting efficiency

Quality management system (QMS) standards, such as ISO 9001 are some of the most widely used standards worldwide. According to ISO, in 2013 there were 1.2 million companies worldwide certified to a QMS standard (see Figure 2), with 47,000 companies certified in the UK alone[7].

QMS standards help companies to ensure quality and boost efficiency. This is achieved through the implementation of management system frameworks that facilitate continual improvement in performance. These frameworks consist of processes that are designed to identify more efficient and time saving procedures and to proactively reduce errors and defects. This can generally lead to greater efficiency and reduced costs through, for instance, the obviated need to recall batches of product already gone to market.

Figure 2: Global certification to quality management standards



Source: ISO Survey 2013, Cebr analysis

But at the same time, QMS standards, provide certainty to customers that they are purchasing a quality product or service, and that it satisfies the customer's quality requirements while also ensuring compliance with applicable regulations and directives (where relevant).

[7] ISO Survey 2013

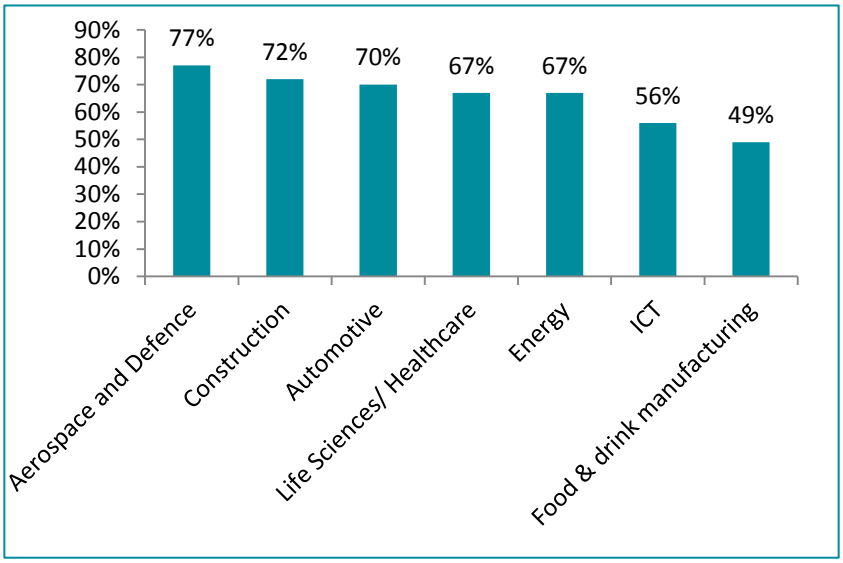
QMS standards contribute to solving the economic problems that arise due to information asymmetry, a situation where sellers have more information than buyers about the quality of their product. To get around this problem companies use a QMS standard which allows them to signal to buyers that they provide high quality products or services.

The BSI Standards in Industry survey reports very high levels of QMS use amongst the sectors covered. Of the 527 companies surveyed, 75% have adopted QMS standards. Use of QMS standards is generally much higher amongst larger companies (250+ employees) - 98% of large companies surveyed reported they have a QMS. This is unsurprising as, to a certain extent, large companies are much more likely to have the resources to implement and refine the required processes. But they are also likely to have a much greater need for QMS in order to retain organisational control and avoid diseconomies of scale (average cost increasing instead of decreasing with size).

Efficient distribution of technical information

Many technical standards also serve the purpose of providing information and product descriptions that align the expectations of suppliers and purchasers. Standards spread technical knowledge by making information readily accessible to all firms. This allows for an efficient and less costly inter-firm exchange of information, reducing the costs of each transaction. This lowers the costs of purchasing intermediate products from external suppliers, allowing manufacturers to outsource more of their activities.

Figure 3: Use of technical standards, by sector



Source: BSI Standards in Industry Survey, Cebr analysis

Standardizing components is essential in complex industries such as aerospace (see Figure 3) where large manufacturers source their components from thousands of suppliers. Airplane manufacturing is a good example of the challenge involved. Each plane is composed of millions of separate parts sourced from thousands of companies across the supply chain. Manufacturers such as Boeing and Airbus use both internal and external standards to effectively communicate technical requirements to their suppliers.

A summary of the different standard types and their impacts is provided in Table 2.

Table 2: Summary of types of standards classified according to the economic problems they solve

Type	Positive impacts	Negative impacts
Facilitating interoperability of products and processes	• Network externalities • Avoids lock-in of old technologies • Increases choice of suppliers • Promotes efficiency in supply chains	• Can lock in old technologies in the case of strong network externalities
Efficient reduction in the variety of goods and services	• Generates economies of scale • Fosters critical mass in emerging technologies and industries	• Can restrict choice • Can increase market concentration • Can lead to premature selection of technologies
Ensuring quality and promoting efficiency	• Helps avoid adverse selection • Creates trust • Reduces transaction costs	• Can be misused to raise rivals' costs
Efficient distribution of technical information	• Helps reduce transaction costs by helping to eliminate information asymmetries • Diffuses codified knowledge	• Can result in excessive influence of dominant players on regulatory agencies

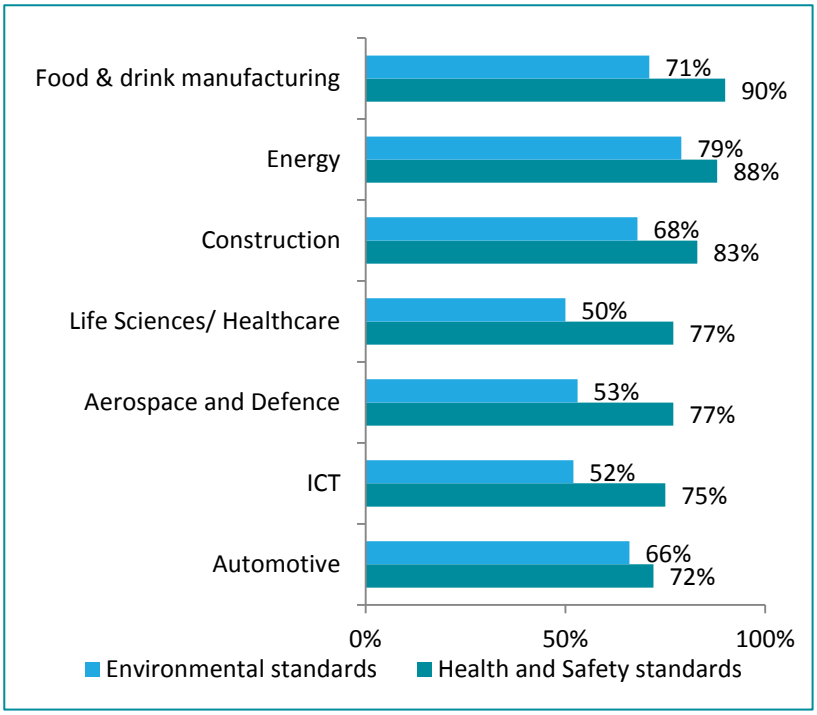
Source: Swann 2000

Other roles of standards

Standards also play an important role in solving other economic problems which may not influence the productivity and efficiency of companies, but can result in benefits to society as a whole. Standards can help companies to meet their obligations under regulations designed to reduce public costs (such as air pollution) or deliver public benefits (such as improvements in road safety, or as already noted, increased network externalities).

Sectors most likely to use these types of standards are those where health and safety and environmental concerns tend to be integral to their operations

Figure 4: Use of environmental and health & safety standards, by sector



Source: BSI Standards in Industry survey, Cebr analysis

and reputation. Standards help these companies meet the various requirements and obligations under health and safety and environmental regulations.

The BSI Standards in Industry survey shows that the highest use of environmental standards is in the energy sector (see Figure 4) – which is highly regulated with regard to the environment - 79% of companies employ an environmental standard.

In the food and drink manufacturing sector, where maintaining food safety standards is essential, 71% of companies have adopted a health and safety standard – the highest amongst the sectors surveyed.

2.4 The important role of standards in facilitating international trade

Standards play an important role in facilitating international commerce by reducing technical barriers to trade. These can occur when countries put in place technical regulations that may be considered unreasonable if they are arbitrarily applied resulting in difficulties for foreign companies trading in that country. The World Trade Organization (WTO) 1995 Agreement on Technical Barriers to Trade seeks to avoid unnecessary barriers by setting out a code of good practice, whereby countries recognize and use international standards as the basis for technical regulations.

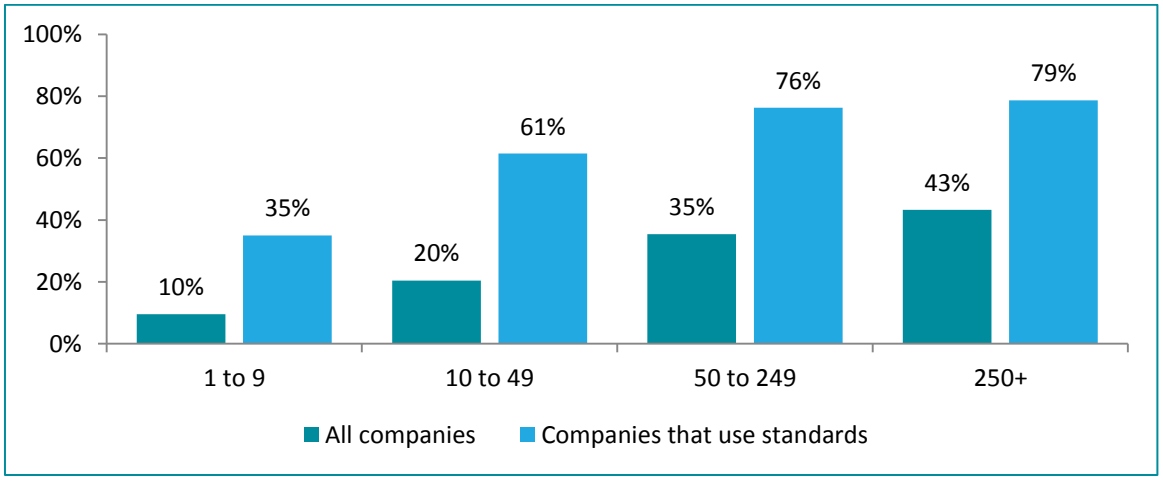
Harmonisation of standards across countries can act as a major catalyst for trade – allowing companies to sell their products and services without the need for adaptations across multiple markets. To facilitate the functioning of a harmonised common market, new European Standards (ENs) produced by the European standards bodies CEN, CENELEC and ETSI must be adopted as national standards by all their national members. In a similar way, elements of many bilateral trade agreements involve the mutual recognition of standards.

The academic literature provides strong evidence to support the notion that the use of international standards supports trade. A recent comprehensive survey of the literature on the relationship between standards and trade (Swann, 2010), shows that using international standards was generally found to be positive for export performance. An exception is where national standards are shown to be superior to international standards. The general consensus in the literature is that international standards support compatibility, reduce transaction costs and provide a signal of quality to customers, thus boosting the export performance of companies.

It is of no surprise therefore that companies that use standards tend to be more likely to export relative to the average. To demonstrate this point, Figure 5 contrasts the proportion of exporting companies in the seven sectors covered by the BSI Standards in Industry survey relative to the general business population[8]. While these groups are not directly comparable, it does indicate that the likelihood of a company being an exporter is higher if that company uses standards.

[8] 'General business population' refers to the UK non-financial business economy (SIC sections A to S). Data are sourced from the Annual Business Survey 2012 – Export and Import Activity (GB)

Figure 5: Proportion of exporting companies, by employment size band



Source: Annual Business Survey 2012 – Export and Import Activity, BSI Standards in Industry survey, Cebr analysis

The academic literature (Swann, 2010) identifies four main channels through which standards enhance trade. These are as follows:

1. **Standards drive trade by providing a signal of quality to consumers and trade partners.** A strong national system of standardization that improves perceptions of quality can facilitate non-price competition (where firms compete in terms of attributes such as product quality, delivery and customer service). The opportunity for domestic exporters to compete with foreign companies on the basis of quality has the potential to increase trade. In addition, by improving transparency, buyers and sellers are more likely to be able to make optimal purchasing decisions, which can help to minimise transaction costs and increase competitiveness
2. **International standards create a 'common language' for potential trading partners.** Standards drive trade where previously technical differences may have been a barrier to trade. International standards that ensure compatibility, for example in terms of product measurements, convey information and form the basis of a universal standard for producers across the world. By creating internationally recognised technical characteristics, standards help to lower barriers to trade and reduce production costs. Such reductions can be passed on or at least shared with customers in the form of lower prices. This would be expected to enhance competitiveness and stimulate international trade.
3. **Standards support international commerce by lowering barriers to trade, reducing production costs and offering opportunities for economies of scale**. Lower barriers to trade (often technical) allow firms to access a wider number of customers globally, thus offering opportunities for economies of scale. In addition, by ensuring compatibility, standards can increase the demand for complementary products and services. For example the invention and continual improvement of mobile phones has led to the development of 'add-on' products and services ranging from accessories to tethered devices to applications.
4. **Standards encourage trade by reducing transaction costs.** Compatibility standards promote the option of outsourcing or even off-shoring of specific tasks to more efficient external producers or service providers. This is, in essence, a division of labour between firms which leads to the differentiation of the supply chains in manufacturing and service industries. For example, it may be optimal for a company to contract a supplier which has lower input costs to manufacture their products while they focus on the design, sales and marketing of the product. Suppliers

benefit from gaining access to information and technology which is already being used within the industry. The primary contractor benefits from being able to produce and sell their product at lower unit costs while concentrating on their core strengths.

2.5 Standards and innovation

Standards are considered to have a catalytic effect on innovation – in the sense that standards facilitate innovation but usually do not themselves directly contribute to the creation of new innovative products and services. Blind (2009) summarises these effects as follows:

1. The standardization process reduces the time to market for inventions, research results and innovative technologies;
2. Standards promote the diffusion of innovative products, which is most important for the economic impact of innovation;
3. Standardization levels the playing field and therefore promotes competition, and consequently innovation;
4. Compatibility standards are the basis for innovation in network industries;
5. Standards set the minimum requirements for environmental, health and safety aspects and consequently promote trust, especially in innovative products.

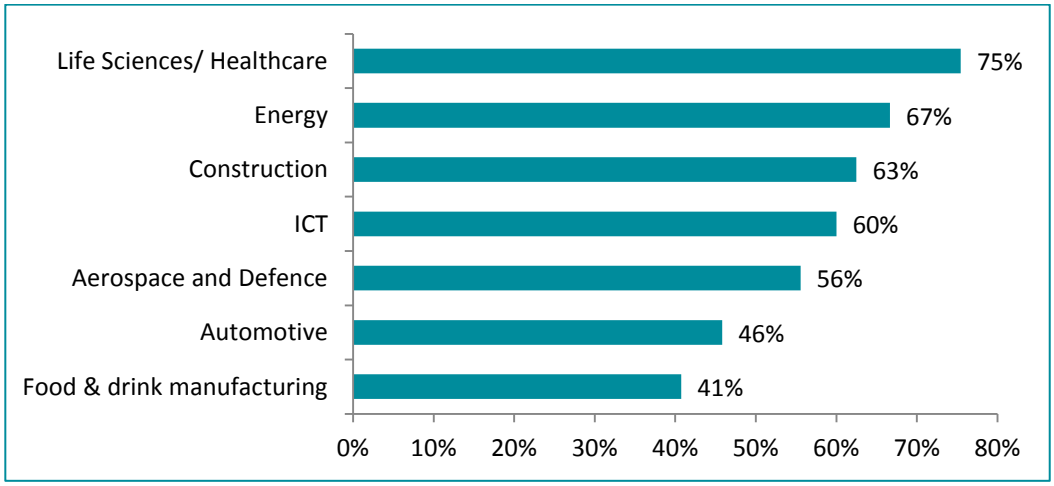
Blind (2009) argues that governments should act to promote and support these catalytic effects wherever possible and to avoid or restrict the negative effects, such as the prescriptive nature of some technical standards, the effect of the consensus approach in standards development on bringing forward the most advanced technologies, and the lock-in effect when standards have no provision for follow-on technologies.

The role of the standards development process in promoting innovation

The standards development process brings together technical committees of experts who volunteer to help develop standards. These include representatives from industry, professional institutions, trade associations, certification bodies, testing and inspection bodies, research organisations, consumer interest organizations, educational bodies and government departments. Combining these varied interests facilitates 'market-driven' innovation and enables user-orientated solutions to be achieved.

The literature proposes that standards have dual informing and constraining roles in innovation - Swann and Lambert (2010) find that companies which say that standards inform innovation and that regulations constrain it, tend to be the most innovative; hence they are the most active at pushing the innovative barrier and also the most constrained by the pace of the standards development process. The BSI Standards in Industry survey provides evidence to support this finding, showing that where there is a higher pace of technological advancement, in sectors such as life sciences, energy and ICT, companies are more likely to experience a lag between the development of standards and the latest technological developments (see Figure 6).

Figure 6: Do standards tend to lag behind technological development? % of respondents that agree, by sector



Source: BSI Standards in Industry survey, Cebr analysis

Standards bodies have been active in addressing this issue. Standards development time has been reduced by the introduction of efficiencies in technical committees and standards body back-office functions, and by shortening some stages of the development process. In some instances where a standard originates from another source, such as an industry consortium and already has widespread acceptance in an industry, a fast track procedure can be used to adopt it into the formal standards system.

However, a balance needs to be struck between the pace of standards development and the fundamental importance of achieving consensus amongst stakeholders. Without such consensus, dominant players could have disproportionate influence on standards (or impose de-facto standards) which might then be misused to raise rivals' costs and increase market concentration.

To summarise, this section gives an overview of the various channels through which standards contribute to economic growth; promoting productivity and efficiency in companies, through the role in supporting international trade and by acting as a catalyst for innovation within companies and sectors. It has been shown that standards play a vital and often invisible role in promoting technological advancement and improving efficiency within companies and industries.

The next section proceeds to analyse the catalogue of standards[9] published by BSI, the past trends in the composition and sector share of the standards catalogue, and trends in the international composition of the catalogue.

[9] It should be noted that any reference to the catalogue of BSI's standards in this report excludes such documents as draft standards, guides and handbooks which may be available through the BSI standards catalogue but are not adopted standards or standards distributed by BSI on behalf of other standards bodies.

3 Trends in standards

The previous section provides an overview of the mechanisms through which standards contribute to economic growth and the performance of companies. This section focusses on the standards themselves, analysing the composition of the stock of standards and showing how it has changed over time.

3.1 Measuring the stock of standards

To evaluate the impact of standards on economic activity and productivity, a measure of the stock of standards over time is required. Such a measure would ideally take account of variations in the quality of standards, the extent to which they are used and useful in industry and how standards come and go as time marches on. But the available data do not support such an ideal measurement so a more straightforward proxy must be used. This is provided by a simple count of the *number* or *quantity* of standards.

There is evidence to support the validity of using a quantity measure of the stock of standards as a proxy for estimating the effect of standards on productivity. As noted in the 2005 DTI study, growth in international trade tends to coincide with an increase in the demand for standards, due to both intra-industry trade[10] and increased productivity. The globalisation of UK trade since the 1990s correlates with strong growth in the stock of BSI's standards, suggesting that this 'stock' measure represents a reasonable proxy for both the level of standardization in the UK economy as well as the demand for standards.

Using data from the catalogue of BSI's standards, a measure of the net stock of standards in the catalogue in any one year was calculated by subtracting the sum of standards that had been withdrawn or retired up to the end of that year from the sum of all published standards up to the end of that year. This calculation is described by the equation in Figure 7:

Figure 7: Equation for the net stock of standards

[10] Intra-industry trade is the trade of similar goods and services within the same industry, often within different countries. For example, the textile industry of two countries may respectively import and export different quantities of cloth, according to how the countries are competitively advantaged.

The measure has been constructed using data from the British Standards Online (BSOL) and Perinorm[11] databases for the period 1921 to 2013. These databases contain detailed information including the date each standard was published and withdrawn, standard type, the original standard issuing body and the sector the standard applies to[12]. Where withdrawal dates were unavailable for early standards, hazard rates[13] estimated for the 2005 DTI study were used to estimate years of withdrawal for each individual standard where this was absent.

The process of publishing and withdrawing standards is in many ways similar to that of the product lifecycle – the process where products are designed, tested, launched in the market and ultimately withdrawn. After the launch of a standard, there might be some maintenance, modifications and updates, based on business needs and market conditions. Once the standard is no longer relevant to the market, even with additional revisions, it will be retired and most likely replaced with a new standard in its place.

Each standard is conceived by industry, in the sense that a requirement for the standard is established and a new standard is proposed. Standards are designed in the technical committee phase and then realized through adoption by the standards body. Like a product, standards go into service and produce benefits for the firms that use them. Eventually, benefits from standards decline, necessitating periodic reviews of whether they are still fit for purpose. If they are not, they are amended or updated, or withdrawn and superseded by other standards. Each new version of a standard therefore represents a step forward in technology or knowledge reflected in the standard.

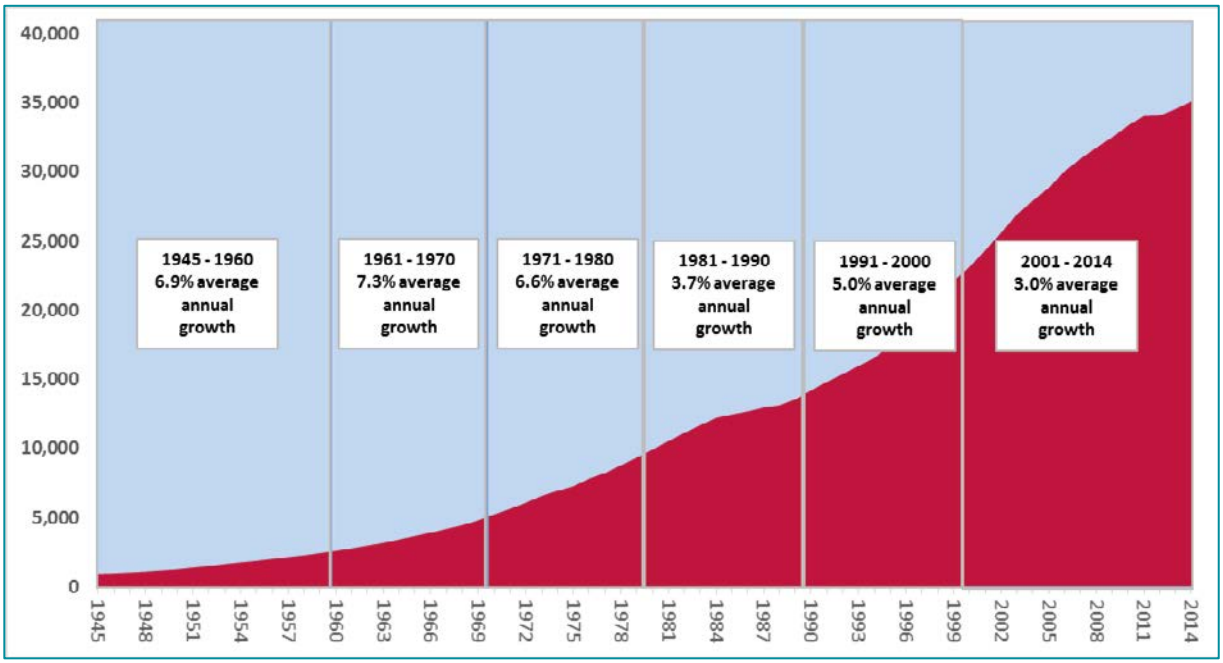
Since the introduction of the first standard in 1903, the BSI standards catalogue has grown exponentially – from less than 100 publications in 1920 to approximately 35,100 publications in 2014. The fastest pace of growth was observed between 1961 and 1970 when annual growth averaged 6.6%, albeit from a much lower base than today. The 1990s saw major changes in the composition of the catalogue with the introduction of harmonised European standards contributing to relatively high annual growth of 5% for the period. In more recent years, the pace of growth has slowed, averaging 3% for the period 2001 to 2014, partly because the period starts from a higher base (see Figure 8).

[11] Perinorm is a bibliographic database maintained jointly by the German (DIN), French (AFNOR) and British (BSI) national standards bodies, containing information on national, European and international standards from more than 200 standards publishing organisations in 23 countries, with a total of more than 1.4 million records.

[12] For the 2005 DTI study, a more limited set of data was available. For the period 1901-1984 data were sourced from the BSI History Book, and for the period 1985 – 2003, from the Perinorm database.

[13] A hazard rate in simple terms refers to the hazard or chance of an event occurring. In the context of standards, it refers to the chance that a standard has been withdrawn at a given point in time.

Figure 8: Net stock of standards in the BSI Standards Catalogue, 1945 to 2014

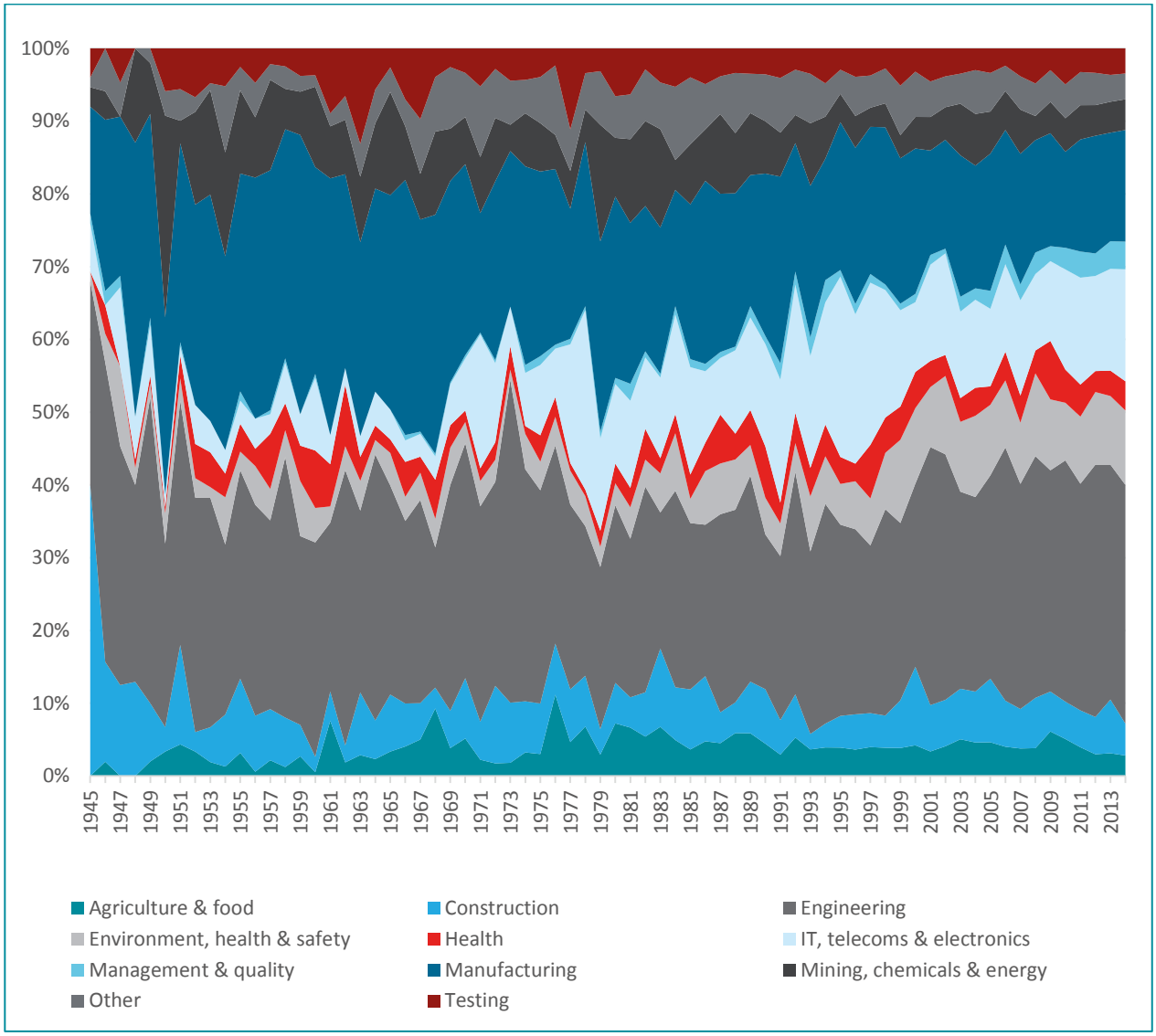


Source: BSI British Standards Online (BSOL) database, Cebr analysis

3.2 The composition of the catalogue of BSI's standards

The composition of the catalogue over the years has changed to adapt to shifts in the structure of the UK economy and the varying and growing demands for standards. Between 1945 and 1970, both engineering and manufacturing had a similar share of the standards stock (approximately 30%). Since 1970, the proportion of manufacturing standards in the catalogue has declined, while the engineering sector has retained its place as the most important source of demand for standards. Over the same period, the importance of the IT, telecoms and electronics sector has grown substantially, with its share rising from 7% in 1970 to 15% in 2014 (see Figure 9).

Figure 9: Composition of the BSI Standards Catalogue, by broad industry group (aggregated ICS fields) and year of publication, % of total



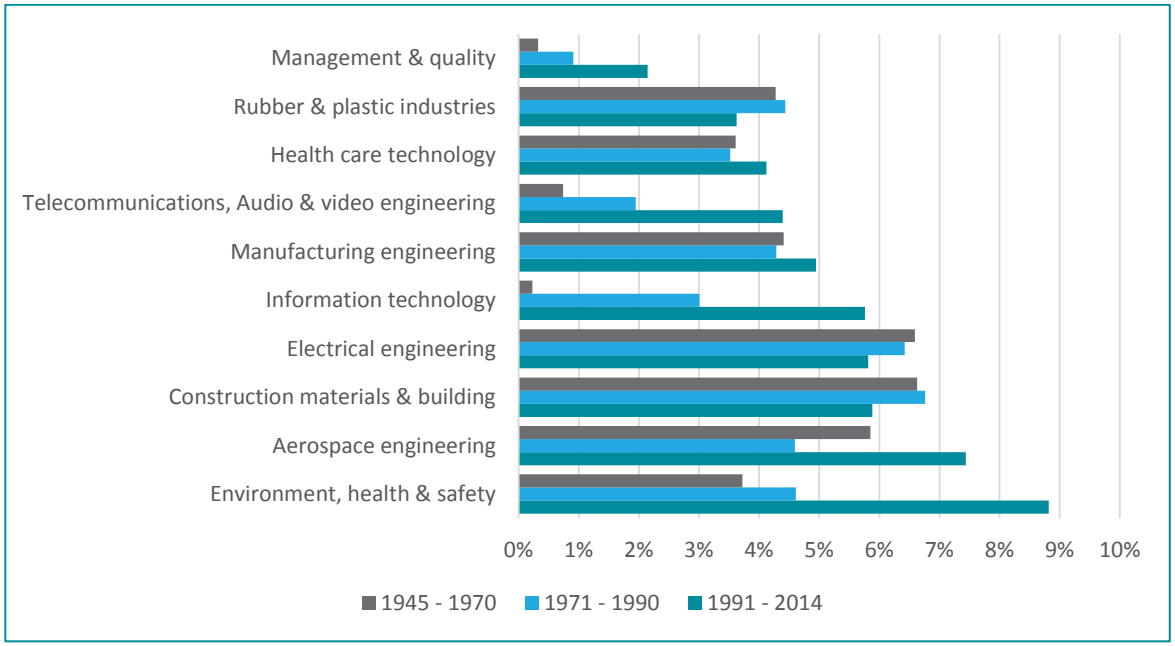
Source: BSI British Standards Online (BSOL) database, Cebr calculations

An examination of the top 10 most published groups of standards in 2014 (Figure 10) reveals how some fields have grown substantially in importance in terms of their share of standards published in each period while others have declined in importance.

Figure 10 shows how the share of standards in ICT fields has expanded rapidly since 1945 while the share of more traditional manufacturing fields such as rubber and plastics manufacturing have declined.

The data also indicate how standards have been developed to assist companies to meet expanding legislation in certain fields. Coinciding with the growing importance and awareness of issues relating to health and safety in the workplace and the protection of the environment, the share of standards in these fields has expanded from 4.6% between 1970 and 1990 to 8.8% for the period 1991 to 2014.

Figure 10: Top 10 most published groups of standards in 2014 (ICS field), % share of standards catalogue by time period

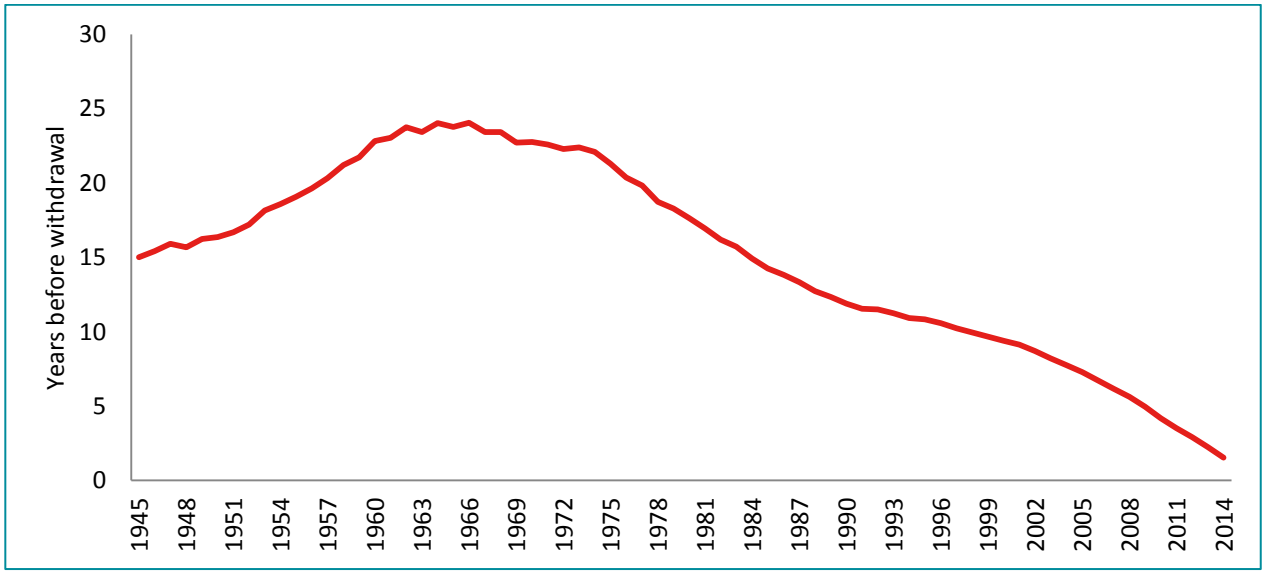


Source: BSI British Standards Online (BSOL) database, Cebr analysis

The pace of standards development in each field reflects, to some extent, rates of technological advancement. The introduction of a new standard normally occurs when problems have been identified with the provisions of an existing standard, necessitating its update or replacement with a brand new standard. In this way, the pace at which standards are withdrawn can in some instances reflect the pace of technological change at that point in time.

Figure 11 shows how standards published between 1945 and 1984 took more than 15 years to be withdrawn, while standards developed more recently being withdrawn more rapidly. To a large extent this reflects the primarily British composition of the standards catalogue prior to 1990, and the rapid withdrawal of many of these standards and their replacement by EU harmonised standards during the 1990s. However it also reflects the pace of technological advancement in recent years and how standards published closer to the present day are more likely to have not yet reached the end of their useful life. These factors contribute to the continual withdrawal of standards.

Figure 11: Average years before standard withdrawal, by published year, 1945 to 2014, smoothed



Source: BSI British Standards Online (BSOL) database, Cebr calculations

3.3 The origin of standards available to UK companies

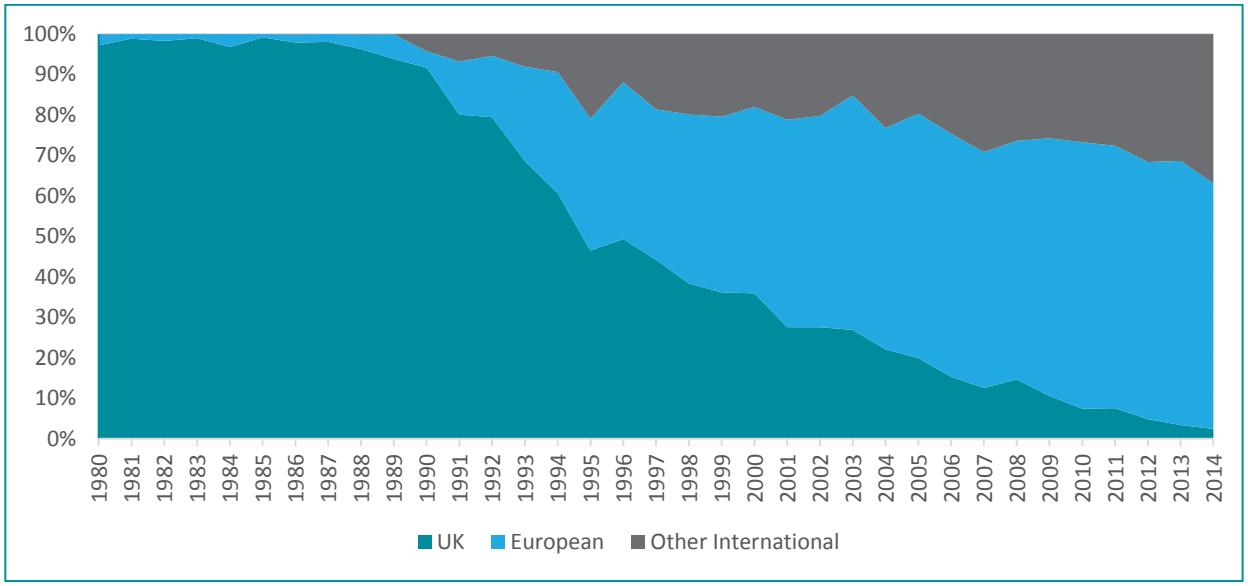
A key driver of the growth in the BSI standards catalogue over the past 25 years has been the increasing internationalisation of standards, at the EU level and beyond. Figure 12 shows that before the 1990s, almost all standards within the BSI Catalogue originated in the UK. EU harmonisation of standards led to the wide-scale adoption of European standards within the UK catalogue.

At the same time the 1991 Vienna Agreement, which formalised technical cooperation between ISO and CEN, and the parallel Dresden Agreement between IEC and CENELEC in 1996 were signed with the aim of minimising overlap in standards by developing single common standards at international and European level.

These agreements resulted in the automatic adoption of many international standards into the BSI catalogue, as they were also European standards. Standards that would previously have been developed solely for UK companies have been replaced by common European standards (some of which are also international standards). Other international standards developed via ISO and IEC are also overwhelmingly adopted as British standards. This has resulted in a staggering drop in the share of British-only standards from 88% in 1990 to 2% in 2014.[14]

[14] While this percentage is low, it is important to note that the UK is one of the strongest contributors to CEN/ CENELEC technical committees, with 293 working group convenors coming from UK committees in 2013. Many standards adopted at EU level have their origins in standards developed by BSI technical committees for UK companies.

Figure 12: Internationalisation of the BSI standards catalogue, 1980 to 2014



Source: BSI British Standards Online (BSOL) database, Cebr analysis

The changing composition of the BSI standards catalogue also reflects the increasing globalisation of trade. As more UK producers trade with EU and non-EU firms, there is a greater demand for standards that improve compatibility and reduce the technical barriers to operating in international markets.

The growing importance of information and communications technologies which are 'standards-intensive' in nature combined with the globalisation of trade suggests that we are likely to see international standards become an increasingly important feature of the UK standards catalogue into the future.

4 Macroeconomic impact of standards on the UK economy

The analysis presented in this section represents an update to a study on the macroeconomic impact of standards on the UK economy commissioned and published by the Department of Trade and Industry (now embodied within the Department for Business, Innovation & Skills) in 2005 (Temple, Blind, Jungmittag, & Spencer, 2005).

This section proceeds as follows: First, an overview of recent national studies on the macroeconomic impact of standards is given. Second, a description of the methodology used in the analysis is provided. Third, the results of the analysis are presented followed by a brief overview and discussion. Fourth, the results are compared with previous national level studies. Fifth, an outline is provided for recent trends in economic growth and the drivers of productivity. The section concludes with a discussion of the differences between the analysis and findings of this report and the previous 2005 DTI study, including consideration of the limitations of the analysis.

4.1 A summary of national studies on the economic benefits of standards

This analysis utilises a similar methodological approach to that of other recent national level studies. Before presenting the results of the analysis, it is useful to first provide a summary of the findings of these national level studies carried out in the UK, Germany, France and Canada.

UK

In the UK, the only national level study carried out to date on the macroeconomic impact of standards was published in a 2005 report by the Department for Trade and Industry (Temple, Witt, & Spencer, 2005). The paper (the first of three papers in the report) used data for the period 1948 to 2002 to determine the long-run relationship between changes in the net stock of standards and productivity growth.

The paper found the existence of a positive and statistically significant relationship between standards and growth in productivity in the UK. The authors however urged caution in the interpretation of the results, since standardization does not act independently of other factors – it acts in combination with other factors (like R&D for instance) to generate gains in productivity and to catalyse innovative activity.

Germany

One of the most recent national-level studies (Jungmittag, Blind, & Mangelsdorf, 2011) analysed the macroeconomic impact of standardization in Germany between 1992 and 2006. This research, commissioned by DIN (German Institute for Standardization), provided an update to an initial study on the issue in Germany, completed in 2000.

The study concentrated on the link between economic growth and the diffusion of knowledge through standardization. To do so, the authors empirically estimate how economic growth is affected by the amount of capital, labour and technological progress. The authors assumed that technological progress is driven by three main factors: domestic technological knowledge, foreign-imported technological knowledge and the diffusion of technological knowledge. These were, in turn, proxied by the stock of patents, licence expenditures and the stock of standards respectively.

The authors estimated that the economic benefit of standardization is equivalent to 0.72% of Germany's GDP per year between 1992 and 2006, which corresponds to an average of €16.77 billion per year during the same time period.

France

The Association Française de Normalisation (AFNOR) published a study in 2009 that examined the economic impact of standardization on the French economy (AFNOR, 2009). The research analysed the effects of standardization from both the macroeconomic and microeconomic perspective.

The macroeconomic analysis found a positive contribution of standards to economic growth equivalent on average to 0.81% of France's GDP growth per year between 1950 and 2007.

The study also evaluated the perceptions held by French firms regarding the impact of standardization using a survey of 1,790 companies. The evidence showed that standardization on average positively impacts the turnover of a firm. The study found that 66% of firms perceive standardization as a benefit to their organisation.

Canada

The Standards Council of Canada (SCC) commissioned The Conference Board of Canada (CBC) to undertake a study to evaluate the impact of standardization on the Canadian economy (The Conference Board of Canada, 2007). Similar to the French study, the research also takes a two-dimensional approach to achieve both a macroeconomic and microeconomic view of the effects of standardization on the Canadian economy between 1981 and 2004.

The study identified a significant positive effect of standards on economic growth between 1981 and 2004, estimating that standards supported 17% of the growth in labour productivity in France between 1981 and 2004 and approximately 9% of economic growth during the same time period. Further, the study suggests that, in 2004, economic output would have been CA$62 billion lower if there had been no growth in standards for the period 1981 to 2004.

The findings of the microeconomic analysis provide strong qualitative evidence in favour of the beneficial impact of standards on businesses in Canada. Using results from fifteen interviews carried out with firms, standards development organisations, trade associations and government departments, the CBC concluded that standardization offers a wide variety of benefits including a foundation for driving innovation and new product development. Interviewees highlighted standardization's enhancing effect on productivity and its contribution towards reducing costs.

4.2 Methodology: a model for the relationship between standards and productivity

It is understood from economic theory that growth in the economy depends on the quantities of the factors of production employed (specifically labour and capital) and the efficiency with which they are used. Growth can be sustained by increasing the amount of labour and capital that are used. However, as additional units of these factors are added, the amount of additional output diminishes.

Modern economic theory states that only increases in the level of technological progress – represented by patents, standards and other forms of technical knowledge – can offset the decline in growth that occurs as an economy matures[15] and diminishing returns to additional capital and labour set in. Growth over the long run can be sustained by increasing the efficiency with which these factors are combined to produce output. This is known as total factor productivity (TFP). Improvements in TFP are driven by a number of factors including technological advancements and improved education that enhance the efficiency of processes and techniques. These advancements and improvements are influenced by standards and other factors such as R&D, imports of foreign technology and proprietary technology (patents). As such, standards play an important role in driving growth in TFP.

Economic theory states that the economy produces output (expressed as GDP) through the inputs Capital (K), Labour (L) and TFP. Our model follows the approach of the 2005 DTI study and previous national level studies on the impact of standards on economic growth. We use a Cobb-Douglas production function to describe how output is a non-linear function of the labour force (L), the capital stock (K) and TFP (A).

$$Y_t = A_t L_t^{\propto} K_t^{1-\propto}$$

This Cobb-Douglas production function can be transformed into a linear equation that is conducive to econometric estimation.[16] This allows the equation to be re-stated as a per-worker production function with components output per worker (labour productivity), capital per worker (capital-employment ratio) and TFP. A simplified representation of this re-stated model is shown in Figure 13. (See the appendix for a detailed exposition of the empirical methodology).

Figure 13: Relationship between Productivity, the capital–employment ratio and TFP

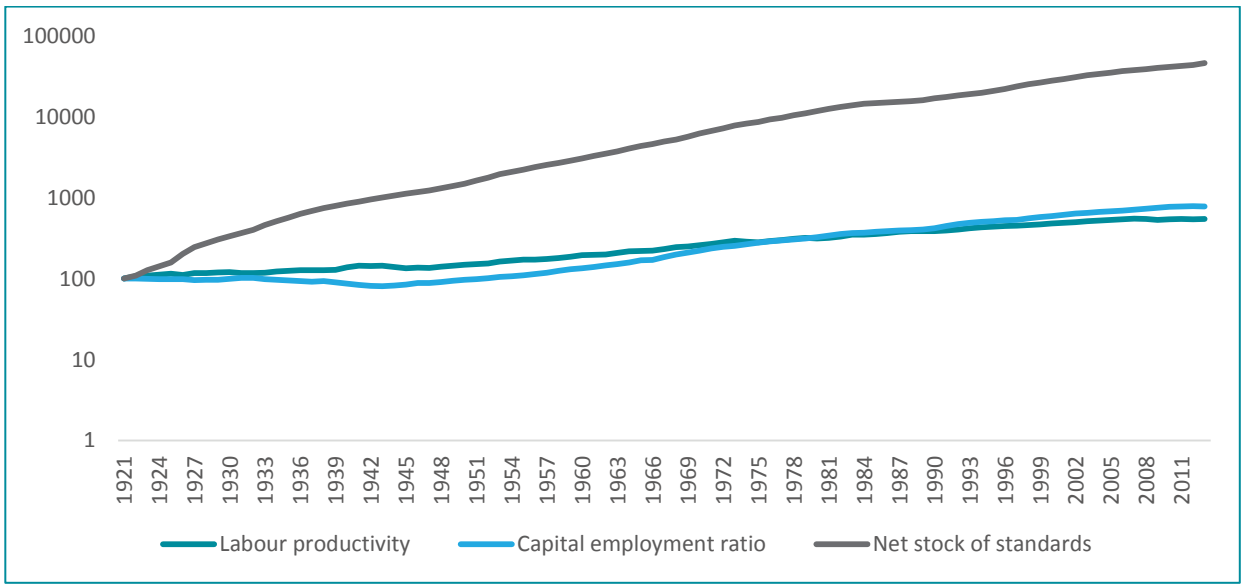
For the econometric equation, we specify labour productivity as a function of the capital-employment ratio, standards and a linear time trend and recession variable, with the unexplained variation (residual) in productivity representing the remaining portion of TFP. The purpose of the econometric analysis is to isolate the contribution of standards to TFP growth and hence labour productivity. A linear time trend is included to account for growth in labour productivity that can be attributed to time. A recession variable is included to account for impacts of recession on labour productivity across the time period under analysis.

[15] One of the most important contributions to growth theory in the 20th century, the Solow-Swan growth model (Solow, 1956), (Swan, 1956) proposed the addition of a third source of economic growth - technological progress – that is external to the other two factors capital and labour. The model postulates that only the rate of technological progress has any influence on the long-run growth rate of per-capita output and consumption. A more recent growth model (Romer, 1990) builds on these fundamental ideas, showing that technological progress is 'endogenous' to economic growth i.e. a higher pace of economic activity can raise the pace of process innovation as firms learn from their experience, resulting in a virtuous circle of growth.

[16] Achieved by taking the natural log of both sides of the equation.

Figure 14 shows the trends in labour productivity, the stock of standards and the capital-employment ratio between 1920 and 2013. The figure shows that the stock of standards has been growing at 6.8% per year, close to triple the rate of labour productivity (1.9%) and the capital-employment ratio (2.3%).

Figure 14: Long-run growth in labour productivity, capital employment ratio and net stock of standards, Index 1921=100, logarithmic scale



Source: ONS, Bank of England, BSI British Standards Online (BSOL) database, Cebr analysis

Figure 14 also shows that prior to 1948, the pace of growth in the capital stock was low, hampered by two world wars and the inter-war depression. Since 1948, the net capital stock has grown at a faster pace, averaging 3.8% growth per year relative to an average 0.4% growth per year in the labour force. Consistent with the growth path of a developed economy, the capital-employment ratio has risen at a much faster pace than labour productivity. This echoes the growing capital intensity (capital per worker) of British industry over the period. This, in turn, has increased the demands for standardization through the increased requirements for technical compatibility and interoperability.

4.3 Testing the relationship between standards and productivity

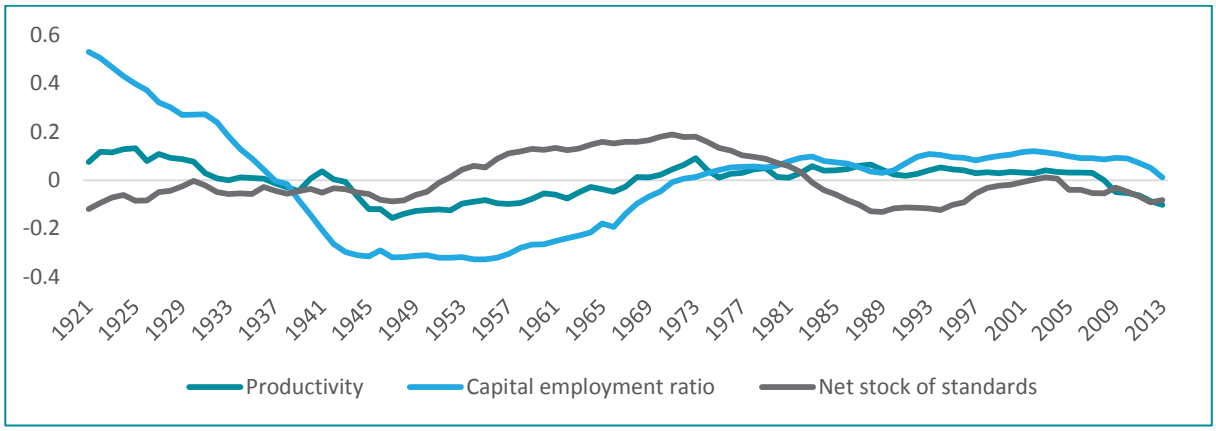
Economic theory suggests that standards should exhibit a causal relationship with labour productivity and that the effect is likely to exists only in the long-run[17] – short-run changes in the stock of standards should have little effect on productivity.[18] The 2005 DTI study found that this was the case in the UK.

[17] The short run in economic theory treats only some inputs as variable over time, such as the amount of labour employed. Only in the long run can all inputs can be varied, including fixed capital.

[18] The absence of short run impacts from standards is a result of the time it takes for standards to diffuse amongst a user population. In other words, there is a time lag between the adoption of a standard and the point at which it reaches maximum effectiveness.

The apparent relationship between labour productivity, the capital-employment ratio and standards can be seen more clearly when the time trend is removed[19] from each series as shown in Figure 15[20]. While the graph illustrates how labour productivity, the capital-employment ratio and standards tend to move together, identifying the direction of causality is more difficult. In other words, does the increasing size of the net stock of standards drive improvements in productivity or is it changes in productivity that drive the creation of more standards?

Figure 15: Labour productivity, Capital employment ratio and Net stock of standards, 1921 to 2013, de-trended



Source: ONS, Bank of England, British Standards Online (BSOL) database, Cebr analysis

Strong uni-directional causality is improbable because, in reality, productivity and the creation of standards will grow in a *virtuous cycle*, with each likely to be reinforcing the other. What is observable is a potential 'cointegrating' relationship between the two or three variables whereby there exists a stable long run statistical relationship. Statistical tests can confirm if this relationship is valid (non-spurious) and whether it exists between standards and productivity. [21]

The results of the econometric estimation are presented in Table 3. The results show that the contribution of standards to productivity growth over the period 1921 to 2013 is positive and statistically significant. The estimation finds that the elasticity of labour productivity with respect to standards is 0.106. The capital-employment, time trend and recession coefficients were also found to be significant.

[19] The time trend is removed (or the variables are de-trended) to illustrate how the variables move across time.

[20] The data series used for the analysis are: GDP at 2006 basic prices, Number of persons in employment age 16+ and non-dwellings net capital stock. Labour productivity is calculated as the ratio of GDP and employment. A detailed summary of the data sources used in the analysis are provided in the appendix.

[21] An Augmented-Dickey Fuller (ADF) test and a Phillips-Perron test were conducted on the residuals of the estimation to confirm that the relationship is non-spurious.

Table 3: Estimation of the impact of standards and capital-employment ratio on labour productivity

OLS	Coefficient	Standard Error	t-statistic	P > t
Capital-employment ratio	0.351**	0.022	15.7	0.000
Net stock of standards	0.106**	0.017	6.1	0.000
Recession indicator variable	-0.027**	0.008	-3.57	0.001
Time trend	0.004*	0.002	2.37	0.000
Constant	6.217	0.226	27.53	0.000
ADF test statistic	-3.134			
Observations	93			
Time period	1921 - 2013			

* Denotes significance at the 5% level ** Denotes significance at the 1% level

The results suggest the following:

- On average for the period 1921 to 2013, a 10% increase in the net stock of standards is associated with a 1.06% increase in labour productivity, and this effect is found to be statistically significant.
- Between 1921 and 2013, the net stock of standards grew by 6.5%, while the average rate of growth in labour productivity was 1.8%. Applying the elasticity of labour productivity with respect to standards (0.106) means **that standards are associated with approximately 0.69 percentage points of the average labour productivity growth of 1.8% a year**.
- This equates to the suggestion that **standards supported 37.4% of labour productivity growth and 28.4% of GDP growth between 1921 and 2013.** Caution should be taken when interpreting these estimates as standards have an interdependent role in driving labour productivity along with other knowledge factors such as higher levels of education and training, advances in technology and increased innovative efforts.
- For the purposes of expressing the findings in monetary terms, if it is assumed that the estimated impact is constant over time, standardization at a national level would be associated with approximately **£8.2 billion of the £29.0 billion of GDP growth recorded in 2013** (2014 prices).

The boost to labour productivity associated with the use of standards is realised when individual firms can increase their output per employee. Standards can support increases in production activity and efficiency within firms through a variety of mechanisms. By ensuring quality and precision, standards help to improve organisational performance, which enable firms to lower their costs – allowing increased output per worker employed. In addition, by spreading technical information and diffusing best practice policies, standards enable firms to build on their specialisations and achieve a better division of labour. In turn, firms benefit from economies of scale and a consequent increase in output relative to the number of staff employed. If large numbers of UK firms experience similar improvements in output per worker as a result of standards use, the analysis suggests that this would represent 37.4% of annual productivity growth at the national level.

To advance understanding of the connection between productivity and its determinants, further econometric methods were used to identify the causal relationship between labour productivity, the capital-employment ratio and the stock of standards. The results of this analysis, presented in Table 26 in the Appendix, confirm that the relationship between productivity, the capital-employment ratio and the stock of standards is not significant in the short-run and that the relationship between productivity and standards exists only in the long-term.

4.4 Comparison of results to other national-level studies

The results of the econometric estimation can be compared to the findings of other national- level studies summarised in section 4.1 – all of which found that standards have a positive and significant impact on productivity. While not directly comparable, particularly due to the different time periods analysed, a comparison of the magnitudes reveals potentially interesting insights about effect of standards on productivity.

Table 4: Comparison of summary results of national studies

Country	France	Canada	Germany	Germany	UK	UK
Organisation and publication year	AFNOR (2009)	Standards Council of Canada (2007)	DIN (2000)	DIN (2011)[22]	DTI (2005)	Cebr (2015)
Period of analysis	1950-2007	1981-2004	1961 - 1990	2002 - 2006	1948-2002	1921-2013
Estimated function	GDP Output	Labour Productivity	GDP Output	GDP Output	Labour productivity	Labour Productivity
Elasticity of stock of standards	0.12	0.36	0.07	0.18	0.05	0.11
Share of labour productivity growth, %	27.1	17	30.1	-	13	37.4
Growth rate of GDP % p.a.	3.4	2.7	3.3	-	2.5	2.4
Share of GDP growth, %	23.5	9.2	27.4	-	11.0	28.4
Contribution of standards to GDP growth, % points	0.8	0.3	0.9	0.7	0.3	0.7

Source: AFNOR (2009), Standards Council of Canada (2007), DIN (2000), DTI (2005), Cebr analysis

[22] Detailed results were not reported in the study.

The results for other national-level studies presented in Table 4 reveal the following:

- AFNOR (2009) found that the elasticity of GDP to the stock of standards between 1950 and 2007 is 0.12. This would suggest that standardization in France contributed 0.8 percentage points per year to the average GDP growth rate of 3.4% during 1950 and 2007.
- The Standards Council of Canada (2007) found that the low growth of standards (0.7%) in Canada between 1981 and 2004 was counteracted by a high elasticity of productivity to the stock of standards (0.356), suggesting that standardization supported 17% of the growth in labour productivity.
- The DIN (2000) paper analyses the economic effect of standards in Germany, and covers the earliest time period in our comparison: 1961 to 1990. The paper concludes that standards contributed 0.9 percentage points to an average annual growth of 3.3% between 1961 and 1990. The 2011 update to this paper finds that the contribution of standards to GDP during the period 2002 to 2006 was slightly lower at 0.7%, although no value for the share of labour productivity due to standards was provided.

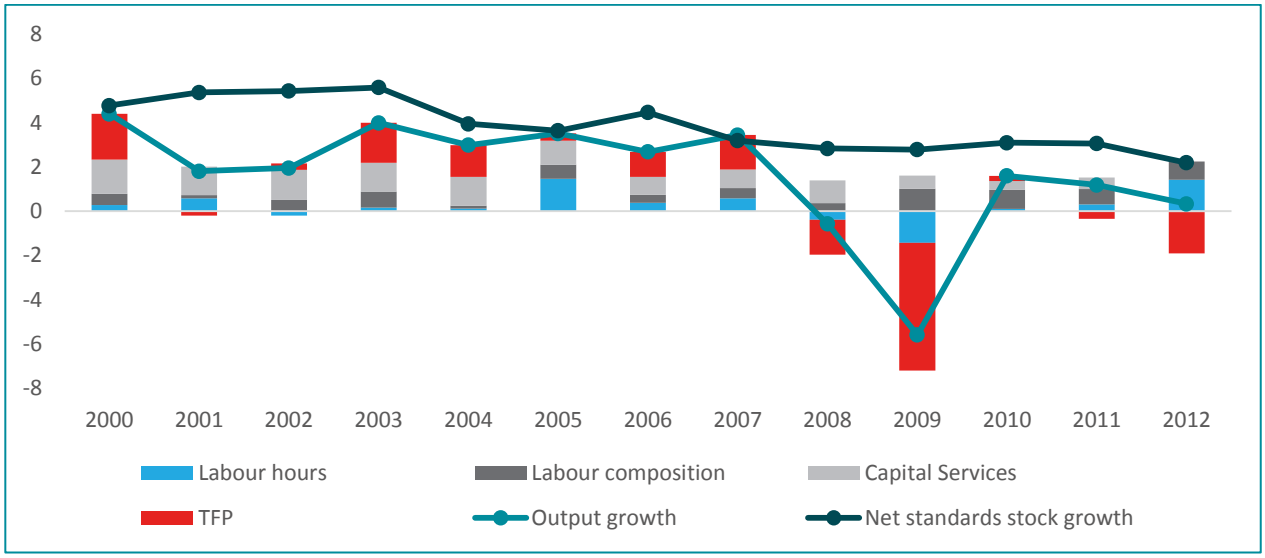
Differences between our results and those of the DTI (2005) study likely relate to the shorter time period used (1948-2002) as well as the fact that we used more up-to-date and comprehensive data series.[23] (See section 4.6 below for a further discussion.) That is, to some extent and in line with the studies from other countries, the differences can be explained by how the magnitude of the impact of standards on labour productivity is likely to be different depending on the time period being considered.

4.5 Productivity and standards since 2000

The original DTI study was completed in 2005 following a period in which the UK had enjoyed 14 years of uninterrupted expansion with an average annual GDP growth rate of 2.9%. Since 2008, the UK has experienced a prolonged economic recession (2008 and 2009), a protracted recovery and a period of economic uncertainty which has coincided with a period of weak productivity growth. Even though the performance of the economy has improved since, productivity per hour in Q3 2014 remained 1.8% below its pre-recession peak.

[23] It is important to note that due to the different data for stock of standards used here, the results are not directly comparable to that used in the 2005 DTI study.

Figure 16: Composition of output growth and growth in the net stock of standards, annual, 2000 to 2012



Source: ONS decomposition of GDP growth, BSI, Cebr analysis

As demonstrated in Figure 16, TFP – a measure of how efficiently labour, capital and other factors combine to produce output - was the biggest contributor to the 5.6% drop in output in 2009. An explanation for this is that there was substantial underutilisation of labour (and capital) during the period – companies opted to keep workers employed, rather than let them go once revenues began to decline. This meant that TFP, which is more responsive to changes in output, made a larger contribution to the decline in output than would otherwise have been the case.

Previous research shows that standards tend to only have an influence on productivity in the long run – standards have very little impact in the short run (Swann, 2010). This implies that other components of TFP, such as technical efficiency, human capital or R&D investment - which are more responsive to cyclical changes - are likely to have been more important drivers in the short term decline in TFP observed above.

There are however channels through which the contribution of standards to productivity could have been impacted. During the 2008-09 recession there was no decline in the growth of net stock of standards. However standards require investment by companies in order for them to have an effect of productivity. If companies decided to reduce investments in the implementation of standards during this period, then it is possible that the contribution of standards could have been impacted in that year and subsequent years.

Standards are also likely to have had an effect on productivity and GDP through their role in supporting export activity. Standards help companies to enter new markets more easily (see section 2.4) and companies that use standards are also more likely to be exporters (see section 2.4). During the 2008-09 recession companies that were able to access international markets – which, with the notable exception of Europe, generally fared better than the UK economy – were likely to have been better insulated from the damaging effect of the recession on their businesses. In addition, the impact of standards on businesses' productivity would likely be greater for high productivity growth industries relative to low productivity growth industries. As a result, it is plausible to think that high productivity growth sectors, boosted by standards may have helped to offset low and even negative productivity growth in some sectors during the recession.

4.6 Differences with the 2005 DTI analysis

The model used to evaluate the relationship between productivity and the growth in standards is consistent with macroeconomic theory on the determinants of economic growth. It also follows closely the 2005 DTI analysis. However, the results arrived at by this study do differ from those found in the 2005 DTI analysis.

The following provides a brief summary of what Cebr believes are the main causes for these differences.

Time period: It is generally desirable to use a longer time period when the data are available as this tends to reduce the standard error of the sample. The availability of the necessary data for this study allowed the extension of DTI's period to cover 1921 to 1947 and 2003 to 2013, incorporating the period since the DTI study was carried out.

Capital stock measure: The capital stock measure (excluding dwellings) used in this study covering the period 1921 to 2013 was created by the Bank of England[24] and incorporates asset capital services growth – a measure of the productivity of capital which better reflects the flow of capital into the productive process. This differs from that used in the previous study, when this data series was not available and a different measure of the capital stock (CIXX series from the ONS) was used.

Net stock of standards: Improvements in the compilation of data on the withdrawal dates of standards on the BSOL database has created some differences in our counts of the net stock of standards.

Recession indicator variable: A 'recession' indicator variable was included in the regression specification to capture shocks from recessions that are unrelated to the long-run relationship between productivity and standards. This was not used in the 2005 DTI study, most likely because the necessity of doing so was not as significant for the time period considered. In contrast, the time period considered in this study includes the turbulent inter-war period, World War II and, of course, the deep global and UK recessions that followed the 2008 financial crisis.

Output measure: A different measure of economic output was used. That is, GDP at constant prices was used to allow for comparability with the findings of other national studies. The DTI 2005 study used GVA at constant prices.

The difference of most significance to the results of the analysis is the extent to which the average growth in the 'net stock of standards' variable is greater than the average growth in the 'productivity' variable – this gap is lower in the DTI 2005 study than in our study. This is because the extended time period analysed in this study is characterised by a period of high growth in the net stock of standards. This translates into a higher coefficient for the impact of standards on productivity. In other words, the lower coefficient found in the DTI 2005 study reflects lower growth in the stock of standards observed in their shorter time period .

4.7 Interpretation of the findings

The results of the analysis suggest that the data corroborate the underlying economic theory. However, there are issues that justify the urging of caution when interpreting the findings. These are outlined in numbered points that follow.

[24] See data appendix for sources

1. **More standards may not produce proportional economic benefit.** The assumption that the stock of standards is a robust representation of how standards contribute to the economy is equivalent to an assumption that each standard contributes an equivalent benefit to the economy. Furthermore, that from one year to the next, the average economic benefit per standard does not change. In reality, these assumptions are unlikely to hold. The benefits of older standards in the Catalogue are likely to be lower than the benefits of newer standards. In addition, where the impact of standards on the economy is generated by the widespread *use* of standards, certain standards may be more widely used in the economy than others. For instance, some standards adopted from abroad will be of less relevance to British companies. However, as stated in section 3.1, the strong correlation between the growth in the stock of UK standards and the growth in UK exports, which generates demand for additional standards to be created, suggests that the 'stock' measure of standards in the economy represents a reasonable proxy for both the level and quality of standardization in the UK economy and the demand for standards.

2. **Standards alone do not boost productivity**. The model does not explicitly take into account other components of TFP, such as the rising level of education in the population, or the accumulation of scientific knowledge. But, in reality, improvements in productivity require other factors that affect technological progress besides standards. The model is an attempt to disentangle the effects of standards from other complementary factors that drive productivity. According to the model, 62.6% of productivity growth (i.e. the proportion productivity growth that is not due to standards) can be attributed to growth in capital per worker and other influences on labour productivity, such as advances in technology and improvements to education, captured by the residual of the econometric model. To the extent that the complementary relationships between the stock of standards and these other factors of TFP explains the specific impacts of standards on productivity estimated by our model, the model's estimates would have to be considered as overestimates.

3. **Standards as a 'black box' –** An important criticism of macroeconomic models such as those used by most of the national level studies including this one is the treatment of the relationship between standards and productivity as somewhat of a 'black box'. We do not attempt to incorporate the mechanisms by which standards generate increased productivity within our quantitative analysis, primarily because the data to examine such factors is not normally available at the national or sector level. Only a study at the company level, either using firm-level data derived from surveys or case studies, can assist in the development of a clearer understanding of these mechanisms and their effects.[25]

4.8 Conclusions – macroeconomic impact of standards

Growth in an advanced economy such as the UK depends on companies being able to utilise the latest technological innovations and knowledge to improve productivity. Standards work by spreading technical knowledge and information, and by supporting the efficient functioning of companies and sectors.

The academic literature shows that standards solve a number of economic problems which impede the efficient operation of companies and the access of their products to markets. Standards help companies and their supply chains to operate in a more efficient manner, reducing costs and expanding revenue – ultimately allowing companies and sectors to become more productive.

[25] Several previous studies, as already noted, incorporate a separate firm-level analysis of standards. These include DIN (2000), Conference Board of Canada for the Standards Council of Canada (2007), AFNOR (2009) and BERL Economics for The Standards Council of New Zealand (2011).

To empirically measure the impact of standards on productivity at the macroeconomic level, an econometric analysis was carried out using a similar methodological framework to a 2005 study for the UK published by DTI, and updating the analysis using new data. The analysis confirms the results of previous studies, finding that standards continue to play an important role in boosting UK productivity, and thus GDP. However standards do not drive productivity exclusively, but instead have an interdependent and reciprocal role in supporting productivity growth along with other forms of knowledge such as improvements to education and advancements in technology.

The quantified contribution of standards to productivity – 37.4% of annual labour productivity growth in the UK economy over the period 1921 to 2013, were larger than those estimated in the 2005 study, but correspond with the findings of other recent national level studies in France and Germany.

This does not necessarily mean that the impact of standards has increased since the last study – variations in the methodological approach, longer time period and data used account for a lot of the differences. However, it does reinforce the notion that standards play a large an often under-noticed role in boosting UK productivity.

5 Contribution of standards to the success of UK companies

5.1 Introduction

The analysis described in the previous section establishes that at a whole economy level, standards contribute significantly to the spread of technical knowledge, leading to a boost in productivity and thus driving the growth the economy. This represents an update to a study published in 2005 that used a similar methodology. A shortcoming of this macroeconomic approach is the absence of any detail on *how* the benefits of standards are transmitted in practice, at the sector and company level. Multiple mechanisms have been identified in the academic literature as to how standards benefit companies but there is limited evidence to show how these mechanisms apply at the sector level in the UK economy.

To further our understanding of the role of standards in the UK economy at the micro level, additional quantitative research has been carried out in Part 2 of this study. The objective was to gain a detailed understanding of the role of standards within sectors in terms of monetary and non-monetary impacts, the role of standards in competitiveness, trade and innovation, and the value of participating in the standards development process. To achieve this, a comprehensive survey of 527 companies in seven key sectors[26] was commissioned as part of the study, asking businesses to think about the general and detailed effects of standards on their operations.

The aims of this second part of the research are to:

- Quantify the monetary impact of standards on the supply chains of some of the UK's largest sectors;
- Establish how standards boost the productivity and efficiency of firms;
- Identify the effect of standards on competition within markets;
- Determine how standards support innovation;
- Understand the role of standards in helping businesses access domestic and overseas markets;
- Understand the value for companies of participating in the standards development process;
- Identify the most important non-monetary benefits from standards.

The purpose of this section is to present the findings relating to these aims.

5.2 The business economy impacts of standards

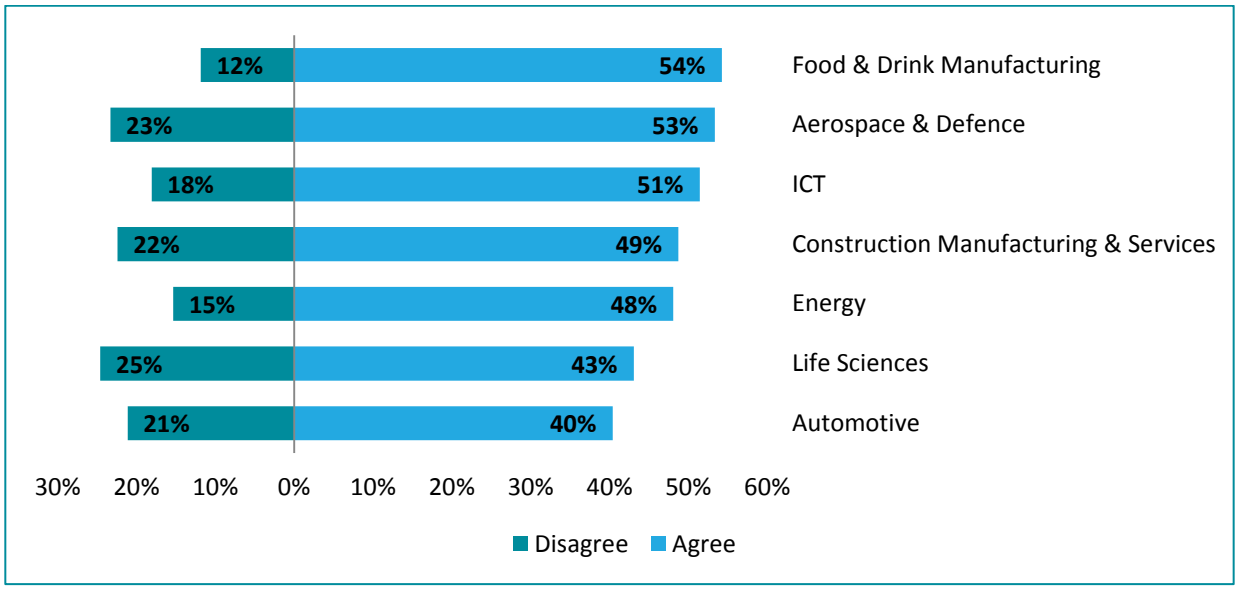
The use of standards is predominantly voluntary. However, in many instances, companies are required to use standards by their customers in order to supply their products or services or to meet regulatory requirements because the alternative (non-compliance) could be more costly. While it is undeniable that there is a cost associated with using standards, the evidence from the BSI Standards in Industry survey

[26] The analysis and survey cover the following sectors: Automotive, Life Sciences, Aerospace & Defence, Energy, Food & Drink Manufacturing, Construction products & services, ICT. These sectors were identified as those where standards-use is most intensive and were targeted to ensure that the findings relating to the impacts of standards would be most accurate. The activities of these sectors cover 25% of the UK non-financial business economy.

shows that, on balance, standards unanimously generate more benefits for companies than they cost to implement.

The majority of survey respondents reported that standardization provided a net benefit for their business (see Figure 17).[27] In particular the majority of firms surveyed in the food and drinks manufacturing industry (54%), the aerospace and defence sector (53%)[28] and the ICT industry (51%) reported that standards benefit their business.

Figure 17: Does your organisation experience a net benefit from standardization? (% of respondents by sector)



Source: BSI Standards in Industry Survey, Cebr analysis

The extent to which respondents reported that standardization benefitted their business differed across firm sizes: 63% of large firms surveyed agreed that standards provided a net benefit to their business while almost half (47%) of small and medium-sized enterprises (SMEs) surveyed responded in the same way.

The survey revealed significant monetary benefits to firms in terms of revenues and value added (GVA), that can be attributed to standards. To convert the reported benefits from the survey into monetary values for the entire sector, the results were re-weighted by the overall business population of each sector, thus ensuring that the survey results are used to produce representative sector-wide estimates.[29]

[27] Firms reporting that they neither agree nor disagree with statements asked by the BSI Standards in Industry Survey are omitted from the graphical representations in this study.

[28] Respondents from the aerospace and defence industry make up a lower than average proportion of the total sample under analysis. As a result, the findings relating to this sector are prone to large sampling error and are thus likely to be unreliable. However the findings are presented for informational purposes.

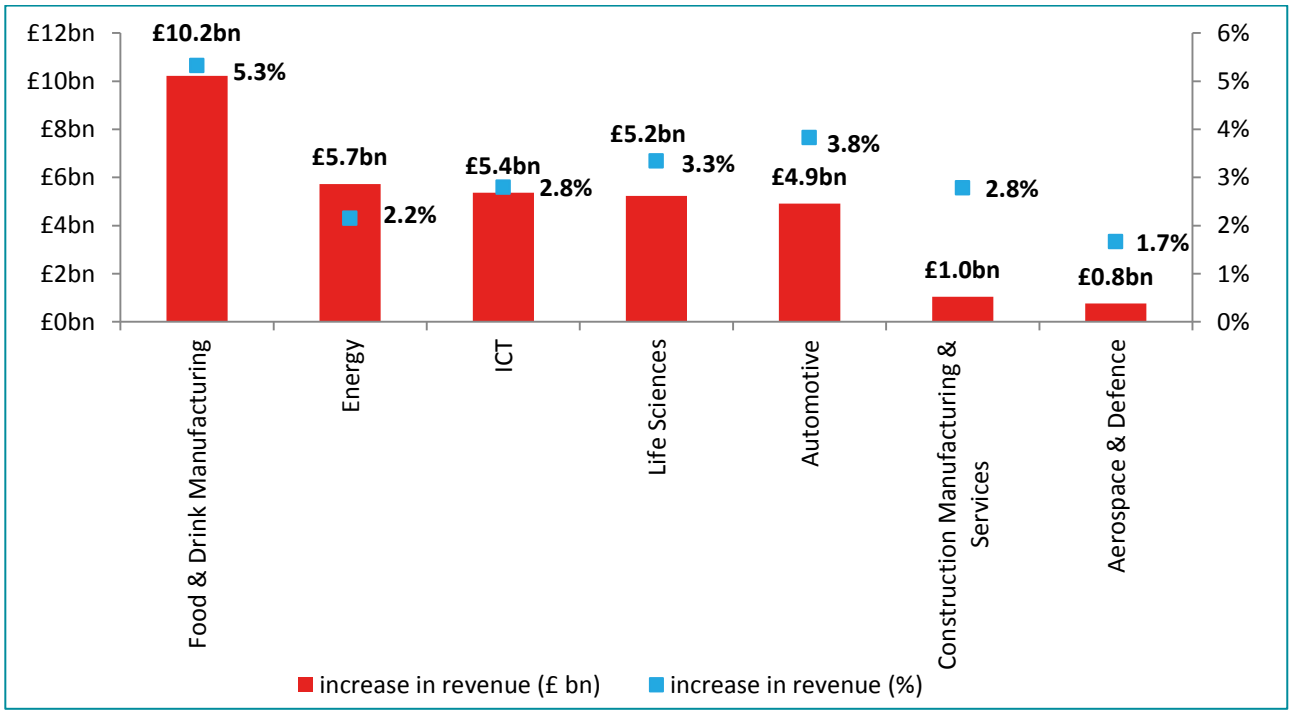
[29] Increases in revenues and exports were calculated using survey responses and official data. Survey responses were scaled by the official business population of each industry (using ONS UK Business Counts statistics) and applied to official sector revenue and sector export revenue data (from the ONS Supply- Use Tables 2012 and ONS GDP (O) Low Level Aggregates 2014). This ensured that findings relating to the aggregate increases to Revenue and Export revenue were representative of each sector. Increases in GVA were calculated using the ratio of industry revenue to industry GVA using ONS GDP Low Level Aggregates 2014 data. The definition used for each sector was limited to the disaggregation of SIC codes available in the supply use tables. In some cases, these definitions differ from those described in Appendix 4.

Revenues (turnover)

The survey reveals that over one-fifth (22%) of all firms benefited from an increase in revenues of at least 1% per year as a result of standardization. For many firms the monetary gain of such an impact is substantial. In particular, the survey revealed that sectors with the highest turnover did not necessarily see the highest gains in percentage terms, implying that firms do not have to be large to benefit from the use of standards. Key findings relating to revenue are as follows:

- Overall, the food and drink manufacturing industry reported the largest impact on revenue in monetary terms (£10.2 billion per year) and percentage terms (5.3%). (See Figure 18.)
- Firms within the energy and ICT sectors reported the next highest monetary impact on revenue as a result of the use of standards, reporting an average annual impact of £5.7 billion and £5.4 billion respectively.
- The automotive sector also reported a large increase in revenue as a result of standardization: on average 3.8% per year. However this does not directly translate into large absolute gains due to the relatively low turnover of the firms analysed.

Figure 18: Increase in revenue that can be attributed to the use of standards (left axis: £ billions, right axis: percentage increase)



Source: ONS Supply-Use Tables 2012[30], ONS GDP Low Level Aggregates 2014 Q4, BSI Standards in Industry Survey, Cebr analysis

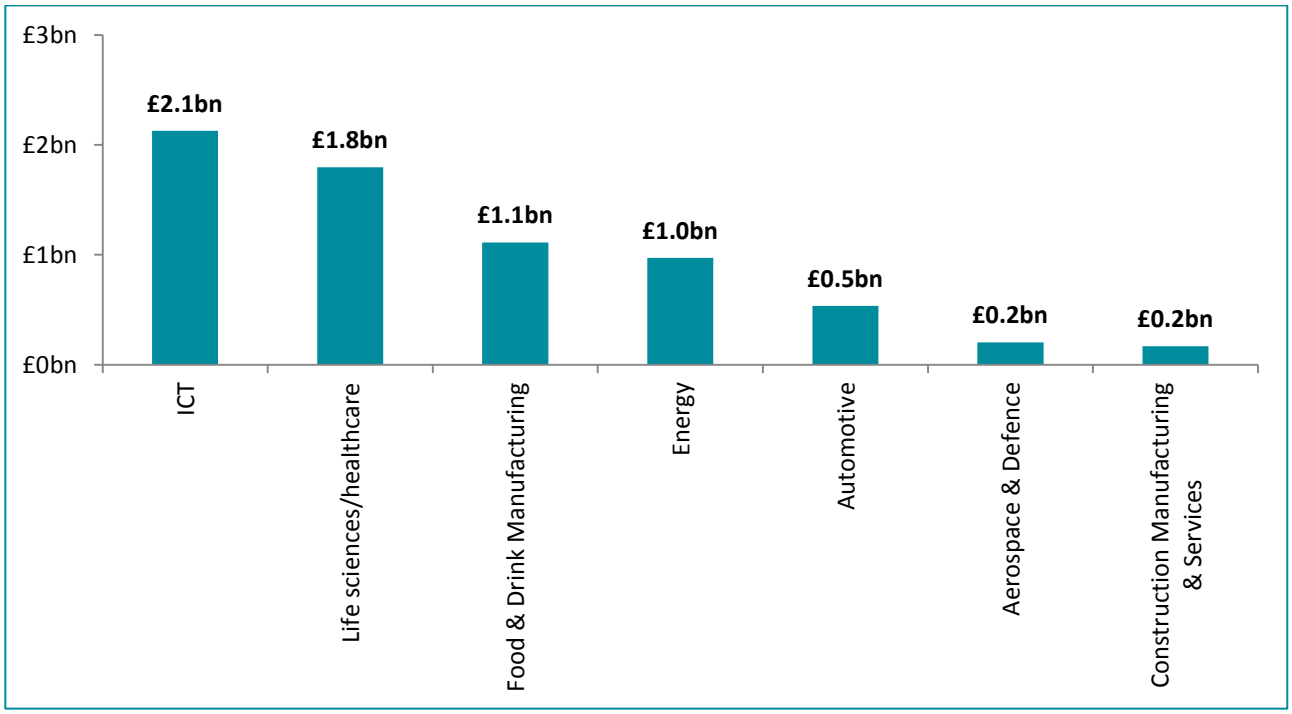
[30] ONS Supply-Use Tables 2012 (latest available) and ONS GDP Low Level Aggregates 2014 Q4 were used to calculate the total revenue, export revenue and GVA of industries. These sources were used because detailed data relating to exports by sector was not available through the Annual Business Survey. In some cases, definitions of these sectors differ from those listed in Table 28 in the Appendix. However every effort was made to rationalise the three data sources.

GVA

When turnover is stimulated, either through the domestic or export market, greater economic output or value added is generated by the firms as a result of using standards. GVA per worker is itself a recognised measure of productivity, where a higher GVA per capita reflects greater productivity. Likewise, the GVA to turnover ratio partly reflects how efficiently intermediate inputs (which are included in turnover because their cost must also be recovered through the price of the product) can be transformed into final goods and services that deliver a high value added contribution. Key findings relating to GVA are as follows:

- Across all industries investigated, standardization contributed to an aggregate increase in GVA of £6.9 billion per year, equivalent to 3% of the total GVA of all industries investigated in 2014.
- Overall, the ICT industry observed the largest increases in GVA as a result of standardization, equivalent to £2.1 billion per year (see Figure 19).
- Firms within the life sciences and healthcare industry and the food and drink manufacturing sector also observed large rises in GVA as a result of standardization: equivalent to £1.8 billion and £1.1 billion respectively per year.

Figure 19: Estimated increase to GVA of industries as a result of standards (£ billions)



Source: ONS GDP Low Level Aggregates 2014 Q4, Cebr analysis

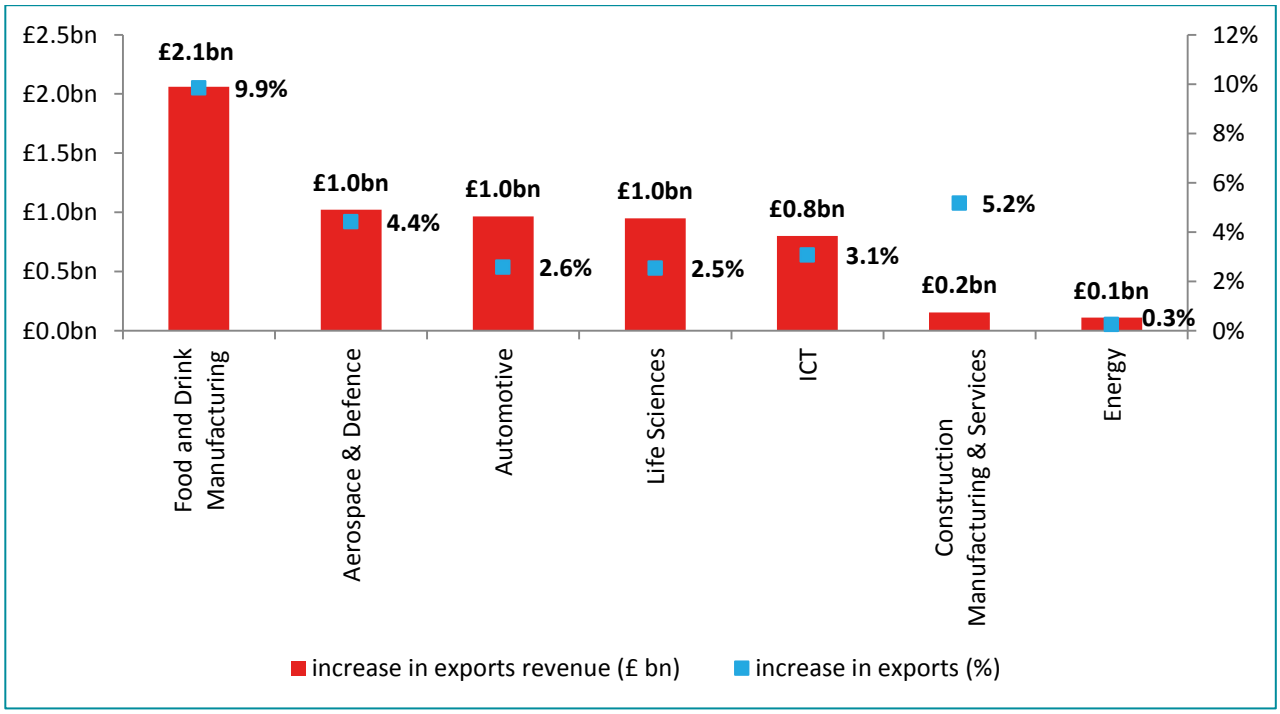
Exports

Of the companies surveyed, 48% indicated that they were active exporters, although this differed substantially between sectors ranging from 70% (aerospace and defence) to 38% (energy). Perhaps unsurprisingly, the sectors that observed the biggest increase in exports attributed to standards were

also those where a higher proportion of companies were exporting. Key findings relating to exports are as follows:

- The food and drink manufacturing industry observed the most significant impact on exports, with firms within the sector reporting a 9.9% increase in exports that can be attributed to using standards[31] (Figure 20). This translated into a £2.1 billion boost to export revenue on average per year in the food and drink industry on.
- Exporters within the aerospace and defence industry and the life sciences and healthcare industry also observed substantial export gains from standards, with exporting firms in these sectors witnessing a 4.4% and 2.5% rise in exports respectively on average, equivalent to a rise in export revenue of £1.0 billion on average per year in both industries respectively.
- Exporting firms within the construction manufacturing and services industry benefitted significantly from standardization, observing a 5.2% rise in exports, although the financial impact of this was much lower compared to other industries due to the relatively small magnitude of exporting activity in the sector.

Figure 20: Increase in exports revenue that can be attributed to the use of standards (left axis: £ billions, right axis: percentage increase)



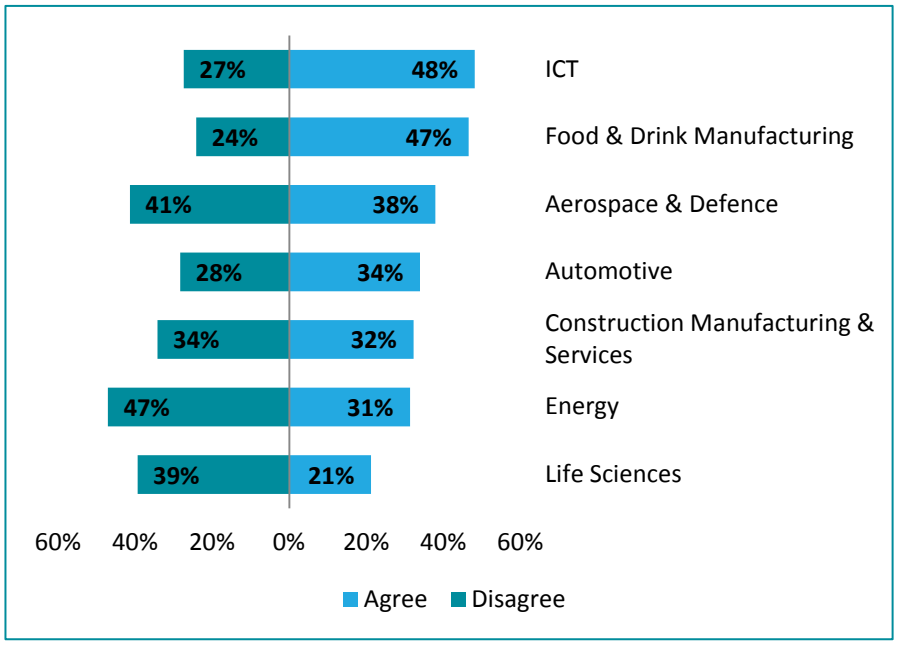
Source: ONS Supply-Use Tables 2012, ONS GDP Low Level Aggregates 2014 Q4, BSI Standards in Industry Survey, Cebr analysis

[31] Exports revenue is just one component of total revenue. As a result, the boost to exports revenue from standards is likely to also be captured by the increase to total revenue explored above. However Figure 18 and Figure 20 reveal different findings. Firstly, there are other components of total revenue, besides exports revenue, that are impacted by standardization. Secondly, there should be a distinction between the effects of standardization on exporting and non-exporting companies.

5.3 How do standards contribute to business productivity and efficiency?

The gains that arise from standards described in the previous subsection are the result of higher productivity and more efficient operations as well as reductions in waste, improved risk management and better use of raw materials, amongst other factors. With competitive markets squeezing the profit margins of many businesses, firms are finding it increasingly important to identify ways to improve productivity and efficiency in their business operations and processes.

Figure 21: Do standards increase productivity? (% of respondents by industry)



Source: BSI Standards in Industry Survey, Cebr analysis

Results from the BSI Standards in Industry survey confirm that on balance standards act as a stimulant of productivity, with more than one-third (36%) of all firms surveyed stating that they had experienced an increase in productivity as a result of standardization.

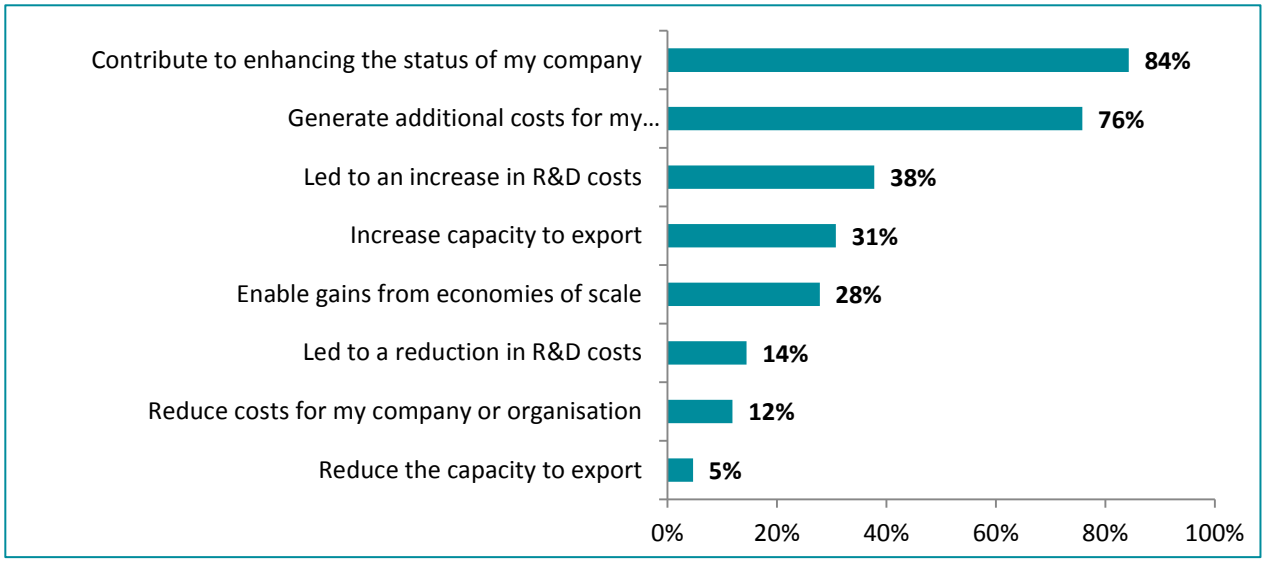
The survey results revealed that higher productivity as a result of standards varied between smaller and larger companies. In particular, 44% of large firms reported an overall increase in productivity as a result of standards, in comparison to 35% for SME firms.

The survey also sought to identify the mechanisms behind the impact of standards on productivity and efficiency. When asked if standards facilitated the optimisation of raw materials and energy usage, 47% of large firms surveyed agreed compared to just over one-third (35%) of SMEs.

5.4 How standards enhance UK business competitiveness and competition

The survey revealed some of the most important mechanisms through which standards improve the competitiveness of businesses (see Figure 22). The most important mechanism is the contribution that standardization has for enhancing the status of firms, which was cited by 84% of respondents. Standards can contribute to businesses' competitive edge by demonstrating to the market that their products and services are of a high quality. This mechanism was even more significant to large firms with 92% reporting this was a factor, relative to 83% of SMEs.

Figure 22: How has standardization affected the competitiveness of your firm? (% of respondents)



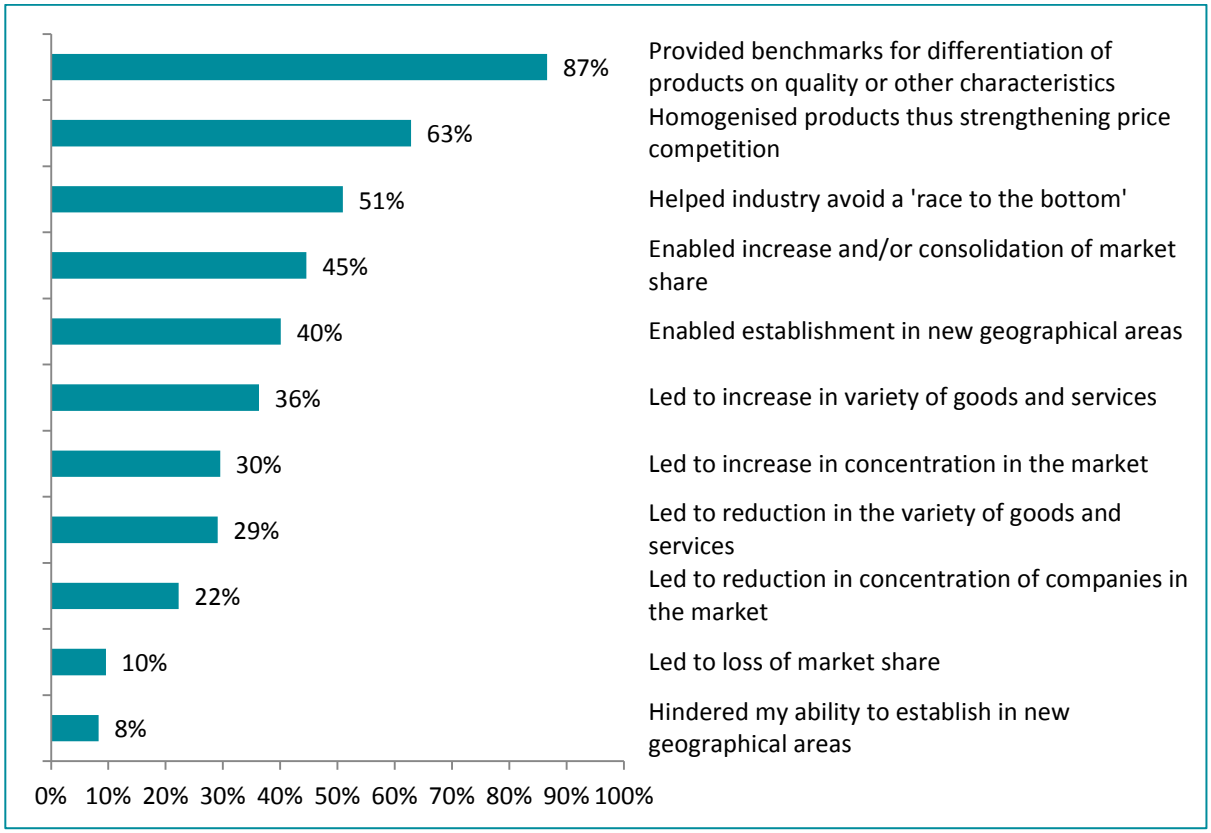
Source: BSI Standards in Industry Survey, Cebr analysis (responses do not sum to 100% as firms were able to select multiple statements)

However, in addition to benefitting from the enhanced status that standards can provide, standards also generate cost during implementation. An average of 76% of firms reported higher additional costs from standards, while 38% of firms reported higher research and development (R&D) costs. This finding needs to be balanced with the understanding that some standards may be necessary and the alternative to using the standard could be more costly, for example, when a standard is used to help meet regulatory requirements.

Overall these findings suggest that standards do contribute to the productivity and efficiency of firms, but that not all businesses are affected equally which is, of course, a reflection of the diversity of business operations in terms of their size and sector. Some smaller firms will inevitably find that the implementation of a standard consumes a higher proportion of available resources relative to larger firms. For such firms, the decision of whether to implement must appraise it as an investment – will implementation of the standard result in the business achieving a healthy rate of return on the investment required, as well as recovering the investment itself?

The survey results also highlight an important impact of standardization on market structure and the nature of competition: the strengthening basis for non-price competition. While 63% of firms cite that standards have homogenised products to the extent that price competition has increased, an overwhelming 87% of firms also believe that standards can act as benchmarks that enable the differentiation of products according to attributes such as product quality, delivery and customer service (see Figure 23). Of those surveyed, 51% of firms believed that standards had helped avoid a 'race to the bottom', whereby firms degrade quality in order to aggressively cut costs to compete on price. Such intense price competition is not always sensible or in the interests of consumers.

Figure 23: Quality competition: how has standardization affected competition within your market? (% of respondents)



Source: BSI Standards in Industry Survey, Cebr analysis (responses do not sum to 100% as firms were able to select multiple statements)

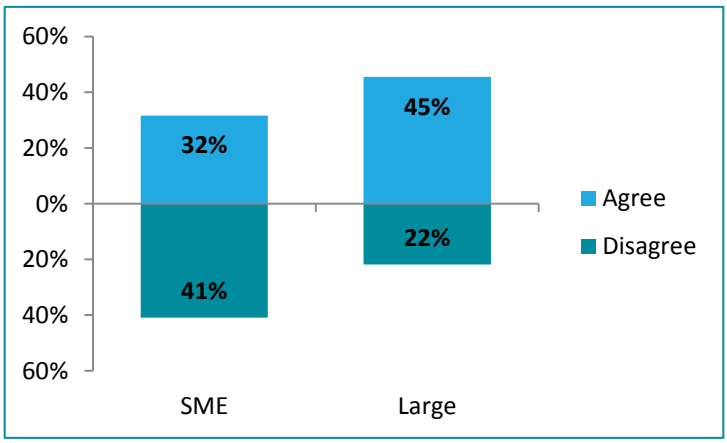
5.5 How do standards help companies enter new markets?

Standards can galvanise trade by lowering barriers to entry and providing a foundation for competition based on product and service characteristics, such as quality. A consequence of this is the strengthening of competition in markets which fosters further opportunities including in international export markets.

The results of the BSI Standards in Industry survey reveal that on average 33% of all firms surveyed had experienced easier access into new markets at home as a result of standardization (see Figure 24).

In addition, the survey highlights that a higher proportion of large firms compared to SMEs found that entry into new domestic

Figure 24: Standardization has made entry in new domestic markets easier (% of respondents by firm size)



Source: BSI Standards in Industry Survey, Cebr analysis

markets was made easier as a result of standardization: 45% of firms employing more than 250 people confirmed that new markets at home were made more accessible through the use of standards compared to 32% of SMEs (see Figure 24).

The survey also emphasised the role of standardization in facilitating firms' access into new foreign markets: 41% of firms in the food and drink manufacturing industry and 38% of businesses in the automotive sector reported easier entry into new markets abroad as a result of standards. These findings are mainly a reflection of the propensity of firms in different industries to export.

The survey identified an overall positive impact of standards in terms of reducing barriers to entry and the subsequent effect on competition. On average, 72% of firms disagreed with the idea that standardization had contributed to higher barriers to trade and a resultant fall in competition.

Businesses in the ICT sector were most likely to disagree with the notion, with 55% of firms surveyed reporting that they have not witnessed an increase in barriers to entry or consequent fall in competition that would be expected. In addition 45% of firms in the aerospace and defence industry had a similar experience. Overall, the survey emphasises the ability of standards to lower barriers to trade by promoting compatibility, thereby fostering trade opportunities that result from higher demands for complementary products and services.

In addition, the ability of firms to differentiate products by attributes besides price presents a huge opportunity for new business. Instead of entering the market and competing with incumbent firms on price alone, new entrant firms are able to capitalise on variations of characteristics which consequently offer consumers and trade partners more choice.

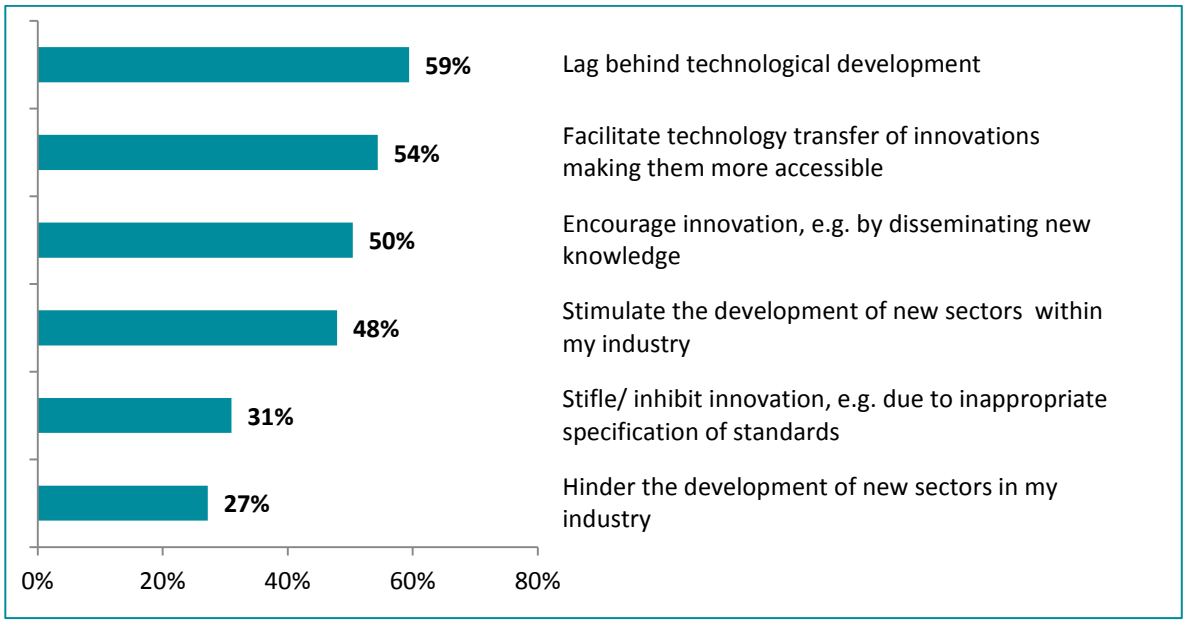
5.6 Do standards catalyse innovation?

The survey results overwhelmingly confirm that standards play a significant role in fostering innovation (see Figure 25). 54% of all firms reported that information was made more accessible through the dissemination of innovation and technology through standards, while half of firms surveyed also stated that innovation was encouraged through the diffusion of new knowledge as a result of the use of standards.

Although the findings reflect the positive impact of standards on innovation, the results also highlight that the raison d'être of standards is not the development of brand new technologies. 59% of the firms surveyed cited that the standards lag behind technological development. This sentiment varied across industries, with 75% of firms in the life sciences and healthcare sector reporting the divergence between standards and state-of-the-art technology. By contrast, only 41% of firms in the food and drink manufacturing industry reported sharing the same concern.

Overall, businesses appeared to confirm that that the role of standards in innovation is not in driving the development of new ideas but in galvanising the innovation process.

Figure 25: Standards and the diffusion of information: how do standards impact innovation in your industry?



Source: BSI Standards in Industry Survey, Cebr analysis

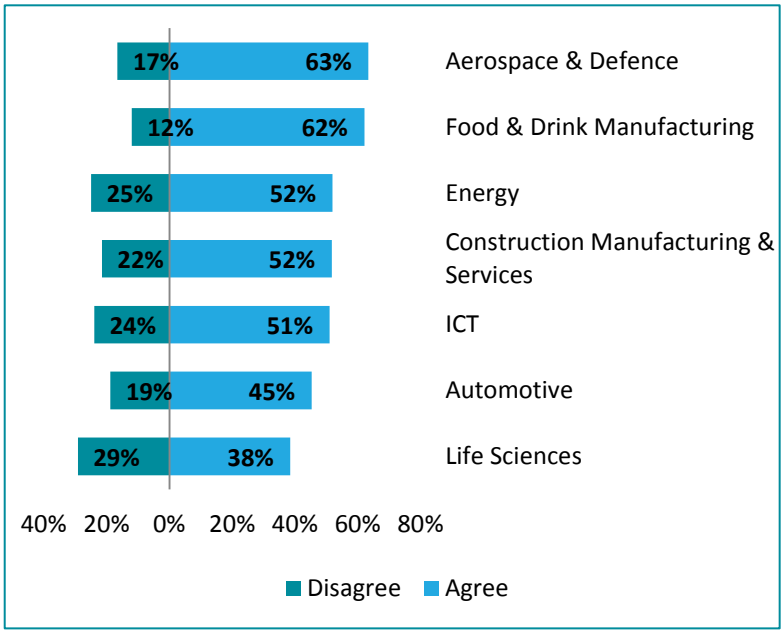
5.7 What is the role of standards in the supply chain?

Standards enhance the supply chain of industries by promoting compatibility between products and processes and boosting confidence between suppliers and clients. On average, over half (51%) of all firms surveyed confirmed that standardization had improved their client-supplier relationship through improved confidence.

This benefit was most widely experienced in the aerospace and defence sector with 63% of all firms reporting an enhanced client-supplier relationship (see Figure 26)

Over half of all firms within the construction manufacturing and services industry and in the ICT sector reported improved client-supplier relationships as a result of standardization.

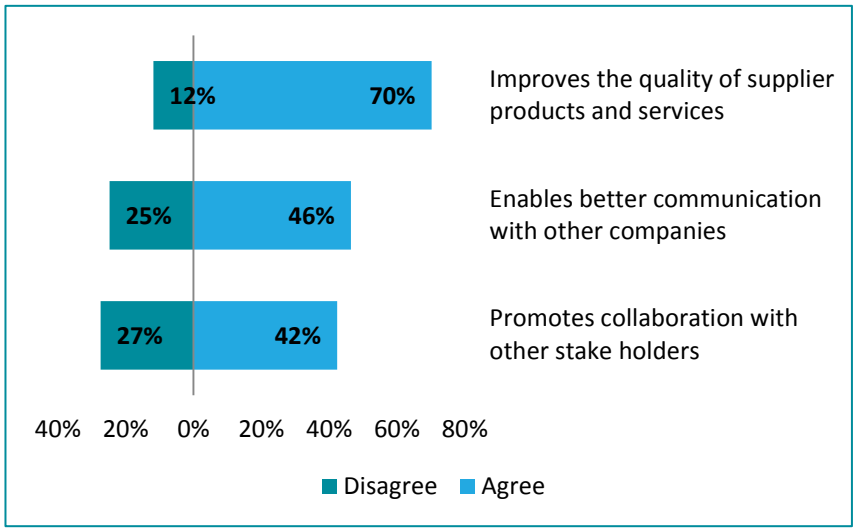
Figure 26: Better connections: standardization has improved my client-supplier relationship



Source: BSI Standards in Industry Survey, Cebr analysis

Industries that are highly reliant on technical standards are likely to benefit most from savings that result from the improved quality of supplier products and services. The survey findings confirm this, with 77% of firms within the aerospace and defence industry and 76% of businesses from the construction manufacturing and services sector confirming that standardization improved the quality of supplier products and services.

Figure 27: How do standards affect your supply chain?

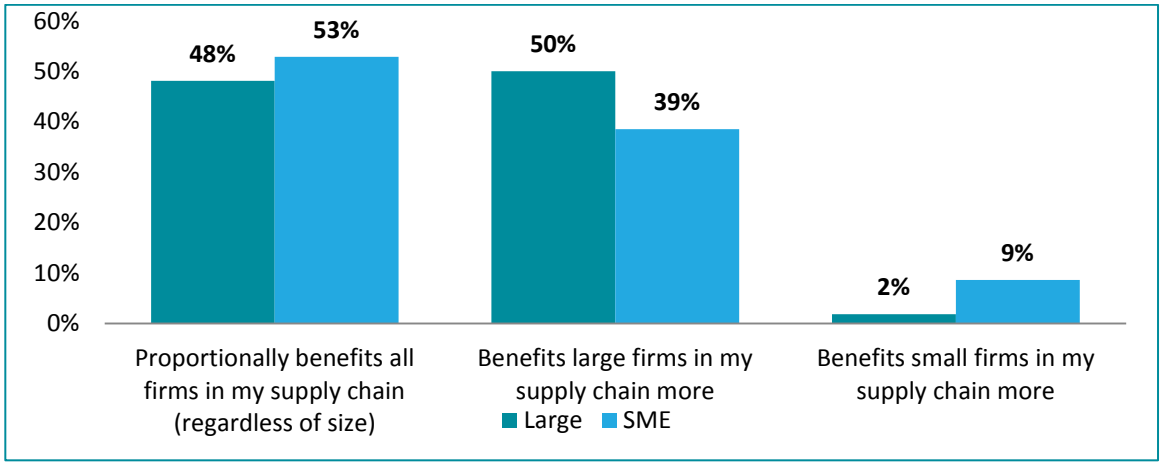


Source: BSI Standards in Industry Survey, Cebr analysis

In addition the survey revealed that 46% of firms find standardization has enabled better communication with other businesses by signalling quality and conveying information about products to consumers and trade partners. Improved communication enables the efficient functioning of markets as it ensures that business needs and demands are matched to supply. Consequently, firms' save time and search costs. The benefits of enhanced relationships between firms are most likely to be witnessed in industries where product compatibility is vital. The survey results confirm this, with a higher proportion of firms in the ICT sector (57%) finding that standards have enabled improved communication between firms.

Overall, the survey results emphasise that the sense of trust fostered by standards lead to business benefits across all firms, including in the supply chain and regardless of size. The majority of firms (52%) surveyed stated that standardization had benefitted all firms within their supply chain proportionately. 53% of SMEs employing less than 250 people reported that standardization benefited firms in their supply chain equally. This sentiment was common across all industries bar one, with the majority of firms stating that the supply chain benefits of standardization were experienced proportionately by firms regardless of size. By contrast, businesses in the energy sector were more likely to see standardization benefitting large firms proportionately more than SMEs.

Figure 28: How does standardization benefit the firms in your market supply chain?

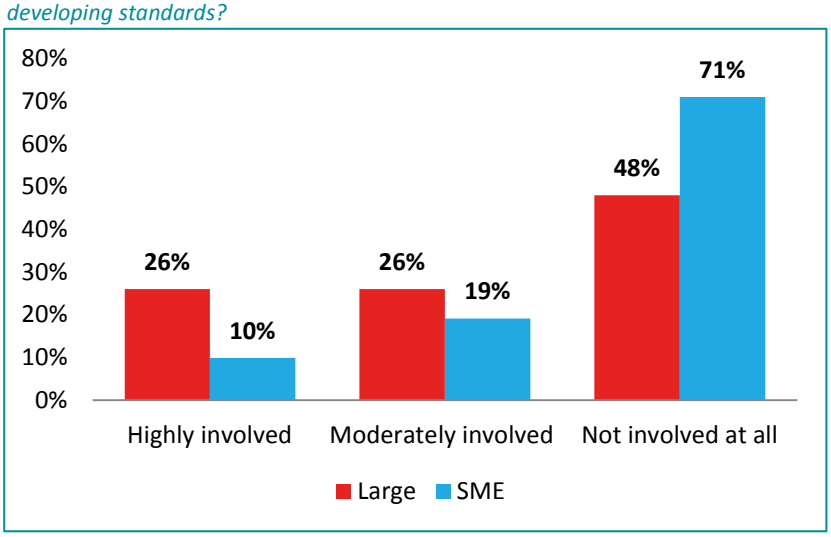


Source: BSI Standards in Industry Survey, Cebr analysis

5.8 Why do companies get involved in the standards development process?

The BSI Standards in Industry survey highlighted the existing capacity of businesses to become more involved in the standards development process. Over two-thirds (68%) of businesses surveyed were not involved, including 70% of SMEs in contrast to 48% of large firms (see Figure 29). At the other end of the spectrum, over one quarter (26%) of large firms stated that they were highly involved in the standards development process in comparison to 1 in 10 SMEs.

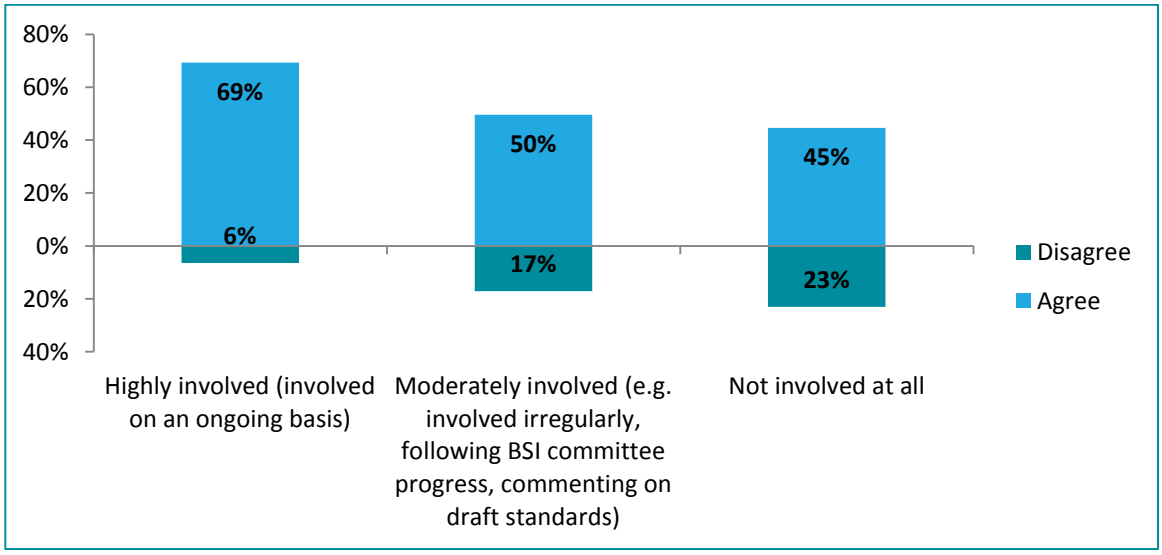
Figure 29: Scope for more involvement: to what extent is your firm involved in developing standards?



Source: BSI Standards in Industry Survey, Cebr analysis

The survey evidence clearly shows that participating in developing standards makes it more likely that a company experiences benefits from using standards. In Figure 30, it can be seen that those highly involved in the standards development process are the most likely to agree that they had experienced a net benefit from standards.

Figure 30: Involvement in the standards development process and experience of net benefit



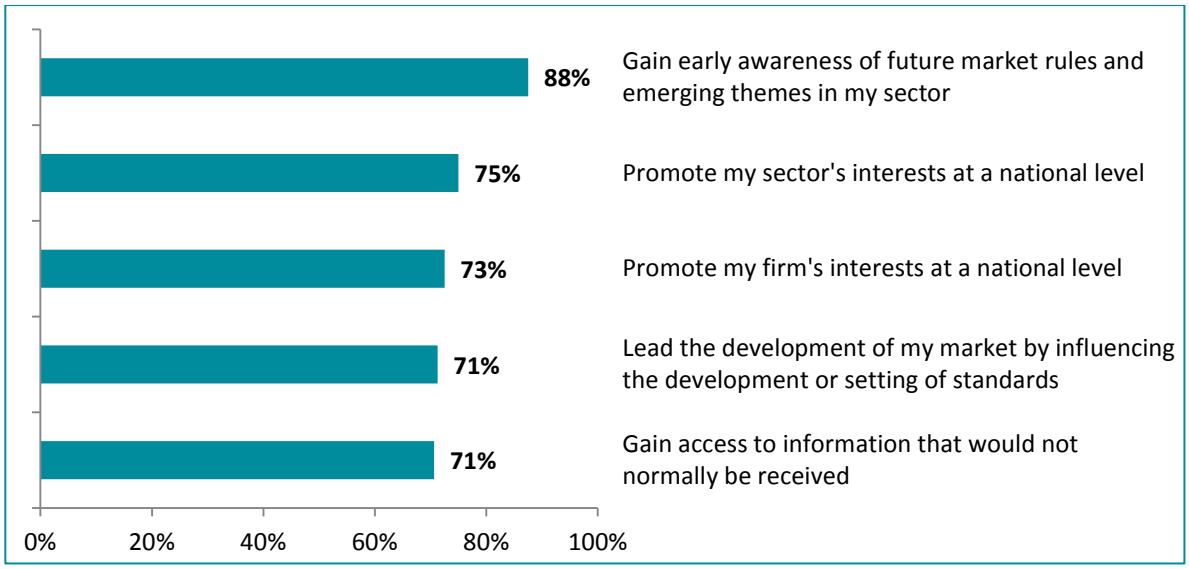
Source: BSI Standards in Industry Survey, Cebr analysis

But what types of benefits are the firms who are not involved in the standards development process missing out on? The survey asked firms that were at least moderately involved in developing standards about the benefits of participating in the process. Overwhelmingly, 88% of firms that were involved in the standards development process stated that participation facilitated the anticipation of future market rules and emerging themes in their industry.

Three- quarters of all firms who are involved in the standards development process were able to promote their industry's interests at a national level while 71% of firms benefitted from gaining access to information that would not normally have been received. Similarly, 71% of all firms participating in the standards development process benefitted from the ability to lead the progression of their market through channels ranging from the setting of standards to promoting new technological solutions.

Overall the survey emphasises the competitive edge gained by firms who are involved in the standards development process. Participating companies are able to capitalise on the latest information first and be at the forefront of their industry.

Figure 31: Top 5 benefits from participating in the development of standards. Participation in standards development lets my company:



Source: BSI Standards in Industry Survey, Cebr analysis (responses do not sum to 100% as firms involved in the standards development process were able to select multiple statements)

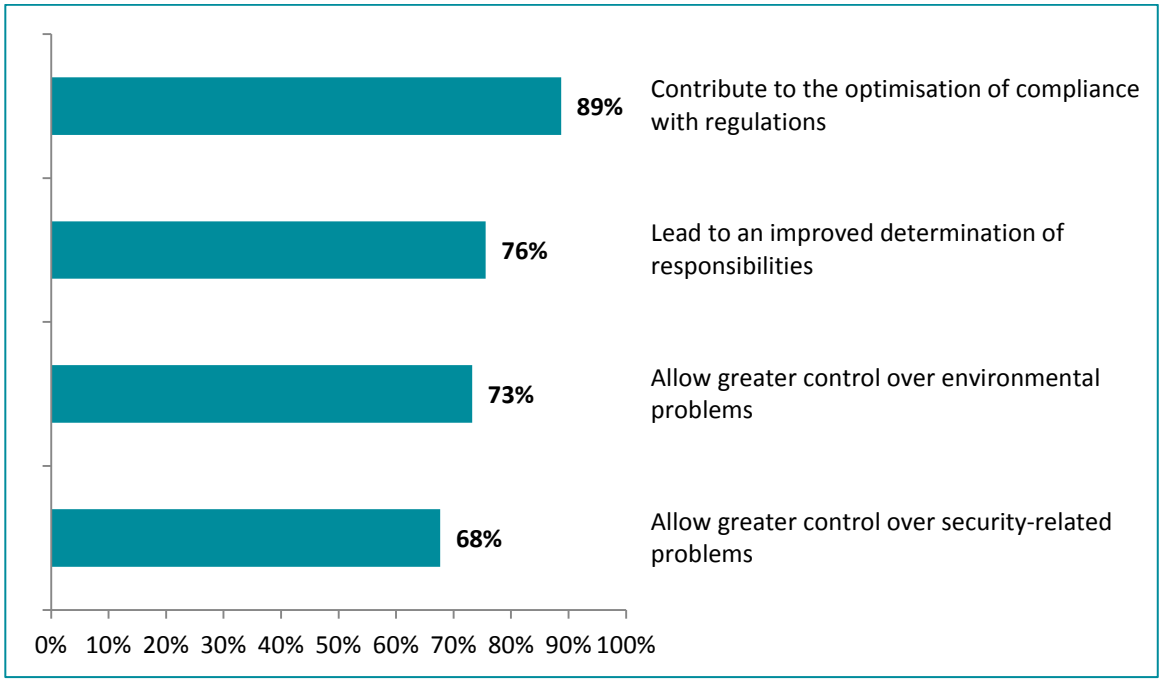
5.9 Non-monetary benefits of standards

The channels through which standardization benefits businesses and are not restricted to purely monetary gains. Companies value highly the safety of their employees and seek to reduce the impact their business has on the environment. Standards can help to mitigate risks in the workplace and to proactively reduce environmental impacts. While they impose costs on companies to implement, non-monetary benefits like employee satisfaction, company reputation and meeting regulatory requirements can be valuable in the long term when, for example, trying to maintain or grow market share and the competitive edge required to do so through reputation and through lower staff turnover.

The most important of these non-monetary benefits, as reported by 89% of survey respondents, is the optimisation of compliance with regulations. Standards such as OHSAS 18001 health and safety management – which helps companies identify hazards and put in place processes and controls to manage them – are widely used. Companies are obliged by health and safety regulations to have such procedures in place, and standards help to demonstrate compliance. Companies report that standards can lead to improved definitions of roles and responsibilities when it comes to risk management (76% of total).

Environmental management is another important area where companies use standards to reduce the risk of environmental breaches or failure to comply with environmental regulation while enhancing the reputation of companies. The survey shows that 73% of companies found that standards allow greater control over environmental problems (see Figure 32).

Figure 32: Top 4 channels through which standards contribute to risk management?



Source: BSI Standards in Industry Survey, Cebr analysis

The Government often regulates companies to minimise external costs to the public (also known as negative externalities) such as air pollution that results from the production of goods and services. Meeting these regulations often imposes costs on companies; however it is still in the company's financial best interest to act, as failure to meet obligations under environmental regulations could result in financial penalties. Standards such as ISO 14001 Environmental Management can help companies to introduce practices that let them meet their obligations, while also producing monetary benefits for companies, such as reducing energy costs and minimizing waste.

The next section proceeds to delve deeper into the impacts of standards at the company level by exploring each of the seven sectors covered in the survey in more detail.

6 Sector analysis

6.1 Introduction

The previous section sets out the evidence from the BSI Standards in Industry survey 2015 on how standards generate costs and benefits at the individual company level, the role of standards in the supply chain and the benefits of participation in the standards development process.

To supplement these findings and to develop a deeper understanding of how standards benefit individual companies, a series of interviews were carried out with individuals from the seven sectors examined in the survey. The interviewees were selected due to their knowledge of how standards are used in their companies and sectors. The list of contributors is as follows:

- Mick Furlong, Manufacturing Engineering manager, GMM Luton Ltd (subsidiary of General Motors)
- Andy Vaughan, Standards Consultant, Association of British Healthcare Industries
- Andrew Norrish, Regulatory Affairs Manager, Becton Dickinson
- Ken Morgan, Quality Manager, Honeywell Aerospace
- Alan Lyons, Assistant Compliance Manager, Dunlop Aircraft Tyres Ltd
- Steve Durrant, Engineering Manager, Sembmarine SLP
- Nigel Elliot, Fuels Technical Advisor, Exxon Mobil Research and Engineering
- Product Development Technologist, major UK soft drink manufacturer
- Kenneth Chinyama, Food Safety Executive, Food & Drink Federation
- Tony Blanch, Business Improvement Director, Costain
- Colin Cook, Chief Scientist, H+H UK Ltd
- James Cemmell, Head of Government Affairs, Inmarsat
- Lara Joisce, Risk and Compliance Manager, Sage (UK) Ltd

Interviewees were asked a series of questions on how standards affect their businesses and sectors, covering the following topics:

- The standards used by the company/sector and how they are used
- Strategic importance of standards to their company/sector
- The costs and benefits of standards to their company/sector
- Role of standards in the supply chain
- Contribution of standards to supporting competitiveness in the sector, exports and competition.

The information gathered through the interviews with contributors was used in conjunction with evidence from the survey and publicly available data to develop a profile on the role of standards in each sector. Estimates of the turnover, GVA and export impact for each sector (as described in Section 5.1) are presented along with additional analysis of the survey results.

6.2 Automotive

Overview of the sector

The automotive sector is one of the UK's most important manufacturing industries, accounting for 10% of the UK's trade in goods, employing 149,000 people and generating £63.8 billion in turnover in 2013[32]. The sector spent £1.7 billion on R&D in 2012 - 10% of the UK total – and increasing 46% in real terms between 2002 and 2012. In recent years, the UK industry has benefited from significant investments by many of the world's major vehicle manufacturers including Vauxhall, Jaguar Land Rover, BMW Group, Ford, Nissan and Toyota. A total of 1.5 million vehicles were built in 2013 and the industry is forecasted to exceed its previous 1972 production peak in 2017.

Automotive	
Annual turnover (2013)	£63.8 billion
Annual Gross Value Added (2013)	£14 billion
Annual R&D spend (2012)	£1.7 billion
Number of UK businesses	2,700
Employment	149,000
Number of industry-relevant standards	2,600

Source: ONS Annual Business Survey 2013, ONS Research and Development in UK Businesses 2012, BSI British Standards Online (BSOL) database

The UK industry has a globalised supply chain characterised by a small number of Original Equipment Manufacturers (OEMs), a large number of tier 1 and 2 component suppliers located not just in the UK but around the world, engineering service providers for production line manufacture and maintenance; and a localised marketing, sales, distribution and after-care system. With such an expansive manufacturing eco-system and the necessity of minimising faults in the finished product, it is essential that components and the processes through which they are made are standardized and that quality is enforced throughout the supply chain.

How are standards used in the automotive industry?

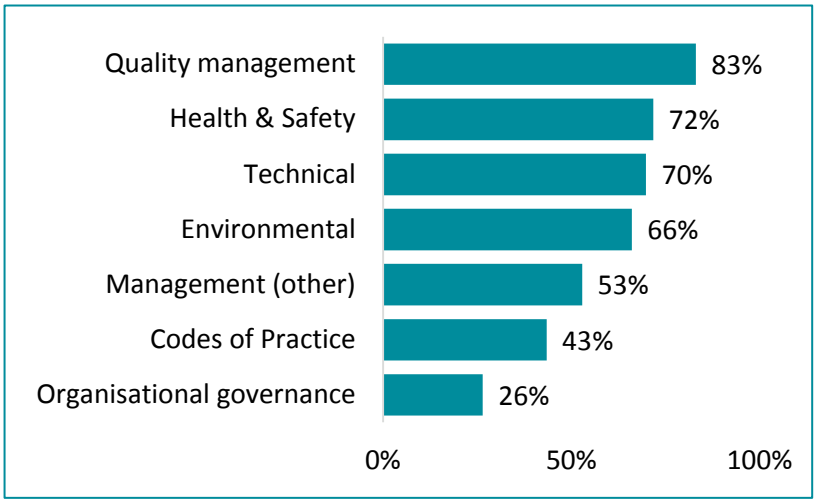
Quality & component testing - Essential to the success of vehicle manufacturers and their suppliers is the ability to achieve consistently high level of quality while minimising the costs of inputs. Quality management standards (QMS) such as ISO 9001 and its application to the automotive industry (ISO/TS 16949) are utilised throughout the industry (83% of companies surveyed).

Many OEMs have developed internal quality management systems – such as General Motors Global Manufacturing System (GMS) - derived from the principles of ISO 9001 which are aimed at continual improvements in the reduction of defects, more efficient manufacturing processes and minimising inventory. To ensure consistent quality, OEMs almost unanimously require suppliers to be certified to ISO 9001 and other standards. OEMs frequently audit their suppliers for production quality. Defects are followed up directly with the supplier to prevent re-occurrence.

[32] For purposes of consistency with the business count and employment totals reported for each sector and the detailed sector definitions listed in appendix 4, turnover and GVA values reported here and elsewhere in this section are derived from the Annual Business Survey 2013. These values may differ from those used to calculate the monetary impacts of standards detailed in section 5.2, which used data from ONS GDP Low Level Aggregates 2014 Q4 and ONS supply-use tables 2012.

Health & safety – Another important focus of standard use in the sector is reducing the risk of health and safety incidents occurring. Of the companies surveyed, 72% reported to use some form of health and safety standard. General occupational safety standards such as OHSAS 18001 are widely used, while specialised standards are used to provide specific safety solutions on production lines, such as ISO 13855 safety of machinery – positioning of safeguards. Companies interviewed reported that the increased cost associated with implementing these solutions and the requisite standards can be considerable, but also yields considerable benefits including a better overall safety outcome and a reduction in the risk profile of a production process and are therefore worth the investment.

Figure 33: Proportion of companies using standards, by type



Source: BSI Standards in Industry Survey, Cebr analysis

Technical standards – The technical standards used in the sector are primarily developed through ISO. Supplier parts are either designed by the OEM or recommended as a part by the supplier and given a product number, allowing the product to be sold across the OEM distribution network. This allows efficient communication of technical information between supplier, OEM and after-sales providers.

"The GM Global Manufacturing System is fundamental to everything we do"
Mick Furlong – GMM Luton Manufacturing Engineering manager

Table 5: Typical standards used in the automotive sector

Sector	Standards
Automotive	• ISO 9001 Quality management • ISO 16949 Application of ISO 9001 to the automotive industry • OHSAS 18001 Occupational health and safety management • ISO 14001 Environmental management • Technical and testing standards, mainly ISO • Design standards

Benefits in the supply chain

A key benefit of standards in the automotive sector is the contribution to improving the relationship between suppliers and OEMs – through improved communication on product specification, improved

quality outcomes and better recognition and allocation of individual and mutual responsibilities. Of the companies surveyed, 45% reported that standards improved the client-supplier relationships, while 19% disagreed.

The automotive sector is one of the highest exporting sectors in the UK, with around 80% of vehicles manufactured in the UK being sold abroad. The UK exported £32.2 billion of road vehicles (including vans) in 2014[33]. Some of the benefits that standards deliver for exporting businesses include helping to meet regulatory approval in new markets and easier communication with global customers through standardized specifications. The survey asked companies that export to report the impact of standards on the value of goods they sell abroad. Companies stated on average that they observed a 2.6% increase in exports that can be directly attributed to the use of standards – equivalent to £970 million in additional exports per year.

Table 6: Estimated financial benefits of standards for the automotive sector

Metric	Value	Rank[34] (out of 7 sectors)
Reported % impact on turnover	3.8%	2
Annual impact on turnover (£m)	£4,900m	4
Estimated direct GVA impact (£m)	£540m	5
Reported % impact on exports	2.6%	5
Annual impact on exports (£m)	£970m	4

Source: BSI Standards in Industry survey, Cebr analysis

A summary of the benefits that standards provide for the automotive manufacturing supply chain revealed through interviews with industry experts is provided in Table 7.

Table 7: Summary of benefits from standards in the automotive manufacturing supply chain

Benefits
More efficient processes - More efficient utilisation of inventory and more efficient layout of units means less interruptions in production and less in-process inventory - allowing more vehicles to be produced per day i.e. higher plant productivity.
Higher quality of supplier's products – Suppliers are required to certify to QMS standards and are subject to auditing. This ultimately leads to lower defects in the completed vehicle, reducing recall costs and inventory disposals.

[33] Office for National Statistics, 2015, UK Trade - January 2015, ONS.

[34] Sectors were ranked out of 7 relative to the other sectors under analysis, in terms of the financial benefits of standards. Rank 1 implies the sector experienced the highest benefit of standards, relative to other sectors, while rank 7 suggests the sector experienced lowest benefit of standards.

Benefits
Reduction of defects and waste – QMS equips companies to proactively seek out the cause of defects and waste, and act to ensure they do not occur again. This results in lower vehicle recalls, ultimately minimizing costs.
Standardized components – Allows purchasing time and time-to-market savings from standardized specifications and design tolerances of components.
More efficient product development – Standardized parts and design processes allow design teams to work more efficiently and to collaborate more easily with manufacturing and engineering teams.
Better environmental compliance – Adhering to environmental best practice and producing sustainably helps the company image in the market.
Increased customer satisfaction – Higher quality vehicles, fewer recalls, better design quality and shorter delivery time all help to improve customer satisfaction.
Faster customer service through standardized components – The automotive car dealer and after-sales network relies on easy access to a catalogue of replacement parts to service vehicles. Standardized parts and an efficient distribution network help to deliver a faster customer service
Assists in achieving regulatory approval, particularly in entry to new markets – Standards help manufacturers to meet their regulatory obligations, for example CE marking legislation in the EU.

Case study
GMM Luton Ltd.

GMM Luton Ltd produces light commercial vehicles sold under the Opel and Vauxhall marques. The company is a subsidiary of Adam Opel AG which itself is a wholly owned subsidiary of General Motors. Vehicles have been produced by General Motors at the Luton site since 1907 and the plant currently produces 62,000 vehicles per year.

- Quality management is the lifeblood of the GMM Luton production process. General Motors has a long established internal quality management system – the GM Global Manufacturing System (GMS) – that is consistent with principles of ISO 9001 and other standards. The GMS governs all aspects of GM and all plants within the General Motors global company are required to fully implement the system. Each plant is frequently audited to ensure that processes are compliant.
- The aim of the process of applying GMS to production is to ensure that every asset and every employee is operating to the maximum of their capacity for the time they are employed. Proactively reducing defects produces quantifiable savings for the company in the form of fewer returned vehicles and lower warranty claims.
- GMS is focused on lean production and reduction of waste. The process facilitates manufacturing managers to make investments to improve quality or reduce defects, and distinguish between different solutions at different stages of the production line lifecycle.
- More efficient utilisation of inventory and efficient layout of units lead to improved productivity which contribute to defining the overall efficiency rating of the plant relative to competing facilities within the wider Adam Opel AG group.
- Another important focus of the GMS is reducing the risk of workplace accidents occurring. One recent example is the installation of new vehicle lifts where there are additional safeguards (motion beams) to prevent the operation of the lift when a person is in the operational area. The company used standards such as BS EN 1493 vehicle lifts, ISO 13855 Safety of machinery -- Positioning of safeguards and ISO 13849 Safety of machinery Safety-related parts of control systems, to develop an optimal solution that delivers a reduced risk profile for processes where this is implemented.

6.3 Life sciences

Overview of the sector

The life sciences sector is comprised of three sub-sectors: pharmaceuticals, medical technologies (med-tech) and biotechnology. The supply chain consists of ingredient and component suppliers, manufacturers, and distribution activities which are often vertically integrated with manufacturers. The sector has annual turnover estimated at over £21 billion and employs 96,000 people directly.

Life Sciences	
Annual turnover (2013)	£21 billion
Annual Gross Value Added (2013)	£8.5 billion
Annual R&D spend (2012)	£4.2 billion[35]
Number of UK businesses	2,400
Employment	96,000
Number of industry-relevant standards	1,700

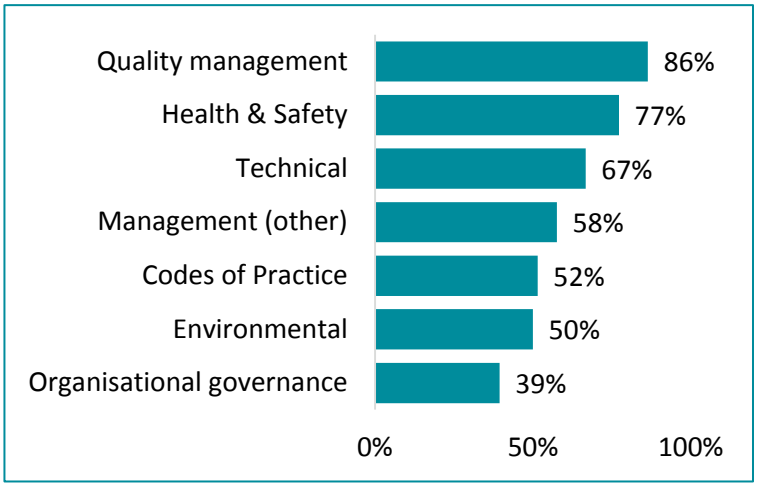
Source: ONS Annual Business Survey 2013, ONS Research and Development in UK Businesses 2012, BSI British Standards Online (BSOL) database

There exists a substantial variation in the types of businesses that make up these sub-sectors - the med-tech sub-sector is dominated by SMEs representing 85% of companies while output in the pharmaceutical and biotech sub-sectors are dominated by a smaller number of large companies.

How are standards used in the life sciences industry?

Regulatory compliance - The life science sector is a highly regulated industry – most products cannot be sold without some kind of regulatory approval. Across all sub-sectors, securing regulatory approval in multiple jurisdictions is crucial for the attaining market access for new products. Quality management systems and testing standards (used by 86% of life science companies surveyed) help demonstrate compliance with regulations and directives. Regulations do not normally preclude the possibility of companies meeting the standards independently, however it is normally considered that it is far easier to adopt the procedures and practices set out in the standard.

Figure 34: Proportion of companies using standards, by type



Source: BSI Standards in Industry survey, Cebr analysis

Quality testing - Standards are frequently used in the laboratory setting for the standardized testing of production batches and the calibration of testing equipment. The methodology used allows for easy demonstration of compliance to regulations.

[35] Excludes R&D spend in the medical technologies sector. Statistics in the ONS R&D in UK businesses 2012 publication do not provide a sufficient breakdown of R&D investment by sector to allow this to be defined.

Management of production/ operations – Given the necessity for human safety, life sciences companies need to maintain exceptionally high quality outputs to be able to continue to be permitted to sell their products. Of the companies surveyed, 85% of SMEs and 100% of large companies use QMS standards. Quality standards such as ISO 9001 and ISO 13485 (the application of ISO 9001 in the medical devices sub-sector) incorporate lean manufacturing while allowing proactive detection of defects and risk minimisation across the production process. Manufacturers normally require suppliers to certify to these standards and audit their suppliers regularly with the frequency determined by the criticality of the product, component or ingredient in the final product.

Research & development - In common across all sub-sectors is the necessity to develop new innovative products. Life sciences is an R&D intensive sector, spending more on new product development as a proportion of revenue than any other industry (£4.2 billion, 25% of UK total in 2012). This focus is driven not only by clinical innovations but on the patent expiration cycle which drives the business model of many pharmaceutical and biotechnology companies. Standards assist in the process of selection and testing of prototypes (medtech) and candidate drugs (pharmaceuticals and biotechnology) and can help reduce the need for clinical testing of products in some instances.

Packaging and labelling – Packaging and labelling standards are often referred to in regulation - in the EU medical devices directive for example. These standards specify the types of information that must be displayed on product labelling, and also describe the kind of sterilization that packaging and products must be subjected to before they can be approved for sale.

Table 8: Typical standards used in the life sciences sector

Sub-sector	Standards
Pharmaceuticals & biotechnology	• ISO 9001 Quality management • Packaging and labelling standards such as ISO 15378 Primary packaging materials for medicinal products • Testing standards, mainly from ISO
Medical technologies	• ISO 13485 Quality management systems – medical devices • ISO 14971 Application of risk management to medical devices • Packaging & labelling standards, for example ISO 15223 symbols to be used with medical device labels; and ISO 11607 Packaging for terminally sterilized medical devices • Sterilization standards, for example ISO 11137 Sterilization of health care products - Radiation • Clinical investigation standards such as ISO 14155 Clinical investigation of medical devices for human subjects

Benefits in the supply chain

The extensive and complex regulatory requirements in the life sciences industry make it essential for companies to apply a standardized approach to quality, production, labelling and testing. Standards simplify the process for regulators to ensure products are compliant – for example medical devices company Becton Dickinson, which manufactures blood collection products and systems at their Plymouth facility, reports that their sites are frequently subject to unannounced inspections and that their quality management systems allow for a more straight forward audit system.

Unsurprisingly therefore, 98% of life science companies surveyed reported that standards contribute to the optimisation of compliance with regulations, higher than any of the other sectors profiled in this report. Using standards also inevitably leads to higher costs of production – 50% of life science companies reported that this is the case. However, this needs to be balanced against the knowledge that it would be more costly for companies, particularly SMEs, to try and demonstrate compliance to regulations using their own procedures.

As with other manufacturing sectors that involve high volume production operations, the use of standards, particularly those related to quality management, help companies to improve efficiency at their manufacturing sites. This is reflected in the financial benefits that companies report from standards. Life sciences ranks third amongst the sectors surveyed in terms of reported increase in turnover that can be directly attributed to standards. This amounts to an estimated 3.3% of annual turnover or £5.2 billion per year in additional turnover for the sector.

Table 9: Estimated financial benefits of standards for the life sciences sector

Metric	Value	Rank
Reported % impact on turnover	3.3%	3
Annual impact on turnover (£m)	£5,200m	3
Estimated direct GVA impact (£m)	£1,800m	2
Reported % impact on exports	2.5%	6
Annual impact on exports (£m)	£950m	3

Source: BSI Standards in Industry survey, Cebr analysis

The UK life sciences sector has a globalised supply chain and exports a high proportion of products to markets around the world. In 2014, the UK exported £20.9 billion in pharmaceutical products alone. This is reflected in the survey, which shows that 56% of companies surveyed are actively exporting. These companies reported an average 2.5% increase in exports from standards, equivalent to £950 million per year.

A summary of the benefits that standards provide for the life sciences supply chain revealed through interviews with industry experts is provided in Table 10.

Table 10: Summary of benefits from standards in the life sciences manufacturing supply chain

Benefits
More efficient production processes – QMS standards help companies to proactively reduce waste in the production process, achieve shorter lead times, reduce defects and minimise in-process inventory.
Quality of input products and components – Suppliers are required to submit to certify to QMS standards and are subject to auditing. This leads to lower defects and batch recalls, helping to improve overall plant productivity.
Environmental management – The use of standards can help reduce the cost of disposing of waste

Benefits
materials, while lowering the cost of meeting environmental regulatory requirements.
Lower cost of meeting regulations – Without standardized processes which allow companies to demonstrate efficiently their compliance with regulations and directives, the cost of meeting regulations would be much higher, particularly for smaller companies.
More efficient product development – Standardized testing procedures allow R&D teams to work more efficiently and to collaborate more easily with suppliers.
Reputational value – Companies use standards such as ISO 14001 environmental management to demonstrate their commitment at a corporate level to environmental responsibility.
Entering new markets – Standards offers a signal of quality when entering new markets, and helps with meeting regulatory requirements in countries where firms have not operated previously.

6.4 Aerospace & defence

Overview of the sector

The aerospace and defence sector is comprised of civilian and military aircraft manufacturing, military equipment manufacturing, naval shipbuilding as well as civilian aviation services[36]. Not included in this narrow definition, but part of the wider sector are the specialist component and engineering companies that serve the industry. The sector in the UK employs 126,000 people and had an annual turnover of £32 billion in 2013, making it one of the largest in Europe. The requirement for R&D and innovation in the aerospace and defence sector is high – with the sector ranking in the top five for UK R&D spend in 2012.

Aerospace & defence	
Annual turnover (2013)	£32 billion
Annual Gross Value Added (2013)	£11.6 billion
Annual R&D spend (2012)	£1.7 billion
Number of UK businesses	1,200
Employment	126,000
Number of industry-relevant standards	3,900

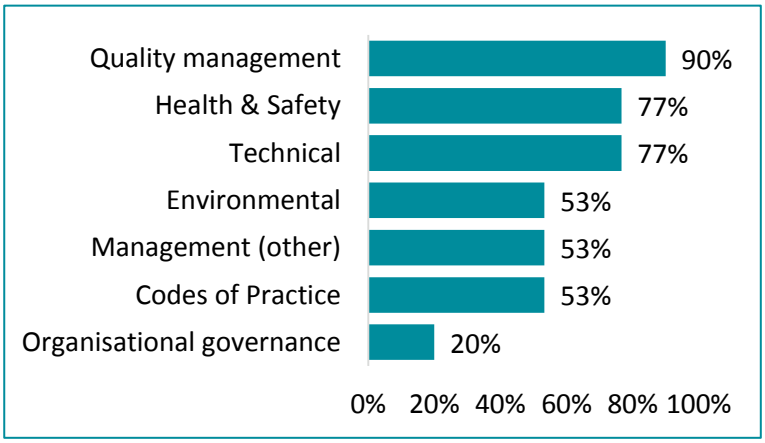
Source: ONS Annual Business Survey 2013, ONS Research and Development in UK Businesses 2012, BSI British Standards Online (BSOL) database

The sector is characterised by a concentration of manufacturing in a small number of original equipment manufacturers (OEMs), and the production and maintenance of technologically complex engineering machinery which require a large network of interconnected suppliers, long lead times and programme lifecycles. With hundreds of thousands of components coming together from hundreds of multinational suppliers to build each aircraft, vessel, vehicle or piece of equipment, managing quality and risk across the supply chain is essential. Managing relationships throughout the supply network requires operational transparency and visibility and efficient validation of quality. Standards are the backbone of the industry, informing nearly all parts that go into the production of aircraft and military vehicles, and the procedures used for maintenance and to ensure safety.

How are standards used in the aerospace & defence industry?

Technical - Component specifications are exacting in the aerospace and defence industry. Design of components generally originates from OEMs, who normally refer to ISO standards in their part specification and also develop and use their own standards. For the largest civilian

Figure 35: Proportion of companies using standards, by type



Source: BSI Standards in Industry survey, Cebr analysis

[36] Respondents from the aerospace and defence industry make up a lower than average proportion of the total sample under analysis. As a result, the findings relating to this sector are prone to large sampling error and are thus likely to be unreliable. However the findings are presented for informational purposes.

aviation OEMs, their catalogue of standards runs into the tens of thousands.

Regulatory compliance - Ensuring consistent quality in the production and maintenance of airplanes is of vital importance. A quality management system (AS 9100, ISO 9001) is used throughout the industry for maintaining an auditing and quality control system, one of its functions being to facilitate easier compliance with air safety regulations. Aerospace firms frequently need to certify with multiple air safety agencies. For OEMs, design and airworthiness approval must be obtained in the jurisdiction. The design must also be certified in other markets where the aircraft is to be exported. To provide maintenance services on aircraft based in a specific market, companies must be certified with the air safety agency of that jurisdiction[37].

Quality control – Aviation components require exacting precision and high quality. The outsourcing of manufacturing to the supply chain means that OEMs rely on their multi-tier suppliers to deliver high quality products on time and on budget. This represents a risk to the OEM, which is mitigated by frequent auditing of supplier quality processes. OEMs normally require suppliers to comply with AS 9100 (quality management system for the aerospace industry)[38]. A frequent number of OEMs are also requiring suppliers to accredit to NADCAP, an industry-managed approach to conformity assessment of special processes and products for the aerospace industry.

Military interoperability – Separate portfolios of standards have been developed by many of the world's largest militaries to make it easier for armed forces to share and jointly procure equipment. The most common military standard portfolios used by UK aerospace and defence companies come from the UK, US and NATO. Military standards provide benefits such as minimising the number of types of ammunition, ensuring compatibility of tools, and ensuring quality during production of military equipment.

Table 11: Most important standards used in the aerospace & defence sector

Sub-sector	Standards
Aerospace	• AS 9100 Quality Management System Requirements for Design and/or Manufacture of Aerospace Products • Thousands of technical standards, for example BS EN 3475 Aerospace series. Cables, electrical, aircraft use. Test methods. • OHSAS 18001 Occupational Health and Safety Management
Defence	• AS9100 Quality Management System Requirements for Design and/or Manufacture of Aerospace Products • ISO 9001 Quality Management System • Military standards from the UK Defence Standards portfolio (DStan), NATO Standardization Office and other militaries

[37] EASA (the European Air Safety Agency) which has jurisdiction over the UK has bilateral agreements in place with Brazil, Canada and the USA where there is reciprocal acceptance of air safety approvals. This has made it easier for UK firms

[38] ADS (the trade body of the UK aerospace and defence industry) have initiated the SC21 programme in collaboration with the UK industry - a key industry venture that aims for all ADS members to gain certification to AS/EN9100 (or applicable standard) by 2021.

Benefits in the supply chain

Of the sectors surveyed, the aerospace and defence sector has the highest proportion of companies that are actively exporting (87% of total). This translates into a reported impact on exports attributed to standards representing 4.4% of total, equivalent to an additional £970 million per year in sales abroad (see Table 12). The drivers for these relatively large impacts on exports are likely to be linked to the assistance that standards give to helping UK aerospace and defence companies to access the largely globalised supply chain.

Table 12: Estimated financial benefits of standards for the aerospace & defence sector

Metric	Value	Rank
Reported % impact on turnover	1.7%	7
Annual impact on turnover (£m)	£760m	7
Estimated direct GVA impact (£m)	£200m	7
Reported % impact on exports	4.4%	3
Annual impact on exports (£m)	£970m	2

Source: BSI Standards in Industry survey, Cebr analysis

Collaboration and cooperation between clients and suppliers can provide substantial benefits in the form of improved risk sharing and more efficient and transparent exchange of information. This is seen in the survey; where 63% of companies agreed (and 17% disagreed) that standardization improved the client-supplier relationship.

In terms of turnover, the reported impact of standards in the aerospace and defence sector is low, ranking seventh among the seven sectors profiled in this report. The benefits reported by survey respondents amounted to 1.7% of turnover equivalent to £810 million per year. Despite this, 53% of companies indicated that they considered that standards produced a net benefit for their business, second highest amongst the sectors profiled. This finding combined with the relatively low reported impact on turnover from standards suggests that a substantial amount of benefits are non-monetary.

For example, predominantly non-monetary benefits are derived from improving interoperability in the sector. A total of 37% of companies agreed (compared to 33% that disagreed) that standards boosted compatibility between products and systems, the second highest proportion among the sectors surveyed after ICT.

A summary of the benefits that standards provide for the aerospace and defence supply chain revealed through interviews with industry experts is provided in Table 13.

Table 13: Summary of benefits from standards in the aerospace and defence supply chain

Benefits
Higher quality of supplier's products – Suppliers are generally required to certify to QMS standards and are subject to auditing by OEMs. The allows a high level of quality throughout the supply chain
Lower cost of meeting regulations – Without standardized processes which allow companies to demonstrate efficiently their compliance with regulations and directives, the cost of meeting regulations would be much higher, particularly for smaller companies.
Standardized components – Allows purchasing time and time-to-market savings from standardized specifications and design tolerances of components
Environmental management – The use of standards can help reduce the cost of disposing of waste materials, while lowering the cost of meeting environmental regulatory requirements.
Accessing the global supply chain – Standards are normally a prerequisite for supplying components and services in the aerospace and defence sector. By certifying to standards required by OEMs, companies can gain access to new markets.

6.5 Energy

Overview of the sector

Energy	
Annual turnover (2013)	£159.5 billion
Annual Gross Value Added (2013)	£48.9 billion
Annual R&D spend (2012)	£0.4 billion
Number of UK businesses	3,700
Employment	191,000

Source: ONS Annual Business Survey 2013, ONS Research and Development in UK Businesses 2012, BSI British Standards Online (BSOL) database

The UK has one of Europe's largest energy sectors, with annual turnover reaching £159.5 billion in 2013. The upstream industry, composed of the oil and gas exploration sector and support services, contributed £48.9 billion of GVA in 2013. Not included in this narrow definition, but part of the wider sector are the specialist manufacturing and professional services companies that serve the industry. Although oil and gas production in the UK continues to decline, the industry is expected to remain an important player in the global energy industry for years to come. The necessity to develop innovative engineering solutions to access deep water North Sea fields has served the industry well, with strong expertise retained in the industry, allowing companies to successfully compete for business internationally. The offshore strengths of the UK industry have also allowed businesses to diversify into the growing renewables sector.

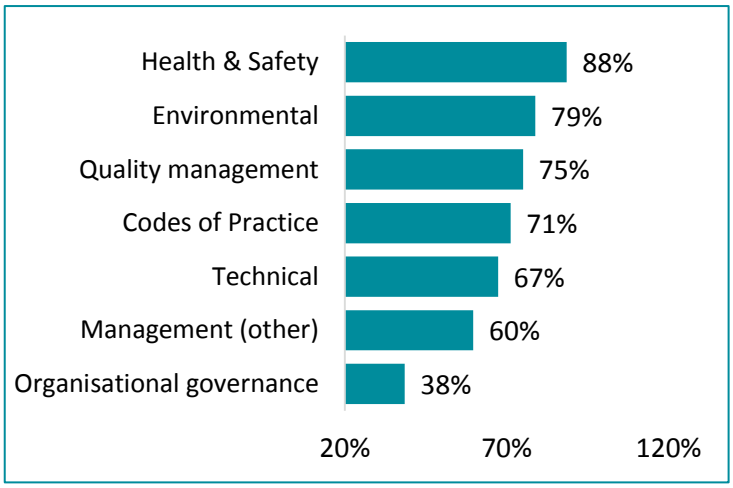
The middle and downstream portion of the supply chain, which includes gas storage, refining, electricity generation, and energy distribution contributed £25.7 billion to the UK economy in 2013 and employed 155,000 staff. The power generation sector will require substantial investment over the next twenty years to replace power plants that are reaching the end of their productive life. The electricity distribution system will also require significant upgrades to manage future patterns of generation and demand.

How are standards used in the energy industry?

Health and safety – The nature of activities in the energy sector, which involves dealing with hazardous materials and working in dangerous environments, means that the health and safety of employees is a top priority. The OHSAS 18001 health and safety management standard is widely used in the supply chain, as are industry developed codes of practice, for example the Energy Institute's codes of practice for offshore safety.

Quality management – Quality management standards are widely used in the energy sector, and particularly for companies supplying the industry.

Figure 36: Proportion of companies using standards, by type



Source: BSI Standards in Industry survey, Cebr analysis

Demonstrating QMS compliance is commonly a pre-qualifying requirement to tender for manufacturing or services contracts. Many of the largest oil and gas companies have developed their own internal quality management systems. For example, Exxon Mobil has developed the ExxonMobil Global Product Quality Management System which provides internal standards on all aspects of production, from fuel testing to logistics to accident prevention.

Technical specifications –The oil and gas sector was one of the first industries to become globalised, pre-dating the establishment of international standard bodies. This generated a need for standardized methods and procedures, which led to the establishment of several organizations that publish standards specifically for the industry. The set of standards used by companies such as Sembmarine SLP, which manufactures oil and gas platforms and offshore wind farm substations, are driven nearly entirely by client requirements which are in turn determined by where the platform will be located – projects in the Gulf of Mexico use mostly U.S. standards, those on the UK continental shelf predominantly use standards from Norway and the EU.

"All fuels manufactured at our refinery are carefully produced to meet the required standards and specifications"
Nigel Elliot – ExxonMobil Fuels Technical Advisor

Oil and gas refining/ processing requires an extensive array of technical standards for fuel testing and parameters for fuel classifications. In oil refineries and gas processing plants, technical standards are used extensively to define the specifications and tolerance for individual components such as pressure vessels and piping.

The interoperability requirements in the electricity generation and distribution sector mean that technical standards are essential for access to the national grid. In the renewables sector, several standards have been developed to standardize specifications and terminology for a range of technologies.

Table 14: Typical standards used in the energy sector

Sub-sector	Standards
Oil & gas	• Quality management standards including ISO 9001 and ISO 29001 quality management systems for the petroleum, petrochemical and natural gas industry supply chain • ISO 14001 Environmental management • Health and safety standards, including industry developed codes of practice for safety in the workplace • Technical standards from multiple standards bodies, including standards developed specifically for the industry from organisations such as EEMUA, DNV, American Petroleum Institute and the Energy Institute (UK). • Design standards
Distribution & storage	• ISO 9001 Quality management • ISO 14001 Environmental management • OHSAS 18001 Occupational health and safety management • Technical standards for energy distribution. For example, BS EN

Sub-sector	Standards
	50160 Voltage characteristics of electricity supplied by public distribution systems
Refining	• Quality management standards including ISO 9001 for suppliers and smaller refineries and internally developed quality standards for multinationals • Health and safety standards, including industry developed codes of practice for safety in the workplace • A large array of testing standards, for example ISO 2719 Determination of flash point • Fuel specification standards such as ISO 8217 Specifications of marine fuels

Figure 37: Case study- ExxonMobil Research & Engineering

Case study **ExxonMobil - Fuels**
ExxonMobil operates the UK's largest refinery at Fawley near Southampton, which produces a full range of petroleum products including petrol, diesel, non-road gasoil, jet fuel, marine fuel and lubricant base stocks. The company *operates nearly 700 kilometres of pipeline in the UK with a network that connects to distribution terminals and airports around the country. Retail operations serve around 800,000 customers every day through a network of over 1000 Esso branded service stations.*
• Standards are essential to nearly every aspect of ExxonMobil's refinery operations. They are used in fuel testing, making sure that fuels meet standard specifications and grades, for the pressure vessels and components in the refinery itself, and for the safe and reliable functioning of the plant. • All the fuels that ExxonMobil produces are subject to a hierarchy of regulations and customer requirements, starting at the EU and national level which sets environmental regulations and performance, moving to the ISO and CEN standards where standard specifications and testing are met, and then to specific customer and internal requirements where appropriate. • As one of the largest companies in the world, ExxonMobil has developed its own Global Product Quality Management System (GPQMS). This system governs all aspects of ExxonMobil's fuel production process through to its final delivery to the customer. Many of the requirements in the GPQMS reference or are consistent with the principles of well-known industry standards.

Benefits in the supply chain

In contrast to most of the sectors profiled in this report, the use of health and safety standards and environmental standards are more common-place in the energy sector than quality management and

technical standards. This is reflected in the survey, where the findings indicate a stronger emphasis on the benefits to companies from easier compliance with health, safety and environmental regulations, and less on performance and efficiency benefits. For example, energy is one of the few sectors where more companies disagreed than agreed with the notion that standards increased productivity. Despite this, 48% of companies reported they agreed that standards produced a net benefit (relative to 15% that disagreed). These findings imply that the while standards are producing benefits for companies, these are often non-monetary, in the form of better safety performance, improved environmental management processes and easier compliance with regulations.

As reported in Table 15, the reported percentage impact of standards on turnover and exports is low in the energy industry, ranking sixth and seventh respectively. Yet due to the scale of the industry, these relatively small impacts translate into much larger monetary impacts, amounting to £5.7 billion in annual turnover and £970 million in gross value added.

The proportion of companies exporting in the energy sector (38% of total) is the lowest amongst the sectors surveyed, which is reflected in the reported impact of standards on exports (0.3%, £110 million per year), the lowest amongst the seven sectors (see Table 15).

Table 15: Estimated financial benefits of standards for the energy sector

Metric	Value	Rank
Reported % impact on turnover	2.2%	6
Annual impact on turnover (£m)	£5,700m	2
Estimated direct GVA impact (£m)	£970m	4
Reported % impact on exports	0.3%	7
Annual impact on exports (£m)	£110m	7

Source: BSI Standards in Industry survey, Cebr analysis

A summary of the benefits that standards provide for the energy supply chain revealed through interviews with industry experts is provided in Table 16.

Table 16: Summary of benefits from standards in the energy supply chain

Benefits
More efficient production processes – Quality standards help companies to improve the efficiency of production processes
Environmental management – The use of standards can help reduce the cost of disposing of waste materials, while lowering the cost of meeting environmental regulatory requirements.
Technical components – Standardized specifications of components used in upstream, midstream and downstream operations helps companies to meet the requirements of customers and regulators, and to meet internationally established specifications that ensure the safe operation of facilities.
Technical specifications – Standardized technical specifications are common-place throughout the industry. The benefit companies by allowing for efficient communication of the technical parameters of a product, providing confidence for the customer, simplifying the production process and reducing

Benefits
the number of varieties that need to be produced.
Testing – Standardized procedures for product testing allow companies to demonstrate that the fuel is fit for purpose and will meet performance requirements.
Health and safety – Standardization helps to improve determination of responsibilities, aid regulatory compliance, and proactively identify health and safety risks, thus reducing the potential of an accident occurring.

6.6 Food & drink manufacturing

Overview of the sector

The food and drink manufacturing sector is the UK's largest manufacturing industry, generating £95.3 billion of turnover in 2013 and employing 412,000 staff. The sector covers a significant section of the food chain, from ingredient manufacturers such as meat processors to manufacturers of final products such as soft drinks. The manufacturing focus of the sector means there is a higher concentration of large companies, with the average business employing about 250+ employees.

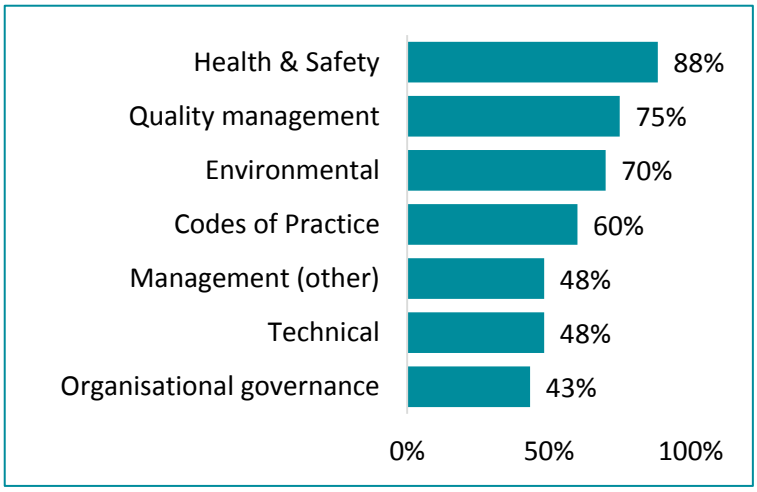
Food & drink manufacturing	
Annual turnover (2013)	£95.3 billion
Annual Gross Value Added (2013)	£25.7 billion
Annual R&D spend (2012)	£0.36 billion
Number of UK businesses	8,200
Employment	412,000
Number of industry-relevant standards	1,400

Source: ONS Annual Business Survey 2013, ONS Research and Development in UK Businesses 2012, BSI British Standards Online (BSOL) database

How are standards used in the food & drink manufacturing industry?

Food safety - Central to the food and drink manufacturing business is the necessity to demonstrate that food is safe, traceable and of good quality. By law, all food businesses must put in place, implement and maintain a food safety management system based on Hazard Analysis Critical Control Points (HACCP) principles to ensure that food products are safe to eat. Food safety management standards such as ISO 22000 food safety management system are designed around the principles of HACCP and ISO 9001 to ensure food safety, meet the specifications of food chain customers downstream, and provide consumers with a high level of confidence in the products they purchase. Quality marks such as Red Tractor have been developed to demonstrate that food has met responsible production standards and is fully traceable back to independently inspected farms in the UK.

Figure 38: Proportion of companies using standards, by type



Source: BSI Standards in Industry survey, Cebr analysis

Quality management – QMS standards are important in the industry, driving changes in plant performance, reducing waste and encouraging continual improvement which ultimately drives down cost. Companies in the sector are commonly certified ISO 9001 and to BRC (British Retail Consortium) Global Standards, a safety and quality certification programme spceifically designed for the food industry. The programme is an industry-wide benchmark for quality and food safety, ensuring

standardization of operational, safety and quality criteria and ensuring that manufacturers fulfil their legal obligations and provide protection for the end consumer. Companies are normally obliged to certify to BRC Global Standards in order to qualify as a registered suplier of leading retailers.

Regulatory compliance – The UK food and drink manufacturing sector is governed by national, EU and international regulations. These regulations cover areas such as food labelling, ingredients, food safety, traceability and rules on food recall. Companies must demonstrate compliance to these regulations. Food safety management standards make it easier for companies to comply with the necessary regulatory requirements.

Ingredient and product testing – Product testing standards are used to ensure that trace amounts of certain ingredients are not in batches, that acceptable limits of other ingredients are not exceeded and to ensure that the composition of the product is consistent with labelling. Ingredient testing standards are used to ensure that ingredients from suppliers are of sufficient quality for use in the final product.

Table 17: Typical standards used in the food & drink manufacturing sector

Sector	Standards
Food & drink manufacturing	• ISO 9001 Quality management • ISO 14001 Environmental Management • BRC Global Standards (safety and quality certification programme) • ISO 22000 Food Safety Management System or similar, based on HACCP principles • BS OHSAS 18001 Occupational health and safety management systems • Product testing standards - for example, BS 4401 Methods of test for meat and meat products • Ingredient testing standards - for example, ISO 2450 Determination of fat content in cream

Benefits in the supply chain

Similar to other manufacturing sectors that involve high volume production operations, the use of standards, particularly those relating to quality management, help companies to improve efficiency at their manufacturing sites. These benefits to production are revealed in the survey results, where the food and drink manufacturing sector has the highest reported financial benefits of any of the sectors profiled in this report. Food & drink manufacturing ranks first amongst the sectors surveyed in terms of reported increase in turnover that can be directly attributed to standards (see Table 18). This amounts to an estimated 5.3% boost to turnover for the sector representing approximately £10.2 billion per year. Direct GVA impacts are estimated at £1.1 billion per year.

The sector also has the highest reported benefits in terms of exports – 62% of exporting food & drink manufacturing companies reported an increase in exports as a result of using standards. Companies surveyed reported on average a 9.9% increase in exports that can be directly attributed to standards.

Table 18: Estimated financial benefits of standards for the food & drink manufacturing sector

Metric	Value	Rank
Reported % impact on turnover	5.3%	1
Annual impact on turnover (£m)	£10,200m	1
Estimated direct GVA impact (£m)	£1,100m	3
Reported % impact on exports	9.9%	1
Annual impact on exports (£m)	£2,100m	1

Source: BSI Standards in Industry survey, Cebr analysis

The survey findings reveal that a large part of these monetary benefits lie in the relationships between companies within the supply chain - 62% of survey respondents reported that standardization has improved the relationship between client and supplier, while 43% indicated that standards had enhanced the whole supply chain. Standards also contribute to more productive processes within the firm, with close to half (47%) of companies surveyed reporting an increase in productivity in their operations as a result of standards.

An important non-monetary benefit is in the area of risk prevention (food safety, quality), where 84% of companies reported an improvement in the determination of supplier-client responsibilities and 91% reporting that standards are helpful in contributing to optimisation of compliance with regulation.

A summary of the benefits that standards provide for the food and drink manufacturing supply chain revealed through interviews with industry experts is provided in Table 19.

Table 19: Summary of the benefits from standards in the food and drink manufacturing supply chain

Benefits
More efficient production processes – QMS standards help companies to proactively reduce waste in the production process and achieve efficiency improvements
Quality of input products and components –QMS and food safety standards allow for lower costs of validating the quality of inputs. This leads to less product recalls, lower auditing costs and helps to improve overall plant productivity.
Food safety management - Allows companies to demonstrate to their customers that they have a food safety management system in place. Recognition of international food safety management standards by national regulators has helped to reduce barriers to trade across borders, allowing companies to develop new markets. Food safety management systems can help demonstrate compliance for food safety and quality audits.
More efficient product development and testing – Standards allow easy compatibility of ingredients, makes for a simpler innovation process; and reduces confusion on the specification of formulations and ingredients between suppliers and customers.

Benefits
Helping companies to meet food safety regulations and customer requirements – Without standardized processes which allow companies to demonstrate efficiently their compliance with regulations, directives and customer requirements, the cost of meeting regulations and passing audits would be much higher, particularly for smaller companies.
Entering new markets – Standards offers a signal of quality when entering new markets, and helps with meeting regulatory requirements in countries where firms have not operated previously.

6.7 Construction

Overview of the sector

The construction sector is composed of three sub-sectors: construction contracting which relates to the construction of buildings and infrastructure, construction products - the manufacture of construction products such as cement, plastic pipes and glass; and construction services which involves ancillary activities such as engineering and architecture.

The sector has an annual turnover of £258.9 billion and employs 1.9 million staff. Construction activity made up 8.1% of UK gross value added in 2013, making it the fourth largest industry in the economy after retail, manufacturing and professional services.

Construction	
Annual turnover (2013)	£285.9 billion
Annual Gross Value Added (2013)	£119.5 billion
Annual R&D spend (2012)	£0.15 billion
Number of UK businesses	353,600
Employment	1,918,000
Number of industry-relevant standards	5,800

Source: ONS Annual Business Survey 2013, ONS Research and Development in UK Businesses 2012, BSI British Standards Online (BSOL) database

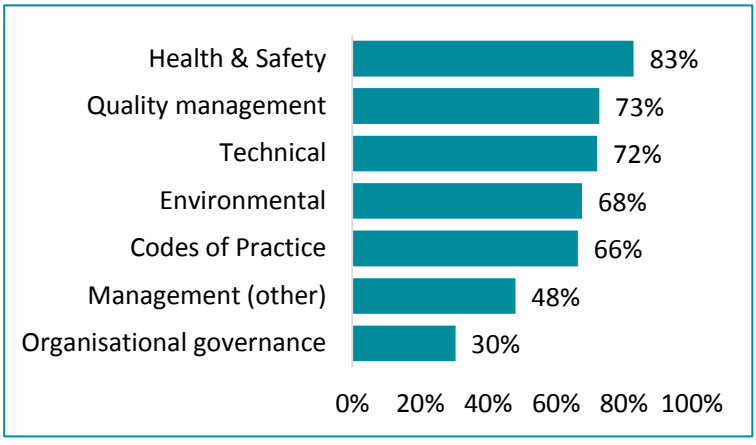
Construction contracting makes up the majority of activity in the sector (71% of turnover and 68% of employment[39]). The contracting sub-sector is composed of a large number of micro (0 – 9 employees) and small (10 – 49 employees) companies. Usage of standards tends to be much lower amongst these companies although their use is increasing, driven by the quality requirements of the major contractors[40].

How are standards used in the construction industry?

Health & safety –The construction sector has some of the highest usage of health & safety standards amongst the sectors surveyed, with adoption levels at 84% for SMEs (up to 249 employees) and 88% for large companies (250+ employees).

Quality management – QMS standards such as ISO 9001 are used throughout the construction industry. Naturally, the highest concentration is amongst construction product manufacturing companies, where enhancing productivity, proactively reducing waste and improving production processes

Figure 39: Proportion of companies using standards, by type



Source: BSI Standards in Industry survey, Cebr analysis

[39] Office for National Statistics, 2014, 'Annual Business Survey 2013', ONS.

[40] Due to the relatively low level of standard usage in the construction contracting sub-sector (with the exception of larger contractors) and for sampling reasons, this sub-sector was excluded from the BSI Standards in Industry 2015 survey.

help boost revenue and reduce cost.

QMS standards also offer companies substantial benefits in terms of cost reductions through improved management systems and improved processes. Usage of QMS standards is much higher among large companies, with 100% of large companies surveyed (250+ employees) using these standards compared to 67% for SMEs (up to 249 employees).

In the contracting sub-sector, QMS standard certification is increasingly becoming a pre-requisite for tendering, with customers requiring companies to demonstrate their commitment to quality management. Large contractors are also working in partnership with sub-contractors to help transfer their knowledge and experience of implementing standards. For example, at project sites operated by Costain (one of the UK's largest contractors), 85% of staff working at project sites are subcontractors. To ensure quality in their supply chain, Costain has established a supply chain academy to train SMEs free of charge in areas such business administration, commercial and financial best practice, insurance, health and safety, and quality.

Regulatory compliance - The construction industry is unique amongst the sectors, in the sense that it is the only sector where standards are mandatory on nearly all construction products sold in the EU. Manufacturers must utilise a harmonised European standard where it is specified directly in legislation and all products must carry a CE marking[41]. This is a major departure from the previous EU construction products directive, where use of standards was voluntary. The sector also has the highest number of sector specific standards in the BSI catalogue, most of which are technical specifications and codes of practice, making it one of the most standard-intensive of all sectors in the economy.

Building information management – Building Information Management (BIM) offers a new approach to designing, creating and maintaining built assets. The system embeds key product and asset data and a 3 dimensional computer model that can be used for effective management of information throughout a project lifecycle. The code of practice for implementing BIM is set out in the PAS 1192 standard. Cost savings from the standard are generated in the design and construction phase, through greater predictability, faster project delivery, reduced safety risk and reduced financial risk. Substantial savings are also achieved in the post-construction maintenance phase, when the BIM model is handed over to the asset manager. Each component is tagged and the manager is informed by the system when maintenance and replacement needs to take place.

[41] The CE marking indicates that a product is consistent with its Declaration of Performance as made by the manufacturer. By making a Declaration of Performance, the manufacturer, importer or distributor is assuming legal responsibility for the conformity of the construction product with its declared performance.

Table 20: Typical standards used in the construction sector

Sector	Standards
Construction contracting	• ISO 9001 Quality management • ISO 14001 Environmental management • BS OHSAS 18001 Occupational health and safety management • Systems • Building Information Modelling standards such as PAS 1192-2 Specification for information management for the capital/delivery phase of construction projects using building information modelling
Construction products	• ISO 9001 Quality management • ISO 14001 Environmental management • BS OHSAS 18001 Occupational health and safety management systems • Thousands of construction products standards such as BS 1090 Execution of steel structures and aluminium structures
Construction services	• ISO 9001 Quality management • Building Information Modelling standards • Civil engineering standards such as BS 5489 Code of practice for the design of road lighting, and BS 752 Drain and sewer systems outside buildings

Benefits in the supply chain

The evidence from the survey shows that while turnover impact of standards in the construction manufacturing and services sub-sectors is low relative to other sectors, the impact on trade is considerable, amounting to 5.2% of exports. Harmonised European construction product standards have made it easier for companies to access other European markets which is likely to have contributed to these reported impacts on exports.

Table 21: Estimated financial benefits of standards for the construction manufacturing & services sub-sectors

Metric	Value	Rank
Reported % impact on turnover	2.8%	5
Annual impact on turnover (£m)	£1000m	6
Estimated direct GVA impact (£m)	£170m	6
Reported % impact on exports	5.2%	2
Annual impact on exports (£m)	£150m	6

Source: BSI Standards in Industry survey, Cebr analysis

An important area where standards have benefited companies is in the relationship between companies in the supply chain. More than half (52%) of companies surveyed reported that standards have improved the client-supplier relationship and 48% report standards improve communication between companies.

Given the high usage of health and safety standards in the sector, many of the benefits experienced by companies are likely to be non-monetary. Although the reported monetary benefits are low (in terms of turnover), the proportion of companies that agreed that standards delivered a net benefit (49% of total) is far higher than those that disagreed (22% of total).

Non-monetary benefits of standards in the construction manufacturing and services sub-sectors include allowing greater control over environmental problems (75% of respondents) and contributing to the optimisation of compliance with regulations (85% of respondents).

A summary of the benefits that standards provide for the energy supply chain revealed through interviews with industry experts is provided in Table 22.

Table 22: Summary of benefits from standards in the construction supply chain

Benefits
Quality of products and services – Assists companies to minimize failure rates in production/delays in construction schedules, while delivering high quality products and services, leading to a more competitive product/service, increases in productivity and higher revenue.
Environmental management – Helps reduce the cost of disposing of waste materials, while lowering the cost of meeting environmental regulatory requirements.
Improved management systems - Allows better documentation and continual improvements of processes and procedures, resulting in cost savings. Allows optimization of processes in terms of time and costs
Customer satisfaction – A by-product of the success companies achieve in streamlining processes and improving delivery times is an improvement in customer satisfaction and repeat orders.
Corporate reputation – Companies such as Costain have found that adopting standards like ISO 14001 environmental management gives the ability to differentiate from competitors, allowing them to win contracts on criteria other than lowest cost.
Workplace safety – Standards help companies to implement systems that reduce workplace accidents. Standards such as BS OHSAS 18001 help drive a safety culture across the organisation preventing accidents from occurring in the future.

Case study
H+H UK Ltd.

H+H UK Ltd is the largest manufacturer of aircrete products in the UK and a market leader in sustainable production. Aircrete blocks are an environmentally friendly sustainable building material and are produced from a mixture of pulverised fuel ash (the residue from coal-fired power stations), sand, cement, quicklime, anhydrite, aluminium powder and water. As a result of careful planning, around *80% of the finished product is made from recycled material. Aircrete is widely used in UK construction due to its lightweight nature, high thermal efficiency and flexibility of use in construction.*

- H+H trades with many of the UK's leading developers and house builders. External certification to the international standards (ISO 9001, ISO 14001, and OHSAS 18001) is a pre-requisite for maintaining partnership agreements with their customers. H+H UK is an industry leader in sustainable sourcing and production. For example, the company's two manufacturing sites in East Yorkshire source water from nearby canal as part of the production process.
- The company was the first in the construction industry to obtain a 'Very Good' product rating when adopting BES 6001 certification. Using the BES 6001 standard, H+H can demonstrate that raw materials are sourced from suppliers who themselves can prove sustainability. Being known for its environmental and sustainable credentials is an integral part of the H+H philosophy and supports the efforts of the company when competing with other building materials. An important company strategy has been to focus significant resource on improving energy efficiency throughout its operations. The company is also certified to ISO 50001 energy management, which has produced some significant benefits as energy use is a major factor when producing aircrete. To further improve efficiency a wind turbine is being installed at the company's East Yorkshire site to provide electricity for the manufacturing process.
- H+H's desire to adopt certification and perform within those standards offers major benefits. Standards such as ISO 9001(quality management), ISO 14001 (environmental management) and ISO 50001 (energy management) - with their emphasis on continual improvement - encourages the development of new innovative processes and solutions, helping to reduce the cost of production and increase output. H+H has used BSI as its external certification body since 1989.

6.8 Information & Communications Technologies (ICT)

Overview of the sector

The UK Information and Communications Technologies (ICT) sector is composed of three broad sub-sectors; communications (wired and wireless networks), computer hardware and computer services (including software development, IT consultancy and web services).

Innovation levels are high in the sector; ranking second in terms of annual R&D spend (£3.7 billion, 21% of UK total) with the majority of this expenditure (51%) in software development and information services.

ICT	
Annual turnover (2013)	£159.1 billion
Annual Gross Value Added (2013)	£83.1 billion
Annual R&D spend (2012)	£3.7 billion
Number of UK businesses	145,300
Employment	890,000
Number of industry-relevant standards	3,300

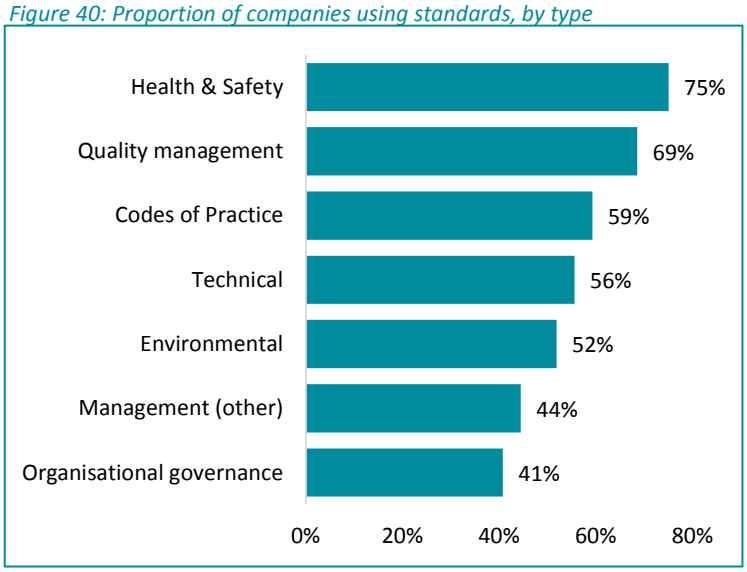
Source: ONS Annual Business Survey 2013, ONS Research and Development in UK Businesses 2012, BSI British Standards Online (BSOL) database

The UK ICT sector ranks third in the EU after Germany and France[42] in terms of annual value added generated and is one of the largest sectors in the UK. In 2013, ICT value added represented 8.2% of the UK non-financial business economy in 2013 making it slightly larger than the whole of the manufacturing sector[43]. Annual turnover in the sector was £159.1 billion in 2013, dominated by telecommunications (39% of total) and computer services (55% of total).

How are standards used in the ICT industry?

Interoperability standards – Standards form the fundamental architecture of the ICT industry. The sector is the business of transmitting, storing and retrieving data using computers and telecommunication equipment. To effectively share data, each device must be able to send and receive information using a standardized format or software language. This requirement for interoperability has precipitated the establishment of industry-led organisations to develop open standards. Internet standards are

Figure 40: Proportion of companies using standards, by type



Source: BSI Standards in Industry survey, Cebr analysis

[42] European Commission Digital Agenda Scoreboard 2014

[43] ONS Annual Business Survey 2013

predominantly led by organisations such as the Internet Engineering Task Force (TCP/IP, SMTP) and World Wide Web Consortium (XML, http, HTML, CSS and WAI) which bring together users and companies to determine voluntary open standards through a consensus process. Communications standards are predominantly led by organisations such as the International Telecommunications Union (ITU), ISO, Institute of Electrical and Electronics Engineers (IEEE) and International Electrotechnical Commission (IEC). ITU also has the role of coordinating the shared global use of radio spectrum. IEC, IEEE and ISO standards are commonplace in computing and communication equipment and in a wide range of information technology standards.

Quality management – Many UK ICT companies use quality standards in the production of products and for the delivery of high quality services to their customers. For example, Inmarsat (a global satellite telecoms company) uses ISO 9001 to optimise costs, improve operational performance and ensure a high quality of service for customers. At software companies such as Sage Financial Software, use of quality standards has a stronger emphasis on risk and group-level quality procedures, with the standard used to promote good corporate governance, facilitate internal audit processes, differentiate products from competitors and minimise the risk of product errors. In some instances, particularly with large public sector clients, ISO 9001 certification is a pre-requisite to bid for contracts.

Health and safety – Occupational safety is an important consideration for ICT businesses and is the most common standard type used by companies in the sector (75% of companies interviewed).

IT security – Company data are a valuable asset. The security of sensitive information and internal networks is becoming an increasing concern within businesses, prompting action to identify risks and improve controls. This has been seen in the growing popularity of the ISO/IEC 27001 Information security management standard, which sets out best practice for maintaining a secure network and putting the necessary controls in place. While this standard has been adopted by companies in a wide range of sectors, its use is particularly high in telecommunications and computer services companies.

Customer service – For companies that have operations in different locations serving multiple markets, quality management systems are used to ensure consistent quality of service for each customer, regardless of where the customer is located. This also allows for a more integrated global company, where each business unit is applying the same procedures and processes.

Table 23: Typical standards used in the ICT sector

Sector	Standards
Telecommunications	• ISO 9001 Quality management system • TL 9000 Quality management system for supply chain quality requirements of the global information and communication technologies industry • ISO/IEC 27001 Information security management systems • ITU, IEEE, IEC and ISO technical standards for communication technologies
Computer services	• ISO 9001 Quality management system • ISO/IEC 27001 Information security management systems • ISO/IEC 20000 IT Service Management
Computer hardware	• ISO 9001 Quality management system • ISO/IEC 27001 Information security management systems

Sector	Standards
	• IEC and ISO technical standards for electronic equipment • IEEE, IEC and ISO technical standards for network connectivity

Benefits in the supply chain

The ICT sector has a relatively low reported impact of standards on turnover (see Table 24). The benefits reported by survey respondents amounted to 2.8% of turnover equivalent to £5,400 million per year. However, as the most productive industry among those profiled in this report in terms of the extent to which value added is generated from each additional pound of turnover revenue, the industry has the highest estimated GVA impact from standards (£2.1 billion per year). Standards also have a strong effect on boosting productivity in the ICT sector, with close to half of companies (48%) reporting that standards increase productivity, the highest among the sectors profiled.

Table 24: Estimated financial benefits of standards for the ICT sector

Metric	Value	Rank
Reported % impact on turnover	2.8%	4
Annual impact on turnover (£m)	£5,400m	5
Estimated direct GVA impact (£m)	£2,100m	1
Reported % impact on exports	3.1%	4
Annual impact on exports (£m)	£800m	5

Source: BSI Standards in Industry survey, Cebr analysis

In total, 51% of companies indicated that they considered that standards produced a net benefit for their business, the third highest amongst the sectors profiled. Part of the reason for the difference between the reported net benefits and turnover impact may be related to how the benefits from standards are dispersed in the sector. Network effects (as explained in section 2.3) are important in the ICT sector and standards have a strong role in creating networks, by diffusing common standards that facilitate interoperability.

Open standards makes it possible for products and software produced by different individuals and companies to work seamlessly with each other. This facilitates the creation of new markets and can release huge benefits for both consumers and customers. For example, the internet has facilitated the creation of entirely new industries focussed on the delivery of online services. The survey results confirmed the importance of standards to interoperability in the sector, with 43% of respondents agreeing that standards improve compatibility of products and systems, the highest amongst the sectors surveyed.

The survey shows that standards are particularly important for facilitating technology transfer in the ICT sector, with 65% of companies agreeing that standards make technology more accessible and thus making it less costly for companies to innovate.

A further area where standards help businesses is in the minimization of risk, particularly in the area of IT security - 74% of companies in the ICT sector reported that standards allow greater control over security-related problems, the highest amongst the sectors surveyed.

A summary of the benefits that standards provide for the ICT supply chain revealed through interviews with industry experts is provided in Table 25.

Table 25: Summary of benefits from standards in the ICT supply chain

Benefits
Quality management – QMS standards help companies to improve workflows and streamline processes. They also provide reputational value for the company, in that they signal the quality of the product to the customer.
Product & software development- Standards help shorten development times for products and the cost of research and development
Technical components – Standardization of components generally tends to improve competition in the market, which reduces the cost of the completed product.
Technical interoperability – Standards that facilitate interoperability can create new markets, with benefits increasing with the size of the network of users
Sales & marketing - Standards help companies demonstrate the quality and compatibility of their products, thus providing assurance to customers about the performance of the product or service.

6.9 Conclusions - contribution of standards to the success of UK companies

The combined evidence from the BSI Standards in Industry survey and in-depth interviews with industry experts gives a comprehensive understanding of the importance of standards to companies.

Using responses from the companies surveyed and re-weighting the results to correspond with the size distribution of companies in each sector, it was also possible to build a picture of the financial benefits of standards at the sector level. The sector level financial impacts of standardization in the seven sectors covered in the analysis were estimated at £6.9 billion for 2013 in GVA terms.

Besides supporting the productivity of UK companies through enabling the optimisation of business operations, one of standardization's most important roles is in supporting trade. By opening up new markets, linking UK companies into global supply chains, reducing technical barriers to trade and through strengthening the basis for non-price competition, standards help companies to enter new markets at home and abroad.

The analysis illustrates the extent to which standards are essential to the functioning of UK businesses, sector supply chains and markets. The sector analysis reveals the extent to which standards are essential to the functioning of businesses and markets. Standards enable savings through enhanced client-supplier relationships and better communication between companies which fosters the overall healthy functioning of markets. The analysis also provides evidence for the role of standards as a catalyst for innovative activity through the diffusion of knowledge.

From the findings, we can make some useful conclusions:

- Standards are for many of the sectors an integral part of the functioning of businesses. In many cases, companies simply would not be able to operate the same way they currently do, or it would become uneconomical to do so, if standards were not widely used in the sector. For example the business model of large aircraft manufacturers (OEMs) has evolved to outsource the production of a vast array of components, and to focus on the design and assembly of aircraft. This allows for substantial cost savings to be achieved. Without standards to allow easy verification of quality and to distribute technical information, manufacturers would need to revert to a traditional vertically-integrated model of business structure, which would reduce the capability of the industry to produce aircraft in sufficient volumes.
- The study reveals that being involved in the standards development process produces surprisingly large benefits for participants, and it raises the questions as to why there is not more widespread involvement among UK companies. In some countries where demand to participate is high, companies pay for the right to sit on technical committees whereas in the UK this is not the case. This may be a result of UK companies simply not being aware of the specific benefits that accrue to companies that get involved in standards development.
- The evidence from the sectors covered in this report shows that standards have been hugely influential in boosting the sales of UK products and services abroad, with reported impacts averaging 3.2% of annual exports, equivalent to £6.1 billion per year in additional exports. Given the current Government emphasis on re-balancing the economy towards export-led growth, this highlights the importance and benefits of further promoting standardization throughout the UK economy.

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Appendix

Data sources for the econometric analysis

Standards: We source our data on standards from the British Standards Online (BSOL) database. This database provides a list of all standards published by BSI in the period 1902 to 2014. The database provides information on the year each standard was published and withdrawn (if applicable), industrial sector (ICS classification) and the publishing body (e.g. ISO, CEN, ETSI). We used these data to produce a long run time series for the net stock of standards.

Output: Gross domestic product at 2006 basic prices, chained volume measure (ONS code ABMI) [1920 to 2013]. Data prior to 1948 sourced from the data annex to the Bank of England 2010 Q4 Quarterly Bulletin article "The UK recession in context — what do three centuries of data tell us?" by Sally Hills, Ryland Thomas and Nicholas Dimsdale. The composite time series in the data annex was constructed using data from (Sefton & Weale, 1995) for the period 1920 to 1948 and ONS Blue Book for the period 1948 to 2013.

Employment: Number of persons in employment age 16+ (ONS code MGRZ). Data prior to 1971 were sourced from the data annex to the Bank of England 2010 Q4 Quarterly Bulletin article as cited above. The composite time series in the data annex was constructed using data from Feinstein[44] (1972) [1920 to 1965] and ONS Blue Book [1966 to 2013].

Capital stock: Non-dwellings whole economy capital stock and asset capital services growth. (Feinstein & Pollard, 1988) and (Mitchell, 1988) for capital stock data and Bank of England calculations for capital services growth [1920 to 2009]. Capital is defined as the non-housing whole-economy capital stock prior to 1963 and non-housing whole-economy capital services thereafter. Capital services are defined as the flow of services into the production of output that are generated by the capital stock. The data series was extended up to 2013 using data from the ONS publication 'Capital Stocks, Consumption of Fixed Capital, 2013'.

Detailed methodology

Following the approach of the 2005 DTI study and previous national level studies on the impact of standards on economic growth, the model starts with the stylised Cobb-Douglas production function which describes how the economy produces output through the inputs Capital (K), Labour (L) and technological progress, otherwise known as Total Factor Productivity (TFP).

The time-variant version of the Cobb-Douglas production function[45] is presented in equation 1 below:

1 $$Y_t = A_t L_t^{\propto} K_t^{1-\propto}$$

To convert this function into a form that can be used in an econometric model and estimated statistically, the Cobb-Douglas function must be transformed into a linear function by taking natural logs of both sides of equation 2:[46]

[44] Feinstein, C H (1972), National income, output and expenditure of the United Kingdom 1855-1965, Cambridge: Cambridge University Press.

[45] For the purposes of simplifying the estimation procedure, constant returns to scale have been assumed for the factors of production i.e. a 10% increase in the amount of labour and capital applied would yield a 10% increase in output.

[46] Where Y_t represents output of the economy at time t, K_t represents capital input at time t, L_t labour input at time t and A_t total factor productivity (TFP) at time t. We assume constant returns to scale and α and (1-α) represent the elasticity of output to a change in one of the factors.

2 $$\ln Y_t = lnA_t + \propto lnL_t + (1-\propto) lnK_t$$

Next, the model is re-written in terms of labour productivity. The model can then be expressed as:

3 $$\ln Y_t - lnL_t = lnA_t + (1-\propto)(lnK_t - lnL_t)$$

4 or in simplified form: $$y_t = a_t + (1-\propto)k_t$$

Where y_t represents output produced per worker employed at time t, a_t represents TFP and k_t represents the capital-employment ratio[47], the amount of capital per worker employed at time t.

- In practice, TFP is the product of many complementary components, which together drive increased productivity. The DTI 2005 study explored the inclusion of patents and technology licences along with standards in their model. The authors of that report found that patents are co-linear with standards, making their addition to the equation unnecessary because it did not enhance the model. The data available for technology licences were only available from 1964 onwards. As a result, the DTI (2005) study (and this study) specifies a model where standards are the sole determinant of TFP in the production function. This model is presented in equation 5:

5 $$y_t = c + s_t + (1-\propto)k_t + \lambda_t + \xi_t + \epsilon_t$$

Where s_t represents the net stock of standards, λ_t represents a time trend, ξ_t represents a recession (binary) variable, ϵ_t represents the residual portion of TFP and c represents a constant.

- An Augmented-Dickey Fuller (ADF) test and a Phillips-Perron test were conducted to confirm the stationarity of the residuals from the model specified in equation 5. The null hypothesis of a unit root[48] is rejected and so we were able to conclude that estimation using Ordinary Least Squares (OLS) should not lead to spurious results. OLS estimation methods were therefore used to estimate the model specified in equation 5.

- A recession variable is included in the model, designed as a binary variable, to control for the effect that economic downturns have on productivity – that are unlikely to be related changes in the stock of standards but may have an impact on the results. A time trend variable was also included to control for the clear trend exhibited within the data.

- The results enable the identification of the contribution of the net stock of standards s_t to productivity y_t between 1921 and 2013. By applying the results to observed trends in the growth of the stock of standards and the growth in labour productivity, the economic impact of standardization can be estimated.

- Further, to confirm the long-run relationship between productivity, the capital-employment ratio and standards, an Error-Correction model (ECM) is used[49]. A three-step procedure is employed, as outlined below:

[47] When the capital-employment ratio is increasing, this is often referred to as capital deepening – where the amount of capital per person employed in the economy is increasing.

[48] The presence of a unit root implies that the time series is non-stationary. The ADF test tests for stationarity, with the null hypothesis being that the data series is trend stationary and that this conclusion is statistically significant. The alternative hypothesis is that the data series is not trend stationary.

- The data series is tested for the presence of a stationary stochastic process i.e. current values of a series depend linearly on past values of the same series. Using the ADF test and Phillips-Perron test for stationarity, it was found that neither labour productivity, the capital-employment ratio nor the net stock of standards exhibited this property.

- Next, to verify that the data used for this study also exhibits a causal relationship, a Johansen Test was conducted. The results of this test confirm that a long-run relationship exists, and that it runs from standards to productivity.

- Finally to identify the long-run equation, an ECM model is implemented, the results of which are described in Table 26. The table illustrates the speed of adjustment factor and the short-run effects. The long run equation is presented here:

6 $$Productivity = 5.81 + 0.385\ capital\ employment\ ratio + 0.151\ stock\ of\ standards$$

- The equation implies that a 1% increase in the stock of standards is likely to lead to a 0.151% increase in productivity in the long-run, and this estimate is statistically significant[50]. In addition the speed of the adjustment factor, equivalent to 0.229, means that the 0.151% increase in productivity that results from a rise in the stock of standards will occur at a rate of 23% per year.[51] This is consistent with economic theory, which suggests that standards contribute positively to productivity in the long-run.

- The short-term relationship between productivity, the capital-employment ratio and the stock of standards are presented in Table 26. These results are not statistically significant, further supporting our hypothesis of the long-run effect between productivity and standards.

[50] The OLS regression illustrated in equation 5 confirms the correlation between standards and productivity through identifying and quantifying the average linear relationship between standards and productivity between 1921 and 2013. The econometric exercise detailed in equation 6 aims to identify, specifically, the long-run impact of standards on productivity.

[51] This implies that productivity will rise by 0.03% in the first year after a 1% increase in the stock of standards (23% of the estimated 0.151%). Productivity will rise in this way until the whole 0.151% increase has occurred.

Table 26: ECM model estimates

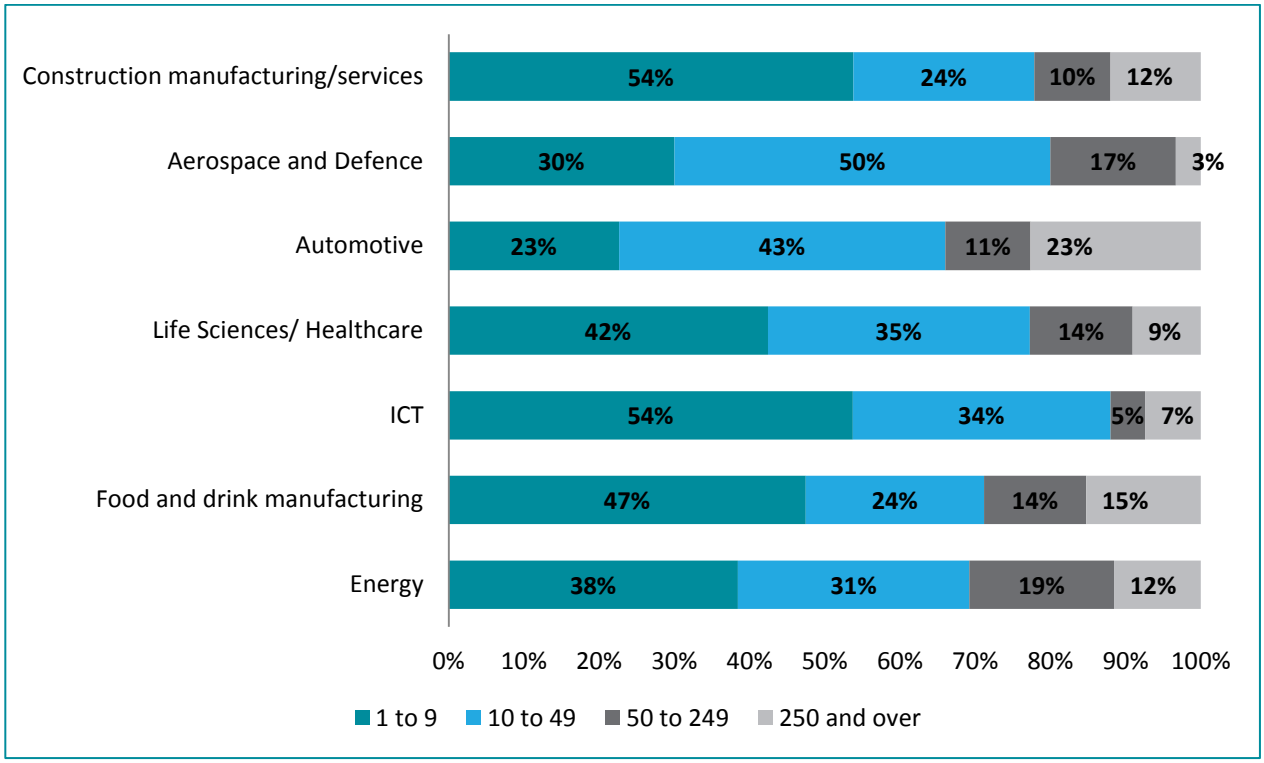
	Dependent variable		
	A	B	C
Explanatory variable	Labour Productivity growth	Capital- Employment ratio growth	Stock of standards growth
Speed of adjustment	0.229	0.058	0.032
Labour Productivity growth (t-1)	-	0.118	0.041
Capital-Employment Ratio growth (t-1)	0.126	-	0.247*
Growth in stock of standards (t-1)	0.034	0.193*	-

** Denotes a significant relationship at the 5% level. ** Denotes a significant relationship at the 1% level.*

Sample structure

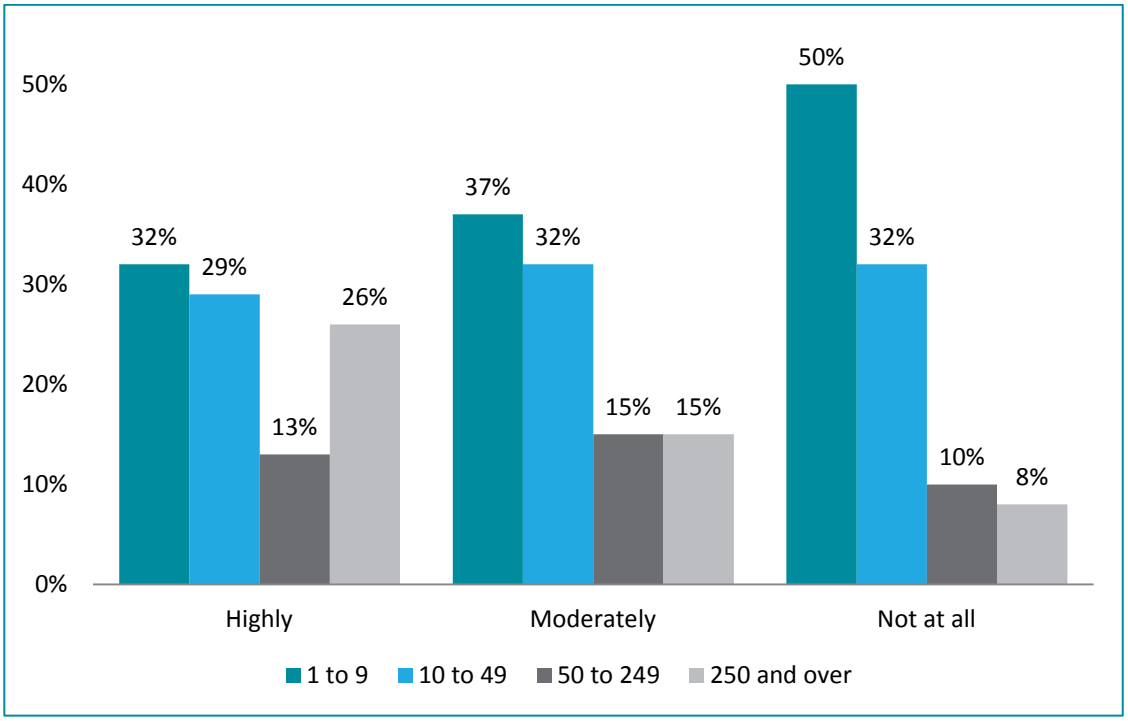
Between January 2015 and March 2015, JRA Research was commissioned by Cebr to conduct the BSI Standards in Industry survey. This involved a survey of 527 decision makers within firms about the impact of standardization on business operations. The survey involved a common questionnaire and was conducted through telephone interviews. The sample was asked about the monetary and strategic benefits of standards use to individual firms and the supply chain and industry as a whole. Views relating to involvement in the standards development processes were also surveyed. It should be noted that some responses to survey questions do not add up to 100%, either because of rounding or because respondents were able to provide multiple answers to some questions. The sample structure can be broken down as follows:

Figure 41: Survey sample structure: breakdown by industry and by size



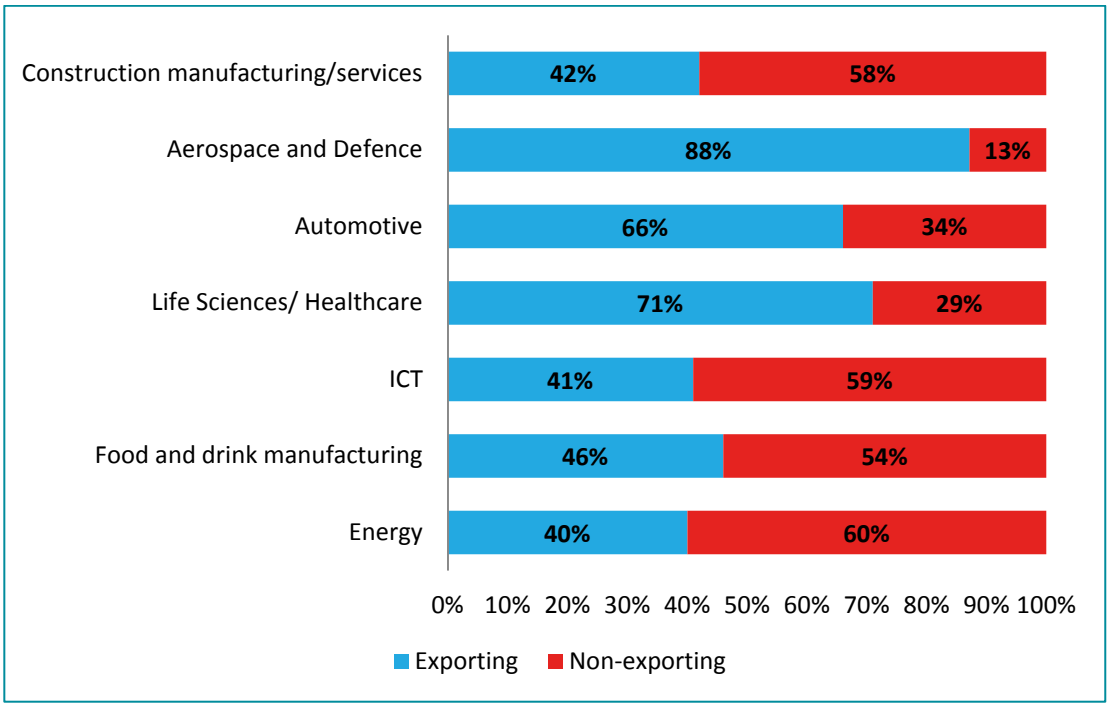
Source: BSI Standards in Industry survey, Cebr analysis

Figure 42: Extent to which involvement in the standards development process varies by size of business



Source: BSI Standards in Industry survey Cebr analysis

Figure 43: Proportion of exporting and non-exporting firms in each sector



Source: BSI Standards in Industry survey, Cebr analysis

Methodological note for Section 5.2

Responses from the BSI Standards in Industry Survey were combined with official sector level revenue exports revenue and GVA data to estimate aggregate increases to revenue, GVA and exports at the sector level.

The survey asked firms to identify the average increase to revenue and exports that had occurred as a result of standardization, in percentage terms.

The survey responses were adjusted to reflect the true UK population of businesses: the survey appeared to over-sample large businesses (employing more than 250 people) an under-sample small firms relative to the UK population of firms. For example, 10% of the BSI Standards in Industry survey sample consisted of large businesses. By contrast, large firms make up only 2% of the total UK business population. This meant that responses to the survey would be skewed, over-representing the views of large businesses and under-representing the opinions of other firms. To account for this, proportions of large and small firms within each industry were obtained from the Business Population Estimates (ONS). These were used to scale the survey responses, adjusting them downward to be reflective of the whole UK business population. As a result, the findings reflected results that would be found had the whole UK business population been surveyed rather than 527.

To estimate the increases to revenue, exports revenue and GVA at the national sector level, the following steps were implemented:

1. The adjusted survey responses, detailing the average percentage increase to revenue as a result of standardization were applied to revenue data at the sector level, obtained from the Supply-Use Tables 2012. These results reflected 2012 volumes and prices. Using ONS GDP Low Level Aggregates 2014, and the rate at which GVA of each sector grew between 2012 and 2014, increases to revenue as a result of standardization was obtained in terms of 2014 volumes and prices.
2. The adjusted survey responses, detailing the average percentage increase to exports as a result of standardization were applied to exports revenue data at the sector level, obtained from the Supply- Use Tables 2012. These results reflected 2012 volumes and prices. Using ONS GDP Low Level Aggregates 2014, and the rate at which GVA of each sector grew between 2012 and 2014, increases to exports revenue as a result of standardization was obtained in terms of 2014 volumes and prices.
3. Increases to GVA were calculated using the ratio of sector revenue to sector GVA, obtained using ONS GDP Low Level Aggregates 2014 data. Using the estimated increase to revenue as a result of standardization (calculated in step (1)) and the revenue to GVA ratio, increases to GVA were estimated at the sector level.

The results of this analysis are summarised in the table below:

Table 27: Estimated financial benefits of standards for all sectors

Sector	Reported % impact on turnover	Annual impact on turnover (£m)	Estimated direct GVA impact (£m)	Reported % impact on exports	Annual impact on exports (£m)
Automotive	3.8%	£4,915	£536	2.6%	£967
Life Sciences	3.3%	£5,233	£1,797	2.5%	£950
Aerospace & defence	1.7%	£760	£205	4.4%	£1,022
Energy	2.2%	£5,730	£972	0.3%	£112
Food & drink manufacturing	5.3%	£10,224	£1,113	9.9%	£2,061
Construction	2.8%	£1,044	£167	5.2%	£155
Information & Communication	2.8%	£5,365	£2,130	3.1%	£802

Source: BSI Standards in Industry survey, Cebr analysis

Sector definitions

A total of seven sectors were covered in the BSI Standards in Industry survey. These sectors were chosen because they represent some of the most standard-intensive sectors in the UK economy. A summary of the definitions used for these sectors broken down by standard industry classification (SIC) code are provided in Table 28. These definitions are largely informed by those used by the Department for Business, Innovation & Skills. It should be noted that while construction contracting companies (SIC 41 to 43) are referred to in the analysis of the construction sector (section 6.7), they were not included in the survey due to the relatively low level of standard usage in the construction contracting sub-sector relative to other sectors (with the exception of larger contractors) and for sampling reasons.

Table 28: SIC code definitions

Sector	SIC code	SIC group
Automotive		
	29	Manufacture of motor vehicles, trailers and semi-trailers
	22.11	Manufacture of rubber tyres and tubes; re-treading and rebuilding of rubber tyres
Life Sciences		
	21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
	26.6	Manufacture of irradiation, electro medical and electrotherapeutic equipment
	32.5	Manufacture of medical and dental instruments and supplies
	72.11	Research and experimental development on biotechnology
Aerospace and Defence		
	25.4	Manufacture of weapons and ammunition
	30.3	Manufacture of air and spacecraft and related machinery
	30.4	Manufacture of military fighting vehicles
Energy		
	51	Mining of hard coal
	52	Mining of lignite
	61	Extraction of crude petroleum
	62	Extraction of natural gas
	81	Quarrying of stone, sand and clay
	91	Support activities for petroleum and natural gas extraction
	19.2	Manufacture of refined petroleum products
	35.1	Electric power generation, transmission and distribution
	35.2	Manufacture of gas; distribution of gaseous fuels through mains
Food & drink manufacturing		
	10	Manufacture of food products
	11	Manufacture of beverages
Construction manufacturing & services		
	23.3	Manufacture of clay building materials

Sector	SIC code	SIC group
	23.5	Manufacture of cement, lime and plaster
	23.6	Manufacture of articles of concrete, cement and plaster
	23.7	Cutting, shaping and finishing of stone
	25.1	Manufacture of structural metal products
	27.4	Manufacture of electric lighting equipment
	16.21	Manufacture of veneer sheets and wood-based panels
	16.22	Manufacture of assembled parquet floors
	16.23	Manufacture of other builders' carpentry and joinery
	22.23	Manufacture of builders’ ware of plastic
	23.11	Manufacture of flat glass
	23.12	Shaping and processing of flat glass
	23.42	Manufacture of ceramic sanitary fixtures
	23.99	Manufacture of other non-metallic mineral products n.e.c.
	25.21	Manufacture of central heating radiators and boilers
	25.72	Manufacture of locks and hinges
	27.33	Manufacture of wiring devices
	28.14	Manufacture of other taps and valves
	28.25	Manufacture of non-domestic cooling and ventilation equipment
	71.11	Architectural activities
	74.901	Environmental consulting activities
	74.902	Quantity Surveying Activities
ICT		
	26.1	Manufacture of electronic components and boards
	26.2	Manufacture of computers and peripheral equipment
	26.3	Manufacture of communication equipment
	26.4	Manufacture of consumer electronics
	58.2	Software publishing
	63.1	Data processing, hosting and related activities; web portals
	63.9	Other information service activities
	58.29	Other software publishing
	62.01	Computer programming activities
	62.02	Computer consultancy activities
	62.03	Computer facilities management activities
	62.09	Other information technology and computer service activities
	63.11	Data processing, hosting and related activities
	63.12	Web portals

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BSI (British Standards Institution) is the business standards company that equips businesses with the necessary solutions to turn standards of best practice into habits of excellence. Formed in 1901, BSI is the UK National Standards Body and a founding member of the International Organization for Standardization (ISO). Over a century later it continues to facilitate business improvement across the globe by helping its clients drive performance, manage risk and grow sustainably through the adoption of international management systems standards, many of which BSI originated. Renowned for its marks of excellence including the consumer recognized BSI Kitemark™, BSI's influence spans multiple sectors including Aerospace, Automotive, Built Environment, Food, Healthcare and ICT. With over 80,000 clients in 172 countries, BSI is an organization whose standards inspire excellence across the globe. **bsigroup.com**

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