The contribution of standards to the UK economy

A Cebr report for BSI

April 2022

Cebr

Authorship and acknowledgements

This report has been produced by Cebr, an independent economics and business research consultancy established in 1992. The main authors of the report are Douglas McWilliams, Cebr Deputy Chairman; and Mike McWilliams, Cebr Director and Chief Energy Adviser. The views expressed herein are those of the authors only and are based upon independent research by them.

The report does not necessarily reflect the views of the British Standards Institution (BSI).

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Executive Summary

This report describes the results of a study to estimate the impact of standards on the UK economy. It updates an earlier study carried out in 2015[1].

The key conclusion of this report is that standards are critical for not only the economy but also for trade, investment including innovation and the environment.

The study consists of a literature search, a survey and economic modelling. The literature search and the survey are to provide inputs to the economic modelling.

The literature search

The full literature search is described in Appendix 2. What is significant, comparing the 2021 search with that carried out in 2015, is the apparent increased importance of standards for purposes that are only indirectly economic, such as health and safety and the environment. Also significant is the increase in research on the impact of standards in countries other than the traditional Western economies.

The general tone of the research remains very much that standards are associated with improved economic performance as well as improved business performance in other areas. The scale of this improved economic performance is approximately the same as that identified in the earlier literature search. This is despite the broader objectives for standards identified in the more recent search and suggests that these broader objectives do not appear to hinder economic performance.

The literature search provides input to the trade and productivity models that are then inputs into the macro modelling.

The survey

A key part of the study was a survey of 1,000 companies to understand better the impact of standards on them. The full details of the survey are set out in Appendix 3.

An important feature of this survey is that whereas the similar survey in the 2015 study focussed on a limited number of sectors (7) that were mainly industrial, this survey covers a much wider spread of sectors (16) including the whole of the commercial service sector.

The key findings of the survey were:

- Firms of all sizes identify more benefits than costs from the use of standards: between 55% and 85% see standards as net beneficial while between 17 and 29% see them as not beneficial;
- 81% of firms see standards as providing an ongoing boost to productivity;
- Firms of all sectors except automotive identify more benefits than costs from the use of standards
- Firms in all sectors identify significant increases in turnover from the use of standards
- The largest gains in GVA identified from the survey are in healthcare, ICT, finance and professional services. This compares with the 2015 survey where the main gains identified were in manufacturing;

[1] The Economic Contribution of Standards to the UK Economy June 2015 Published in June 2015 by BSI, 389 Chiswick High Road, London W4 4AL.

- Very few firms see standards as stifling innovation – by contrast the bulk of firms identify standards as widening the potential markets for innovation and hence encouraging it;
- Standards are seen as boosting competitiveness, especially in export markets

The survey also provides input to the trade and productivity models that in turn provide inputs to the macro modelling.

Impact of increases in standards

Using the results of the literature search and those of the survey, the study models directly the economic impact of each years accretion of net new standards.

Each year the net increase in standards is on average 4.3%[2] of the total of standards outstanding.

- These give a 0.4% per annum boost to growth over 10 year period worth £8.8 billion a year annually and still rising as investment kicks in
- Investment is boosted by 1.1% per annum over a 10 year period worth £1.7 billion a year. This new investment incorporates increased innovation. After the 10 year period the boost to investment continues to grow reaching 3.5% after 15 years.
- Exports are boosted by 0.8% per annum after 5 years' worth £5.4 billion a year
- The sectors that benefit most are IT (+1.5%) and construction (+1.0%)
- The cost of living is reduced by 0.3% after two years
- The public finances benefit by an amount that builds up to £14 billion per annum eventually
- Employment is initially depressed by the boost to productivity but after 15 years is up by 0.34% or 102,000
- SMEs benefit nearly as much as the whole economy on average because of their prevalence in the most affected sectors such as IT, despite survey evidence that large firms generally benefit more than small firms from standards
- Environmental emissions are reduced by 0.26% (despite the faster growth) because of reduced waste and more professional management

The cumulative impact of standards

Obviously the total impact of standards is much bigger than that of just a single year's accretion of standards.

We estimate that in total 23% of all UK GDP growth in the current century is attributable to the impact of standards and 38% of all productivity growth.

So we estimate that standards have boosted the UK's annual GDP by £161 billion since 2000.

[2] Based on the average net increase in the stock of standards 2014-2020. See Appendix 1 for a fuller discussion.

Wider implications of standards

Increasingly standards are targeted at goals that are not primarily economic, even if they may contribute to the economy indirectly. The literature search and the survey indicated that since the 2015 report, the importance of both health and safety and the environment in standards had increased.

With increasing focus by investors on ESG performance we would expect this focus on broader issues to increase further over time.

1 Introduction

1.1 Introduction

This is an update of Cebr's 2015 report for BSI on the economic contribution of standards to the UK economy.

The 2015 report was based on earlier work by Department for Business, Energy and Industrial Strategy (BEIS) and its predecessor Departments and is in turn linked to work by DIN, the German standards organisation.

The study uses an updated methodology based partly on the research Cebr has carried out for BSI in conjunction with the Prosperity Fund of the FCDO and with the Standards Administration of China to evaluate the contribution of international standards in China.

Whereas the work for with BSI for the FCDO looks at the contribution of international standards and is based on forecasting how a change might affect the variables that are being studied, this report looks at the impact of all standards and is essentially concerned with evaluating the historic impact of standards already in place.

We have modelled not only the impact on productivity and on GDP for the UK but also:

1) Impact on trade
2) Sectoral impact
3) Impact on employment
4) Impact on the environment and
5) Impact on SMEs

The methodology also includes direct modelling of the impact of standards on trade using agent based modelling. This is important post-Brexit because arguably standards will be of increased importance to UK trade in this context and hence to the UK economy[3].

[3] This is hinted at by Scott Steedman, BSI Director General Standards https://www.quality.org/knowledge/ensuring-a-smooth-transition-post-brexit

2 Standards used in the British Economy

2.1 Introduction

In this section, we present some background to the standards used in the British economy. It is set out in rather more detail in Appendix 1.

2.2 What is a standard?

A standard is an agreed way of doing things. It can be a product specification, a process for producing a good or service, or a process for undertaking any other form of economic activity such as supplying goods or services.

2.3 General economic effects of standards

Standards help to solve fundamental process, organisational and technical problems. If these issues are not addressed, they can lead to inefficient and economically ineffective operations. One of the first standards introduced by the BSI - standardising the number of tram gauge specifications from 75 to 5 in 1903 (Standard BS 2) - was designed to ensure manufacturing quality while eliminating the unnecessary variety that existed in the tramway track market, which limited the interoperability of the tram network and led to longer delivery times for tramway track. The reduction in variety reduced procurement costs for tram companies and allowed tram manufacturers to expand their markets[4].

A common classification of standards in the literature[5] relates to the economic problems they address. This classification usually indicates that standards play a direct or indirect role in the productivity and efficiency of a firm or an organization - by reducing the costs of producing goods and services, increasing revenues by opening up new markets, or increasing the efficiency of producing goods and services. This categorisation based on the economic effect of a standard is useful in order to analyse the economic driving forces for standardisation and the economic impact dimensions[6].

Standards can be used for a variety of purposes and so can solve a variety of problems, even if they were developed to serve one purpose. Only around 25 per cent of European standards are associated with public policies and legislation[7]; use of other standards is voluntary and their usage are expected to solve business issues as the responsibility for complying with these standard requirements rests with the supplier of goods and services.

2.4 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, in the extent to which they are used and useful in industry and in how standards come and go as time marches on. But the available data does not support such an ideal measurement so a more

[4] Dow, A. (2014): "The Railway: British Track Since 1804," Pen & Sword Books Ltd

[5] See David P.A. (1987): "Some New Standards for the Economics of Standardisation in the Information Age," in Dsgupta, P. and P. Stoneman (eds), Economic Policy and Technological Performance, Cambridge: Cambridge University Press and Swann GMP (2000) The economics of standardization. Final report for standards and technical regulations directorate, Department of Trade and Industry. University of Manchester,

[6] Blind, K. (2004). "The Economics of Standards: Theory, Evidence, Policy." Cheltenham: Edward Elgar.

[7] BSI statement (2018): "Brexit and Standards Update," downloadable via https://www.bsigroup.com/globalassets/localfiles/en-gb/about-bsi/nsb/brexit/bsi-brexit-standards-update-20-jul.pdf

straightforward proxy must be used. This is provided by a simple count of the number or quantity of 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 newly published standards up to the end of that year. This calculation is described by the equation in Figure 1.

Figure 1: Equation for the net stock of standards

The measure has been constructed using data from the British Standards Online (BSOL) and Perinorm databases for the period 1991 to 2020.

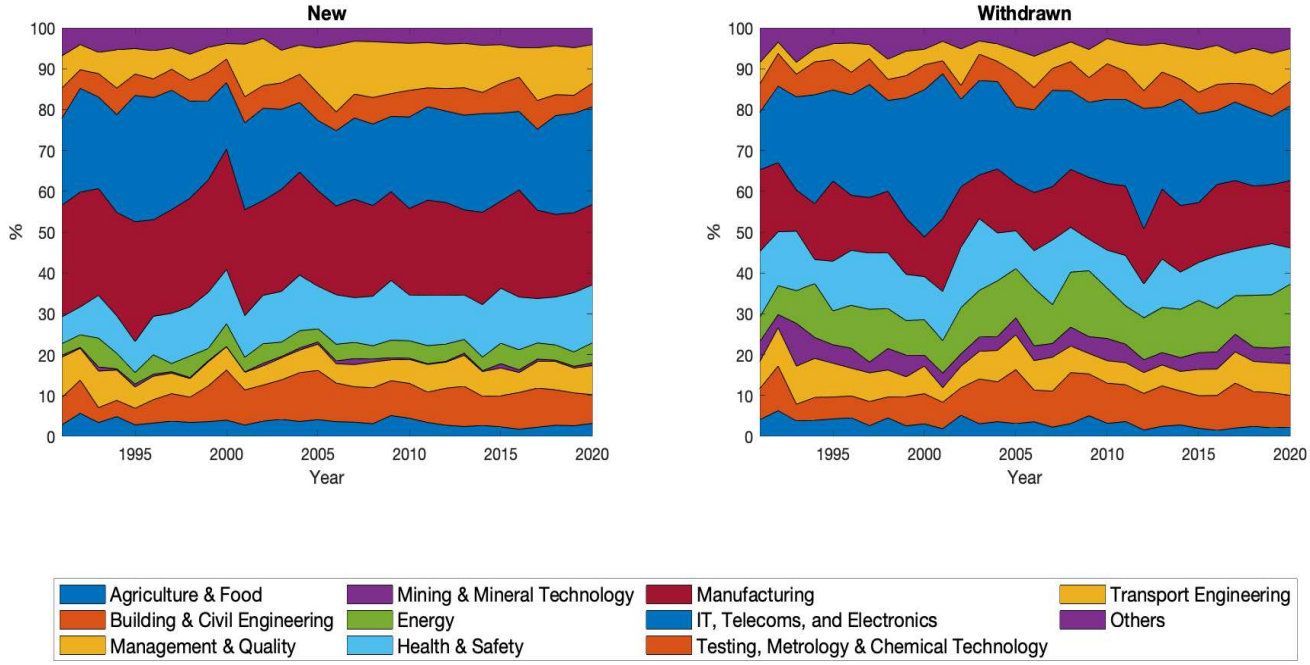
2.5 The composition of standards

The composition of standard catalogue over the past three decades has changed to adapt to shifts in the structure of the UK economy. An examination of 10 important aggregate groups/sectors of standards (Figure 5) demonstrates how some fields have become more important in terms of their share of standards published in each year, while others have declined in significance. We also look at the standards withdrawn for these sectors in each year, giving us a better understanding compared to the 2015 report.

Since 1990, the proportion of manufacturing standards in the catalogue has declined from 27.3% to 19.6%. This is a similar pace of change to that identified in the 2015 report, though with some small difference in the definition.

The IT, telecoms, and electronics sector grew in the period 1991-1998, and then from 2010, it has held steadily 22% - 23% of the standards published. Health and safety standards were much more important in 2020 (14.2%) than in 1991 (6.6%). Finally, transport engineering standards grew faster than others during 2000-2010, though subsequently the number of this category of standards has been stabilized.

Figure 2: Composition of the BSI Standards Catalogue (by aggregated ICS fields)



2.6 Literature on the economic impact of standards

There is an extensive literature on the economic impact of standards. This is reviewed and summarised in Appendix 2.

3 The 2021 survey of the impact of standards

3.1 Introduction

This section sets out the broad results of the 2021 survey of the impact of standards. The more detailed results are described in Appendix 3.

3.2 Objective of survey

The objective of the survey was to obtain a detailed understanding of the role of standards within sectors looking at their economic impacts, the role of standards in competitiveness, trade and innovation, and the value of participating in the standards development process. The survey followed a similar survey for the 2015 study and where possible tried to replicate the questions from the earlier survey for comparability.

To achieve this, a comprehensive survey of 1,000 (compared with 527 in the 2015 survey) firms in 16 (compared with 7 in the 2015 survey) key sectors was commissioned as part of the study, asking businesses to think about the general and detailed effects of standards on their operations. The survey aims to:

- Establish how standards boost the productivity and efficiency of firms;
- Identify the effect of standards on competition within markets;
- Quantify the economic impact of standards on the supply chains of some of the UK's largest sectors;
- 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 environmental effects from standards.

This section presents the survey's summary findings.

3.3 The economic impacts of standards

The use of standards is predominantly voluntary. However, in many cases, firms 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 survey shows that, on balance, standards unanimously generate net benefits.

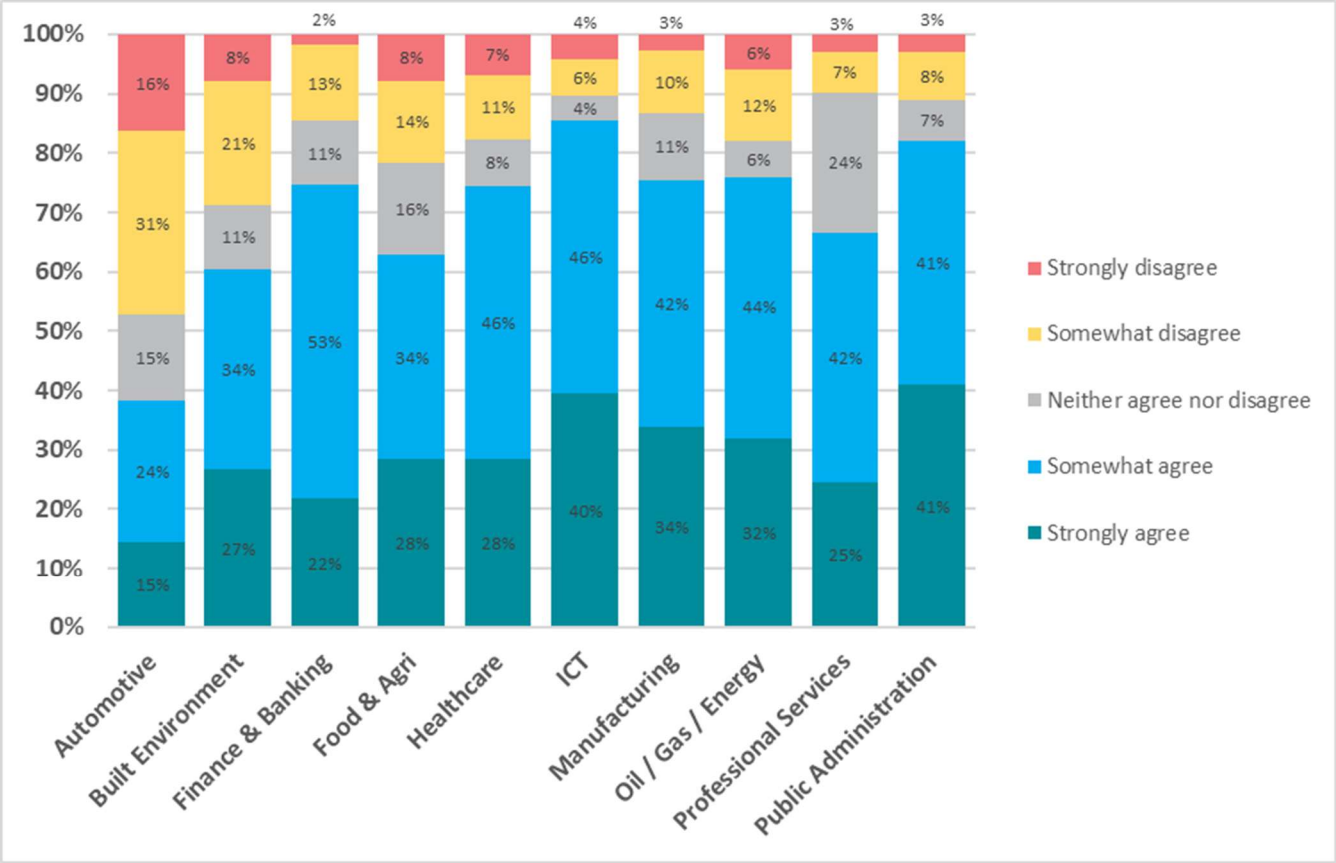
The majority of survey respondents reported that standardisation provided a net benefit for their business (see Figure 4 and Figure 5). In particular, the majority of firms in the finance and banking sector (75%), healthcare sector (75%), ICT (82%), and manufacturing (76%) reported that standards benefit their business.[8] This is similar to the 2015 report, but the earlier report focussed on manufacturing – the fact that the results are similar in the current survey covering a much wider range of sectors implies a much more widespread role for standards.

The respondents from the automotive sector are not as positive about standardisation as those from other sectors, which we think partly reflects the fact the standardisation in this sector may have more of a "license to trade" effect than pure economic benefits described above. The response might reflect the government's decision to ban the sale of internal combustion engined cars announced not long before the

[8] Here, we count the number of "Somewhat agree" and "Strongly agree".

survey was carried out and which has proved controversial within the industry. Although technically this is a regulation and not a standard, it is possible that it has been treated as if it were a standard.

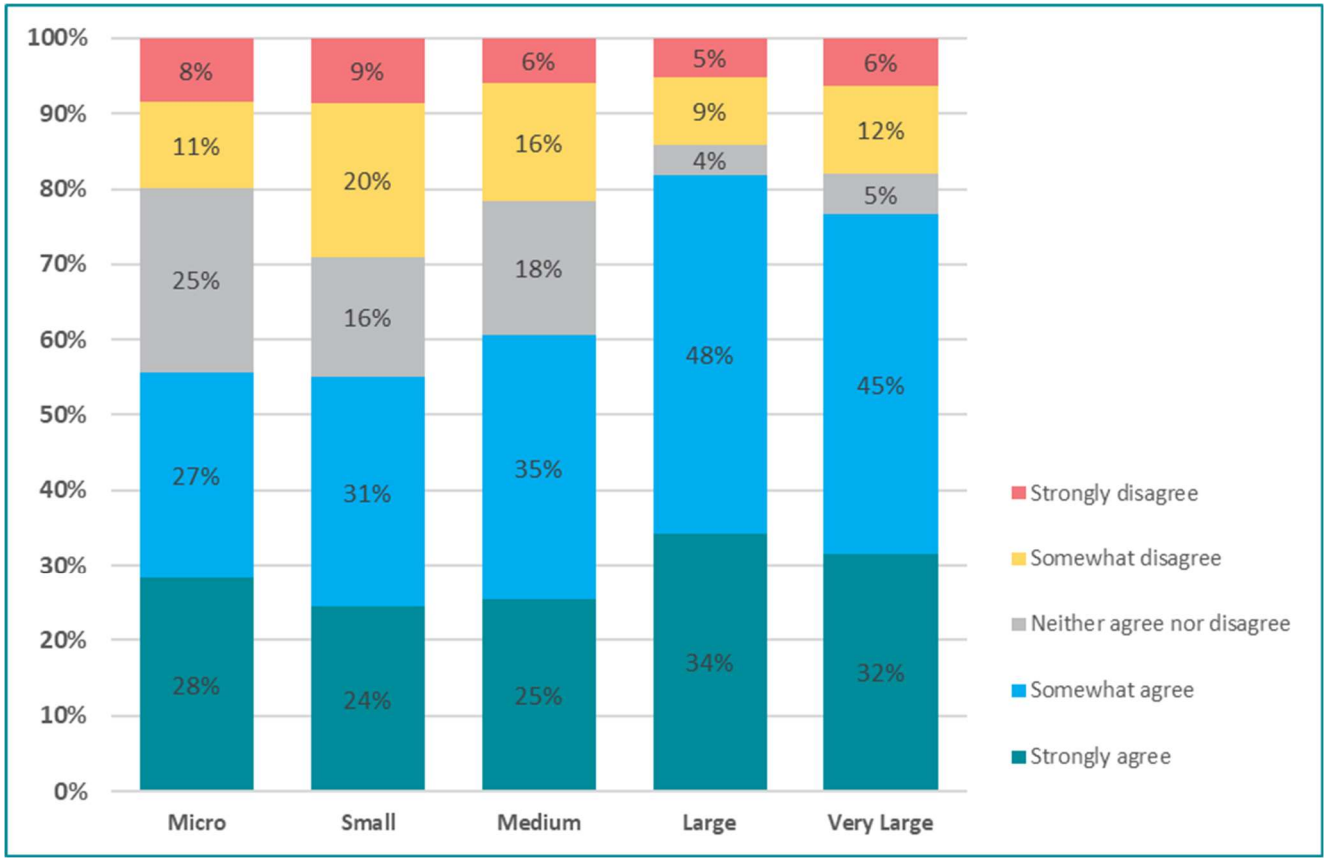
Figure 3: Does your organisation experience a net benefit from standardisation? (% of respondents by sector)



The extent to which respondents reported that standardisation benefitted their business differed across firm sizes: 85% of large firms with employees from 500-2,499 surveyed agreed that standards provided a net benefit to their business while around 55% of small and medium-sized enterprises (SMEs, with employee numbers below 250) surveyed responded in the same way. These are significantly higher than the numbers reported in the 2015 survey.

It is important to note that standardisation benefits small firms as well as large ones. Additionally, it seems that standards do not bring comparably more benefits for very large firms, comparing the impact on firms employing more than 2,500 people with smaller but still large firms.

Figure 4: Does your organisation experience a net benefit from standardisation? (% of respondents by employee size)



3.4 How do standards contribute to business productivity and efficiency?

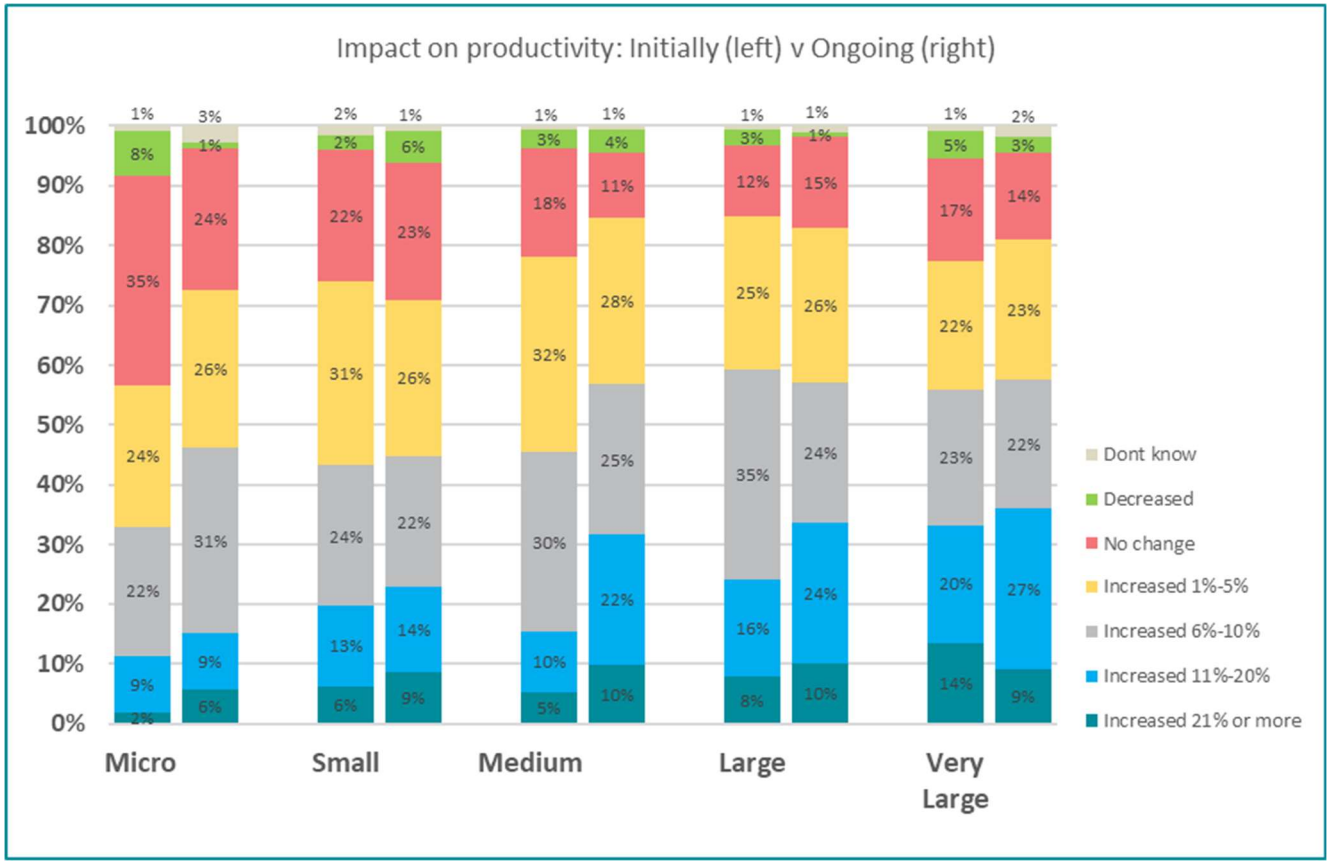
The gains that arise from standards described in the previous subsection are the result of higher productivity and more efficient operations, amongst other factors. With competitive markets squeezing the profit margins of many businesses, firms are finding it increasingly important to identify ways to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

The survey shows that 78% of all respondents stated that they had experienced an initial increase and 81% an on-going increase in productivity as a result of standardisation compared with 36% giving a positive response to a slightly different question on productivity in the 2015 report.

The survey results revealed that higher productivity as a result of standards varied between smaller and larger companies. In particular, 80% of large firms reported a significant overall increase in productivity as a result of standards, in comparison to 63% for SME firms. Both numbers are larger than those in the 2015 report (although the question in 2015 was slightly different). For most firms, especially micro firms, the increase in productivity is more evident after the initial year of meeting/use of standards.

The survey also sought to identify the mechanisms behind the impact of standards on productivity and efficiency. 67% of firms indicated that costs of production went up as a result of standards, but 76% indicated that they could charge higher prices. These answers do not significantly vary by size of firms.

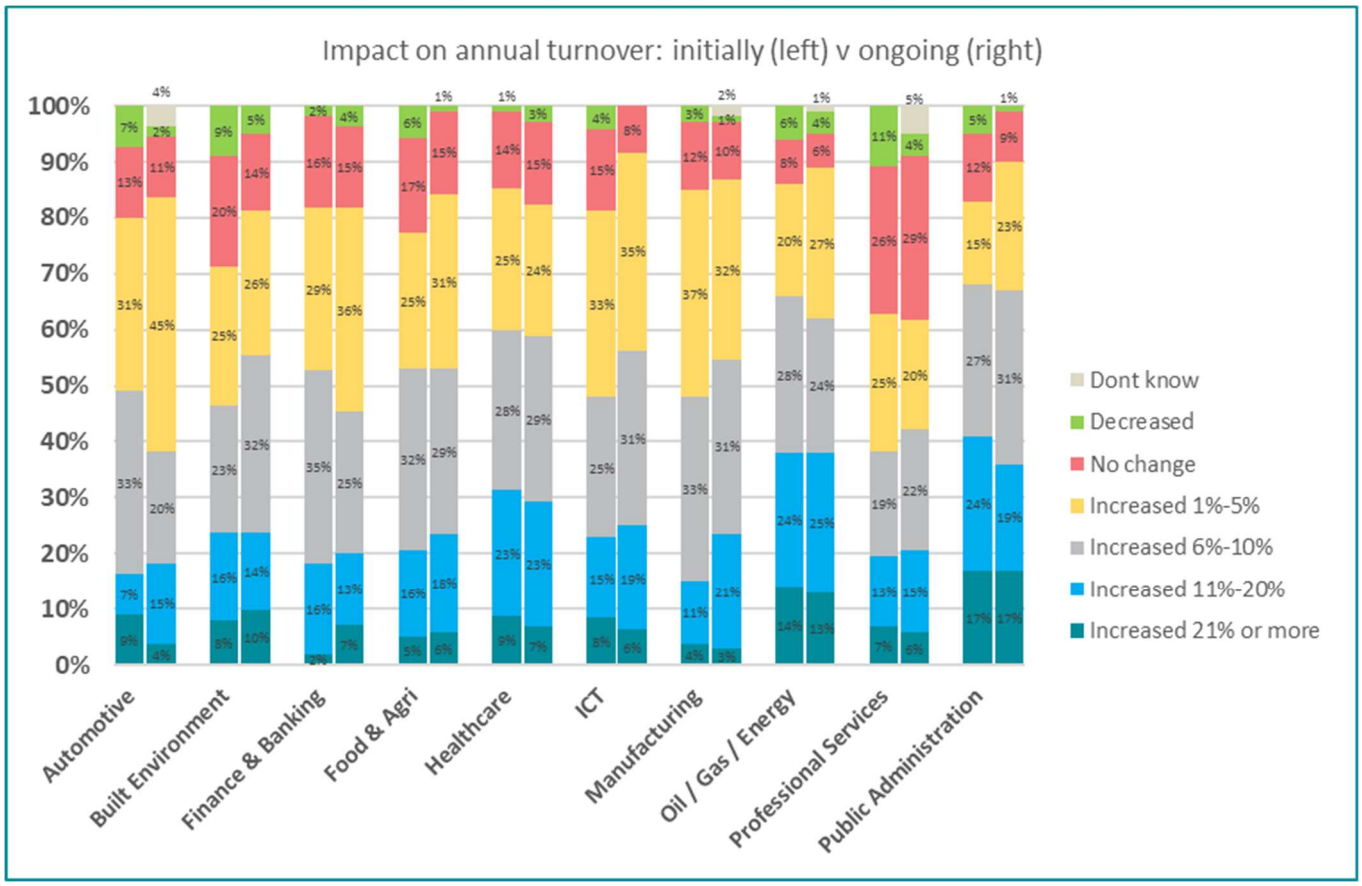
Figure 5: Do standards increase productivity? (% of respondents by size)



3.5 Impact of standards on turnover

The survey asked a question about turnover after meeting/adopting standards differentiating between initial and ongoing impact. The results showed that 78% of all firms benefited from an increase in revenues of at least 1% per year as a result of initial standardisation and 82% report an on-going benefit. Part of this might be the higher prices referred to above. These results are shown by sector in Figure 7.

Figure 6: How has the use of standards impacted your organization's annual turnover?

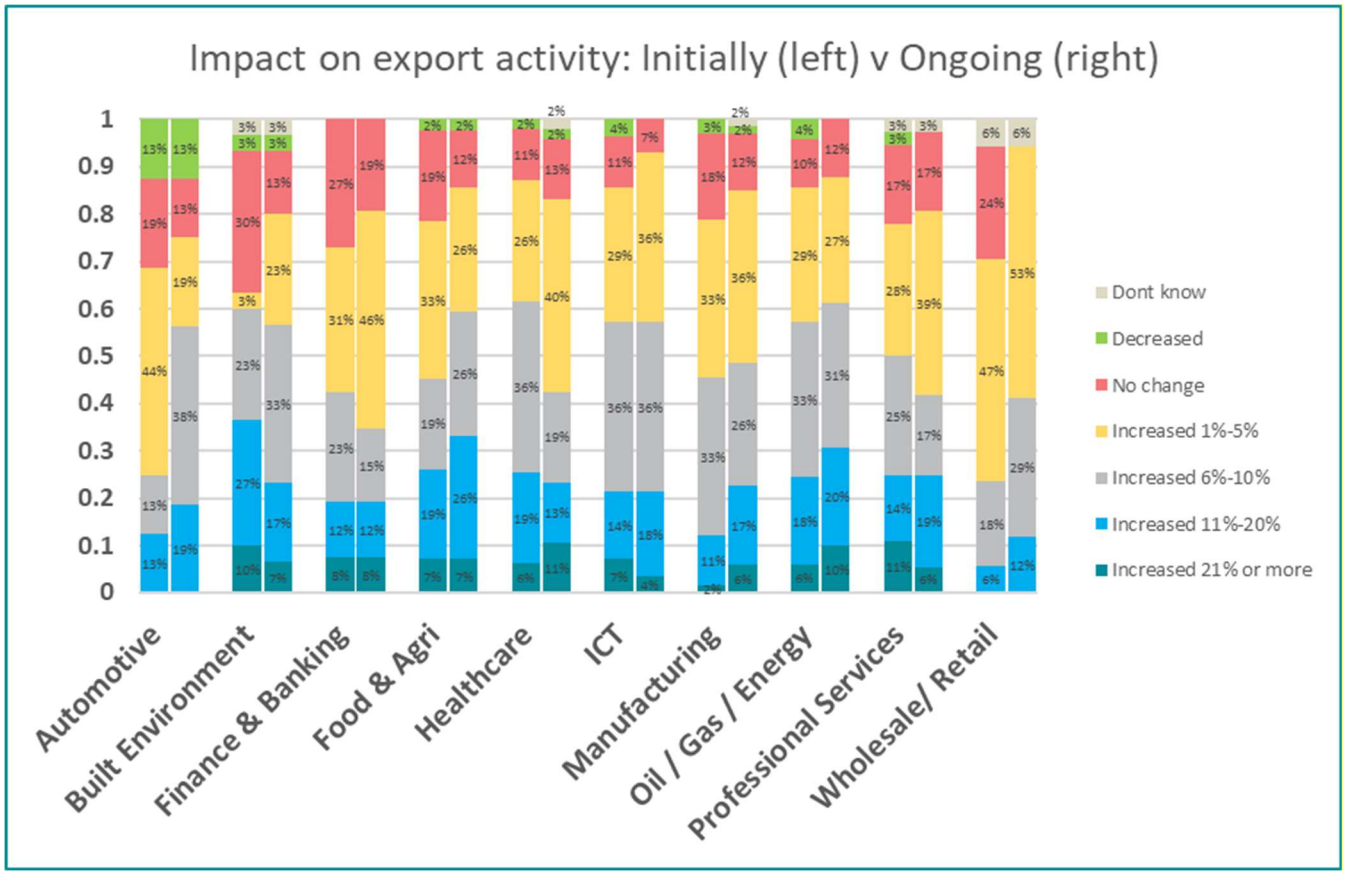


3.6 Impact of standards on exports

Of the companies surveyed, 40% (48% in 2015) indicated that they were active exporters, although this differed substantially between sectors.

Perhaps unsurprisingly, the sectors that observed the biggest increase in exports attributable to standards (see Figure 8) were also those where a higher proportion of companies were exporting (healthcare, finance, ICT, energy, and retail).

Figure 7: Increase in exports revenue that can be attributed to the use of standards



3.7 Impact of standards on GVA

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.[9]

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, standardisation contributed to an aggregate increase in GVA of £11.9 billion per year initially, and £16.9 billion per year later, equivalent to 0.60% and 0.85% of the

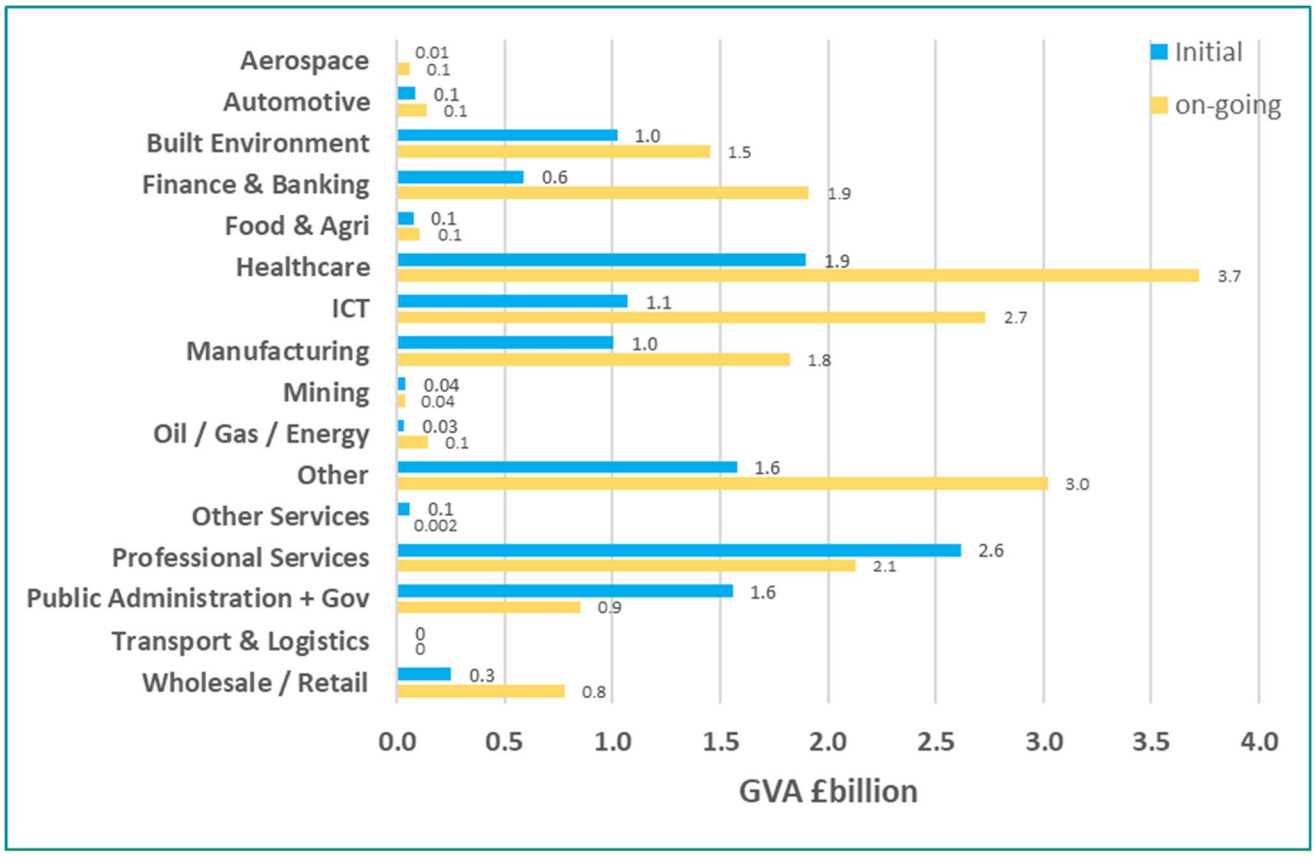
[9] Increases in revenues were calculated using survey responses and official data. Survey responses were scaled by the official business population of each industry (using ONS UK Business population statistics) and applied to official sector revenue data (from the ONS Supply- Use Tables 2018 and ONS GDP (O) Low Level Aggregates 2020). This ensured that findings relating to the aggregate increases to 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 2020 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 in the sample.

aggregate GVA of all industries in 2019. The numbers are higher than 0.42% (£6.9 billion) overall reported in the 2015 report.

- Overall, the health care industry observed the largest increases in GVA as a result of standardisation, equivalent to almost £1.9 billion per year initially, and £3.7 billion per year on going (see Figure 16).

- Firms within finance, construction, manufacturing, ICT, and professional services also observed large rises in GVA as a result of standardisation: equivalent to £1.5 billion to £3.0 billion respectively per year for each sector. Also, the on-going GVA increase is usually larger than the initial increase.

Figure 8: Estimated increase to GVA of industries as a result of standards (£ billions)

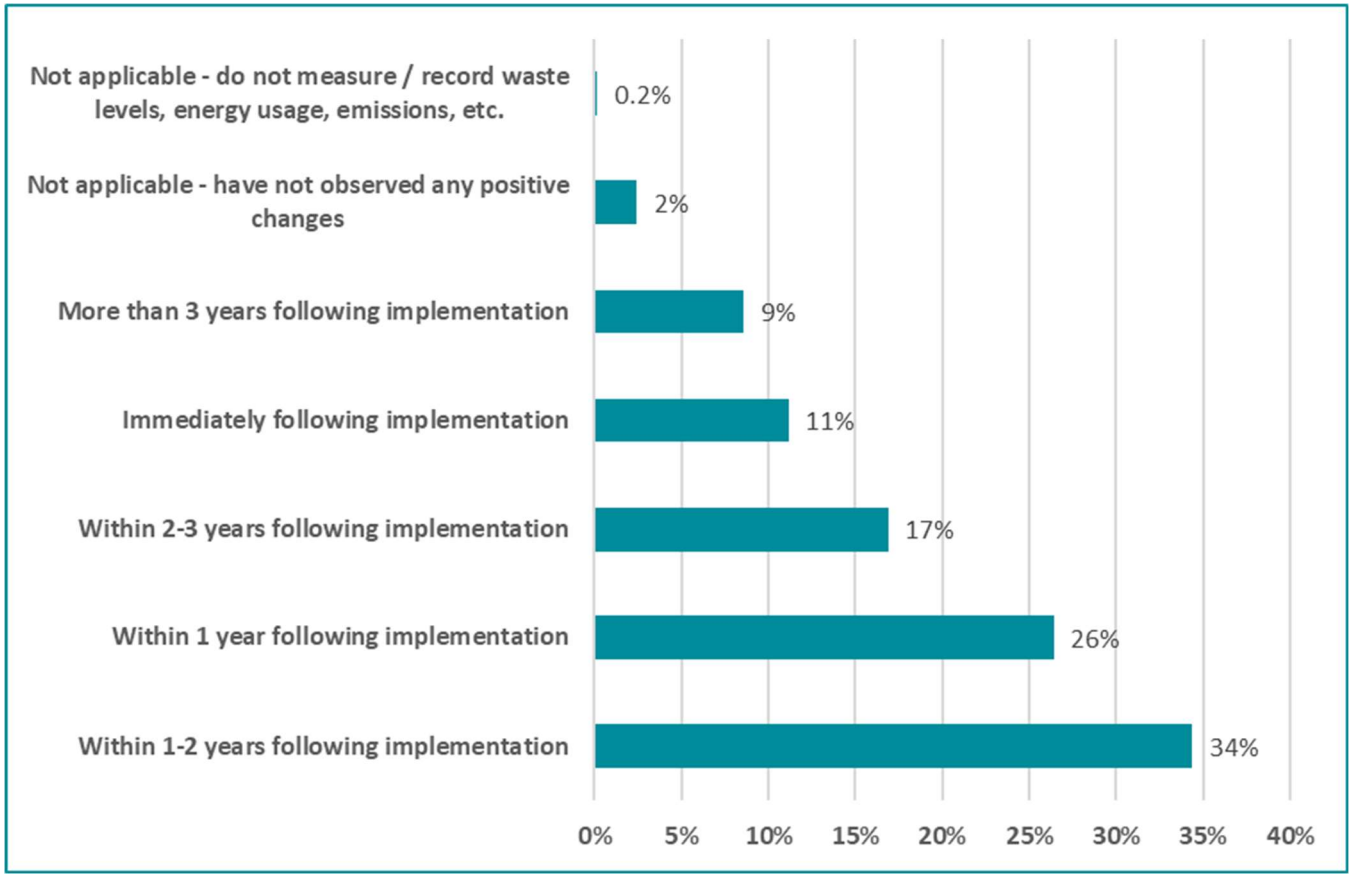


3.8 Environmental effects of standards

Environmental management is another important area where firms 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 89% (73% in 2015) of companies that use environmental standards found that standards generate an impact (i.e., having an effect within 3 years) over environmental problems (Figure 10).

Figure 9: When do environmental standards have an effect?



4 Modelling the economic impact of standards

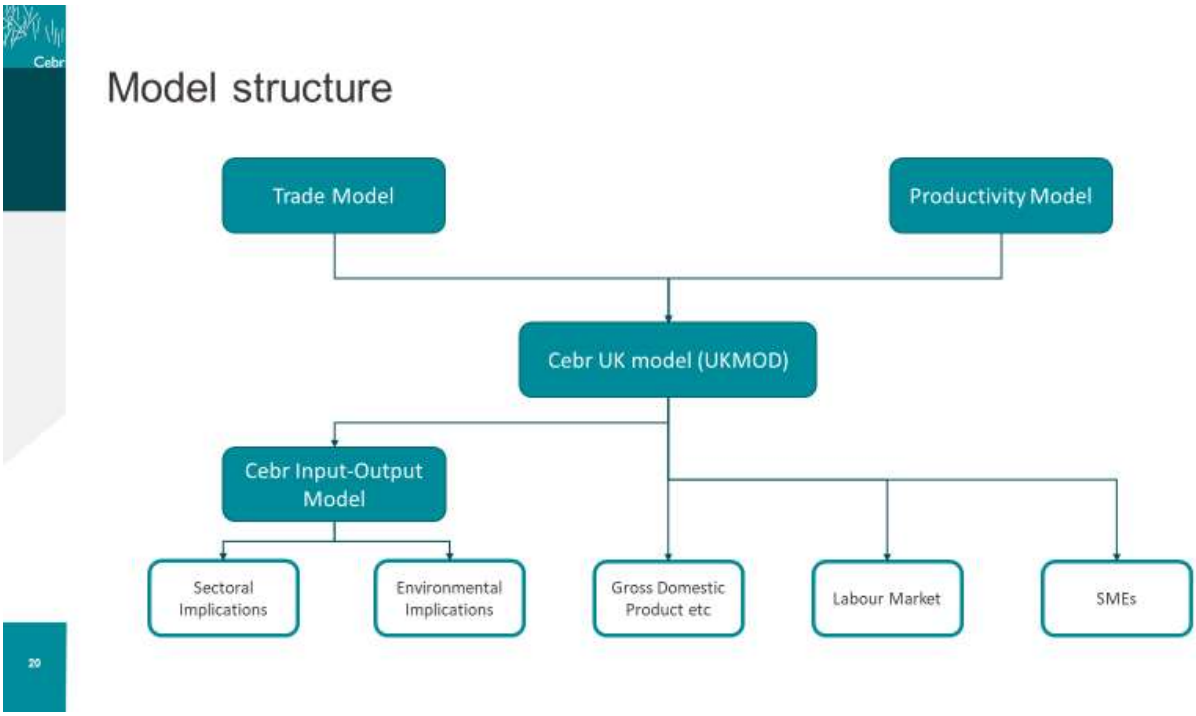
4.1 Introduction

This section gives an overview of the methodology used to integrate the results of the research described above into a modelling framework to give quantified results.

4.2 Overview

Figure 28 below shows the total model structure.

Figure 10 The macro modelling structure



The 'exogenous' inputs come from the trade model described below and the productivity model also described below.

These produce outputs that become inputs to 'shock' UKMOD which is Cebr's UK model. This model gives outputs for the main macro impacts for GDP, its components, inflation, the labour market, public finances, interest rates etc.

These are in turn fed into Cebr's input output model which gives the implications for each of over 100 sectors.

The sectoral results plus a separate environmental analysis provide the environmental results.

And the impact on SMEs is derived partly directly from the UKMOD results and partly from the sectoral analysis from the input output results.

4.3 The trade model

Cebr's thinking on how standards fit into international trade is based on our modelling of this trade. We have used this modelling to assess the impact of various frictions in international trade and it has provided many useful insights. For a fuller description of our approach to international trade using agent-based modelling (ABM) please see Cebr's report 'An agent-based model of trade: market distortions and output'[10]. Agent-Based Models (ABMs) situate agents – such as consumers and firms – within an environment that may be physical, or network based (or both) and allow these agents to interact with each other and their environment. Such modelling frameworks have a natural application to the economics of trade.

Cebr has used the thinking in the agent-based model of trade to model and estimate the potential impact of smart ledgers (blockchain) on international trade[11]. The impact of standards is analogous to that of a reduction in transactions costs such as would emerge from smart ledgers, although the impact of standards is of a different order of magnitude.

Under this model, standards affect international trade in two different ways. The first is a straight forward door opening effect. Some trade simply isn't possible without adherence to international standards. The second uses standards as a way of conveying information which reduces the information frictions associated with trade. Cebr's agent-based modelling is a technique for estimating how trade frictions affect trade volumes. Armed with this, we can then calculate how different levels of knowledge can reduce these frictions and hence how standards, which create such knowledge, will affect trade.

Applying the analysis to our data on trade

The analysis in this section and the worked examples in Appendix 4 can be used to make an estimate of the benefits of standards to trade.

We have three sources of information to apply:

- The agent based modelling
- The results of the literature search; and
- The results of the survey.

The agent based modelling

The implication of Cebr's agent based model is that improved information, of the kind that is provided by standards is likely to boost trade (output here is in practice a synonym for trade) by 6% for a relatively small increase in information and by about 25% for significant improvements in information.

So if this is the total impact of standards, it implies a boost to exports from one year's increase in standards of between 0.26% and 1.1%. This is a wide range and needs refining which is why we have cross checked it against the other sources of data.

[10] *An agent-based model of trade: Market distortions and output'* Cristian Niculescu-Marku and Shanker Singham, Cebr report for IEA. February 2019

[11] https://www.longfinance.net/media/documents/Economic_Impact_Of_Smart_Ledgers_On_World_Trade.pdf The Economic Impact Of Smart Ledgers On World Trade The Economic Impact Of Smart Ledgers On World Trade Douglas McWilliams Cristian Niculescu-Marcu Beatriz Cruz April 2018

The literature search

The analysis of the impact of standards on trade in Appendix 4 quotes the Banque de France's survey of standards harmonisation impacts. These quantify the impact of harmonisation of standards as the equivalent of a tariff reduction of 2.1%[12].

Cebr's own study for BSI on the secondary benefits for the UK of China adopting international standards suggested that such an eventuality would shift the demand curve for UK exports by 0.17% and also improve the terms of trade by 0.19%.

The 2021 survey

The results on exports for the 2021 survey are shown in Section 3.6. Weighting for each sector's share of exports, we estimate an average boost to exports of 15.5% for the totality of standards.

So our estimate of the impact of the change in standards for an average year (an increase of 4.3%) is that it boosts exports by 0.67% (= 0.043*15.5%).

The total impact

Using the agent based modelling analysis, it is clear that the impact of standards is not just that of boosting exports. The improvement in the flow of information is more like the impact of a tariff reduction, improving the terms of trade as well as boosting trade. We have therefore used for our analysis:

An assumed shift in the export demand curve of 0.67% boosting the level of exports for a given level of global demand and relative prices based on the results of the 2021 survey; and

An improvement in the terms of trade of 0.76%, scaling from the analysis in the secondary benefits study by the relative boosts to the exports (=0.19*0.67/0.17).

These numbers are then input to 'shock' the macroeconomic model to derive the total estimated impact of standards.

4.4 Estimating the impact of standards on productivity

This section translates the results of the literature review and the survey into a quantified estimate of the impact of standards on productivity.

The literature review

The literature review in Appendix 3 specifically addresses the impact of standards on productivity. It concludes:

'The message is that a 10% increase in the stock of standards can be associated with

- *0.5%-1.1% increase in labour productivity,*
- *or 0.32%-0.71% increase in total factor productivity (using the capital share 0.351 estimated from the 2015 study).*

[12] https://publications.banque-france.fr/en/no-double-standards-quantifying-impact-standard-harmonization-trade#:~:text=We%20find%20that%20the%20impact,to%20standard%20harmonization%20every%20year.

- *Keeping everything else constant, a further increase of 10% of the stock of standards (that can deal with the same amount of economic problems found in the previous studies) can be associated with a further GDP increase of £6.95-£15.42 billion (in 2019 £)'.*

The survey

The results of the questions in the survey on productivity are set out in Section 4.4. We estimate that this implies that standards raise productivity by 6.9% on average. This compares with the estimate that a 10% increase in standards would boost labour productivity by 0.5% to 1.1%, implying that the full impact is 10 times larger at 5.0-11.0%. As the 6.9% estimate is well within this range it seems sensible to use it as a base.

Combined impact

We have therefore calculated our impact productivity by using the survey results. These show the total of standards raising productivity by 6.9%. This implies that one year's increase in standards raises productivity by 4.3% times 6.9% which gives 0.3%. We have therefore 'shocked' our macro model by a 0.3% boost to productivity.

5 The macro modelling results

5.1 Introduction

This section shows the results of the macro modelling which generates the main outputs of the study.

It starts by describing Cebr's UK model which is used for the simulation. It then describes how the model is 'shocked' to produce the simulation results.

Finally it describes the results obtained from the simulation.

5.2 Cebr's UK macro model

The heart of the modelling system is Cebr's UK macro model which produces the key economic results which are then fed into the other models.

Cebr's macro model is used to provide the forecasts for the subscribers to the Cebr Prospects Service. In addition, the same forecasts are provided to the official UK Passenger Demand Forecasting Panel.[13] Cebr won the 'beauty contest' to be the macroeconomic forecast providers to this panel 8 years ago and has consistently won the retenders since then. Cebr's forecasts based on the macro model have been officially recognised and published in HM Treasury's comparison of external forecasts for nearly 30 years.

Our results will come from 'shocking' the model with the outputs from the productivity model and the trade model and then comparing the 'shocked' results with the 'pre-shocked' results.

Model Structure

The model is based upon the familiar national accounting framework. It uses the standard ONS data. We do not provide the coefficients here for intellectual property reasons.

The equations are set out in Appendix 5.

Shocking the SMM

When the equations for the SMM are programmed, the theoretical form:

A = f(B, C)

is programmed as:

$A = f(B, C) + \varepsilon_{At}$ where ε_{At} is the error term for variable A for period t. The 'shock' involves adding a series of estimated values to ε_{At} to reflect the impact of the 'shock' for the period for which it lasts.

The model will calculate a series of differences tables for all the key macro variables mentioned above comparing the values pre shock with the values post shock. This is the estimated impact. So if the pre shock value of GDP is 100 and the post shock value 105, the table will show an effect on GDP for the relevant time period of 5.

The model produces annual results to 2035. We have applied the 'shock' in 2021.

13 This is the official transport forecasting panel for the UK comprising all the main transport providers, TfL and the Department for Transport.

As pointed out in the previous two sections, the model is shocked in three areas:

1) An assumed shift in the export demand curve of 0.67% based on the results of the 2021 survey;
2) An improvement in the terms of trade of 0.76%, and
3) A 0.3% boost to productivity.

We have fed all these changes in to the model starting Q3 2021. The effects feed in over a year.

5.3 The simulation results

The results of the simulation are shown in Table 6 to Table 9.

It is important to note that these show the impact of just one year's accretion of standards. So to find the total impact one needs to cumulate the impact of a year's standards happening every year.

Table 6 shows the impact of one year's accretion of standards on the components of demand. The most important result is the impact on GDP. In the 5th year the impact on GDP is to boost it by 0.4%; in the 10th year by 0.5% and in the 15th year by 0.8%.

The reason that some of the effects take so long to work through can be seen through their impact on investment shown in both Table 6 and in more detail in Table 7. There is an initial impact where investment is boosted by 0.6% in the second year. This effect doubles to 1.25% by the 7th year. But then it builds up rapidly to a boost of 3.5% by the 15th year. It is normal to expect investment to lag an economic change[14]. Meanwhile exports are boosted fairly immediately but the impact then remains fairly constant, starting to tail off in the out years.

And consumers spending is boosted but only by just over 0.1%.

Table 1 Simulation results for the components of demand – percentage change from base

	Consumers' Expenditure	Government Consumption	Fixed Investment	Domestic Demand	Exports G&S	Imports G&S	GDP at Market Prices
2021	0.00	0.00	0.18	0.03	0.70	0.12	0.20
2022	0.12	0.00	0.60	0.18	0.70	0.26	0.32
2023	0.11	0.00	0.67	0.19	0.70	0.25	0.34
2024	0.10	0.00	0.70	0.20	0.73	0.22	0.36
2025	0.10	0.00	0.81	0.22	0.75	0.21	0.40
2026	0.11	0.00	0.98	0.26	0.77	0.21	0.44
2027	0.12	0.00	1.13	0.29	0.76	0.25	0.45
2028	0.11	0.00	1.25	0.31	0.74	0.29	0.45
2029	0.11	0.00	1.43	0.34	0.69	0.35	0.45
2030	0.11	0.00	1.72	0.40	0.63	0.45	0.47
2031	0.11	0.00	2.09	0.49	0.58	0.57	0.50
2032	0.11	0.00	2.51	0.60	0.53	0.73	0.55
2033	0.12	0.00	2.96	0.73	0.48	0.95	0.60
2034	0.12	0.00	3.54	0.93	0.44	1.26	0.70
2035	0.13	0.00	4.11	1.12	0.41	1.58	0.80

[14] This is a standard economics result. The original definitive journal article on the subject is 'Lags Between Investment Decisions and Their Causes' By Shirley Almon The Review of Economics and Statistics Vol. 50, No. 2 (May, 1968), pp. 193-206 (14 pages)

Table 7 disentangles the components of investment that are boosted. It shows that the biggest impacts are on the business sector where the impact builds up to nearly a 5% boost and on public corporations where the impact is assessed to be nearly as strong as the impact on the business sector.

Table 8 shows the impact of the simulation on jobs. Initially the impact on productivity is assessed as net reducing jobs but ultimately the improved competitiveness means that after 5 years the net impact on jobs is positive and by 15 years is a gain of 0.34%. The way the model works is that it solves to hit an inflation target of 2% (see the results of Table 9 which show that after an initial cut in prices, the scale of the cut remains constant, implying an unchanged rate of inflation).

This in effect means a minimal net impact on unemployment, so the gains in employment largely come from an increase in the proportion of population in work.

The other impact shown in this table that might be of interest is that the boost to employment is much stronger in the manufacturing sector than in the non-manufacturing sector. This reflects the manufacturing sector's greater exposure to trade and to investment.

Table 2 Simulation results for the components of investment – percentage change from base

	Intangible Fixed Assets	Private Dwellings	Business sector	Total Private Sector	General Government	Public Non-Financial corp	Total Fixed Investment
2021	0.04	0.00	0.29	0.22	0.00	0.22	0.18
2022	0.16	-0.01	0.96	0.73	0.00	0.73	0.60
2023	0.30	-0.03	1.00	0.79	0.00	0.79	0.67
2024	0.41	-0.03	0.99	0.81	0.00	0.81	0.70
2025	0.50	-0.03	1.13	0.93	0.00	0.93	0.81
2026	0.60	-0.03	1.36	1.12	0.00	1.12	0.98
2027	0.69	-0.03	1.56	1.29	0.00	1.29	1.13
2028	0.76	-0.03	1.70	1.41	0.00	1.41	1.25
2029	0.81	-0.02	1.94	1.61	0.00	1.61	1.43
2030	0.85	-0.02	2.29	1.91	0.00	1.91	1.72
2031	0.89	-0.02	2.73	2.30	0.00	2.30	2.09
2032	0.95	-0.02	3.23	2.73	0.00	2.73	2.51
2033	1.01	-0.02	3.75	3.20	0.00	3.20	2.96
2034	1.10	-0.02	4.36	3.77	0.00	3.77	3.54
2035	1.19	-0.02	4.97	4.34	0.00	4.34	4.11

Table 3 Simulation results for the employment – percentage change from base

	Manufacturing	Non-Manufacturing	Employees in Employment	Other Employment	Employed Labour Force
2021	0.27	-0.41	-0.32	-0.30	-0.32
2022	0.34	-0.22	-0.15	-0.14	-0.15
2023	0.36	-0.17	-0.11	-0.11	-0.11
2024	0.38	-0.15	-0.09	-0.09	-0.09
2025	0.41	-0.10	-0.05	-0.05	-0.05
2026	0.45	-0.05	-0.01	-0.01	-0.01
2027	0.47	-0.03	0.02	0.02	0.02
2028	0.49	-0.03	0.02	0.02	0.02
2029	0.51	-0.03	0.02	0.01	0.02
2030	0.53	-0.01	0.03	0.02	0.03
2031	0.56	0.02	0.06	0.05	0.06
2032	0.60	0.07	0.11	0.10	0.11
2033	0.65	0.13	0.16	0.15	0.16
2034	0.72	0.22	0.25	0.24	0.25
2035	0.79	0.32	0.34	0.33	0.34

Finally, Table 9 shows the impact on prices and interest rates. The price level is reduced by close to 0.4%, reflecting the improvement in the terms of trade and also the boost to productivity. As a result interest rates are slightly lower – the Treasury bill rate is lower by 0.03 percentage points (three basis points).

Also shown in Table 9 is the impact on public borrowing. It can be seen that in the initial years the effects are not large, partly because of the impact of lower inflation. But as the beneficial economic impacts build up, they get reflected in tax revenues (mainly income tax) and by the 15th year public finances are £14 billions per annum better off.

5.4 Conclusions

The results in these tables show the scale of the macroeconomic benefits emerging from each year's changes in standards.

There are gains to exports, investment and GDP.

There are gains though lower prices and interest rates.

Employment is ultimately higher despite an initial negative effect from higher productivity.

And public borrowing is lower.

Table 4 Simulation results for inflation and interest rates actual difference (not percentage)

	Consumer Price	Retail Price Index	Treasury Bill	Base Rates	Reduction in Borrowing
2021	-0.19	-0.19	-0.01	0.00	0
2022	-0.42	-0.41	-0.03	-0.01	-644
2023	-0.39	-0.37	-0.03	-0.01	-33
2024	-0.38	-0.36	-0.03	-0.01	108
2025	-0.38	-0.36	-0.03	-0.01	-399
2026	-0.37	-0.35	-0.03	-0.01	221
2027	-0.37	-0.35	-0.03	-0.01	452
2028	-0.36	-0.35	-0.03	-0.01	732
2029	-0.37	-0.36	-0.03	-0.01	968
2030	-0.37	-0.37	-0.03	-0.01	1,253
2031	-0.38	-0.38	-0.03	-0.01	1,788
2032	-0.38	-0.38	-0.03	-0.01	2,888
2033	-0.38	-0.39	-0.03	-0.01	4,908
2034	-0.38	-0.39	-0.03	-0.01	8,066
2035	-0.39	-0.40	-0.03	-0.01	13,997

6 The input output model results

6.1 Introduction

We have used input output modelling to estimate the impact on sectors, on SMEs and on the environment. This section describes the approach and the results.

6.2 Input output modelling

Input output modelling is a powerful form of economic analysis that is widely used to show how the economy works.

What such modelling demonstrates is the extent of the supply chains in the economy, showing how each sector employs not only labour and its own buildings, tech and machinery but also inputs from its own and other sectors[15].

For the UK the input output tables for the economy split it into 104 sectors (listed in Appendix 6) which show how the outputs of each sector either become final consumption or else become the inputs to another sector.

For the modelling of the impact of standards we use the results of the macro simulation described in the previous section and specifically the impact on the components of demand shown in Table 6 to show how changes in these components of demand affect each of the 104 sectors. This shows the direct economic impact of a year's change in standards on each sector.

But the sectors are themselves impacted by standards to a different extent as is clearly shown from the results of the survey. So to get the full impact of a year's accretion of standards on each sector, we have to factor in a direct impact from standards. To prevent double counting the impact of standards we incorporate this by scoring each sector relative to the average based on the results of the survey.

So the estimated impact of standards for each sector is:

Direct impact of standards for sector *plus* modelled impact from I-O model *minus* average impact for whole economy.

This gives us our total sectoral results for the impact of a year's accretion of standards.

We then use this to drive two different further analyses.

The first is the environmental impact. First we measure the environmental impact of each sector, using the sectoral results from the input output model and the environmental coefficients from the UK environmental accounts. This gives the impact of the change in the volumes of each sector. But obviously this does not pick up the direct impact of improving standards in each sector on the environment. To find this we separately measure the direct environmental impact by sector scaling by using the survey results. The total impact measures the environmental impact.

[15] The full UK input output tables are produced by the ONS and are available on the web page: https://www.ons.gov.uk/economy/nationalaccounts/supplyandusetables/datasets/ukinputoutputanalyticaltablesindustrybyindustry

The second is the impact on SMEs. We first take account of the percentage of output covered by SMEs in each of the 104 sectors. And then again we adjust to take account of the differential impact of standards on SMEs.

The total impact shows the total impact of standards on SMEs.

6.3 Sectoral impact

Table 10 and Table 11 show the sectoral impacts of a year's accretion of standards listed by proportional and by absolute impact respectively for the top ten sectors affected in each way.

They both show that because the biggest economic impact of standards is on investment the two sectors at the top of these tables are the most investment intensive sectors of the economy - IT and construction. By comparison, consumer goods sectors are near the bottom of the list, although those items that are more liable to be exported generally do better than those that simply aim at the domestic market.

Table 5 Sectors listed by order of percentage impact from standards – top ten sectors (for impact on all 104 sectors see Appendix 6)

	Percentage	£ millions
Computer programming, consultancy and related services	1.6%	594
Scientific research and development services	1.4%	536
Computer, electronic and optical products	1.1%	161
Architectural and engineering services; technical testing and analysis services	1.1%	196
Real estate services on a fee or contract basis	1.0%	94
Legal services	1.0%	119
Construction	1.0%	1600
Other chemical products	0.9%	37
Weapons and ammunition	0.8%	7
Services of head offices; management consulting services	0.8%	200

Table 6 Sectors listed by order of their total absolute impact– top ten sectors (for impact on all 104 sectors see Appendix 6)

	Percentage	£ millions
Construction	1.0%	1600
Computer programming, consultancy and related services	1.6%	594
Scientific research and development services	1.4%	536
Wholesale trade services, except of motor vehicles and motorcycles	0.5%	353
Financial services, except insurance and pension funding	0.5%	349
Services auxiliary to financial services and insurance services	0.8%	203
Services of head offices; management consulting services	0.8%	200
Architectural and engineering services; technical testing and analysis services	1.1%	196
Office administrative, office support and other business support services	0.7%	174
Insurance, reinsurance and pension funding services, except compulsory social	0.3%	162

6.4 Environmental impact

In the last few decades there has been an increasing focus on sustainable development and 'green growth', which seeks to balance economic growth with environmental protection. Sustainable development is defined as 'meeting the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development (1987). The ISO and its international standards are playing a prominent role in achieving environmental sustainability as countries look to move away from traditional forms of environmental regulation that can be inflexible and costly towards international voluntary frameworks that help to maintain industry competitiveness through rewarding innovation and fostering continuous improvement.

Our modelling of the impact of standards on the environment has to take into account the fact that standards lead to higher growth as well as the fact that they also lead to cleaner growth through more professional management and through reduced waste.

Our calculation here is that the impact on reducing the carbon intensity of growth is significantly greater than the impact on boosting growth itself.

The impact on emissions from boosting growth is only, at 0.2% for each year's accretion of standards, half the boost to GDP growth assumed (we used the figure of 0.4% to represent the average of the 5 year and 10 year impact).

Meanwhile we estimate that the boost to productivity in the use of resources cuts carbon emissions by 0.47% based on the modelling of the likely impact on productivity and allowing for the fact that the environmental savings are likely to be at the top end of the range.

So net, carbon emissions are reduced by 0.26% for each year's accretion of standards.

This figure may appear low. But it simply measures the ongoing impact of reduced waste and more professional management. What it does not take into account is the impact of government policy.

6.5 Impact on SMEs

In nearly all countries, SMEs constitute the majority of all enterprises – making up 99% of companies in USA and Europe. SMEs are the lifeblood of modern economies, being crucial for economic development at the local, regional and national level. SMEs are recognised as agents of innovation and productivity, and crucial vehicles for employment creation and economic growth, accounting for 80% of global economic growth. The churn of SMEs competition and entrepreneurs drives economic wide innovation and production, playing the 'seedbed and turbulence role'. SMEs are also important for the functioning of larger firms, generally acting as their suppliers.

Although the survey suggests that standards have a relatively smaller impact on small firms as shown in Figure 5 in Section 3, this is largely offset by the fact that the sectors most boosted by standards are sectors with a relatively high intensity of smaller firms[16] like construction and IT (see sectoral results in Tables 10 and 11).

We have defined SMEs as firms with 250 and fewer employees.

After weighting for the share of small firms in each of the 104 sectors we estimate that the boost to GDP of SMEs is 88% of that for the whole economy.

[16] Business Population Estimates for the UK and Regions 2020

7 Conclusions

7.1 Introduction

This report describes the results of a study to estimate the impact of standards on the UK economy. It comprises a literature search, a survey and economic modelling to calculate the impact of standards.

7.2 Results

The results of the study indicate the scale of the impact of standards.

We estimate that in total 23% of all UK GDP growth in the current century is attributable to the impact of standards and 38% of all productivity growth.

In addition standards boost employment, reduce prices and interest rates and lead to lower government borrowing.

7.3 New research

The report uses new primary research. The large sample research covers a wide range of firms of different sizes and sectors.

This new research indicates the substantial importance of standards not just in the domestic market but also in export markets and for sustaining a modern supply chain.

One of the striking conclusions of the research is that in addition to the economic benefits of standards, their role in other areas is becoming more important. We have found for example that 89% of all firms in our survey believe that standards lead to environmental improvements over the short term.

One of the other conclusions of the research is that the impacts of standards extend well beyond the industrial sector into a wide range of service sectors such as ICT, professional services and finance.

7.4 We have used a pathbreaking methodology

This report has used a pathbreaking methodology that combines a number of different approaches that Cebr have used in other areas of economics.

The areas which are novel are set out below:

1) **Using a macroeconomic model to combine the impacts of standards on trade and productivity**

This is the first time that a macroeconomic model has been used to evaluation the economic impact of standards. This allows for knockon effects to be evaluated, particularly those for investment and innovation.

We have used Cebr's macroeconomic model to incorporate the assessed impacts of standards on trade and productivity. This enables knock on effects to be estimated.

The particular benefit of this is that it shows how standards boost investment.

In addition it allows the impact on a wide range of macro-economic variables to be estimated such as consumption, inflation, public finances and interest rates.

2) Using an Input Output model to evaluate the impact by sector

This is the first time that the impacts of standards have been run through an input output model to evaluate their benefits on each of 104 sectors in the economy. Previous work on sectors has looked specifically at the individual sectors. Input Output modelling allows the impact of each sector on each other sector to be established.

This work is pathbreaking in looking at how a national policy might have differential sectoral effects. We see no evidence of this having been done anywhere before in any other country. The ability to compare the differential impacts on different sectors is a powerful tool for policy analysis.

3) Using agent based modelling to analyse the impacts of reduced trade frictions

Probably the most novel methodological breakthrough in the modelling suite that has been put together for this study is the use of agent based modelling (ABM) of trade frictions to analyse the impact of standards in reducing information frictions so that the impact of adoption of international standards on trade frictions based on information asymmetries can be estimated.

To our knowledge ABM has only occasionally been used to investigate trade related issues. And our literature search has found no previous approach to evaluating the impact of standards through estimating their impact in reducing information asymmetries. We strongly believe that this approach should be increasingly fruitful in progressing future research on the impact of standards, since a key element in our approach is that standards reduce information imbalances.

4) Modelling the environmental and SME impacts

Our methodology enables us to develop quantified estimates of not just the economic impacts but also certain social impacts such as the impact on SMEs and on the environment. Traditionally analysis and estimation of impacts of policies has focused mainly on the impact on GDP and occasionally household incomes and employment.

Our modelling suite enables us to develop submodels where we incorporate both information on directly estimated about impact on such measures (eg direct impact on emissions from adopting more efficient techniques) with the estimated impacts of the impacts of additional activity in particular sectors. As a result we can see the impact on labour markets, on the environment and on SMEs.

Appendix 1 Standards used in the British Economy

A1.1. Introduction

In this section, we present some background about standards used in the British economy. The appendix contains details of the data used.

A1.2. 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 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 standardisation in the UK economy as well as the demand for standards. One potential improvement is to look at "harmonisation" of standards, which are, for example, both used in the British economy and in other European countries (or in other areas of the world, classified as "international" 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 newly published standards up to the end of that year. This calculation is described by the equation in Figure 12.

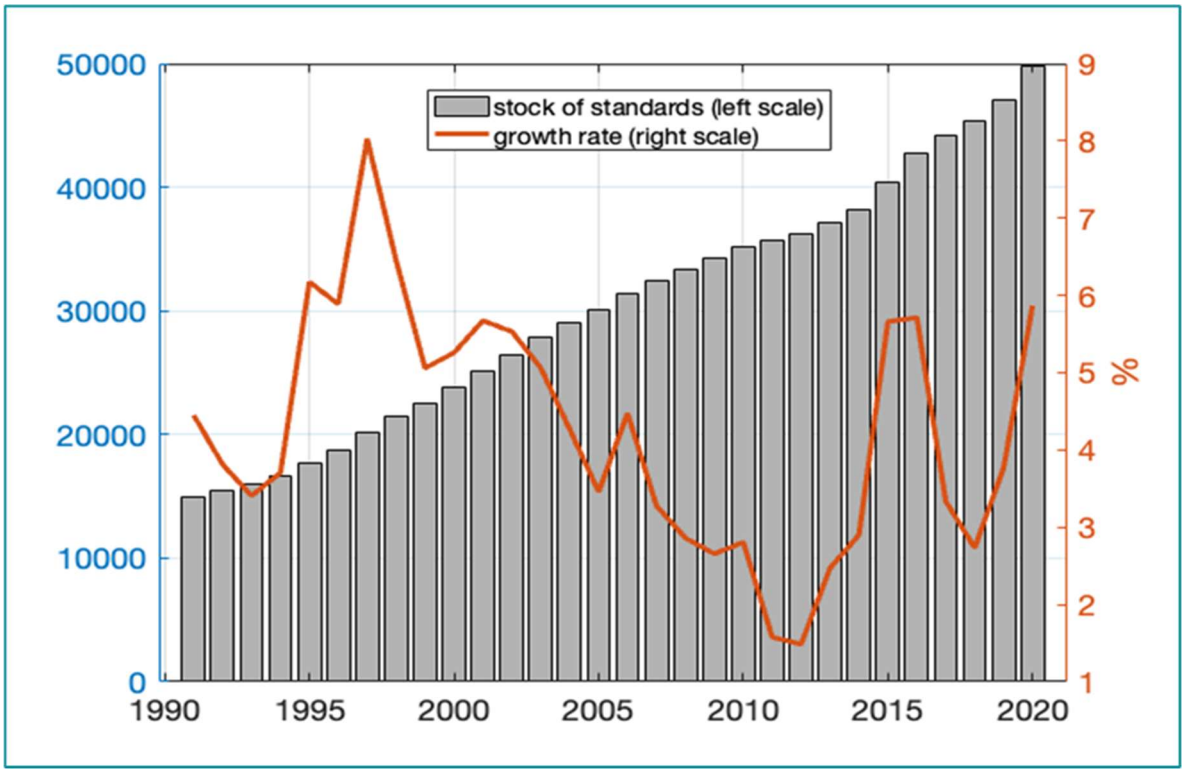
Figure 11: Equation for the net stock of standards

The measure has been constructed using data from the British Standards Online (BSOL) and Perinorm databases for the period 1991 to 2020. The 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. The BSI-CEBR report (2015) has more information prior to 1990 (and the data ends

in 2014). But an advantage of focusing on the period after 1990 is that the data about withdrawal for each standard is not missing and thus more accurate.[17]

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.

Figure 12: The stock of standards and the growth rate



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.

The BSI standards catalogue had less than 100 publications in 1920, and now it has about 50K. Between 1991 and 2020, the fastest pace of growth was observed in the first decade when the annual growth averaged 5.2%, 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 (to be discussed again later) contributing to relatively high annual growth for the period. Between 2001 and 2013, the pace of growth has slowed, averaging 3.5%, partly because the period starts from a higher base (see Figure 2).

[17] The 1990 stock of standards is from the BSI-CEBR (2015) estimate. Together with the updated number of new standards and the updated number of standards withdrawn in each year, we then construct our measure of stock of standards between 1991 and 2020.

However, the updated data suggests that the net stock growth (average 4.3%) picks up from 2014, though not as high as the first decade.

A1.3. A closer look at flows

The stock measure is a useful starting point. We also look at the contribution from new publication of standards, from withdrawal of standards, as well as from the net increase of standards. This flow view broadens the understanding compared to the 2015 report.

Figure 13: The evolution of standard publication: new, withdrawal, and net increase (in natural log)

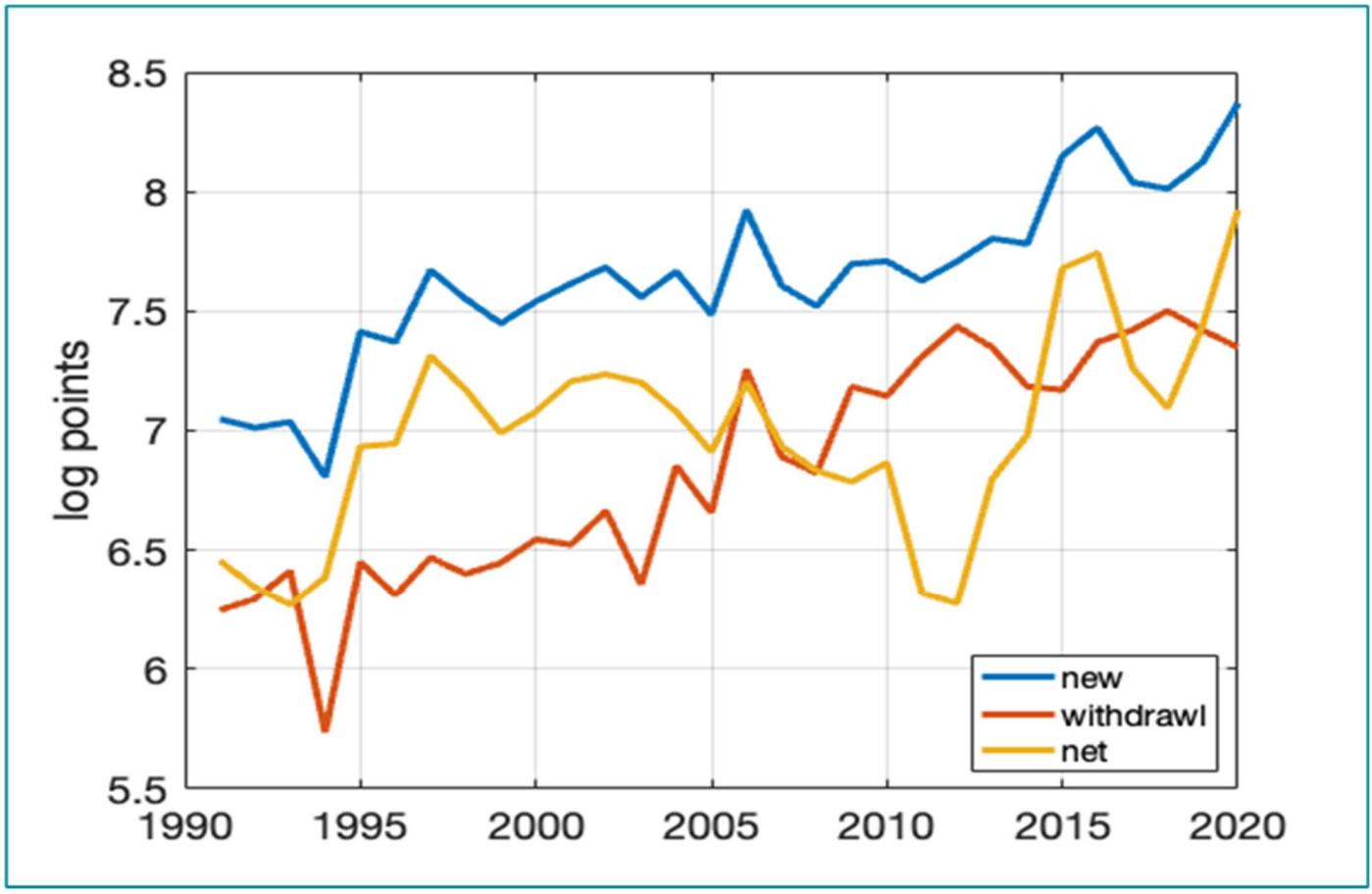


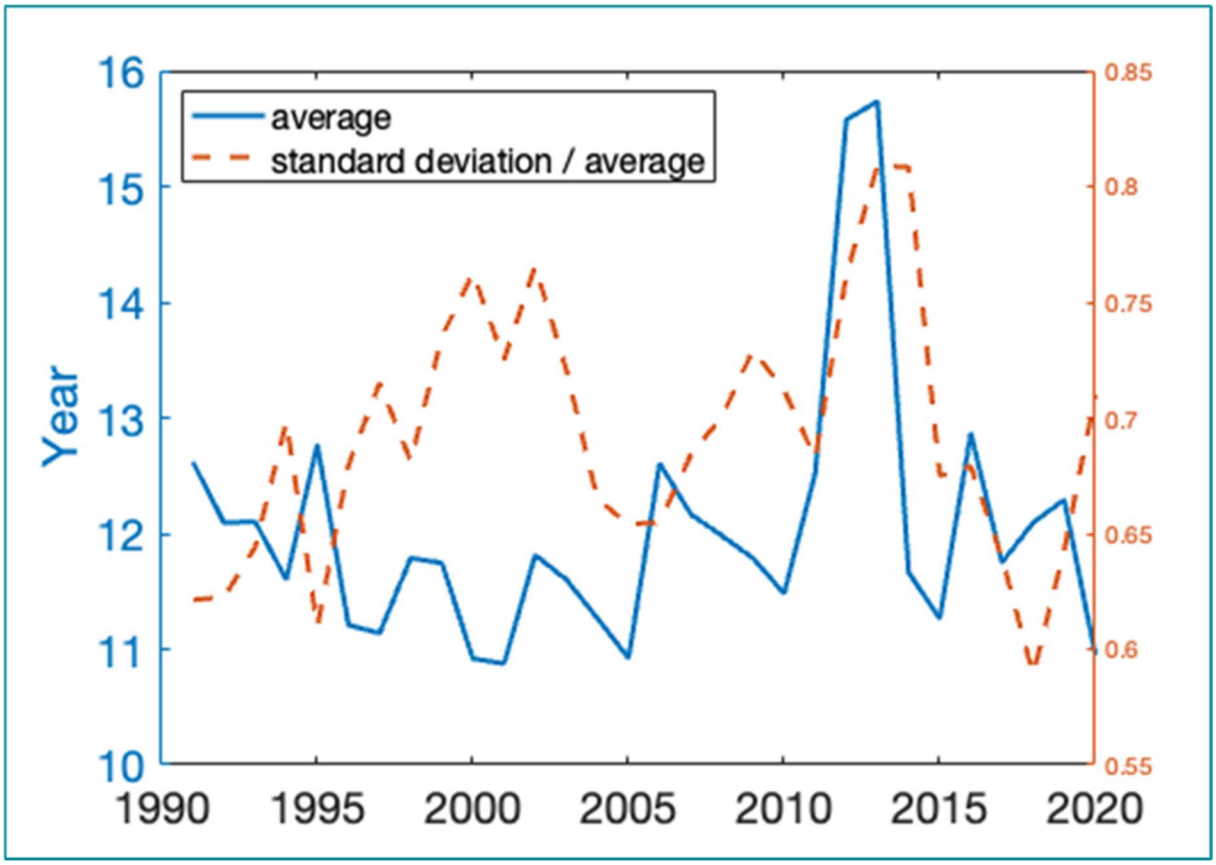
Figure 14 shows the number of publications of new standards, the number of the withdrawals of old standards, and the number of the net increase in standard, all in natural log. As explained before, the slope of each curve is approximately the growth rate (because the time series are plotted in natural log). As can be seen from the Figure, the large net increase in standards between 1995 and 2004 was mainly driven by the new publication (about 15% on average), while the withdrawals were relatively stable. This "hot period" saw large changes in information/electronic technology, and the structure of various sectors of the economy were experiencing significant transformation. From 2005 until 2013, the withdrawal grew at a fast speed while the new publication did not. As will be discussed below, many standards published in the "hot period" were likely withdrawn from 2011. Therefore, the growth rate of net increase in standards fell significantly.

Though we will be specific later about industry composition, it is natural at this point to notice that the pace of standards development in each industry, 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 15 shows the life-span information of standards withdrawn. That is, for each year (e.g., 2010), we look at the standards that were withdrawn, and we calculate the year gaps between this specific year (e.g., 2010) and the standards' original publication years (e.g., 2000). For each year, Figure 4 plots the average life span of those standards, as well as the standard deviation normalized by the average (commonly known as the coefficient of variation).

Most of the time, the average lifespan was roughly between 11 and 12.5 years. However, in 2012 and 2013, the average lifespans were significantly higher, 15.6 and 15.7 years, respectively. As discussed previously, there were overall more withdrawals in these two years; Figure 4 then implies that there were proportionally more old standards withdrawn, and many were first published around 1995 and likely related to standards of information/telecoms/electronics. In these two years, the high normalized standard deviations (around 82% of average) also confirm the fact that many old standards were withdrawn besides the usual withdrawals of standards that had been used for 11 to 12.5 years. As a comparison, the normalized standard deviations (around 75% of average) were also high around 2000, but this was mainly driven by withdrawals of younger standards.

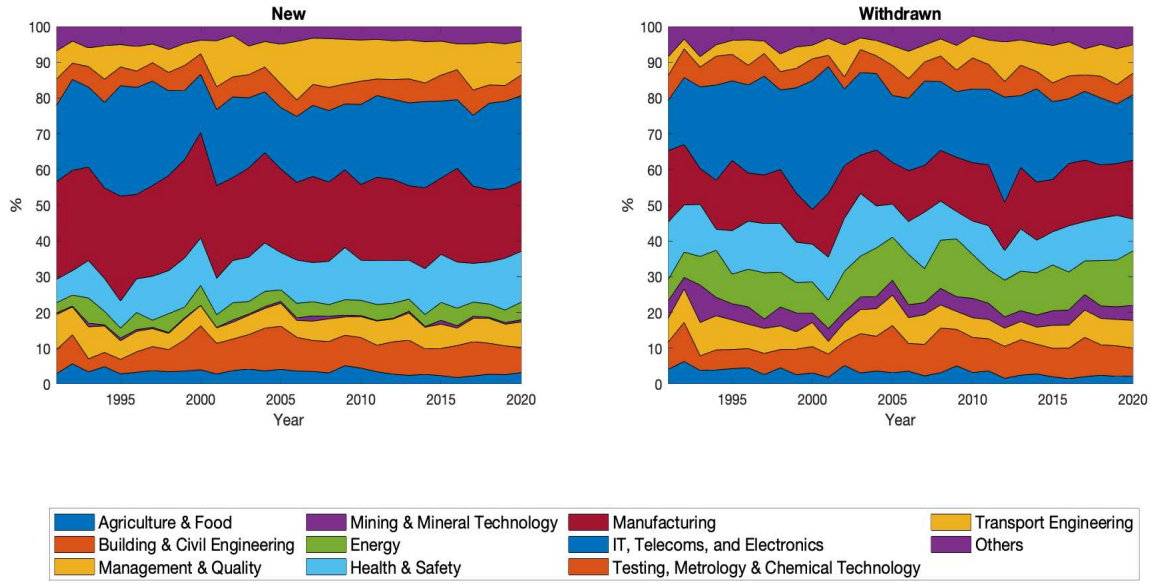
Figure 14: Years used when being withdrawn



A1.4. The composition of standards

The composition of standard catalogue over the past three decades has changed to adapt to shifts in the structure of the UK economy. An examination of 10 important aggregate groups/sectors of standards (Figure 16) demonstrates how some fields have become more important in terms of their share of standards published in each year, while others have declined in significance. We also look at the standards withdrawn for these sectors in each year, giving us a better understanding compared to the 2015 report.

Figure 15: Composition of the BSI Standards Catalogue (by aggregated ICS fields)



Since 1990, the proportion of manufacturing standards in the catalogue has declined from 27.3% to 19.6%. This is similar to what was in the 2015 report, though with some small difference in the definition. The IT, telecoms, and electronics sector grew in the period 1991-1998, and then from 2010, it has held steadily 22% - 23% of the publication. Health & safety standards became much more important in 2020 (14.2%) than 1991 (6.6%). Finally, transport engineering standards grew faster than others during 2000-2010, while in recent years the number of this type of standards has been stabilized.

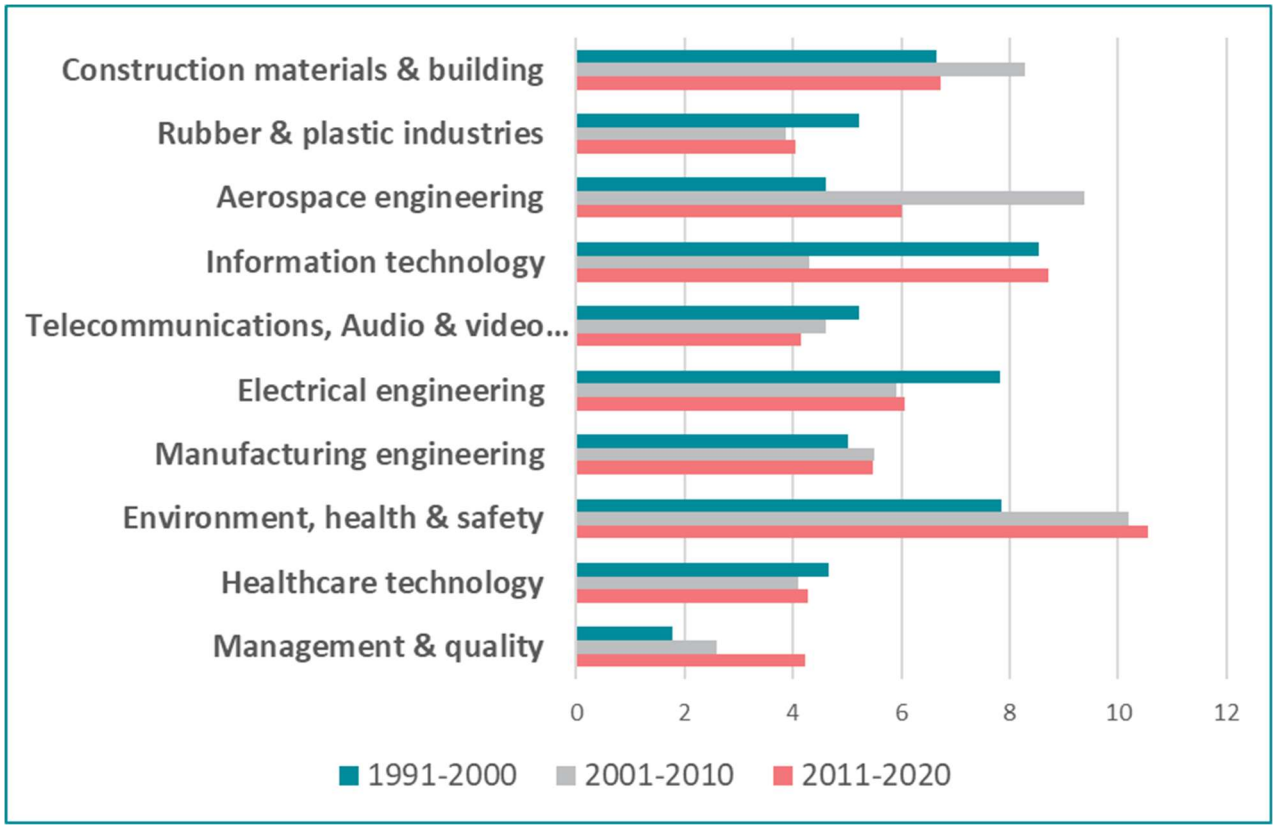
For the case of standards withdrawn, the noticeable pattern is that the withdrawn in IT, telecoms, and electronics sector was significant around 2000, as well as around 2012, partly reflecting the lumpy changes of generations of technologies. The withdrawn of transport engineering standards has also become more important recently.

We should stress that a standard can be applied to different uses in various sectors. Among all the published standards between 1991 and 2020, 12704 (about 19%) of them fall into more than two aggregated ICS sectors. First, even technological standards may be related to management process, which are also recorded in “Documentation” and “Management & Quality" sector. There are 2950 of such items, about 23% of the multi-sector standards. Second, the remaining 9754 multi-sector standards (77%) are still cross-sector standards: 91.64% of them (8929 items) belong to two sectors, and 8.36% are across more than 2 sectors. Though these statistics depend on how we classify sectors, the analysis shows that many standards have been used in various aspects, addressing different economic problems as discussed before.

Moving into smaller ICT fields, Figure 17 illustrates how the shares of standards of many industries have changed since 1990, while the shares of more traditional manufacturing fields such as rubber and plastics manufacturing have declined (but the share has been stabilized recently). The data also indicates how standards have been developed to assist companies to meet expanding legislation in certain fields.

Similar to the BSI-CEBR 2015 report, 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; the share was 7.9% between 1991 and 2000 and was 10.5% for the period 2011 to 2020. The recent data suggests that, however, aerospace engineering and telecommunications, audio & video engineering have declined. Information technology lost some significance before 2010 but has gained important shares once more after 2010.

Figure 16: Selected published groups of standards (ICS field), % share of standards newly published



A1.5. The origin of standards available to UK companies

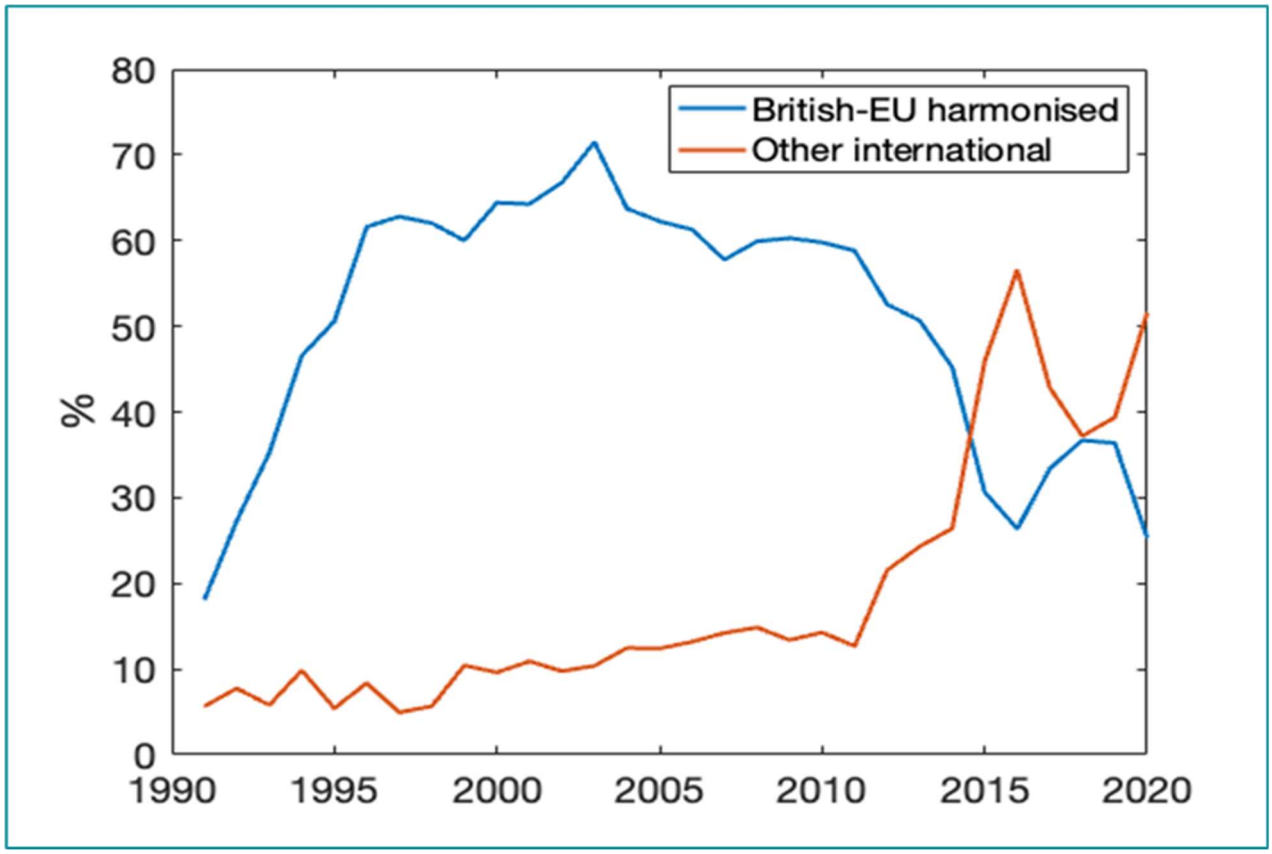
A key driver of the growth in the BSI standards catalogue over the past three decades has been the increasing internationalisation of standards, at the EU level, and beyond. According to the 2015 report, less than 10% within the BSI Catalogue originated in the UK around 2014. EU harmonisation of standards 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.

To illustrate the idea of harmonisation (not the focus in the BSI-CEBR 2015 report), in Figure 7 we show the share of standards that include both "BS" and "EN" / "CEN" (indicators for European standards) in their documentation number values to approximate the "harmonised" British and European standards. For example, "BS EN 50525-2-12:2011" published in 2011 is about electric cables that applies to thermoplastic (PVC) insulated and PVC sheathed extensible. This standard specifies particular low voltage energy, temperature, and insulation requirements. The standard replaced "BS 6500:2000", which partly replaced "BS 6500:1994" and "BS 6141:1991"; these standards were more British specific.

Figure 17: International and British-EU "harmonised" standards as percentage of new publication



We also show standards that do not include "BS" but nonetheless in the BSI catalogue. These include European standards as well as standards established in various international organisations (e.g., ISO and IEC); it should be stressed that, in all these standards bodies, BSI has important roles throughout the years.

Two significant features are observed. First, among the newly published standards, British-EU harmonised ones increased rapidly from 18% in 1990 and peaked around 71.5% in 2003. Then, the share declined, and 2016 (the EU membership referendum year) and 2020 showed lower shares. Second, other international standards started to become more important in 2003. The share peaked at 83% in 2016, and it still stood at 77% in 2020.

A1.6. Notes

Every effort has been made to ensure data accuracy. However, with the constant update of data, statistics and results may be subject to changes. We provide the detailed procedure of obtaining the dataset used in this section.

The main source of data is accessed via BSOL, “advance search” option. We select updated types “new” and “withdrawn” for each calendar year between 1991 and 2020. Also, we select aggregated 10 ICS fields from the 40 smaller ICS fields.

Three procedures are implemented before the analysis.

1). For new standards published, the publication date is recorded. For standards withdrawn, if the publication date is not available, we use computer program to detect the four-digit year after colon symbol from the document number values. There are still 130 items that have missing publication year and do not contain the four-digit year information; we remove them.

2). For standards withdrawn, there are cases that cannot be found in the new standards published in the years between 1991 and 2020. We add back these withdrawn items to the new items with the corresponding years (using the four-digit year in the document number values again if necessary).

3). For aggregate analysis, we sum over all ICS fields. We delete duplicated standards that appear in multiple ICS fields, leaving the cleaned data for aggregate analysis.

Appendix 2 The literature on economic effects of national/international standards

A2.1. Introduction

Voluntary consensus business standards have long been associated with a significant contribution to economic growth and productivity, although until the late 1990s few studies attempted to examine this issue in detail. Since then, a large body of research has been developed to explain the mechanisms by which standards affect economic growth and productivity.

In this section, we outline the main channels identified in the literature through which business standards contribute to economic growth - supporting productivity and efficiency within firms, facilitating trade, and acting as a catalyst for innovative activity. It is important to note, however, that some standards may sometimes, depending on the usage, have a negative impact. We extended the coverage of 2015 report, and in particularly put more emphasis on the impact of standards on innovations, standards and harmonisation.

Tables 7 – 12 set out the key studies that we have used for our analysis for each topic. In addition at the end of this Appendix we set out a longer list of the other relevant studies.

A2.2. General economic effects of standards

Standards help to solve fundamental process, organisational and technical problems. If these issues are not addressed, they can lead to inefficient and economically ineffective market operations. One of the first standards introduced by the BSI - standardising the number of tram gauge specifications from 75 to 5 in 1903 (Standard BS 2) - was designed to ensure manufacturing quality while eliminating the unnecessary variety that existed in the tramway track market, which limited the interoperability of the tram network and led to longer delivery times for tramway track. The reduction in variety reduces procurement costs for tram companies and allows tram manufacturers to expand their markets (Dow, 2014).

A common classification of standards in the literature (see David (1987) and Swann (2000)) relates to the economic problems they address. This classification usually indicates that standards play a direct or indirect role in the productivity and efficiency of a firm or an organization - by reducing the costs of producing goods and services, increasing revenues by opening up new markets, or increasing the efficiency of producing goods and services. This categorization based on the economic effect of a standard is useful in order to analyse the economic driving forces for standardisation and the economic impact dimensions (Blind, 2004)

Standards can be used for a variety of purposes and so can solve a variety of problems, even if they were developed to serve one purpose. Only around 25 per cent of European standards are associated with public policies and legislation (BSI, 2018); use of other standards is voluntary and their usage are expected to solve market economic issues as the responsibility for complying with these standard requirements rests with the supplier of goods and services. Below we briefly discuss the different types of standards, what they do and how they can improve efficiency.

- **Facilitating compatibility of products, services 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 benefits of adoption of a given technology, product or service 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/Twitter, 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.

A disadvantage of strong network effects is that customers can be locked into older or less functional technologies (Swann, 2000). Highly specialised computer software systems, such as those used in the engineering, design or financial sectors, tend to lock firms in because they require specialised training to use them. As competing software packages can have different approaches and require different skill sets, businesses can be locked into other systems because of business disruption and the cost of retraining. This can lead to businesses using the same software for years, even though other, more advanced software may be more effective.

Compatibility is vital for business in the UK. BSI publishes around 2,500 standards per year and withdraws around 1,000 standards per year that are no longer needed by the market or conflict with new standards adopted in the UK. Around 95 per cent of BSI's work is on international and European standards. The UK government Brexit White Paper (2018) states clearly that ``the British Standards Institution (BSI) would retain its ability to apply the 'single standard model' – so that where a voluntary European standard is used to support EU rules, the BSI could not put forward any competing national standards''. This statement suggests that compatibility is a vital concern after Brexit.

- **Efficient reduction in the variety of goods and services**

Standards limit a product to a certain range of number of features such as size and quality. The benefit is effectively aligning the expectations of buyers and sellers. If different versions of a product need to be produced for each market, then costs for both consumers and producers are likely to increase. Standards may serve as a selection device of a good market equilibrium (Farrell and Saloner, 1986), in which we see economies of scale. For example, the dimensions of freight containers used to transport goods need to be standardised across the global market so that they can be stacked as efficiently as possible on ships, trucks

and trains. If containers are not standardised, then it is difficult to load, unload and move goods seamlessly between different modes of transport, leading to higher costs for producers and therefore higher costs for consumers of goods. It is thus effective to standardise the size of containers to ensure that as much cargo as possible can be transported at the same time. Consequently, world trade expanded rapidly since 1960s when standardisation of containers disseminated by ISO, with the contribution of containerisation estimated to be higher than that of free trade agreements (Bernhofen et al., 2016).

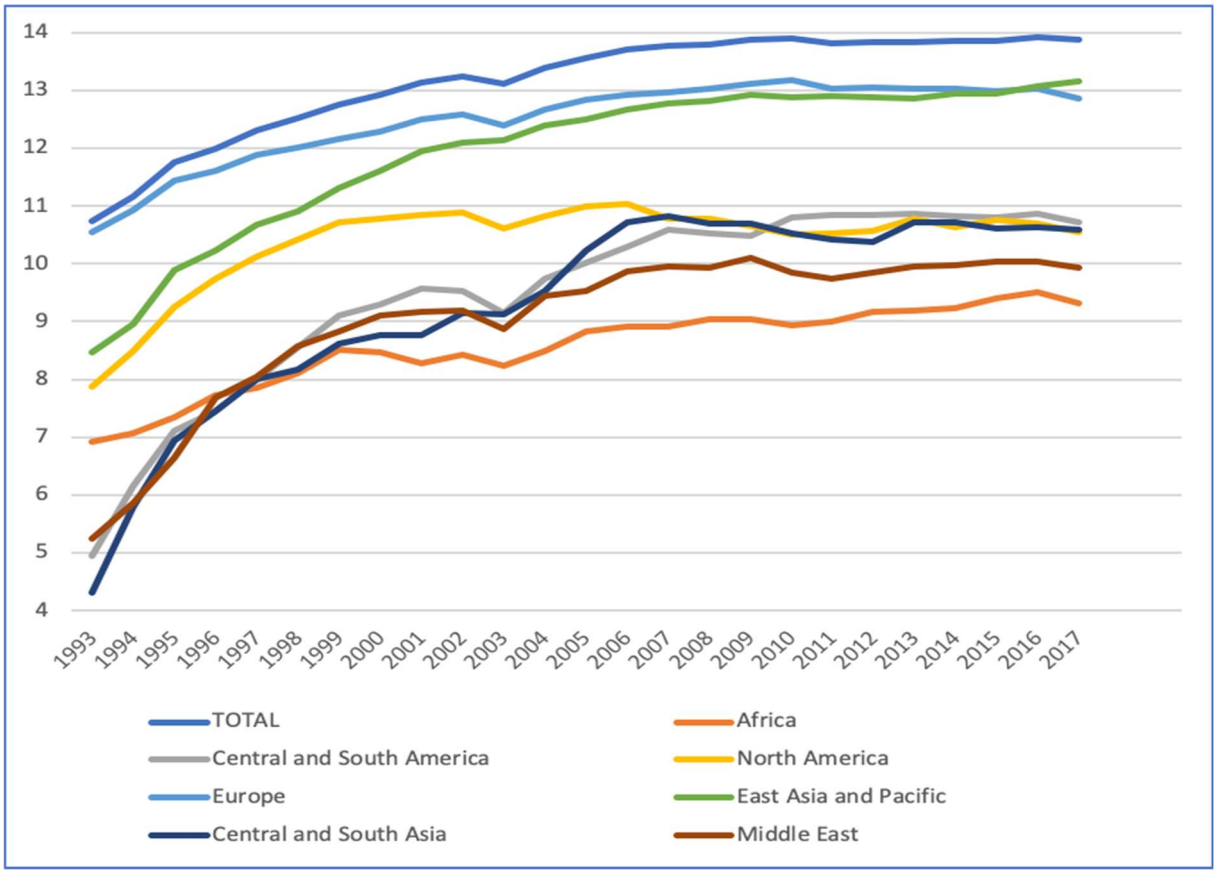
A more recent example of a standardised product is the USB connector, introduced by industry to provide a standardised way of powering cameras, mobile phones and other handheld devices and allowing these devices to communicate with each other.

One should notice that variety reduction, although enabling economies of scale, may or may not reduce competition and often increasingly exclude small, but potentially innovative firms from entry because of the efficient level of scales to operate (Blind 2004).

- **Ensuring quality and safety, while promoting efficiency**

Quality management system (QMS) standards, such as ISO 9001, are some of the most widely used standards worldwide. According to the annual ISO survey, there were 1.1 million companies worldwide certified to ISO 9001 (see Figure 19) in 2016, with 37,901 companies certified in the UK alone[18].

Figure 18: The ISO9001 certification number (in natural log)



[18] ISO Survey 2018.

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.

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).

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. In international settings, the standards also provide a common language, reducing trade and linguistic barriers. Siltori et. al. (2020) show a recent survey of ISO 9001:2015 implementation and certification in Brazil and confirms the benefits.

Notice that Figure 19 shows the growth rate (i.e., the slop of the curves since we take natural log transformation) of ISO certification dropped to around zeros from 2007/2008 for almost all areas (except that East Asia and Pacific started to have more certification around 2017). This observation is related to the benefit and cost of certifying standards. Summarizing previous studies, one can label four different phases of the diffusion of ISO 9001 certifications, growth phase, maturity or saturation phase, decline phase, and post-decline phase. These phases are determined by incentive to certification and decertification (for example because of costs and bureaucratic burden in the application and maintenance of ISO standards).

To identify these phases for similar groups of countries, Mastrogiacomo et.al. (2021) use a cluster analysis with major European countries to update the standard diffusion model with different development phases. The post-decline certification numbers are roughly 50%-60% of the peak. An empirical study, by Cândido et.al. (2021), match the list of 278 SME Portuguese firms certified with ISO 9001 initially in 2008 to the firm-level AMADEUS database that contain their financial information. Those firms (in total 23) that decertified in 2011 do not have significantly different performance (in fact, a slightly better performance) compared to others that continued with the certification. The benefits of ISO 9001 might be internalised after the initial three years for these firms, or their market reputation has been established after the first three years, and the cost of continuing certification outweighs the benefit.

QMS certification tends to be much higher amongst larger companies. This is due to larger companies being much more likely to have resources to implement and refine their required process and having a much greater need for QMS in order to retain organisational control and avoid diseconomies of scale (i.e., average cost increasing instead of decreasing with size).

Besides ensuring quality, standards play an important role in solving other economic problems which may not influence the productivity and efficiency directly 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 and reputation. In the 2015 BSI industry survey, companies in sectors of food and drink manufacturing, energy, construction, life sciences/healthcare, ICT, and

automotive, are more likely to use these standards. In these sectors, at least 70% of companies surveyed use health and safety standards, and at least 50% use environmental standards. According to their responses, standards help these companies meet the various requirements and obligations under health and safety and environmental regulations.

- **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. Purchasers can buy with confidence and it is unnecessary to carry out his/her own independent test that the product is what it is supposed to be, reducing greatly the transaction costs (e.g., the example of different grades of petrol referred in Swann, 2000). Information, measurement and product description standards also 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.

Case study: The House of Lords debated on 27 of November 2020, the "draft Product Safety and Metrology etc. (Amendment etc.) (UK (NI) Indication) (EU Exit) Regulations 2020", a law in the area of product safety and metrology (weights and measures). This law is about product conformity markings: EU CE mark, the new UKCA and UK(NI)marks during the transition period. The change of product conformity markings has non-negligible economic costs, according to the House of Lords Secondary Legislation Scrutiny Committee "between 10,000 and 17,000 UK manufacturers and up to 135,000 UK wholesalers and retailers will be impacted".[19] It estimated costs to businesses over a ten-year period of £25.7 million for conformity marking, £3.7 million for conformity assessment and £6.6 million for "familiarisation". This would be a total of around £36 million. The committee stated that this meant the regulations affected a "significant" number of businesses.

Standardizing components is essential in complex industries such as aerospace 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. In the 2015 BSI industry survey, 77% of the surveyed companies in aerospace and defence reported using technical standards, compared to construction (72%), automotive (70%), life sciences / healthcare (67%), energy (67%), ICT (56%), and food and drink manufacturing (49%).

To close this part, a summary of the different standard types and their impacts is provided in the following table. One should further notice that these benefits and costs of standards may not be immediately following standards are adopted/published. There could be a few years before the benefits/costs are fully realized. The industry survey carried in 2021 (to be discussed later) will look at the initial impact and on-going impact of meeting/adopting standards.

[19] See House of Lords Library website: https://lordslibrary.parliament.uk/product-standards-and-measurements-after-brexit/

Table 7: Summary of types of standards classified according to the economic problems they solve

Type	Positive impacts	Negative impacts
Compatibility 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 • Market concentration
Efficient reduction in the variety of goods and services	• Economies of scale • Fosters critical mass in emerging technologies and industries	• Restrict choice • Market concentration • Premature selection of technologies
Ensuring quality and safety	• Helps avoid adverse selection • Creates trust • Reduces transaction costs	• Can be misused to raise rivals' costs
Efficient distribution of technical information	• Reduce transaction costs by alleviating information asymmetries • Diffuses codified knowledge	• Can result in excessive influence of dominant players on regulatory agencies

Source: Modified Swann 2000 to the need of this report.

A2.3. Standards and total factor productivity

Economic growth is dependent on both the use of the different production factors (specifically labour and capital), and the efficiency to which these factors are utilised. The efficiency of the factors of production is known as the total factor productivity (TFP). Growth can be seen in the short run by increasing the quantities of labour and capital that are used. However, as additional units of these factors are added, the amount of additional output diminishes (i.e., diminishing marginal product).

Whilst the employment of the factors of production is important for short-run growth, increases in TFP are critical for long-run economic growth and to overcome these diminishing returns to capital and labour. 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).

TFP measures the technological progress of the economy and represents the efficiency with which resources are utilised, which as before, both technological progress and efficiency standards strongly influence. Standards are thus associated with a significant proportion of the growth of productivity in the long run.

Empirical studies predict that the growth of standards account for between an eight and quarter of TFP growth (Swann, 2010). However, in the short-run changes in standards should have little effect on productivity, as there is a time lag between the adoption of a standard and the point at which its role for the industry reaches maximum effectiveness. Swann (2010) describes standards as a ‘coupling’ device,

with other long-run drivers of productivity growth – human capital, innovation and the creation of knowledge. Helping to create 'thicker' markets, more competition and less duplication of research. The idea has been applied in a few studies assessing the macro impact of standards; DIN (2011) and SN, DS, SIS, SFS, IST, Menon (2018) let standards and other factors, such as patents and license, contribute to productivity. Barron and Schmidt (2019), using macro data and standard data such as Perinorm, measure the macroeconomic effects of the adoption of new technologies. First, new technologies diffuse slowly. TFP decreases temporarily, implying that the newly adopted technology is incompatible with the incumbent technology. Second, standardisation reveals information about future productivity as evidenced by the positive and immediate reaction of stock market variables.

The three main channels through which standards impact TFP are described below. As one shall see, the three are not independent and turn out to reinforce with each other. This new aspect is emphasized compared to the BSI-CEBR 2015 report.

- **Standards and Economic of Scales**

Standards boost productivity through improving organizational performance and promoting economies of scale for companies. In terms of organisational performance, standards' properties of inter-operability of products and processes, as well as reducing information asymmetries, enhance supply chains, enabling firms to lower their production costs. Although the reduction of the variety of products as a result of standards may lead to less choice for consumers, it importantly enables firms to achieve larger economies of scale and resultantly increase their productivity (Dixit and Stiglitz, 1977). The four types of economic benefits reviewed before all contribute to this property. For this reason, most of the literature discussed next is related to this point.

- **Standards in International Trade and Harmonisation of Standards**

International standards facilitate trade which in turn increases productivity growth. International standards strongly promote global commerce – Swann, et.al. (1996) is an early contribution to analyse the impact of both national and international standards; Swann (2010) demonstrates the clear link between the adoption of international standards and trade. While there is comprehensive empirical support that trade positively impacts productivity growth.

On the export side, trade increases productivity. Firstly, at the firm level as companies gain from the even larger economies of scale due to having access to foreign markets. Secondly, at the national level following standard trade theory, increased exportation allows countries to specialise in their comparative advantages, which in turns boost productivity. On the import-side, international standards stimulate an increase in competition among heterogenous firms, which leads to the least productivity companies being forced to exit the market and an allocation of resources towards the more productive firms (Melitz and Ottaviano, 2007).

By only accounting for number of standards, any analysis may suffer from the 'mixed bag' problem (Swann, 1996, 2010); The economic effect of standards also may be more likely to be dependent on their function, rather than their number (WTO, 2005). There were some proposals such as measuring technical complexity, e.g., number of pages (Czubala et al., 2007); this is still problematic since language is different.

International harmonization can limit the scope for regulatory protectionism, attenuating the negative effects of standards on exporters; This means that a higher number of standards itself may reduce trade. Czubala et al (2009) show that harmonisation of standards has positive impact on export volume. The study may also be the first to include less developed economies. The cross-country evidence suggests that the positive impact is stronger with more harmonisation. As mentioned before, both British government

white paper 2018 and BSI statement 2018 emphasize the importance of harmonization of standards and the impact on exports.

Shepherd (2016) further shows the positive impact on export variety (besides volume) even if compliance cost is higher (for both harmonizing and non-harmonizing countries). The increase of number of non-harmonized standards actually reduces export variety and volume. As a cross validation, he uses an instrument variable approach; he looks at EU-wide sizes of each sector because this affects the resources to lobby governments to prevent harmonization. The study indeed shows that harmonisation is more difficult if the size of the sector is higher, and the increase of standards does not lead to increase in exports volume and variety.

A recent study by Schmidt and Steingress (2019), summarized in Schmidt (2020), shows that cross-country standard harmonisation is on average equivalent to a tariff reduction of 2.1 percentage points, using bilateral product-level trade data for 1995-2014 and Perinorm database for release of standards. Actually, the share of products subject to harmonisation is larger than the share of those affected by tariff changes. Growth of trade flows following harmonisation events is significant (0.67%). Besides many benefits, one important feature of harmonisation suggested by their study is reducing information asymmetry.

Case study: The Royal Institute of British Architects (RIBA) ran its second Brexit survey of UK architects between December 2017 and January 2018 among its members. With the UK importing from EU 2/3 of the construction products it uses from elsewhere, RIBA members identified the retention of common product standards with the EU after Brexit as a top priority in the survey. The survey results highlight the risk of divergence from the European standards system leaving the UK unable to influence the development of standards and unable to compete with the cost of products from outside the EU. Architects warned against using Brexit to initiate a short-sighted race to the bottom on standards that would compromise the UK's reputation for supporting the highest quality in the built environment. This reputation is believed to be maintained and strengthened by continued participation in the European standards system after Brexit, according to RIBA after the publication of Brexit White Paper (2018).[20]

- **Standards and Innovation**

Standards have a catalytic effect on the innovation process. The influence of innovation on standardisation has been confirmed at the macro, industry, and company levels, but the impact of standardisation on innovation has been investigated only to a limited extend (Blind, 2004). Traditionally, standardisation has been considered as a barrier to innovation, with the two terms seemingly contradictory. However, standards feed information for innovation, accelerate diffusion of innovation, reduce risk and time to market of innovation (Tassey, 2000; Blind, 2016) if several framework conditions, like openness of the standardisation process are considered.

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. Blind (2009,

[20] https://www.architecture.com/knowledge-and-resources/knowledge-landing-page/brexit-white-paper-what-you-need-to-know

2016) shows that overall standards are positively related and likely promote innovation, whose degree depends on the openness of the process considered. He summarises these effects as follows:

1. The standardisation 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. Standardisation 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.

He 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.

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. For example, the variety aspect of standards can reduce the risks faced by suppliers (even if this means more competition, see Swann, 1985). In the early stages of a market for a new technology, standards play a crucial role of shaping the future path. Technologies may get locked into a pre-paradigmatic stage since market participants are too dispersed; the market lacks focus and critical mass for the new technology, and the standards can help the innovation to take off (Blind, 2004).

Standards also shape the path of future technological developments (Blind, 2016), forming the technical infrastructure to which a canopy of new technologies and markets are grown, providing the basis for subsequent generations of innovation. In this sense, as opposed to patents which are private and maintain exclusivity, technical standards can be considered as a public good.

Finally, by limiting, or as Zoo, De Vries and Lee (2017) label 'optimizing', the variety of products, standards help to build focus and cohesion for emerging technologies and consequently promote the development of critical masses in innovation (Swann, 2000 and Blind, 2004).

Therefore, the timing of the implementation of standards is crucial. If standards are implemented too early in the lifecycle of technology, a standard may shut-out future superior technology, and too late, the cost of transition to the standard may be too high (DTI, 2005). When standards aren't regularly updated, they can create 'lock-in', where standards extend past their current technology lifecycle beyond the point that is considered optimal. To overcome lock-ins can be difficult and time-consuming (Tassey, 2017).

Case study: A notable example carefully explained in Allen and Sriram (2000) is the QWERTY keyboard configuration (ANSI X4.7—1966). The keyboards were configured, and still are configured, to be a fairly inefficient typing configuration. For example, the letters o, a and i are among the top six letters most commonly used in letters in English, yet they must be depressed with relatively weaker fingers (ring and pinky) on the QWERTY keyboard. The left hand performs most typing (57%); many common words (was, were, extra) only involve the left hand. The pinky is overloaded with shift, backspace and tab.

Since 1911, however, the state of the art in keyboard technology has advanced such that any typing speed would be acceptable. In fact, in the 1930s, August Dvorak developed a more efficient keyboard. For example, the right hand does more typing than the left (56 to 44%). The keyboard is designed so that the middle row of keys includes the most common letters. Common letter combinations (qu, in, un) are positioned in such a way that they can be typed more quickly than on QWERTY. It was estimated that professional typists can type up to 20% faster using a Dvorak keyboard. Beyond that, during an 8-h day, a typist's hand travels 16 times further on a QWERTY keyboard than a Dvorak one. The American National Standards Institute publishes a standard (ANSI) X4.22 to endorse the Dvorak keyboard.

Yet, despite these advantages, 99.99% of keyboards today are QWERTY based, demonstrating, in this case, that standards hindered innovation. This is an example of a product entering the market during the process innovation phase. Because QWERTY was a de facto standard for more than 20 years before Dvorak's keyboard appeared, society was (and will probably remain) too entrenched in that standard to accept a product that changed it, even if doing so improved performance.

The empirical literature tests that standards have dual informing and constraining roles in innovation. The DTI (2005) finds that information content of the stock of standards has a non-monotone relationship with the number of available standards and the median age of the standards. A similar non-monotone effect is also found in the constraining role of standards. That is, both rather old and rather new standards constrain innovation; The old standards lock in innovator into legacy systems, and the new standards challenges the innovator. King (2006) used more recent data and show that this non-monotone and non-linear effect is not robust.

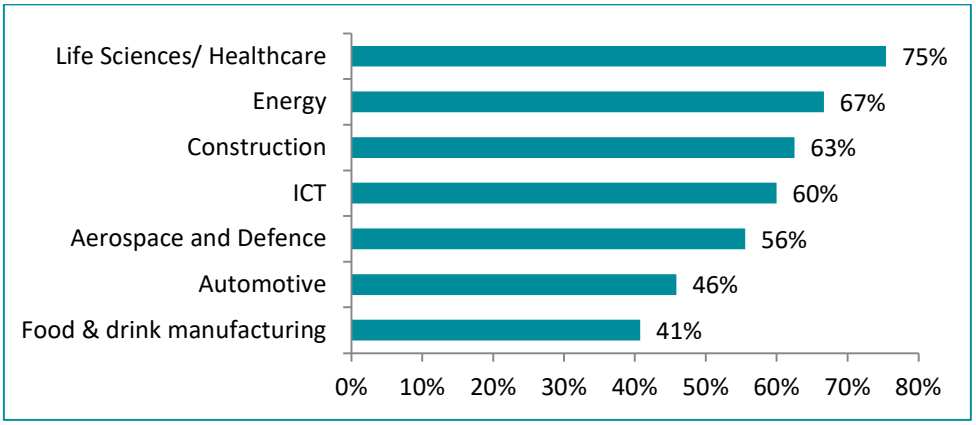
Swann and Lambert (2010) find that British companies which say that standards inform innovation and that regulations constrain it, (unexpectedly) tend to be the most innovative; hence they are the most active at pushing the innovative barrier and also the most constrained by the pace of the standards development process. They note that any standard will be both informative and constraining. Firms then could be efficient in squeezing information from standards and more successful in overcoming the constraints imposed by regulations. Frenz and Lambert (2012) use factor analysis including standards as a source of information for innovation. It seems that other external information sources such as other public information are also important. Using standards is a relatively specialised way of using public but codified information in a firm's innovation strategy. Other studies, Mangiarotti and Riillo (2010) for ISO 9000 certification in manufacturing and service sectors, Blind (2006a) for R&D-intensity in the whole German industry, Aphrodite (2011) for biometrics standards, and Michel (2012) for Dutch EV charging infrastructure all find positive relationship between standards and innovations.

Standards pivotal role in the process of innovation is multi-faceted. TFP is often used as a measure of the level of knowledge within the economy (Abdih and Joutz, 2005). Standards encode within them the knowledge about how to build things, design for a purpose or how to behave in a certain circumstance or otherwise known as the expertise of best practice (Swann, 2000). So, whilst technological innovation expands the level of existing knowledge, standards are crucial for the diffusion of this knowledge. A better diffusion of the knowledge can naturally attract more innovation efforts.

Moreover, only a small number of companies are actively engaged in the shaping of standards – For example, Wakke et al. (2015) show that less than 5% of Dutch service companies are active in standardisation. These tend to be the largest companies and maybe not the most innovative. As implementing innovation can be associated with hugely costs, standards due to these vested interests may represent the lowest common denominator in terms of innovation.

Finally, the BSI Standards Industry survey 2015 provides evidence to support the finding in the literature, 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 (Figure 20).

Figure 19: Do standards tend to lag behind technological development? % of respondents that agree, by sector in 2015 survey



Source: BSI Standards in Industry survey 2015, Cebr analysis

A2.4. A summary of national studies on the economic benefits of standards

The analysis performed in our study will utilise a similar methodological approach to that of other recent national studies, which measure the overall economic benefits of standards. A summary of the findings of the national level studies carried out in the UK, Germany, France, Canada, Australia, and Nordic economies are presented. Compared to the previous BSI-CEBR report (2015), we update the review by adding a few national studies, including two (2006 and 2012) analysed for Australia and another recent one (2018) analysed for the Nordic economies. In these studies, the stock of standards is generally used alongside a proxy for technological innovation – value of R&D, number of patents, etc., to formulate total factor productivity or labour productivity which in turn impacts economic growth.

Table 8 summarises the estimates of the impacts of standards on economic performance from these national-level studies. Although the degree varies, it is clear that standards are strongly associated with economic growth. Studies such as these have helped policymakers become increasingly aware of the importance of standards for economic performance, within the last decade Canada, China, Germany, Japan, Russia, UK and USA have implemented national standardisation strategies (Hemphil, 2009; Limin et al., 2005). Moreover, whilst this empirical evidence focuses on the impact of standards on innovation in developed countries, Zoo, De Vries and Lee (2017) find that innovation and standardisation have become increasingly important for the long-term growth of developing countries.

- **The UK**

In the UK, before the BSI-CEBR 2015 study, the only national level study carried out on the macroeconomic impact of standards was published in a 2005 report by the Department for Trade and Industry (DTI, 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 2005 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 standardisation 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.

The BSI-CEBR report (2015), which extended the starting time to 1921 and the end time to 2013, found a larger impact from standardisation partly because of the update of the standards information which leads to a higher growth rate of the net stock of standards.

- **Germany**

Jungmittag, Blind, & Mangelsdorf (2011) analysed the macroeconomic impact of standardisation in Germany between 1992 and 2006. This research, commissioned by DIN (German Institute for Standardisation), 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 standardisation. 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 standardisation 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 standardisation on the French economy (AFNOR, 2009). The research analysed the effects of standardisation 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 standardisation using a survey of 1,790 companies. The evidence showed that standardisation on average positively impacts the turnover of a firm. The study found that 66% of firms perceive standardisation 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 standardisation 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 standardisation 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 Canada 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 standardisation offers a wide variety of benefits including a foundation for driving innovation and new product development. Interviewees highlighted standardisation's enhancing effect on productivity and its contribution towards reducing costs.

- **Australia**

Standards Australia recently published a research paper demonstrating the value of Australian standards to the Australian economy, covering the period 1982 – 2010 and 12 key sectors of the Australian economy (Standards Australia, 2012). The study focused on the impact of standardisation on technological progress and the efficiency to which resources are utilised, and its subsequent impact on total factor productivity.

The study follows a similar format to the DIN (2011) study: explaining economic growth empirically through capital, labour and technological progress; and estimating technological progress using a combination of the annual number of patent registrations, which represents the stock of knowledge, and the annual production of standards, which represents the diffusion of knowledge. However, foreign-imported technological knowledge has to be excluded from the measure of technological progress, as there is no requirement for technology licences to be registered within Australia and therefore no indicator of knowledge imports.

Standards are demonstrated to exhibit a positive relationship with GDP such that a 1% increase in the production of standards is associated with a 0.18% increase in GDP. The study notes that the entirety of the multi-faceted impact of standards is not included in the macro-analysis.

- **Nordic Economies**

Standards Norway, Danish Standards, Swedish Standards Institute, Finish Standards Association, Icelandic Stands, and Menon Economics Research published a study in 2018 assessing the macro effects of standardisation across the Nordic economies. Standardisation has contributed to increased labour productivity in all of the Nordic countries. In particular, 10% increase of standards is associated with 0.105% rise in labour productivity, similar to the BSI-CEBR 2015 study. The relevant estimates are 0.089% for Denmark, 0.147% for Sweden, 0.133% for Norway, 0.108% for Finland, and 0.047% for Iceland. All of these estimates are statistically significant.

The study also performs separate estimations for selected industries across the Nordic countries. For example, doubling the stock of standards available for the construction sector is associated with an increase in labour productivity of 6.9% within the sector. Given the annual growth rate in the stock of standards relevant for the sector during the period 1976-2014, standardisation is associated with an annual increase in labour productivity of 0.6 percent within the construction sector.

Table 8: Estimate of the impact of standards on economic growth from the national-level studies

Publisher	Country	Time Frame	**Estimated Function**	Growth Rate of GDP	Contributions of Standards to growth	Elasticity of standards to productivity
DIN. (2000)	Germany	1960 - 1990	GDP Output	3.3%	0.9% points (27.27%)	0.07
DIN (2011)	Germany	1992 - 2006	GDP output	3.1%	0.8% points (25.80%)	0.18

AFNOR (2009)	France	1950 - 2007	GDP output	3.4%	0.8% points (23.52%)	0.12
DTI (2005)	UK	1948 - 2002	Labour productivity	2.5%	0.3% points (12%)	0.05
Standards Council of Canada (2007)	Canada	1981 - 2004	Labour productivity	2.8%	0.25% points (9%)	0.36
Standards Australia (2006)	Australia	1962 - 2003	GDP output	3.6%	0.8% points (22.2%)	0.12-0.17
Standards Australia (2012)	Australia	1982 - 2010	GDP output	3.3%	N/A	0.10-0.15
BSI and CEBR (2015)	UK	1921-2013	Labour productivity	2.4%	0.68% points (28.4%)	0.11
Standards Norway, Danish Standards, Swedish Standards Institute, Finish Standards Association, Icelandic Stands, and Menon (2018)	Nordic Countries	1976-2016	Labour productivity	2.5%	0.7% points (28%)	0.105

Notes: if the study is with "labour productivity", the last column indicates the contribution to labour productivity, otherwise to total factor productivity (TFP).

One can see that the estimates differ across time and countries (Table 2); across all the studies about 22% of economic growth is associated with the increase of the net production of standards. If we focus on the British economy, the results of elasticity of the stock of standards are similar compared to other studies. The message is that a 10% increase in the stock of standards can be associated with

- 0.5%-1.1% increase in labour productivity,
- or 0.32%-0.71% increase in total factor productivity (using the capital share 0.351 estimated from the 2015 study).
- Keeping everything else constant, a further increase of 10% of the stock of standards (that can deal with the same amount of economic problems found in the previous studies) can be associated with a further GDP increase of £6.95-£15.42 billion (in 2019 £).

To close this section, we would like to stress that these studies are all about correlation not causation. Nevertheless, given that the development of standards requires significant human efforts and most of adoption of standards are voluntary, they should bring net economic benefits overall by addressing the four types of economic issues reviewed in the beginning of this section (or, they may not bring the benefits

immediately before a few years' time), whether standards are the reasons or results of productivity growth. The potential benefits of standards are thus significant.

Standards and the environment

In the last few decades there has been an increasing focus on sustainable development and 'green growth', which seeks to balance economic growth with environmental protection. Sustainable development is defined as 'meeting the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development (1987). The ISO and its international standards are playing a prominent role in achieving environmental sustainability as countries look to move away from traditional forms of environmental regulation that can be inflexible and costly towards international voluntary frameworks that help to maintain industry competitiveness through rewarding innovation and fostering continuous improvement. The ISO provides a number of different frameworks to help organisations be sustainable in their activities:

ISO 14000 series – implementation of an environmental management system

ISO 26000 series – operating in a way that contributes to sustainable development

ISO 14090 series – framework enables organizations to adapt to climate change impacts

Traditional 'command and control' regulations – permits, requirements for technology-based controls for specific activities that cause pollution developed in the 1960s tend to be reactive, focusing on dealing with environmental problems after they are created rather than on preventing them. International voluntary frameworks increase pressure on businesses to self-regulate and take responsibility for the environmental impact of their activities (Stenzel (2008)), with many multinational corporations adopting 'clean technologies'

Self-Regulation

International standards are well-known for being a facilitator of international trade, with their implementation greatly reducing non-tariff barriers. Traditionally, globalization has been viewed as being harmful for the environment. The theory follows that multinational corporations, can take advantage of the cross-country differences in environmental regulations by moving production capacity to the country with the laxest environmental standards. Faced with the prospect of industrial flight, nations (especially developing) enter a 'race to the bottom' and become 'pollution havens' (Walters (1982)) or risk facing higher levels of unemployment and an erosion of their tax base.

However, as lower barriers to trade encourage firms to transfer environmental technologies and management systems from countries with stricter environmental standards to developing countries, which lack the necessary access to environmental technologies and capabilities (Drezner (2000)), globalization can be in some respects be viewed as being beneficial for the environment. Globalization increases multinational companies investment in developing countries, as MNCs face pressure from interests groups to improve their worldwide reputation on environmental responsibility and legitimacy. Therefore, MNCs self-regulate their subsidiaries or place pressure on their suppliers in developing countries to self-regulate environmental performance. Self-regulation refers to an organisation's adoption of environmental performance standards or implementing environmental management standards beyond the requirements of government regulations. For firms participating in the global economy local government regulation is only one consideration in the selection of an environmental strategy (Christmann and Taylor (2001)). Moreover, as globalization increases exports from developing to developed countries where consumers might use environmental performance as supplier-selection criterion, export-oriented firms in developing countries are strongly encouraged to pursue environmental self-regulation. Free trade

can lead to a levelling up of environmental standards in developing countries (Prakash and Protoski (2006)).

ISO 14000

The ISO 14000 series was first released in 2004, and subsequently up ISO 14000 first released in 2004, and subsequently updated in 2004 and 2015, used the best practices of the ISO's 9000 series and added environmental processes and policies to create a management system rooted in environmental best practices. The series is intended to help organizations take environmental considerations into all aspects of their operations. The widespread application and global popularity of the 9000 series has lent the ISO 14000 series a level of credibility that other environmental management standards do not possess. The environmental management standard works by making organisations:

- Establish an environmental policy appropriate to itself
- Identify the environmental impact of its activities
- Identify the relevant legislative and regulatory requirements
- Identify priorities and set appropriate environmental objectives and targets
- Establish a structure to implement the policy and achieve objectives and targets
- Ensure that the environmental management systems remain appropriate
- Capable of adapting to changing circumstances

ISO 14000 does not establish environmental performance objectives and targets for the organizations and requires them to deduce their own methods for protecting the environment. This flexibility is necessary for the standard to cover a wide range of companies.

Stenzel (2008) describes the main benefits of ISO 14000 certification for businesses:

- **Attract Investors –** A growing number of investment and mutual fund managers are searching for environmentally responsible firms
- **Prevent Pollution Releases and Save on Insurance –** The company may save money on insurance premiums and clean-up environmental accidents. Due to the reduced risks of accidental pollution releases, insurance companies may reduce rates on insurance policies
- **Enhanced Relationships with Financial Institutions –** Financial institutions are sensitive to environmental risks and their impacts on collateral. Lenders are requiring environmental audits before extending loans to businesses
- **Internal Cost Savings –** By implementing an EMS, a company may achieve internal cost savings, resulting from waste reductions, use of fewer toxic chemicals, reduced energy use, and recycling
- **Public Education –** ISO 14000 certification can serve as a vehicle to educate employees and local communities about the environment

Environmental regimes and financial performance are becoming increasingly interlinked, as ISO 14000 certification becomes a necessary pre-condition for doing business on global markets, especially in environmentally sensitive sector (Clapp (1998)). In the future, ISO 14001 could effectively become a non-tariff barrier. Tari, Milina-Azorin and Heras (2012) study suggest that without considering environmental performance ISO 14001 has clear benefits on organizational, people and customer results.

Although ISO 14000 cannot replace government environmental regulation it provides an important supplement to domestic environmental law and multilateral international agreement, acting as a bridge between domestic regulation and a global framework for environmental management. As ISO 14000

encourages businesses to become environmentally conscious and sustainable in their activities, its certification can help improve compliance with domestic environmental laws and policies. Furthermore, by encouraging businesses to set environmental targets the management system helps compliant firms achieve performance improvements beyond environmental regulations. Widescale adoption of ISO 14000 can fill the regulatory vacuum and result in pressure being placed on governments to develop policies and regulations, especially in developing countries where there is a lack of state regulation and effective global environment policies (Brandi (2016).

ISO 14000 has the potential to become part of a global culture as the public view ISO 14000 certification as the environmental benchmark (Stenzel (2008)), if a company is certified consumers will view the company as a responsible corporate citizen being more likely to purchase their products or services. As the standard becomes more popular the more organisations would voluntarily cut back on their polluting habits and inefficient waste of resources further reducing the need for government intervention.

Prakash and Protoski (2006) analysing the recent empirical literature, generally find that firms which are certified with ISO 14001 are more likely to pollute less and better comply with government law. Some of the recent studies are summed up below.

Table 9 Studies of the impact of standards on the environment

Author(s)	Paper	Key Findings
Dasgupta, Hettige and Wheeler. (2000)	What Improves Environmental Compliance? Evidence from Mexican Industry	Studying 236 Mexican firms in the food, chemical, nometallic minerals and metal industries, find that ISO 14001 adopters show better compliance with government environmental regulations.
Russo. (2001)	Institutional Change and Theories of Organizational Strategy: ISO 14001 and Toxic Emissions in the Electronic Industry	Analysing 316 US electronic facilities find that ISO 14001 membership is associated with decreased toxic emissions.
Potoski and Prakash. (2005)	Covenants with Weak Swords: ISO 14001 and Firms' Environmental Performance	Studying over 3,000 US facilities regulated under the Clean Air Act, find that ISO 14001 adopters pollute less and show better compliance with law.
Anton, Rose, Deltas and Khanna. (2004)	Incentives for Environmental Self-Regulation and Implications for Environmental Performance	Find that more comprehensive EMS (core requirement imposed by ISO 14001) lead to lower toxic emissions, particularly for firms that have higher pollution intensity.

However, the flexibility of the ISO 14000 can be considered one its biggest weaknesses. As the standard does not establish environmental performance objectives and targets for the organisation, for example

not calling for any specific reductions in hazardous waste generation, and companies set themselves their own environmental goals, they may be very lenient in these goals. Especially when companies are using the EMS as a short-term measure to gain entry into global markets and when the stakeholder's motivations who pressure firms to become certified is to safeguard their own reputations and legitimacy. A results of this, is there is no information to suggest that ISO 14001 certification indicates anything other than the most basic form of compliance and environmental planning. King (2005) argues that firms who consider themselves to be leaders in the field of environmental management and are engaged in environmental impact reduction are less likely to certify, whilst Yin and Ma's (2009) study on manufacturing firms in China, found that ISO 14001 certification was merely used as a passport to gain entry into advanced markets rather than to improve environmental performance.

Companies may also try to use ISO 14000 certification to obtain regulatory relief, according to Clapp firms have already tried as such in the US and other industrialised countries. In Argentina, firms are pressuring the government to relax environmental regulation for those firms that have obtained certification to the ISO 14001 standard.

Implementation and certification costs of ISO 14000 remain substantial, which could affect its wide-scale application. The costs to certify plants run by a multinational corporation are estimated to be in the range from $100,000 to $1 million, and for SMEs $10,000 and $100,000 depending on the company's individual needs and circumstances (Stenzel (2008)).

A2.5. SMEs

Impact of International Standards for SMEs Efficiency

SMEs tend to be suppliers for larger companies that deliver the final product to consumers, especially within the manufacturing sector where SMEs produce specialist components and parts. Quality is therefore pivotal for SMEs, as the input of poor-quality products can adversely affect the competitiveness of larger organisations (Singh et al. (2010)). International standards, including both technical and management standards play a vital role in ensuring SMEs provide products and services of the highest quality.

International management standards address a variety of issues including quality management, environmental management, social accountability and working conditions. ISO 9000 and ISO 14000 are the best-known family of management standards: ISO 9000, can be applied to any organisation and represents an international consensus on good management practice; ISO 14000, built on the success of ISO 9000 and relates to best-practices environmental management. Overall management standards result in increased quality, efficiency and operational practices, through improved organizational structure and communication between employers, cost savings, reduced paperwork, greater competitive advantage, more organized design and output. SMEs stand to gain the most from these standards, often having managers with limited skills and weak organisational structures. Although these management standards do not guarantee product quality they certain encourage it, through the procedures they implement (Wayhan et al. (2002); Tersiovski et al. (1997).

The ISO 9000 series has more than 1 million certificates issued worldwide since its introduction in 1987. The main benefits offered by ISO 9000 are lower costs through reduced wastage and quality improvement, and increased market share through perceived higher quality (Dick (2000)). These benefits tend to be especially strong for SMEs, and also for firms in developing countries – where ISO 9000 can partly substitute for the role of the pressure the market exerts on the performance of firms. However, there

exists no strong consensus in the literature about the extent to which ISO 9000 certification has a positive effect on business performance. The table below details the most prominent literature on business performance and ISO 9000 certification, focusing on SMEs.

Table 10 Studies of the impact of standards on SMEs

Author(s)	Paper	Key Findings
Bayati and Taghavi. (2007)	The Impact of Acquiring ISO 9000 Certification on the Performance of SMEs in Tehran	The performance of small-to-medium sized enterprises within greater Tehran have been improved after acquiring ISO 9000 certification.
Casadesus, Gimenez and Heras. (2001)	Benefits of ISO 9000 Implementation in Spanish Industry	65% of the companies with the ISO certification in Spain have gained from internal and external benefits.
Chow-Chua, Goh and Wan. (2003)	Does ISO 9000 Certification Improve Business Performance	Study on 146 companies, find that certified companies show better performance than non-certified companies.
Dick. (2000)	ISO 9000 Certification Benefits, Reality or Myth	Finds that ISO 9000 is not associated with having a quality assurance system that delivers improved process control, quality control or better conformance quality.
Koc. (2007)	The Impact of ISO 9000 Quality Management Systems on Manufacturing	Study on 106 SMEs, found that certified companies performed better than non-certified companies in terms of performance, manufacturing and competition practices.
Terziovski, Samson and Dow. (1997)	The Business Value of Quality Management Systems Certification Evidence from Australia and New Zealand.	Finds only a significant difference in terms of cash flow among 13 performance criteria between certified and non-certified companies in Australia and New Zealand.
Wayhan, Kirche and Khumawala. (2002)	ISO 9000 Certification: The Financial Performance Implications	Found ISO 9000 has no effect on sales, equity and gross margin, and a very limited effect on return on assets.

However, the positive effect of international standards on the performance of SMEs is not guaranteed, many SMEs implement management standards not to improve efficiency, but as a 'necessary evil', forced upon them by purchasers, particularly large organisations and government departments (Brown et al. (1998)). SMEs also tend to lack 'absorptive capacity', which is the expertise and organisational infrastructure that is beneficial for proper implementation of management standards (De Vries, Blind, Mangelsdorf, Verheul and Der Zwan (2013)). Compared to large firms which have specific departments to implement standards, that minimise the length of time for certification and maximize its benefits, and gain more from standardising complex management structures (Dobbin and Sutton (1998)). Dick (2000) suggests that the competitive advantage from better quality management may be dissipating since most firms have already improved their quality through quality initiatives.

The cost of ISO certification remains substantial, to the extent that this may prevent their implementation for smaller firms, with the certification costs spread over a much smaller revenue stream compared to large firms. Moreover, certification is costly, time-consuming and demanding in the short-term, whilst its benefits are mainly visible in the long-run (Stevenson and Barnes (2001)). These costs can explain why few small firms apply for an ISC despite their potential benefits. The cost of certification is substantially higher in less-developed and institutionally weak countries (Maskus et al. (2005)), where access to certification bodies is difficult, procedures expensive, and managerial infrastructure insufficiently developed to implement the correct procedures. The average time to implement a quality management remains lengthy reported to be between 12 months to 16 months (Raynor and Porter (1991); Pyra and Preston (1996), and SMEs unlike big companies may struggle to allocate resources during the period of certification (Karapetrovic et al. (1997); Puderbach and Brown (1998)).

Importance of International Standards for SMEs Accessing the Global Economy

ISO standards provide immediate credibility throughout the world which can be particularly important for smaller and newer businesses looking to enter foreign markets (intracen (2016)), quality certification is a low-cost instrument capable of signalling a firm's unobserved quality (Goedhuys and Sleuwagen (2013)). Moreover, management decisions are crucial for export success and ISO standards lead to better managed firms. According to the World Trade Report (2016), border regulations and standards are one of the main barriers hindering SMEs from engaging in export activities. This is because SMEs are more sensitive to trade barriers, as they have fewer resources available to deal with entry costs, international standards helps to alleviate this use as SMEs no longer have to conform to each countries national standards.

SMEs increasingly participate in international trade through global value chains (GVCs), with almost two thirds of trade is in intermediate goods and services produced by firms specializing in just one stage of the production process. However, the diversity of regulatory standards can be a major barrier for SMEs integration into GVCs (OECD (2018)), mutual recognition and convergence of regulatory standards through the adoption of international standards would reduce the burden of compliance for small-scale exporters in particular.

A2.6. The Role of International Standards in Facilitating Global Trade

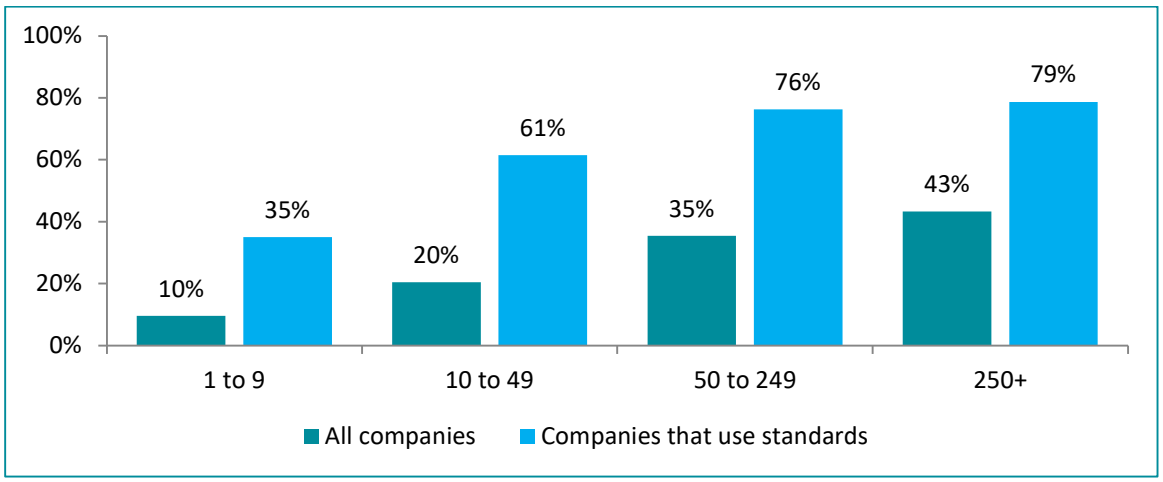
International standards play an important role in facilitating global trade by reducing technical barriers to trade. As world tariff rates have fallen non-tariff barriers have become increasingly important determinants of trade. Non-tariff barriers to trade can occur when countries put in place technical 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 at a regional and global level can act as a major catalyst for trade – allowing companies to sell their products and services without the need for adaptations across multiple markets. In Europe, 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.

Unsurprisingly, companies that use international standards tend to be more likely to export relative to the average. To demonstrate this point, Figure 29 contrasts the proportion of exporting companies relative to the general business population[21] within the UK, in the seven sectors covered by the BSI Standards in Industry survey. The majority of BSI standards are international standards. 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.

Figure 20: 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 general consensus is that international standards support compatibility, reduce transaction costs and provide a signal of quality to customers, thus boosting the export performance of companies. The main channels are detailed as follows:

> *International standards create a 'common language' for potential trading partners. Without the need for companies to adapt their products for multiple markets in order to comply with different countries national technical standards, a 'level playing field' is created, which enhances trade through lowering production costs for exporters and provides a foundation for global competition. This is famously demonstrated through the introduction of international standards for the specifications of containers in 1964, which drastically reduced transaction costs and boosted worldwide trade.*
>
> *The trade enhancement effect of international standards is particularly strong in industries where network effects exist, for example telecommunications. Network effects are generated when the*

[21] '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)

adoption of a given technology, product or service produce benefits that increase with the number of users. As standards create a common language they help companies access to a much larger network of users. Furthermore, by ensuring the compatibility of inputs, products and components across borders, international standards can increase the demand for cross-border 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.

Through ensuring the computability of products and processes international standards enhance global value chains. Inputs can enter the production process without the need for processing, which promotes trade in intermediate products and thus intra-industry trade, thus making out-sourcing an increasing viable option for companies. These lower transaction costs result in different parts of the production chain being located where comparative advantages exist, increasing specialization and the fragmentation of the production process throughout the world. For example, it may be optimal for a company to contract to a foreign supplier which has lower inputs cost to manufacture their products while they focus on design, sales and marketing of the product.

International standards increase consumers and trade partners perception of product quality. Lack of transparency in product quality often impedes trade. Standards reduce information asymmetries between global actors, which results in buyers and sellers more likely to be able to make optimal purchasing decisions, which can help to minimise transaction costs and increase competitiveness.

International standards are often used by firms in developing countries to increase their access to international markets, being a signal of adherence to good practices to consumers. In that sense international standards can be viewed as a necessary bridge between increasingly demanding consumer requirements and the participation of distant international suppliers.

How International Standards May Hinder Trade

In order to comply with the international standards, exporters have to adapt their products, this can result in an increase in both the marginal and fixed costs of exporters (Mangelsdorf (2011); Swann (2010); Moenius (2010)). These adjustment costs tend to be large relative to their long-run economic benefit. If the costs to adapt to the standard are too high for the company to make exporting their products or service viable, then they can act as a barrier to trade.

These compliance costs tend to be largest for middle to smaller size companies (Hanson (2005); Blind (2001)) and companies from developing countries. SMEs and developing countries tend to have a smaller impact on the development of international standards, which results in the standards being least suited to their business needs, creating an insider-outsider dynamic. Developing countries are generally 'standard takers' rather than 'standards makers' (Maskus et al. (2005)), the EU has a dominant influence on the ISO, holding far more leadership positions than any other major economic power – often referred to as a 'regulatory superpower' (Fagersten and Ruhlig (2019)).

Standards tend to be more of a trade hindrance when they are national, differing across countries. They represent additional transaction costs for exporters who need to adjust to standards that differ across trading partners.

Empirical Literature

Although the empirical literature on the effect of international standards on trade flows remain uncomprehensive, due to the difficulty of the subject and nature of the data, there is strong evidence that

they facilitate trade. Swann (2010) in a recent survey of the empirical literature finds that international standards have a positive impact on trade flows. Studies tend to use a 'black box' to estimate the relationship between standards and trade, due to its complexity. However, the effect of national standards on trade remains far more ambiguous. Whether national standards are trade creating depends on the net effect of the increase in compliance costs and decrease in information costs they generate. A summary of the key studies is presented in Table 12 below:

Table 11: Key studies of standards and their findings

Author(s)	Paper	Key Findings
Blind. (2001)	The Impact of Innovation and Standards on Trade of Measurement and Testing Products	Switzerland's stock of standards are positively associated with trade flows in instruments for measurement and testing to Germany, France, and UK
Blind and Jungmittag. (2002)	The Impacts of Innovation and Standards on German-France Trade Flows	Germany's adoption of international standards leads to a higher level of imports from France.
Blind, Grupp, Hullmann and Jungmittag. (1999)	The Relationship Between Standardisation and External Trade	Studying the effects of standards on Germany's trade balances, find that international standards promote German imports.
Clougherty and Grajek. (2012)	International Standards and International Trade: Empirical Evidence from ISO 9000 Diffusion	Whilst the adoption of ISO 9000 – The most successful standard implanted by the ISO – has enhanced trade for European countries, it has had the opposite effect for developing countries.
Czubala, Shepherd and Wilson. (2009)	Help or Hindrance? The Impact of Harmonised Standards on Exports and Imports	Internationally harmonized standards help to facilitate African exports.
Gandal and Shy. (2001)	Standardisation Policy and International Trade	Internationally harmonised standards are trade creating.
Mangelsdorf. (2011)	The Role of Technical Standards for Trade Between China and the European Union	For China's exports to Europe, national standards have a negative impact, but internationally harmonised standards have a positive effect
Moenius. (2004)	Information Versus Product Adaptation: The Role of Standards in Trade	Bilaterally shared standards are favourable to trade.
Otsuki. (2011)	Effect of ISO Standards on Exports of Firms in Eastern Europe and Central Asia	ISO certification improves the export performance of firms in Argentina and in Central Asia
Schmidt and Steingress. (2019)	No Double Standards: Quantifying the Impact of Standard Harmonization on Trade	Studying international standard harmonization across 26 countries, harmonizing standards leads to a 0.67% increase in trade flows

Formation of International Standards

SMEs representation in international standard development remains limited, due to their constraints on time personnel and financial resources (De Vries, Blind, Mangelsdorf, Verheul and Der Zwan (2009)). Smaller firms have to rely on their trade associations, national standard bodies, and supplier relationships to keep them informed about new standards (Egan (2002)). This means that international standards are less likely to reflect the business interests of SMEs than that of larger firms.

A2.7. References from the literature search

The key relevant studies from the literature search that we have used for formulating estimates of economic impacts are set out in Tables 7 – 12. But in addition the list below gives the other main studies which we considered for the literature search.

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Appendix 3 Full results of the 2021 survey of the impact of standards

A3.1. Introduction

The previous analysis described that at the aggregate level, standards contribute significantly to the spread of technical knowledge, leading to a boost in productivity and thus driving economic growth. This represents an update to previous studies that used a similar methodology. A drawback of this macroeconomic approach is the absence of any detail on how the benefits of standards are transmitted in practice, at the sector and at the firm level. Multiple mechanisms have been identified in the academic literature as to how standards benefit firms; we now provide evidence to show how these mechanisms apply at the sector level in the UK economy recently.

Additional quantitative research has been carried out in this study. The main goal was to gain a detailed understanding of the role of standards within sectors in terms of economic 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 1,000 (compared to 527 in 2015 survey) firms in 16 (compared to 7 in 2015 survey) key sectors was commissioned as part of the study, asking businesses to think about the general and detailed effects of standards on their operations. This part of research plans to:

- Establish how standards boost the productivity and efficiency of firms;
- Identify the effect of standards on competition within markets;
- Quantify the economic impact of standards on the supply chains of some of the UK's largest sectors;
- 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 environmental effects from standards.

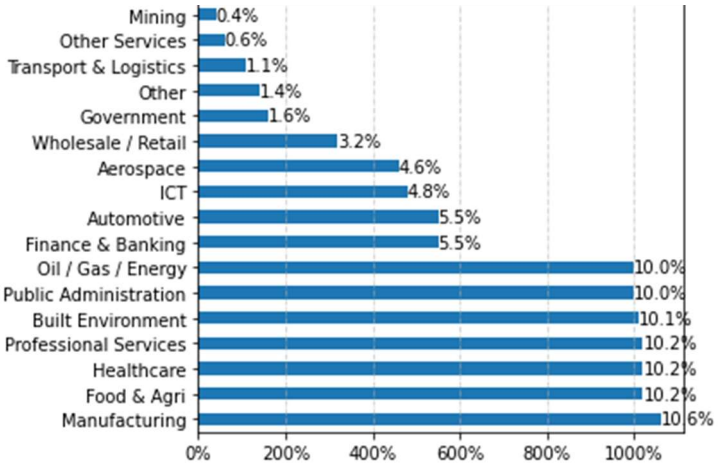
The purpose of this section is to present the findings relating to these aims among the firms we surveyed.

A3.2. An overview of the sample structure

We first look at a few basic characteristics of firms appeared in the sample.

First, these 1,000 firms span across 16 sectors (see Figure 21). For example, 10.6% of the firms are in manufacturing, 4.8% in ICT, and 0.4% of the firms in mining. Second, the firm's sizes are captured by 10.6% micro firms (1-9 employees), 12.7% small firms (10-49 employees), 28.7% medium firms (50-249 employees), 36.9% large firms (250-2,499 employees), and 11.1% very large firms (2500+ employees). Both of these features suggest that the sample covers a wide range of firms. Third, among all the firms surveyed, 73.7% of them

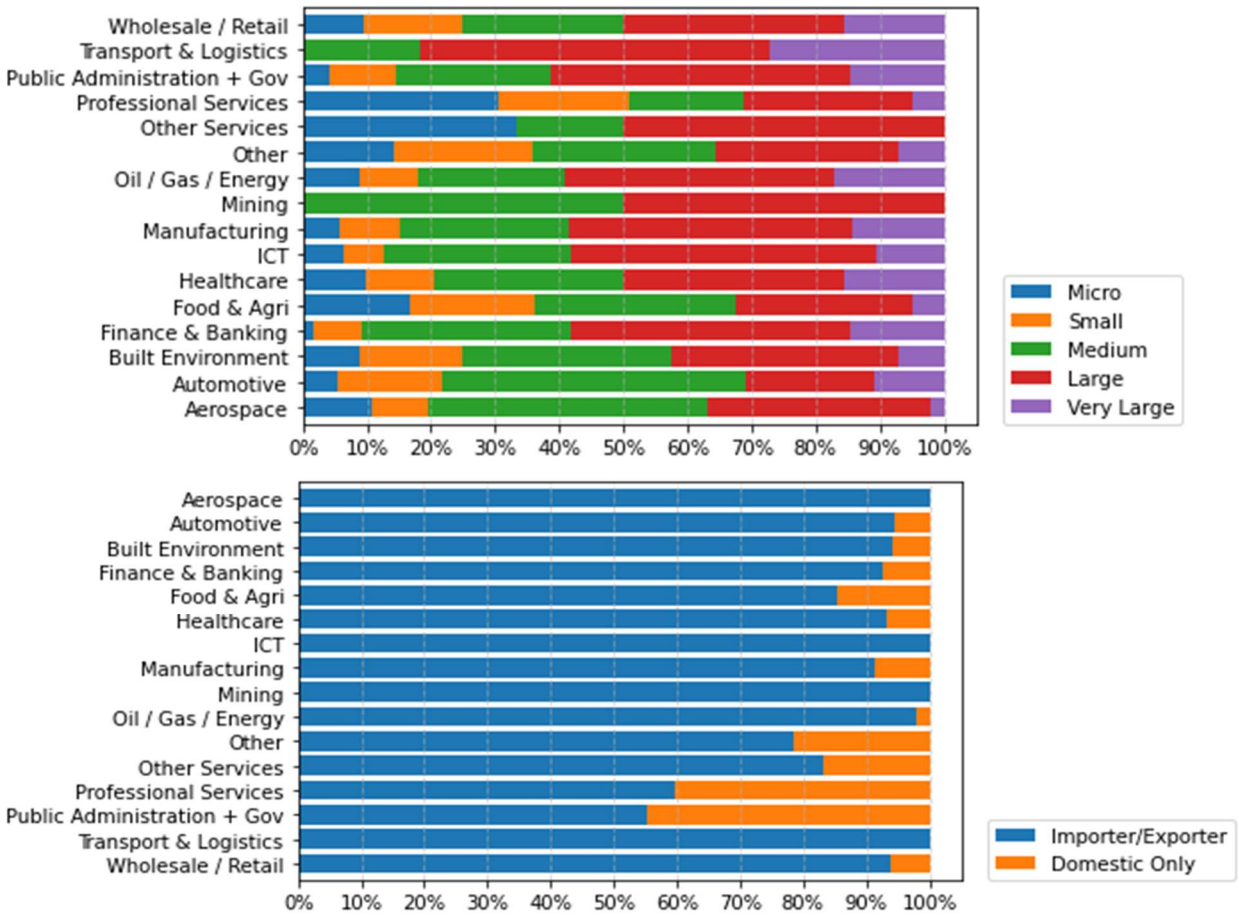
Figure 21: Sector Decomposition



import goods/services, and 40% export. 14.5% of firms run domestically only, implying that the British economy is very open.

A further decomposition into sectors suggest that there is heterogeneity across sectors. For example, the transport & logistics sector has less than 20% of SME (micro + small + medium firms) while both the professional services and the automotive sectors have close to 70% SME. The professional service sector has more than 40% of firms that only run domestically, while all ICT firms import from or export to foreign markets. Compared to 2015 survey where each sector has firms with 250+ employees from 12% to 31%, large firms are much more represented in the current sample.

Figure 22 The sizes and export/import status across sectors



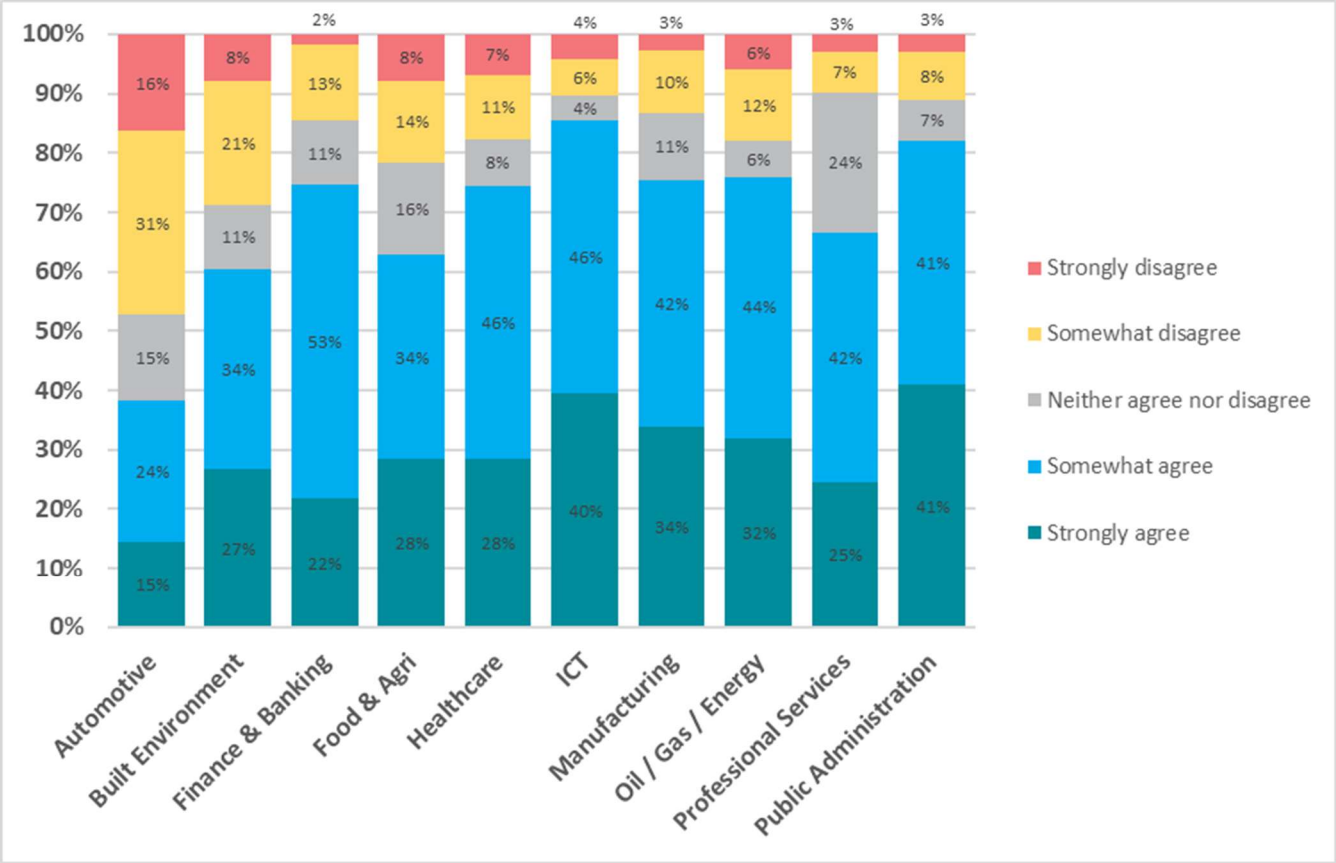
A3.3. The business economy impacts of standards

The use of standards is predominantly voluntary. However, in many cases, firms 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 survey shows that, on balance, standards unanimously generate net benefits.

The majority of survey respondents reported that standardisation provided a net benefit for their business (see Figure 23 and Figure 24). In particular, the majority of firms in the finance and banking sector (75%), healthcare sector (75%), ICT (82%), and manufacturing (76%) reported that standards benefit their

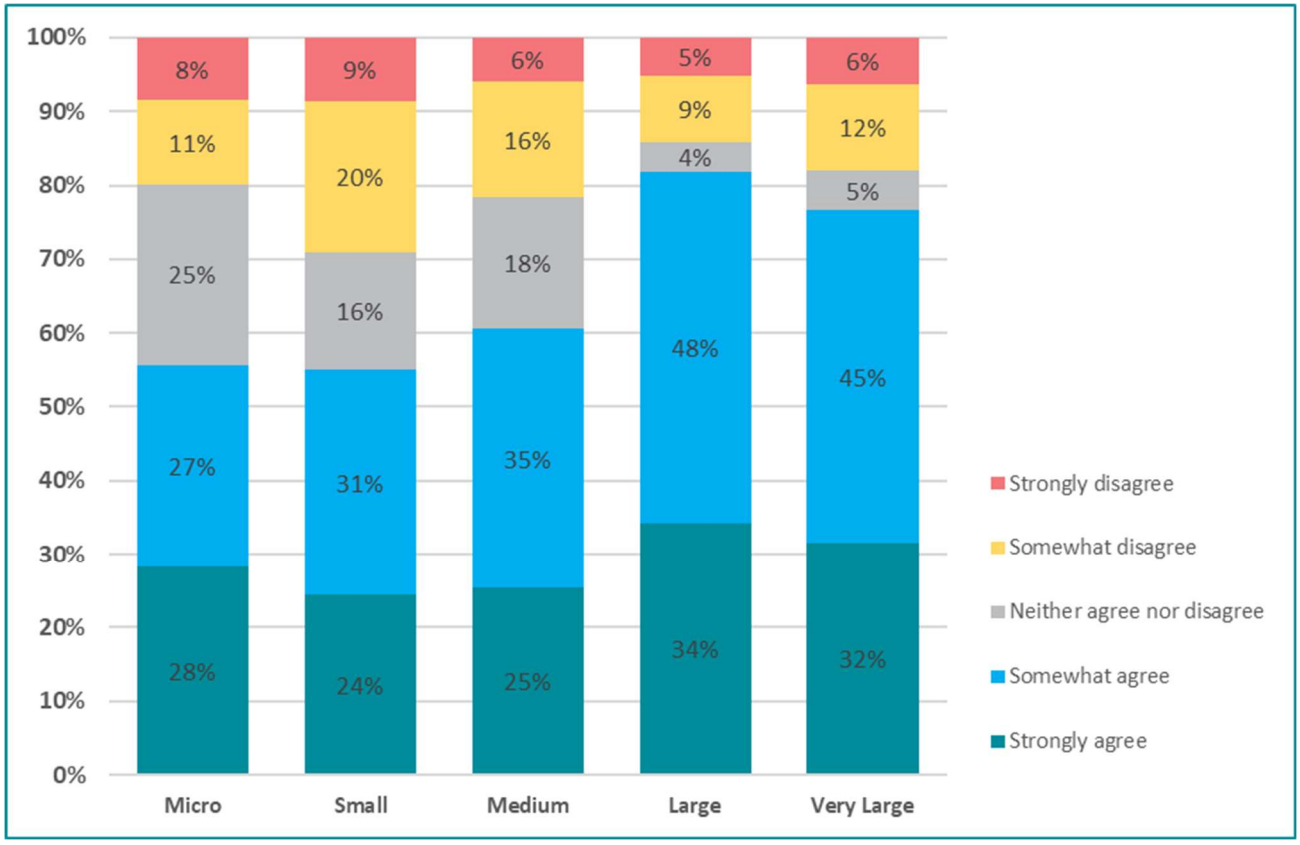
business.[22] This is similar to the 2015 report, but the inclusion of the finance and banking sector suggests that service standards in the UK are equally important for economic benefits. The respondents from the automotive sector are not as positive about standardisation as those from other sectors, partly reflecting the fact the standardisation in this sector has more "license to trade" to trade effect than pure economic benefits illustrated before.

Figure 23: Does your organisation experience a net benefit from standardisation? (% of respondents by sector)



[22] Here, we count the number of "Somewhat agree" and "Strongly agree".

Figure 24: Does your organisation experience a net benefit from standardisation? (% of respondents by employee size)



The extent to which respondents reported that standardisation benefitted their business differed across firm sizes: 85% of large firms with employees from 500-2,499 surveyed agreed that standards provided a net benefit to their business while around 55% of small and medium-sized enterprises (SMEs, with employee numbers below 250) surveyed responded in the same way. These are significantly higher than the numbers reported in the 2015 survey.

It is important to note that standardisation also benefits small firms, and the majority of them still view that standardisation bring net economic benefits so we should be sure that the "License to trade" effect is still dominated by the positive benefits mentioned before. Additionally, it seems that standards do not bring comparably more benefits for very large firms with employees more than 2,500 people, partly because of potential larger compliance costs.

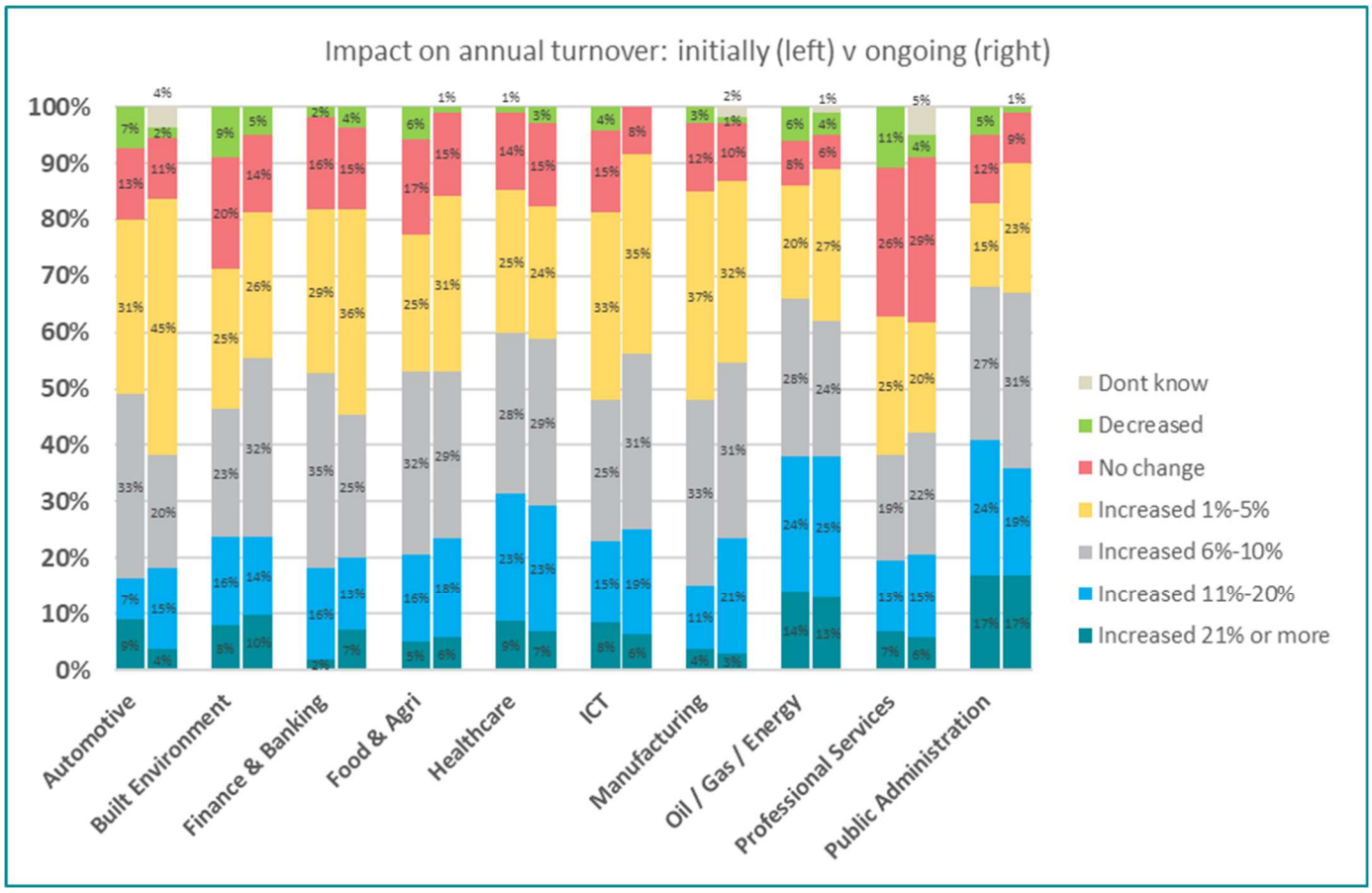
Turnover/Revenue

The survey asked a question about turnover after meeting/adopting standards. In particularly, we look at the initial impact and the on-going impact to highlight the dynamic effects of standards. Such differentiation is new compared to past surveys. The survey reveals that 78% (22% in the 2015 report) of all firms benefited from an increase in revenues of at least 1% per year as a result of initial standardisation. 82% reports on-going benefit. This reflects that large firms appear more in the current sample mentioned before, and these firms derive more benefits from standardisation.

A significant pattern among almost all sectors, except the healthcare, is that the increase of initial turnover is less than the increase of on-going turnover, suggesting that the initial fix cost of adopting standards may be important, especially for the automotive sector, the construction sector, and the ICT sector. These

sectors rely more on technical aspects of standards and it may take time to fully realize the potential of the benefits coming from standards.

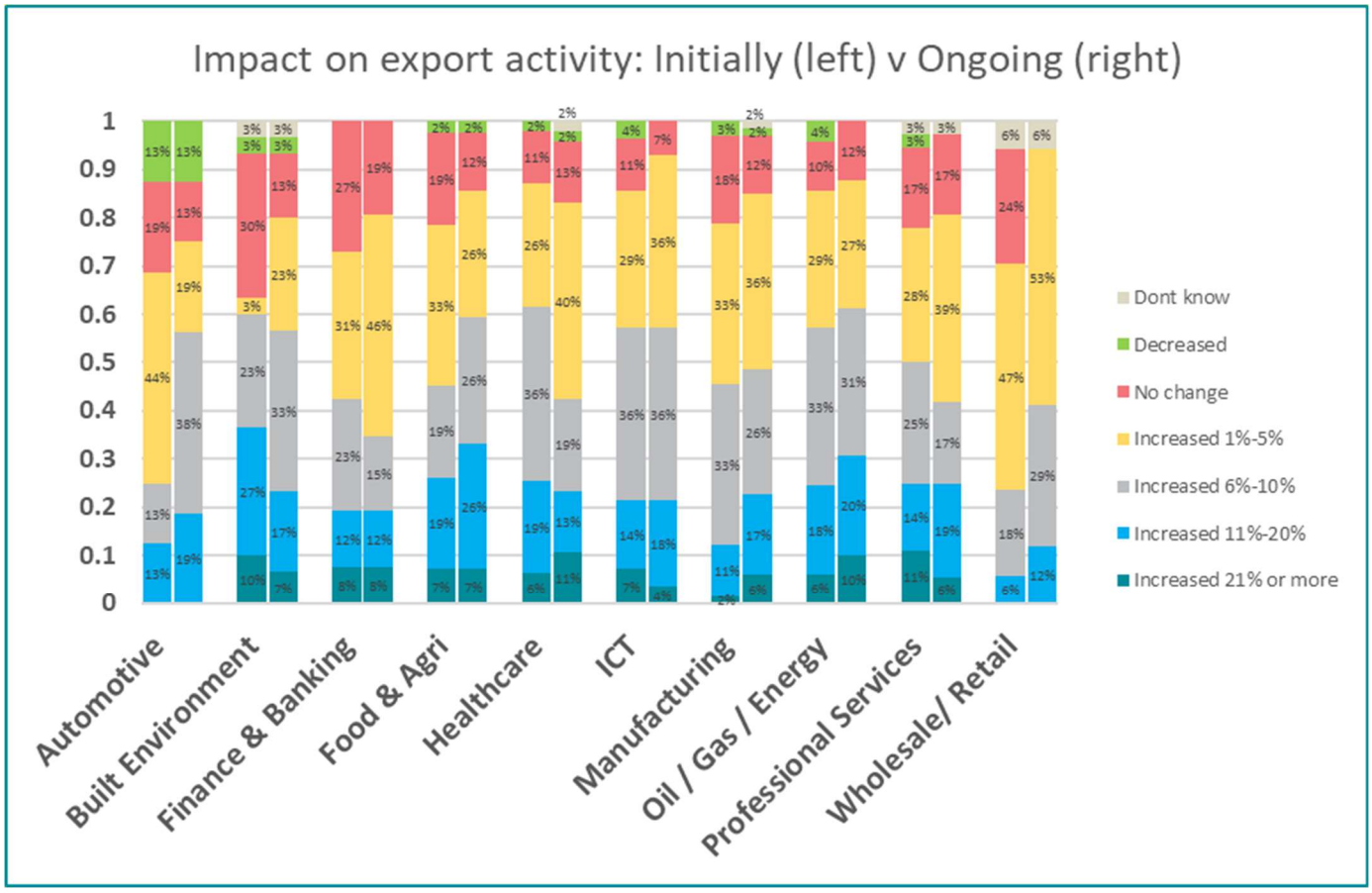
Figure 25: How has the use of standards impacted your organization's annual turnover?



Exports

Of the companies surveyed, 40% (48% in 2015) indicated that they were active exporters, although this differed substantially between sectors ranging from 26% (aerospace and defence, 70% in 2015) to 49% (energy, 42% in 2015). 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 (healthcare, finance, ICT, energy, and retail).

Figure 26: Increase in exports revenue that can be attributed to the use of standards



GVA

The survey revealed significant benefits to firms, 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.[23]

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, standardisation contributed to an aggregate increase in GVA of £11.9 billion per year initially, and £16.9 per year later, equivalent to 0.60% and 0.85% of the aggregate

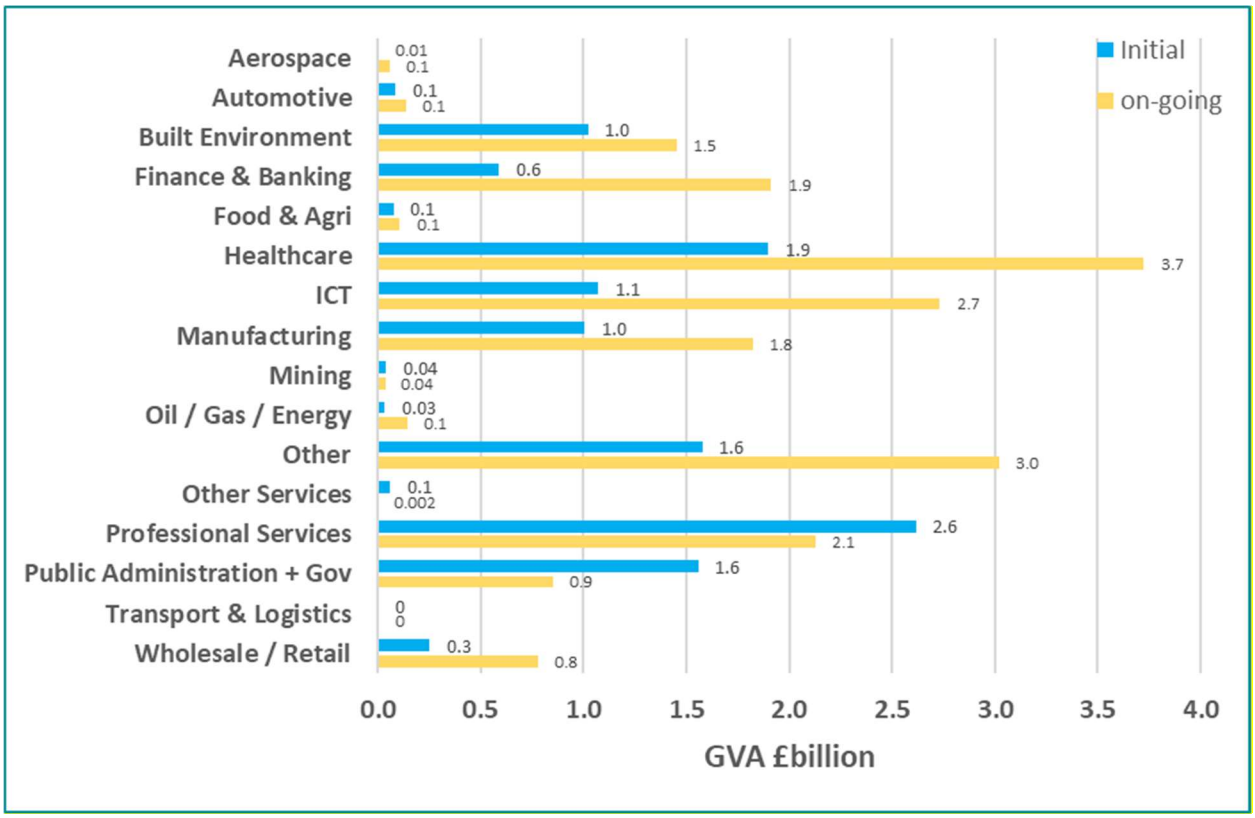
[23] Increases in revenues were calculated using survey responses and official data. Survey responses were scaled by the official business population of each industry (using ONS UK Business population statistics) and applied to official sector revenue data (from the ONS Supply- Use Tables 2018 and ONS GDP (O) Low Level Aggregates 2020). This ensured that findings relating to the aggregate increases to 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 2020 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 in the sample.

GVA of all industries in 2019. The numbers are higher than 0.42% (6.9£ billion in 2014) overall reported in the 2015 report.

- Overall, the health care industry observed the largest increases in GVA as a result of standardisation, equivalent to almost £1.9 billion per year initially, and £3.7 billion per year on going (see Figure 16). In 2015, this was the ICT industry.

- Firms within finance, construction, manufacturing, ICT, and professional services also observed large rises in GVA as a result of standardisation: equivalent to £1.5 billion to £3.0 billion respectively per year. Also, the on-going GVA increase is usually larger than the initial increase.

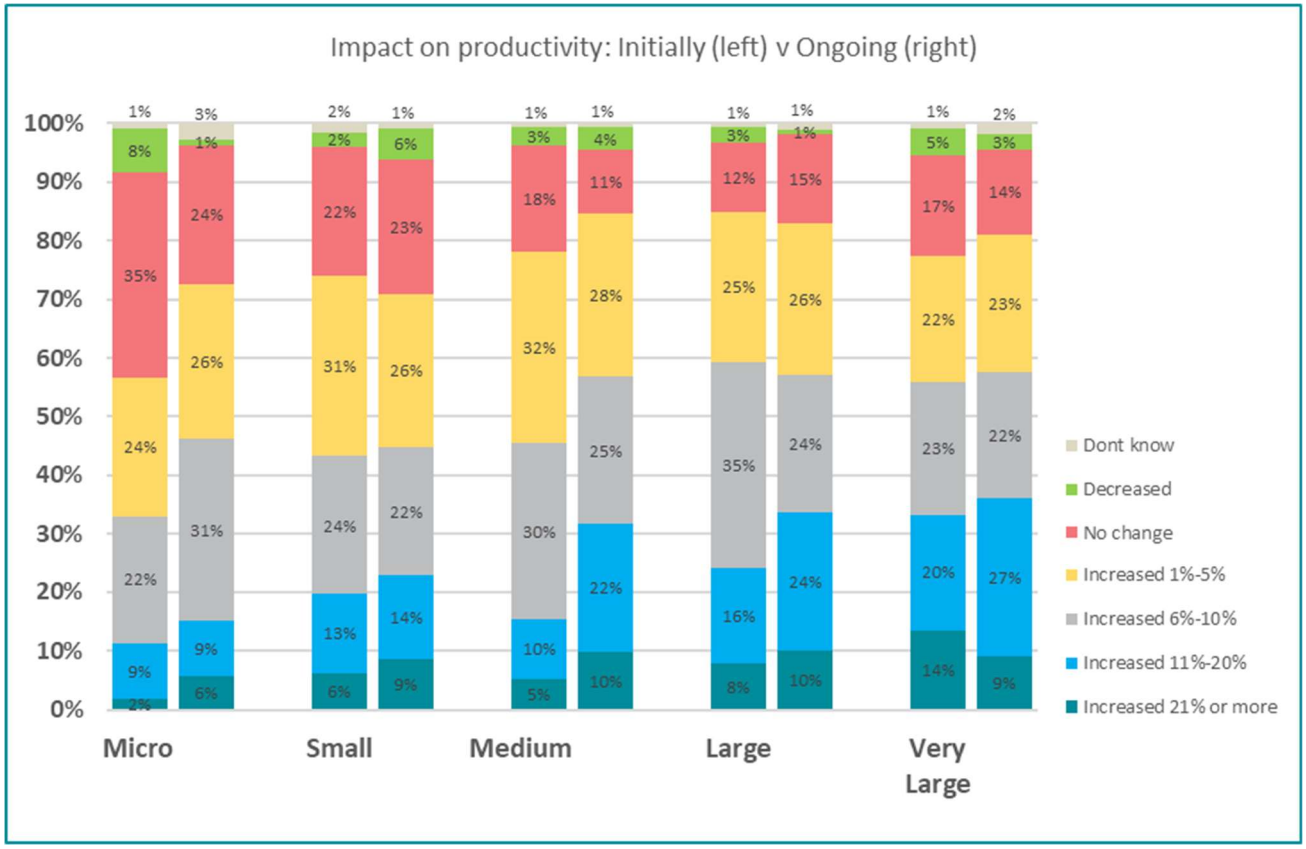
Figure 27: Estimated increase to GVA of industries as a result of standards (£ billions)



A3.4. 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, 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 28: Do standards increase productivity? (% of respondents by size)



The results of this survey confirm that on balance standards act as a stimulant of productivity, with 78% and 81% of all firms surveyed stating that they had experienced an initial increase and on-going increase in productivity as a result of standardisation respectively, compared with 36% (about general productivity increase) in 2015 report.

The survey results revealed that higher productivity as a result of standards varied between smaller and larger companies. In particular, 80% of large firms reported an overall increase in productivity as a result of standards, in comparison to 63% for SME firms. Both numbers are larger than those in the 2015 report. For most firms, especially micro firms, the increase in productivity is more evident after the initial year of meeting/use of standards. For very large firms, the fraction of respondents who answered large initial increase in productivity (21% +) are more significant than those who answer on-going large increase. Therefore, standardisation have different dynamic impacts on productivity for small and large firms.

Besides the benefit of economic scales that is reflected in enhanced productivity, the survey also sought to identify the mechanisms behind the impact of standards on productivity and efficiency. Roughly 67% of firms indicate that costs of production go up, but about 76% indicate that they can charge higher prices. The answers do not significantly change across the sizes of firms.

Therefore, standardisation, which may not necessarily reduce overall costs of production, do generally contributes to economic of scale / productivity and do signals quality of products and allow firms to charge higher prices.

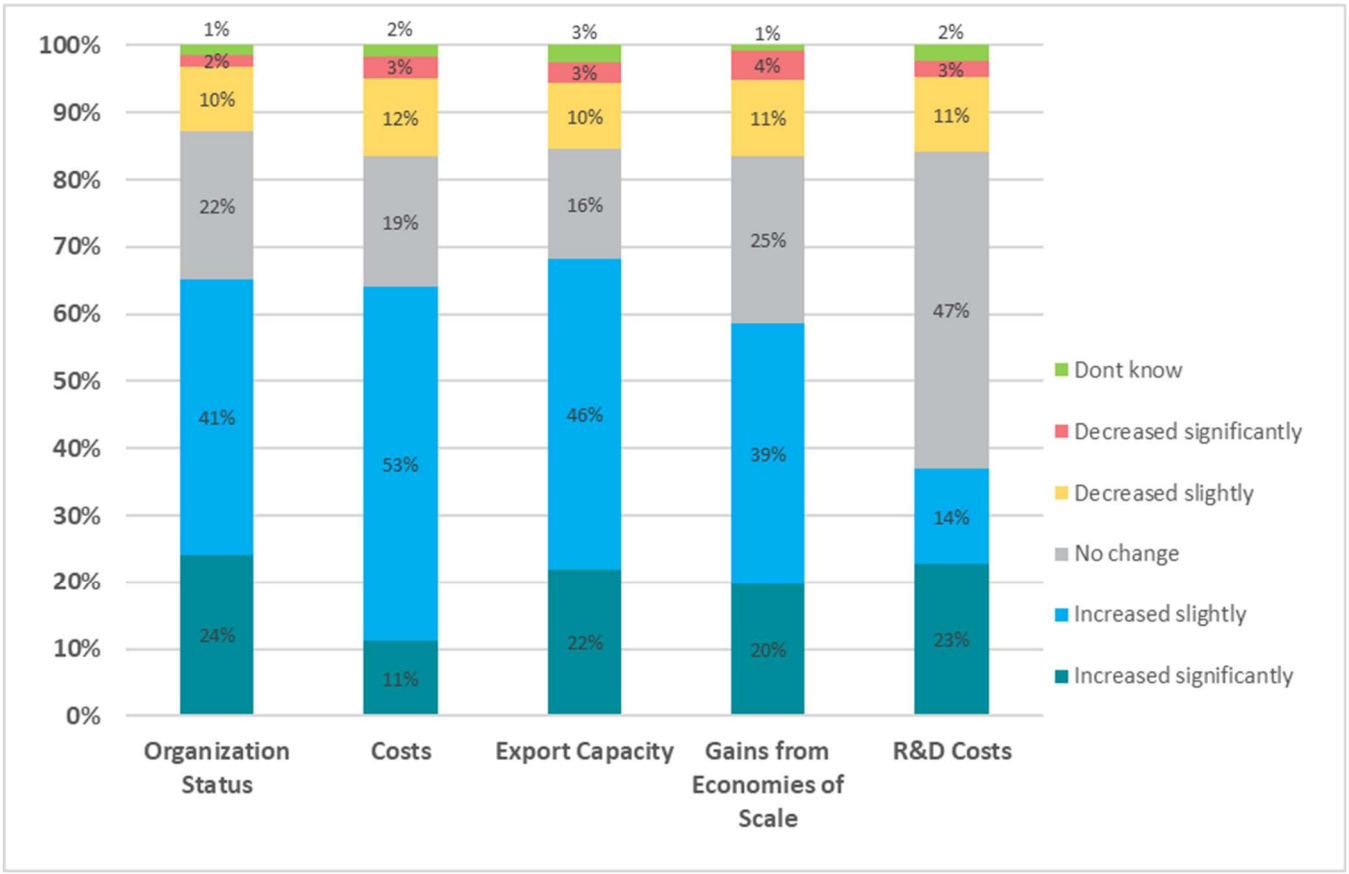
A3.5. How standards enhance UK business competitiveness and competition

The survey revealed some of the key channels through which standards improve the competitiveness of businesses (It is worthwhile to comment on the effect of standards on businesses' competitive edge by demonstrating to the market that their products and services are of a high quality (i.e., enhance the status of firms in the survey question). For this channel, similar to the 2015 finding, more significant to large firms with 68% (92% in 2015) reporting this was a factor, relative to 63% (83% in 2015) of SMEs. We see again that standardisation can benefit firms of all sizes. However, this effect has become less important compared with the effects of standards on economic of scale and export capacity.

The most important mechanism is the contribution that standardisation has for export capacity (68%), which is more than double the number (31%) in 2015. Additionally, standardisation also enhance the status of firms (65%), compared to 84% of respondents in the 2015 survey. Related to the finding about productivity, 58% of respondents view that standards contribute to economic of scales, while only 28% had this view in 2015.

It is worthwhile to comment on the effect of standards on businesses' competitive edge by demonstrating to the market that their products and services are of a high quality (i.e., enhance the status of firms in the survey question). For this channel, similar to the 2015 finding, more significant to large firms with 68% (92% in 2015) reporting this was a factor, relative to 63% (83% in 2015) of SMEs. We see again that standardisation can benefit firms of all sizes. However, this effect has become less important compared to standards' effects on economic of scale and export capacity.

Figure 29: How has standardisation affected the competitiveness of your firm? (% of respondents)

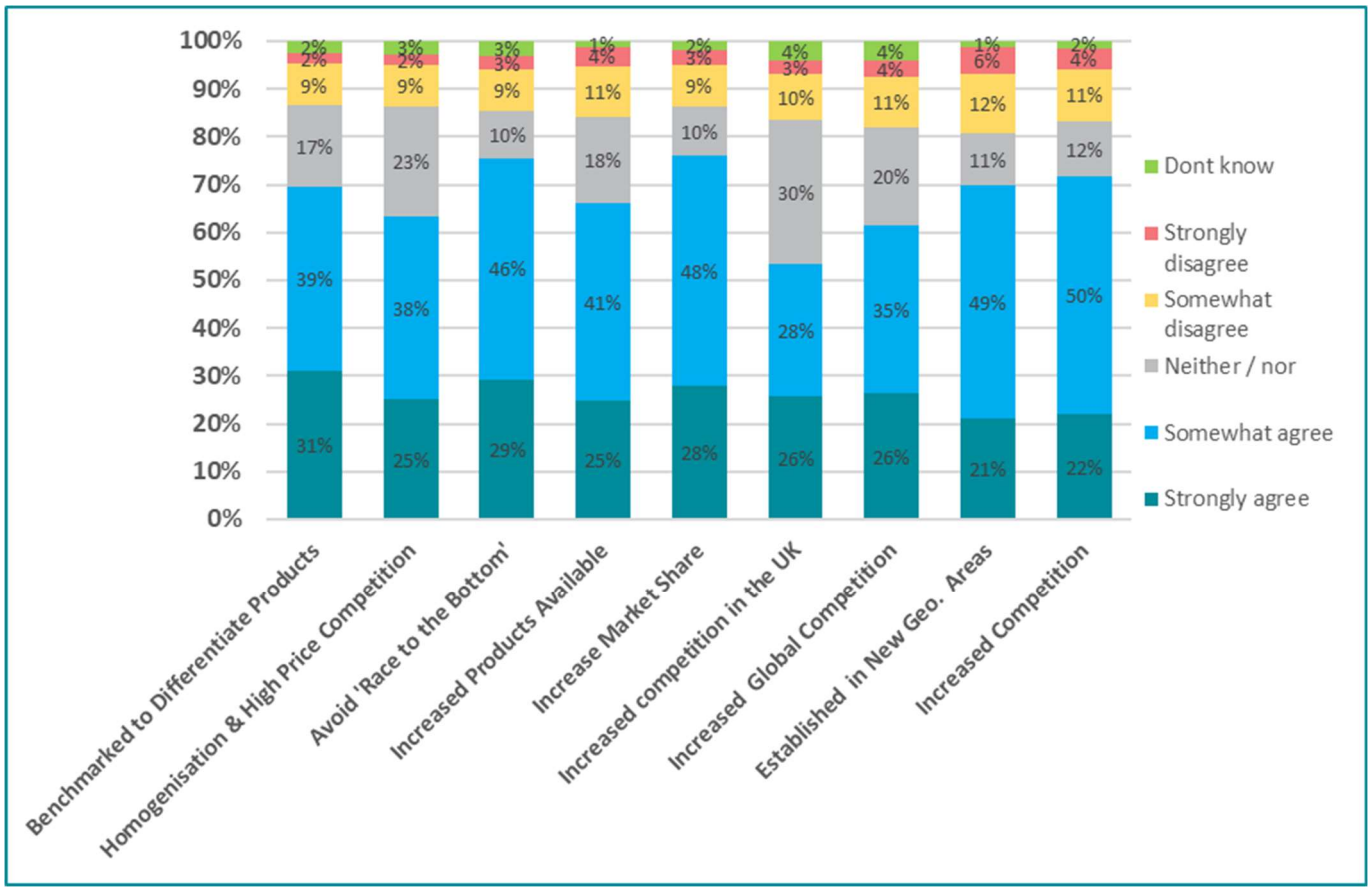


Notice that standards also generate cost during implementation. But less than 64% reported higher additional costs from standards, compared to 76% in 2015; 37% of firms reported higher research and development (R&D) costs, slightly below 38% in 2015. These results suggest that the regulatory cost side from standardisation decreased significantly over the past six years, while the cost related to technological aspect of standards fell only slightly.

The survey results also highlight an important impact of standardisation on market structure and the nature of competition (Figure 30): the strengthening basis for non-price competition. 63% of firms cite that standards have homogenised products to the extent that price competition has increased, identical to that in 2015. Additionally, almost 70% 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, but this is significantly lower than 87% reported in 2015. This comparison also explains the discussion above about firm status.

Of those surveyed, around 76% 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; the corresponding 2015 result was 51%. A similar fraction (77%) of responses believe that standards 'increase market share'. However, we should notice that such intense price competition is not always sensible or in the interests of consumers.

Figure 30: Quality competition: how has standardisation affected competition? (% of respondents)



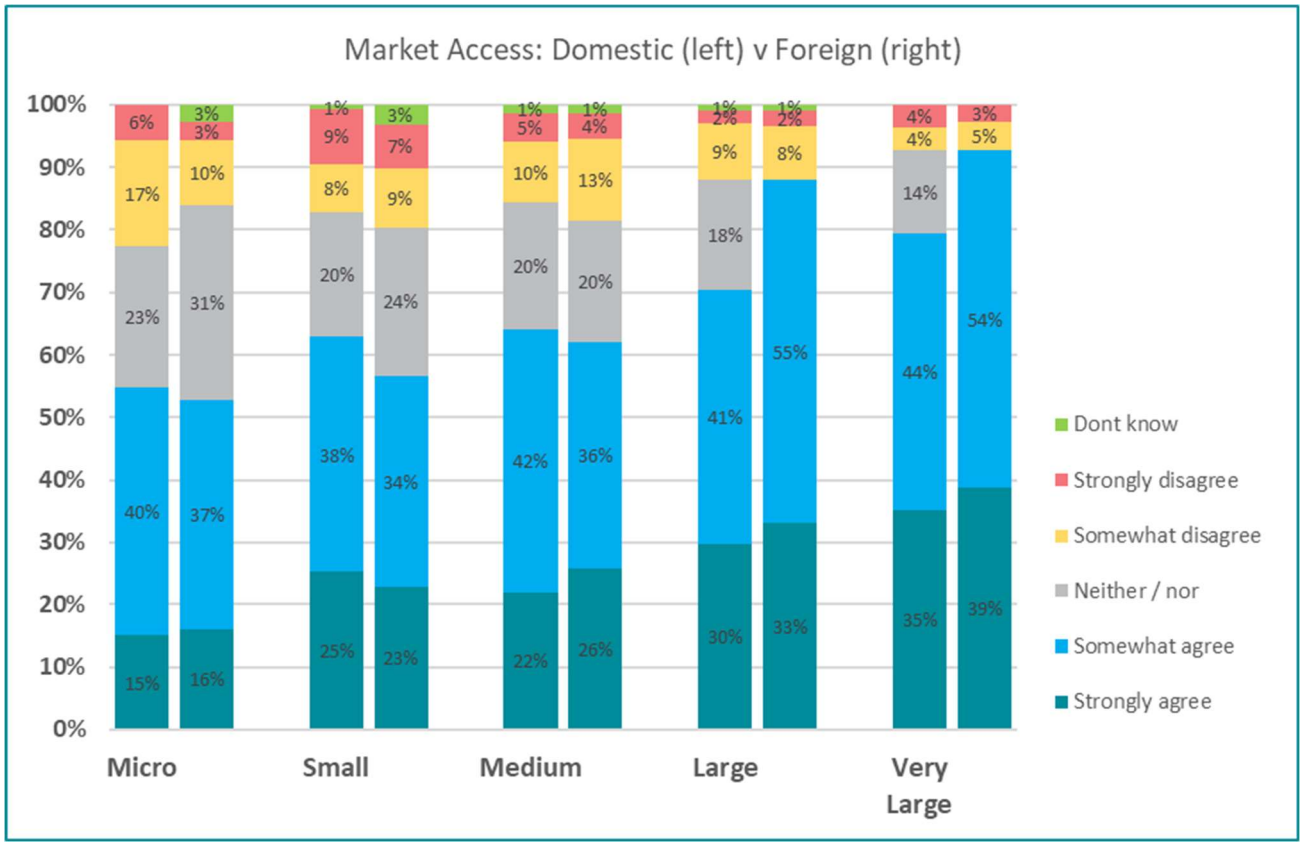
A3.6. How do standards help companies enter new markets?

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

The survey reveals that on average about 67% (33% in 2015 report) of all firms surveyed had experienced easier access into new markets at home as a result of standardisation. In addition, the survey highlights that a higher proportion of large and very large firms compared to SMEs found that entry into new domestic markets was made easier as a result of standardisation: 73% (45% in 2015) of firms employing more than 250 people confirmed that new markets at home were made more accessible through the use of standards compared to 62% (which was 32%) of SMEs.

The survey also emphasised the role of standardisation in facilitating firms' access into new foreign markets, especially for large firms. More respondents view that entering new foreign markets is easier after using/adopting standards, compared to entering domestic markets. For example, almost 93% of very large firms agree that standards benefit accessing new foreign markets, while only 53% of micro firms agree (see Figure 20). For very definite answers ("strongly agree"), the percentage numbers are 38.7% versus 16.0%. For large and very large firms, they are more optimistic about entering international markets than domestic ones. 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.

Figure 31: Standardisation has made entry in new markets foundation for competition based on product and service characteristics, such as quality.

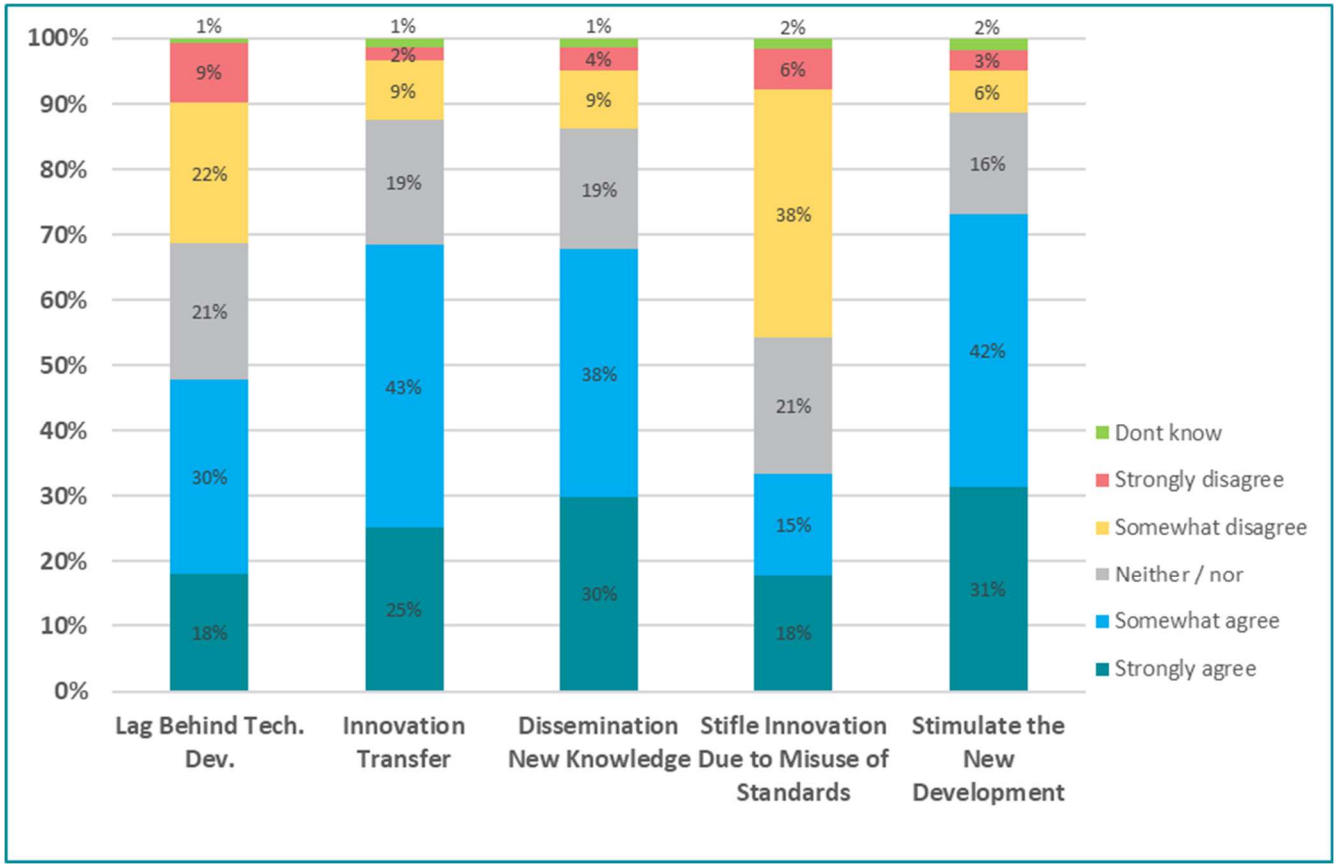


A3.7. Do standards catalyse innovation?

Similar to 2015 report, the survey again confirms that standards play a significant role in fostering innovation (Figure 32). 68% (54% in 2015 report) of all firms reported that information was made more accessible through the dissemination of innovation and technology through standards, and 68% (50% in 2015 report) 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 survey also highlights that standards are not mainly for the development of brand-new technologies. 48% of the firms surveyed cited that the standards lag behind technological development. The number was 59% in 2015 report, suggesting that standards have become more informative about future technology changes, which is one important aspect of standards explained in the literature. Overall, businesses appeared to confirm that that the role of standards in innovation is not in driving the development of new ideas but in promoting/assisting the innovation process, though the degree is less compared to six years ago.

Figure 32: Standards and the diffusion of information / innovation

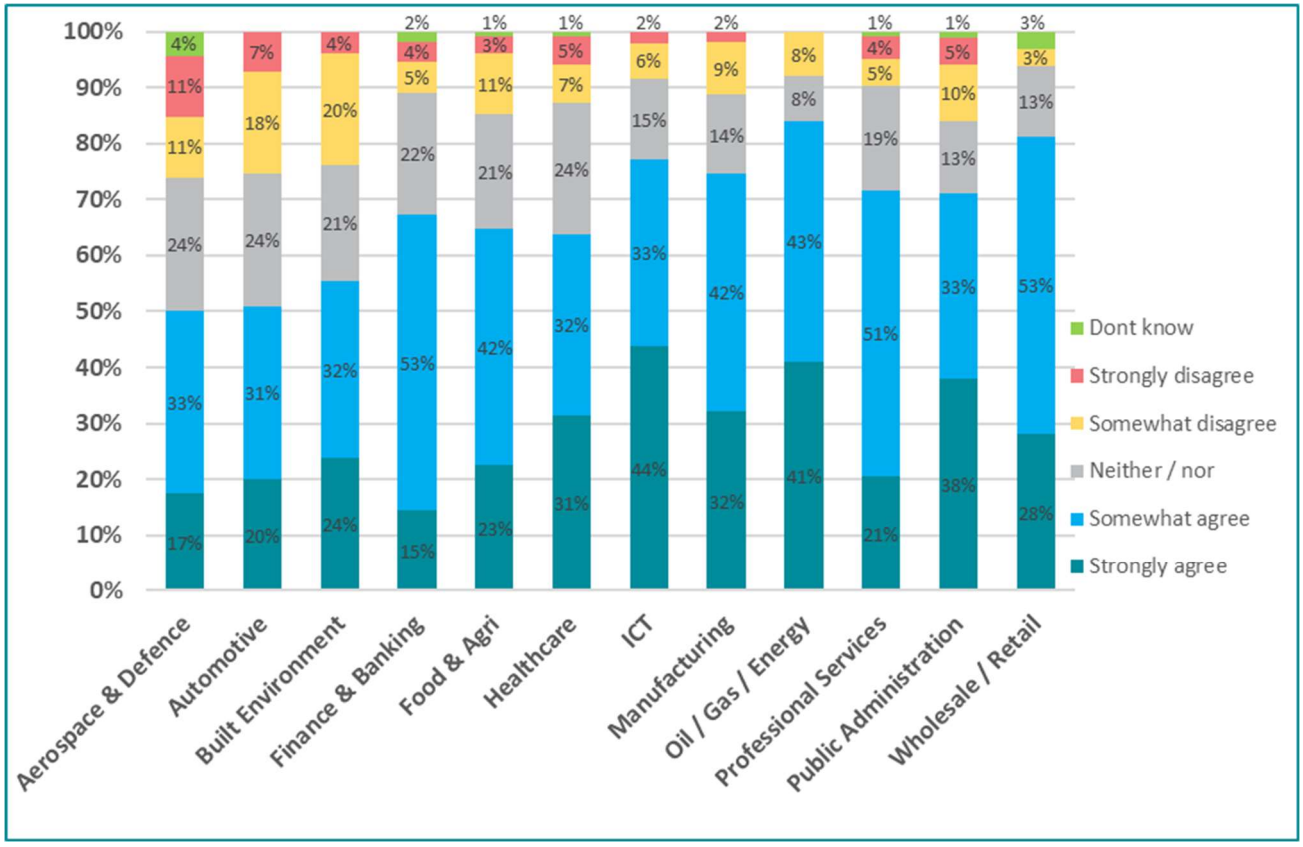


A3.8. What is the role of standards in the supply chain?

Standards enhance the supply chain of industries by promoting compatibility between products and processes and boosting confidence between suppliers and clients. On average, over 68% of all firms surveyed confirmed that standardisation had improved their client-supplier relationship through improved confidence.

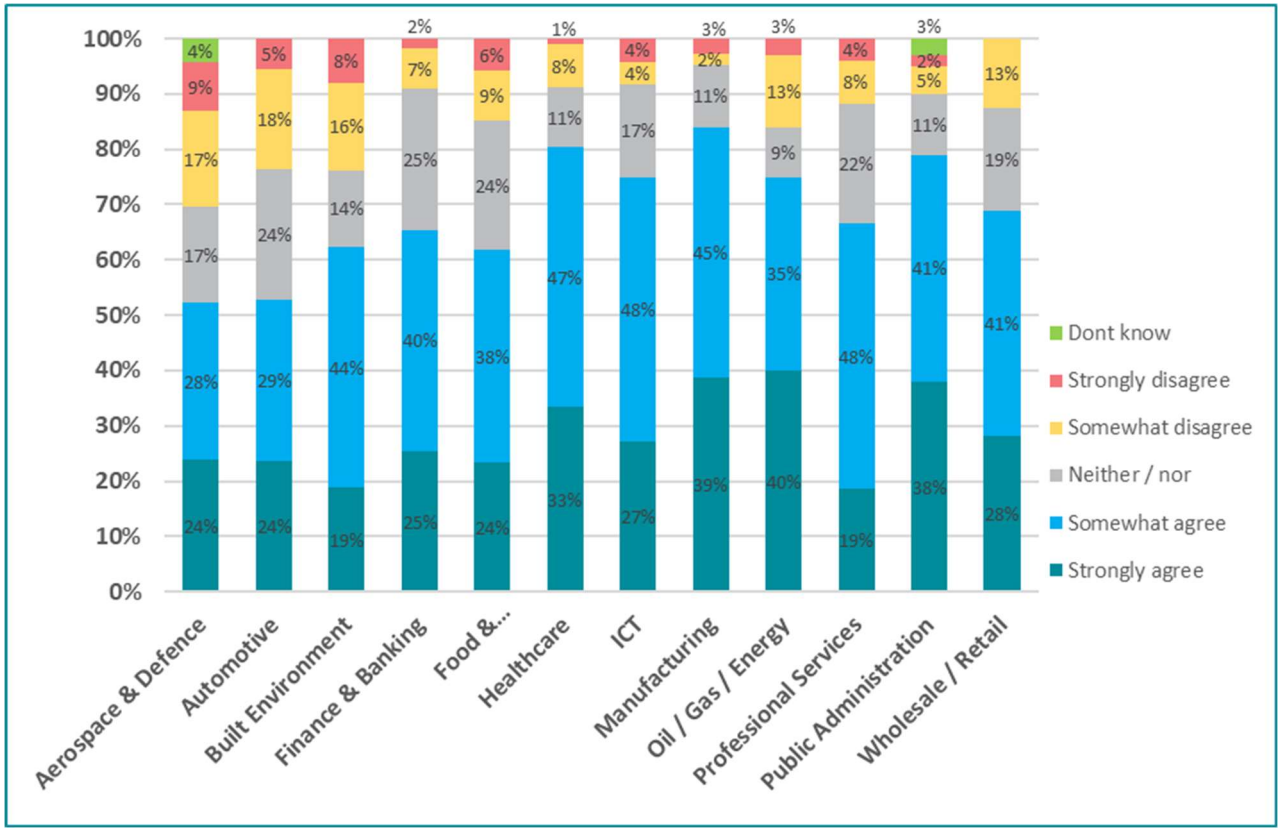
This benefit was most widely experienced in the energy sector (84%) and the wholesale/retail sector (81%) of all firms reporting an enhanced client supplier relationship (see Figure 33). In the 2015 report, the highest number (63%) belonged to the aerospace and defence sector, while it is now 50%. Over half of all firms within the construction, manufacturing, and the ICT sectors reported improved client supplier relationships as a result of standardisation, all above the 2015 results. Therefore, standards have become even more useful for many key sectors' supply chains in recent years.

Figure 33: Better connections: standardisation has improved my client supplier relationship



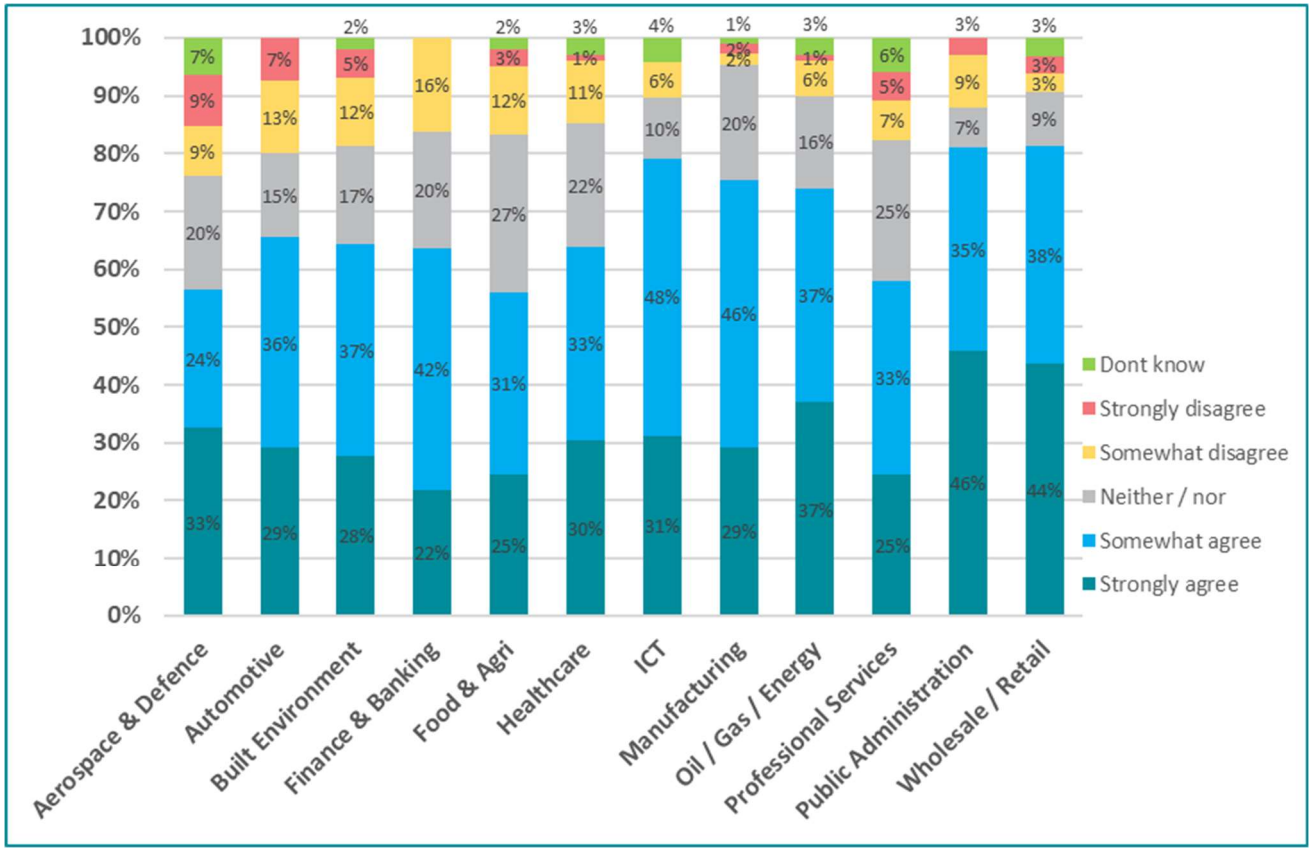
Industries that have more technical standards are likely to benefit most from savings that result from the improved quality of supplier products and services. The survey findings confirm this, with 52% (77% in 2015) of firms within the aerospace and defence industry, and 84% (76% in 2015 report) of businesses from the manufacturing sector confirming that standardisation improved the quality of supplier products and services.

Figure 34: How do standards affect your supply chain?



In addition, the survey revealed that 68% of firms find standardisation has enabled better access to global supply chain by signalling quality and conveying information about products to international 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 (79%) and the manufacturing sector (75%) finding that standards have enabled improved access to global suppliers.

Figure 35: How does standardisation benefit the firms in your market supply chain?



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. Around 22% of firms (52% in 2015 report) surveyed stated that standardisation had benefitted all firms within their supply chain proportionately. About 23% stated that large firms mostly benefit from standardisation, compared to about 12% view that small firms are better off with standardisation and 38% view that medium-size firms are better off. The survey result suggests medium-size firms are viewed to benefit most, which is different from 2015 report. This finding may reflect the deepened interconnectedness of the economic structure in recent years; medium-size firms that are better connected to both upstream and downstream supply chains can benefit the most from standardisation.

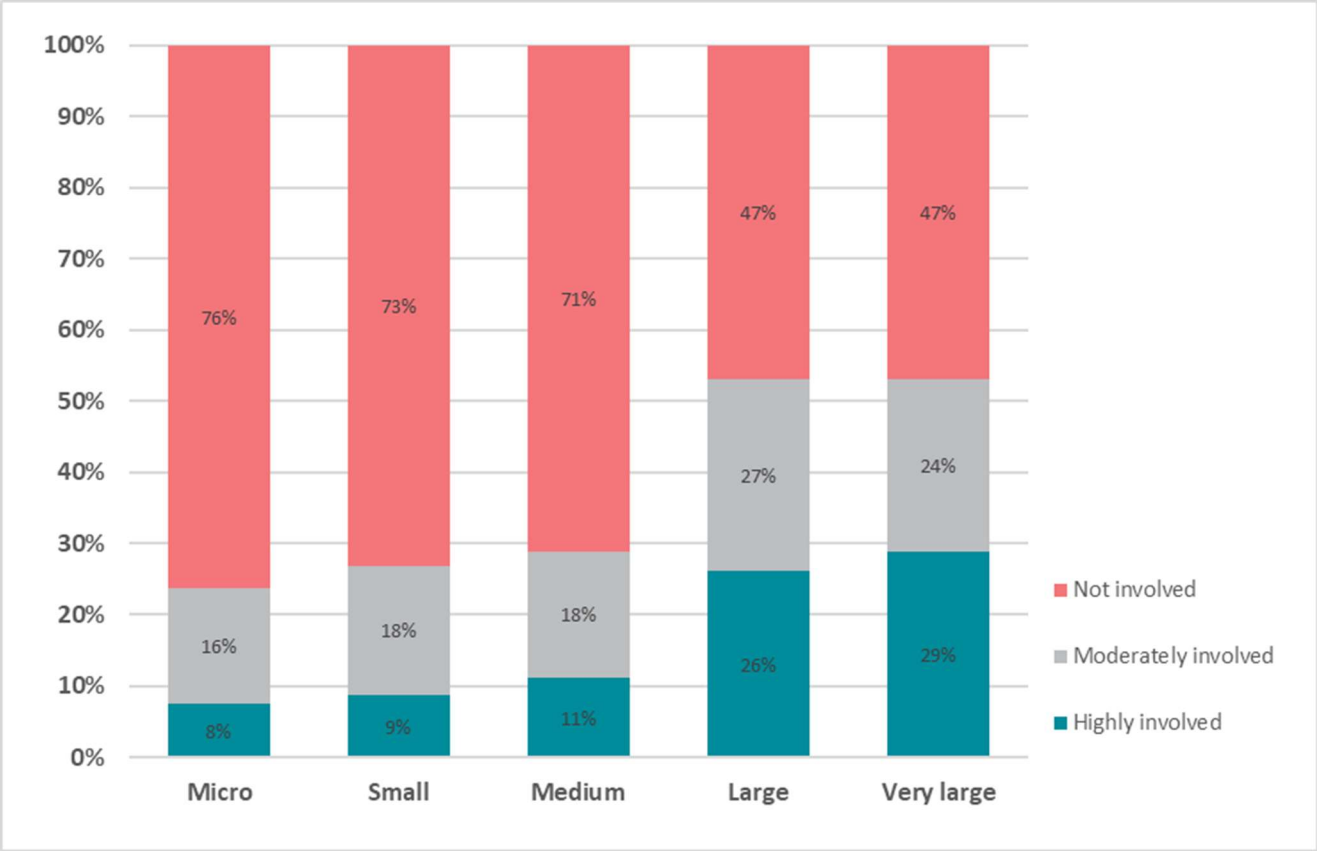
A3.9. Why do companies get involved in the standards development process?

The survey highlighted the existing capacity of businesses to become more involved in the standards development process. Over 60% of businesses surveyed were not involved, compared to 68% in 2015. Therefore, firms have been engaged more with the standards development process, whether it is because of economic benefits or because of minimise the negative effects of regulatory constraints.

Notice that 73% (70% in 2015) of SMEs report not involved, in contrast to 33% (48% in 2015) of large firms report not involved. Therefore, large firms have been more actively involved with the development process, while we see the opposite for SMEs. At the other end of the spectrum, 32% (26% in 2015) of large firms stated that they were highly involved in the standards development process in comparison to 10%

(10% in 2015) for SMEs (Figure 36). All of these suggest that British firms have become increasingly involved with standards development lately, and the active involvement mainly comes from larger firms.

Figure 36: Involvement: to what extent is your firm involved in survey highlighted the existing developing standards?

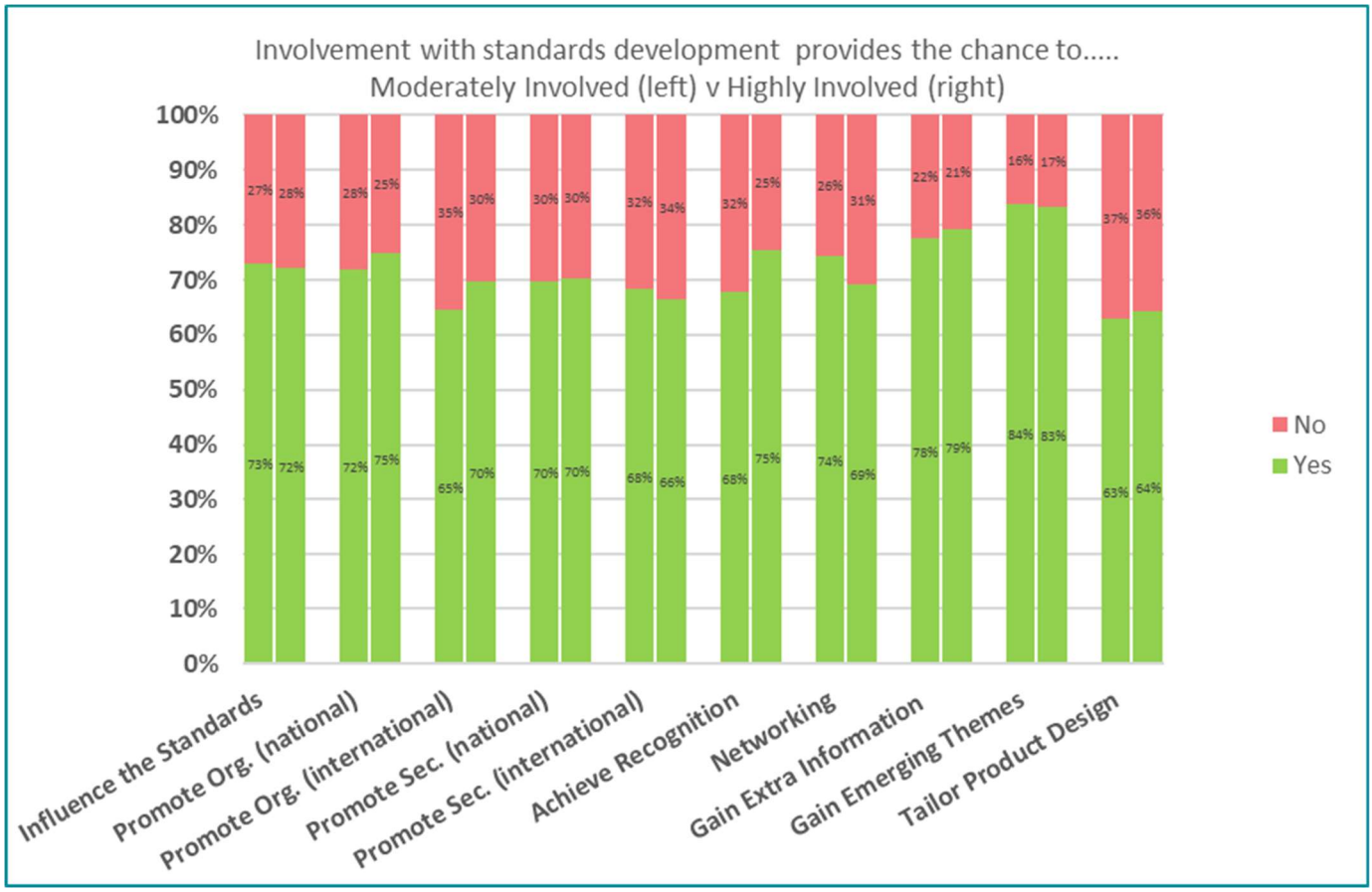


Not surprisingly, the survey evidence clearly shows that participating in developing standards makes it more likely that a company experiences benefits from using standards. The result is quite similar to 2015 report. The survey asked firms that were at least moderately involved in developing standards about the benefits of participating in the process (Figure 26). Around 84% 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. In 2015, the number is 88%, so we have a similar outcome in 2021.

73% (about three- quarters in 2015) of all firms who are involved in the standards development process were able to promote their industry's interests at a national level while 78% (71% in 2015) of firms benefitted from gaining access to information that would not normally have been received. Similarly, 64% (71% in 2015) 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, and this effect has become more important since 2015.

Figure 37: Top benefits from participating in the development of standards. Participation in standards development lets my company

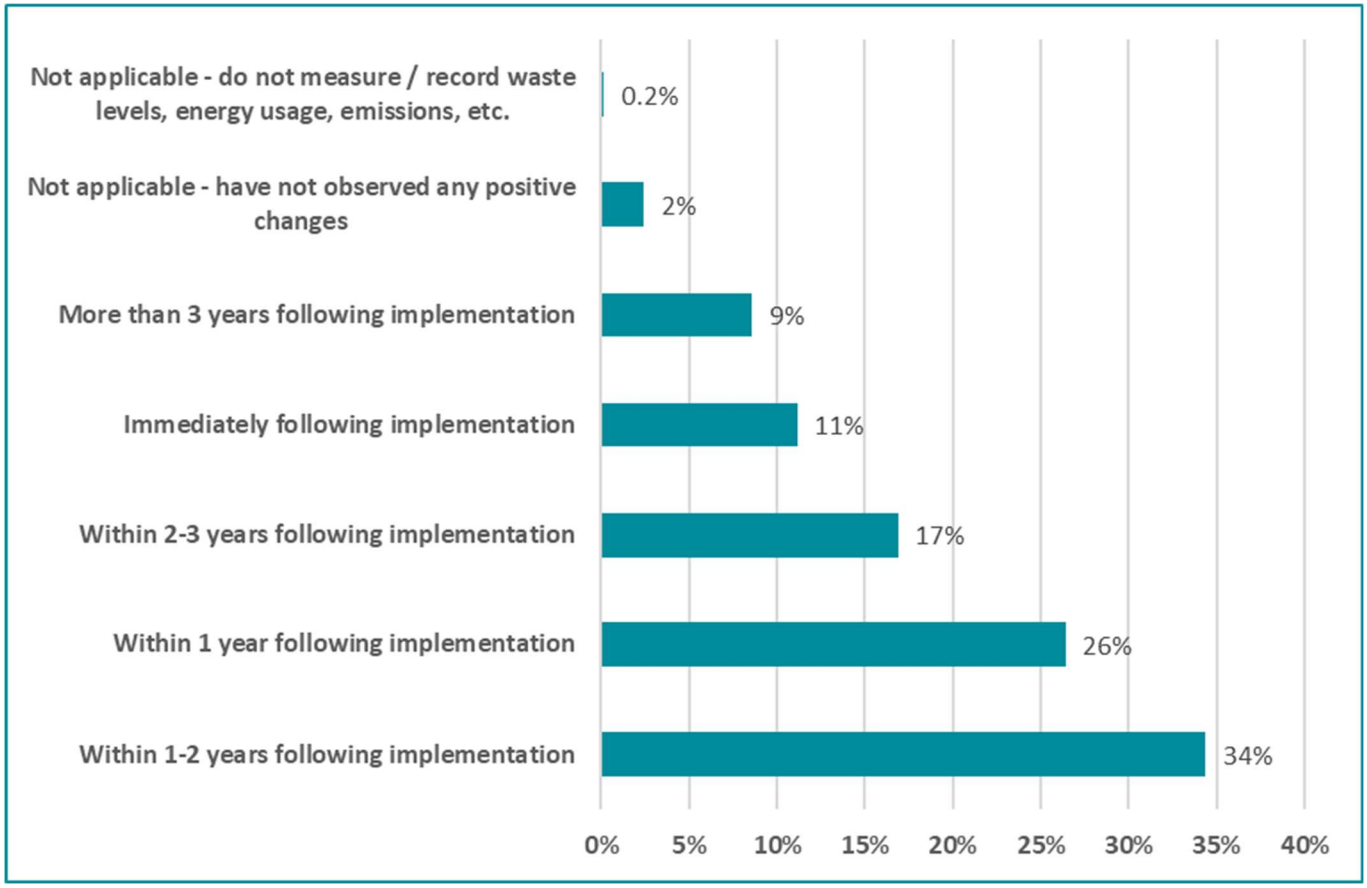


A3.10. Environmental effects of standards

Environmental management is another important area where firms 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 89% (73% in 2015) of companies that use environmental standards found that standards allow greater control (i.e., having an effect within 3 years) over environmental problems (Figure 38).

The significant pattern is that most firms found environmental impacts the largest between 1 and 2 years. The initial implementation of environmental standards may not be as successful after the production process and emission process have been integrated. This suggests certain important timing consideration for environmental standards.

Figure 38: When do environmental standards have an effect?



The Government often regulates firms to minimise external costs to the public (sometimes referred as negative externalities) such as air pollution from the production of goods and services. Meeting these regulations often imposes costs on firms; however, it is still in the firm'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.

Appendix 4 The trade model

A4.1. Introduction

Cebr's thinking on how standards fit into international trade is based on our modelling of this trade. We have used this modelling to assess the impact of various frictions in international trade and it has provided many useful insights. For a fuller description of our approach to international trade using agent-based modelling (ABM) please see Cebr's report 'An agent-based model of trade: market distortions and output'[24].

Cebr has used the thinking in the agent-based model of trade to model and estimate the potential impact of smart ledgers (blockchain) on international trade[25].

Under this model, standards affect international trade in two different ways. The first is a straight forward door opening effect. Some trade simply isn't possible without adherence to international standards. The second uses standards as a way of conveying information which reduces the information frictions associated with trade. Cebr's agent-based modelling is a technique for estimating how trade frictions affect trade volumes. Armed with this, we can then calculate how different levels of knowledge can reduce these frictions and hence how standards, which create such knowledge, will affect trade.

This section starts with a description of how international standards operate in the trade context. It then reviews some of the relevant literature. Finally, it describes the modelling process used to estimate the impact of frictions, such as those imposed by lack of the knowledge that standards can rectify, in depressing trade. This provides a building block for Cebr's modelling which is described in Section 8.

A4.2. Background on the economics of international trade

Following the seminal contribution of Krugman (1979)[26], a significant body of economic literature has analysed the implications of economies of scale for international trade. Krugman's key insight was that trade need not be driven differing comparative advantages across countries, but rather by economies of scale. This helps explain why in reality in we observe trade between countries that are very similar in terms of production, technology and endowments. These gains from scale are conceptually different to gains from specialisation, while also helping to rebut mercantilist notions of trade that focus on the accumulation of trade surpluses.

Economies of scale arise in industries where there are significant fixed costs and operational synergies associated in production, such that the average cost of production may fall over a range of output levels. The implication here is that opening up markets to international trade can allow firms to increase the scale of production and exploit economies of scale. The key theoretical result is that the volume of trade will increase, with a given good being produced in one country.

[24] *An agent-based model of trade: Market distortions and output'* Cristian Niculescu-Marku and Shanker Singham, Cebr report for IEA. February 2019

[25] https://www.longfinance.net/media/documents/Economic_Impact_Of_Smart_Ledgers_On_World_Trade.pdf The Economic Impact Of Smart Ledgers On World Trade The Economic Impact Of Smart Ledgers On World Trade Douglas McWilliams Cristian Niculescu-Marcu Beatriz Cruz April 2018

[26] Krugman, P.R. (1979) "Increasing returns, monopolistic competition, and international trade", *Journal of International Economics*, 9, pp. 469-479.

The existing economic theory largely focuses on equilibrium outcomes and assumes that both (representative) consumers and firms optimise their consumption and production decisions, respectively. Whilst the validity of these assumptions is not the specific focus of this paper, it is well-recognised that consumers may not act fully rationally and that pathways to equilibrium outcomes require greater attention. An alternative modelling approach that can help provide answers to these questions – in particular with respect to the dynamic outcomes that can emerge – is that of Agent-Based Modelling.

A4.3. An Agent-Based Model of trade

Agent-Based Models (ABMs) situate agents – such as consumers and firms – within an environment that may be physical, or network based (or both) and allow these agents to interact with each other and their environment. Such modelling frameworks have a natural application to the economics of trade, and indeed this is the focus of this paper.

We develop a simple model of within- and between-country trade that is composed of

1. A physical *environment* that is partitioned into two countries (A and B);
2. Two types of *agents* – consumers and firms; and
3. The *behavioural rules* of consumers and firms.

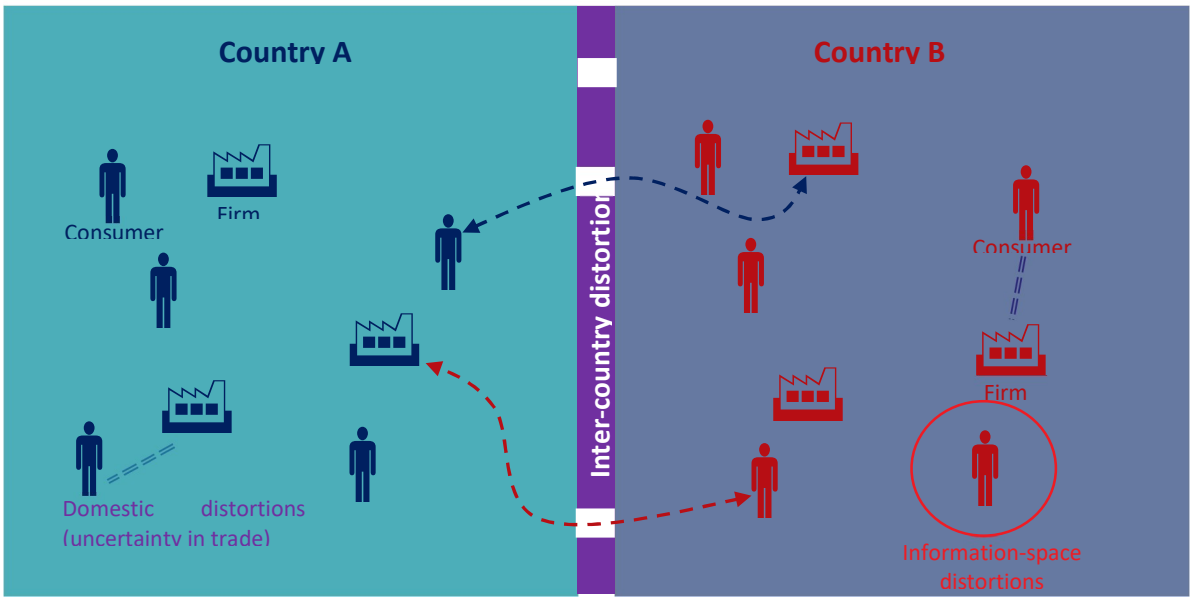
The total population of consumers and firms are allocated across countries A and B. Consumers have a reservation price that determines their maximum willingness-to-pay for one unit of a homogenous consumption good that is produced by firms. Firms require labour to produce the good and face a cost function that exhibits economies of scale (as in Krugman, 1979). The costs faced by firms are distributed to the consumers as wages/remuneration for their labour supply[27].

An important facet of ABMs is the information space that is available to agents. In this model both consumers and firms are able to observe a circular area around themselves; the size of these circular areas is determined by radius parameters. A consumer can observe the unit-price charged by firms within its sampling radius and subsequently chooses to purchase from the firm within this subset of firms that has the lowest price. Firms cannot observe the specific reservation prices of individual consumers but can

[27] There is no formal model of labour supply/choice.

observe a set of "summary statistics" about these consumers: they then set their price based on an expectation of the demand that they will face at a range of price levels.

Figure 39: Graphical overview of the ABM of trade



Notes: Both countries (A and B) are composed of consumers and firms. Within the model one can either assume that the number and distribution of parameters across consumers and firms are the same across both countries or can allow for underlying difference.

Sources: Cebr Analysis

The purpose of the model is to establish how total volume[28] output – both of countries and globally – depends on the magnitude of trade distortions that exist between- and within-countries. The model features three types of trade distortions that may inhibit the extent of trade between consumers and firms, both within a country and between countries:

1 *Between-country trade distortions* limit the extent of cross-country trade. These distortions operate through restricting the number of consumers from country A that can trade with firms in country B, and vice versa. Within the context of the model, this is equivalent to restricting the number of firms in country B that can attract consumers from country A, and vice versa. In Figure 30, this is illustrated by the porous vertical lines. The greater the number of pores, the greater the number of consumers that can trade with firms from another country

2 *Within-country trade distortions* generate uncertainty in otherwise beneficial transactions between consumers and firms. These mutually beneficial trades only take place with some probability that is decreasing in the level of the distortion.

NB. The within-country distortion prevents transactions that would otherwise certainly take place from occurring, while the between-country distortion prevents consumers and firms accessing foreign markets, in which they may subsequently choose to trade. For example, the lowering of

[28] Throughout this report "output" related to volume output. A richer modelling environment is needed to fully explore the magnitude of the value impacts compared to the volume impacts.

between-country distortions does not in general guarantee that additional trade will take place, whereas lowering within-country distortions should.

3 *Informational distortions/restrictions* limit the information that is available to firms, as captured through the extent to which they can observe their environment. The results generated by the model can therefore be conditioned on the scale of informational distortions.

The model suggests that between- and within-country trade distortions have a substantial effect on country and global levels of output. For example, a between-country trade distortion of 25% acts to lower global output relative to the benchmark case with no distortions by around 4%. A within-country trade distortion of 25% acts to lower global output relative to the benchmark case with no distortions by around 14%. When both types of distortion are present, output is approximately 17% lower than the benchmark case with no distortions. While further investigation is required, the joint effect of the two types of distortions would appear to be "broadly" linear (i.e. the sum of the two partial effects of each distortion).

Within the context of the model, **within-country distortions have a greater impact on domestic and global output than do between-country distortions.** This arises because the majority of economic transactions occur within a country, rather than across countries. In reality, this is likely to hold for a great many countries. This may point in particular to the importance of **domestic liberalisation policies**, as well as **international trade liberalisation**.

It is important to note that the ABM developed here is a highly stylised representation of trade. It makes a number of strict assumptions that should be relaxed going forwards, in order to establish the extent to which the results continue to hold in a richer – but ultimately more complex – model.

- First, the model is silent on the distributional implications of trade within and between countries. As there is no underlying model of labour supply/choice, it assumes that all consumers receive the same income (a fraction of the total labour costs faced by firms). This implies that all consumers are employed and either (i) all command the same wage and work for the same amount of time, or (ii) command different wages but differences in labour supply mean everyone ultimately earns the same.

- Second, consumer behaviour is myopic: consumers will attempt to exhaust their budget constraint on the consumption good in each period. The model should be generalised going forwards to include intertemporal consumption decisions and so saving.

- Thirdly, the current of the model does not explicitly tackle the trade-related issues of labour, capital and other factor mobility. For instance, **the ability to reach economies of scale in cost may be contingent on countries also having access to a common pool of labour and other pooled resources that would require more than the liberalisation of trade in a narrow sense.**

- Lastly, the current model covers the gains from trade associated with scale, as has already been mentioned. **We have not looked at the gains from specialisation that come through comparative advantage.** Indeed, an extension of the framework to cover trade through specialisation would provide an enormously valuable addition to the current work, especially in terms of how scale interacts with scope. However, in this specific application to the impact of standards, the impact of specialisation is likely already to have been taken into account in the current modelling framework through its impact on productivity.

A4.4. Summary

This analysis sets the framework for assessing how much standards can affect trade and hence output. Fuller details are set out in the Appendix to this chapter.

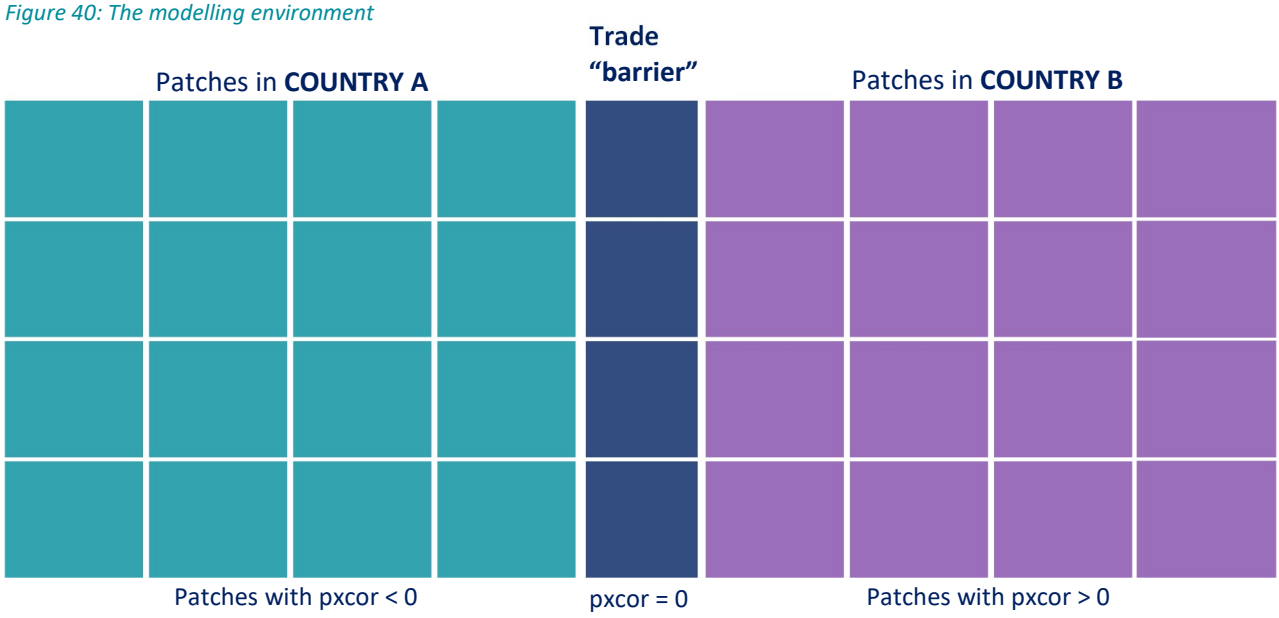
This section provides a detailed overview of the ABM of within- and between-country trade developed in this report, focusing in particular on the heuristics and decision rules of the two types of agent in the model: consumers and firms.

Section 6.7 describes the structure of the model environment and then proceeds to discuss the decision-making process of consumers and firms, and how they interact with each other. Following this, the cost function that firms face, and how this exhibits economies of scale in production (a more technical treatment of costs can be found in the detailed analysis below).

A4.5. Detailed description of model

The physical environment is a square grid of "patches" , as illustrated in Figure 41, that are divided into two types: country A and country B. Each patch is labelled as belonging to country A, country B or neither (trade "barrier"). The appeal of this approach is that we can then allocate agents (consumers and firms) to a given country through instructing them to be setup on patches with a given country label.

Figure 40: The modelling environment



Notes: "pxcor" denotes positon of the patch on horizontal (x) axis. Country A is defined by all patches with negative x-coordinates, while country B is defined by all patches with positive x-coordinates. The trade barrier is composed of all patches at the origin. The figure is illustrative; the number of patches drawn here are not representative of those in the model.

Source: Cebr Analysis

The environment is constructed such that each country has the same geographical size, though the concentration of consumers and firms within a given country can be varied. The default setting is to have an equal distribution of consumers and firms across each country. Our concern in this framework is largely with the effect of trade distortions on global output, as opposed to any asymmetric/distributional consequences for individual countries.

Consumers

The model is endowed with a total number of consumers; these consumers are then distributed across country A and country B, respectively. Both the total number of consumers and the country allocations (shares) of these consumers can be varied by the user.

Consumers have the following key attributes:

- *"country"* – *this* variable denotes whether a given consumer belongs to country A or B.
- *"reservation-price"* – the maximum amount that a consumer would be willing to pay for one unit of the commodity.
- *"intl*?" – a Boolean variable (true/false) that determines whether a consumer can purchase the commodity from firms in a different country. I.e. if a consumer in country A (B) has intl?=true they can purchase the commodity from a firm in country B (A).
- *"budget"* – the total resources available to a consumer in a given period. The budget is cumulative, such that any resources not spent in the previous period are carried forward into the current period.

Reservation prices are distributed across consumers, leading to heterogeneity in preferences. We assume a standard normal distribution, as characterised by mean and standard deviation (s.d.) parameters. Formally, if we let R denote the reservation price:

$$R \sim \mathcal{N}(mean, s.d.)$$

Both the distribution parameters and the type of distribution function itself can be adjusted by the user.

Consumer perspective

Figure 42 provides an overview of the information set available to consumers. Consumers are able to observe the prices charged by firms that are sufficiently close to themselves: in particular they can observe the prices charged by firms within a circular area around themselves, the size of which is determined by the radius parameter "consumer-sampling".

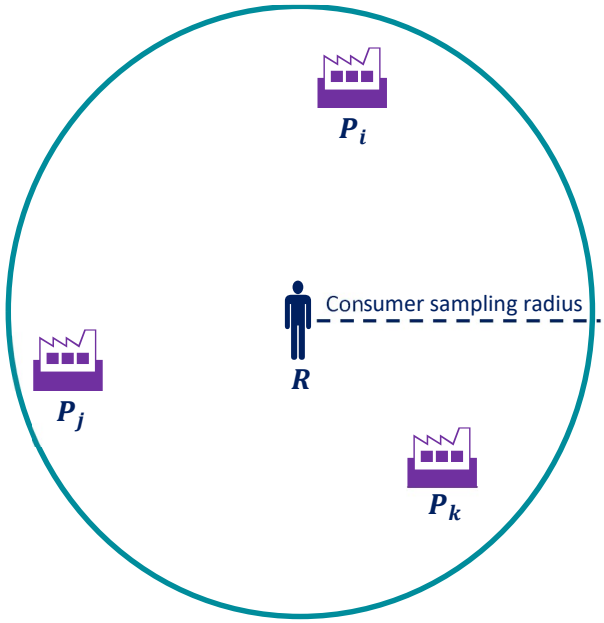
Consumers thus have local information on prices, as opposed to a complete picture of all the possible prices that are available in the economy. Note that this radius parameter is the same for all consumers in the model; as such it is defined as a global variable and not included in the list above. While it may be interesting to examine the implications of differences in information space across consumers, this would really require a framework that examines more closely the distributional implications of trade across consumers within a given country.

Given this local information on prices, a consumer then chooses to purchase the commodity from the firm that offers the cheapest unit price. For simplicity, we assume that a consumer will request to purchase the quantity that exhausts their budget constraint. We therefore abstract from any intertemporal consumption decisions, i.e. decisions to save and borrow. Consumer behaviour can therefore be described as myopic.[29]

[29] As will be discussed in the concluding remarks, this assumption will need to be relaxed in future developments of the model.

Consumer movement

Figure 41: Consumer perspective



Note: The consumer has a reservation price of R, which is the maximum amount that they would be willing to pay for a unit of a given product. The consumer is able to search for the lowest price offered by firms: the search region is a circular space whose area is determined by the radius parameter "firm-sampling". Within the figure the prices charged by firms i, j and k are denoted by P_i, P_j and P_k, respectively. The consumer will identify the minimum of these prices and only purchase if $R \geq MIN\{P_i, P_j, P_k\}$.
Source: Cebr analysis

In order to encounter firms with different prices, consumers move around the environment. For simplicity, we impose a "mechanical" consumer movement procedure: each period a consumer will move a given distance forward in a given direction. The movement of consumers (effectively information gathering) is assumed to be costless.

However, a consumer may be restricted in their movement by between-country trade distortions. If a consumer faces these trade distortions they can only move within their country: whenever they reach the trade-barrier they will reverse their heading. Alternatively, a consumer who is unrestricted because they do not face trade-distortions can move freely between countries.

This prescriptive movement process is a strong simplification; a richer framework going forwards would analyse optimal movement decisions whereby consumers will move in the direction of firms with the optimal price-quantity combination given their budget. Furthermore, there may be periods in which it is suboptimal for consumers to move because the most affordable prices are already available to them.

Whilst we capture between-country trade-distortions through restrictions to consumer movement, this can be readily interpreted as the ability of firms to access consumers in foreign markets. For example, if a consumer in country A can traverse to country B and purchase the commodity off a firm in country B, we can interpret this as that firm in country B not facing any export restrictions.

Firms

The model is endowed with an initial number of firms; with these firms distributed across country A and country B. Both the initial number of firms and the country allocations can be varied.

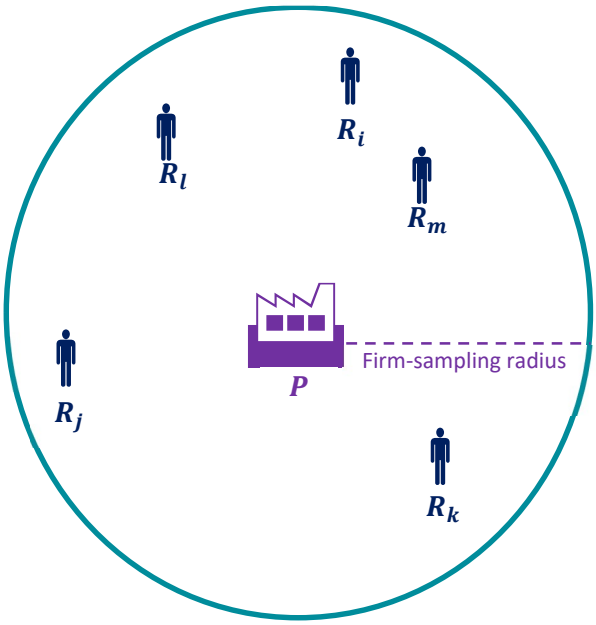
Firms have the following key attributes:

- "*country*" – as with consumers, this variable denotes whether a firm belongs to country A or B.
- "*price*" – this is a placeholder variable for the price charged in a given period by a firm. This is a choice variable of the firm.
- "quantity" – the quantity of output produced by a firm in a given period.
- *"deal?"* – a variable that records whether a firm agrees to a given trade with a consumer.

Firm perspective

A firm is able to observe the number of consumers within a circular area around itself, as illustrated in Figure 43, with the size of this area determined by the radius parameter "firm-sampling". In terms of informational asymmetries, a firm cannot observe the specific reservation price of a consumer (for this is private information), but it can observe a set of "summary statistics". In particular, a firm can observe the *minimum, median and max* reservation price of these consumers. It can also observe the average budget across these consumers.

Figure 42: Firm perspective

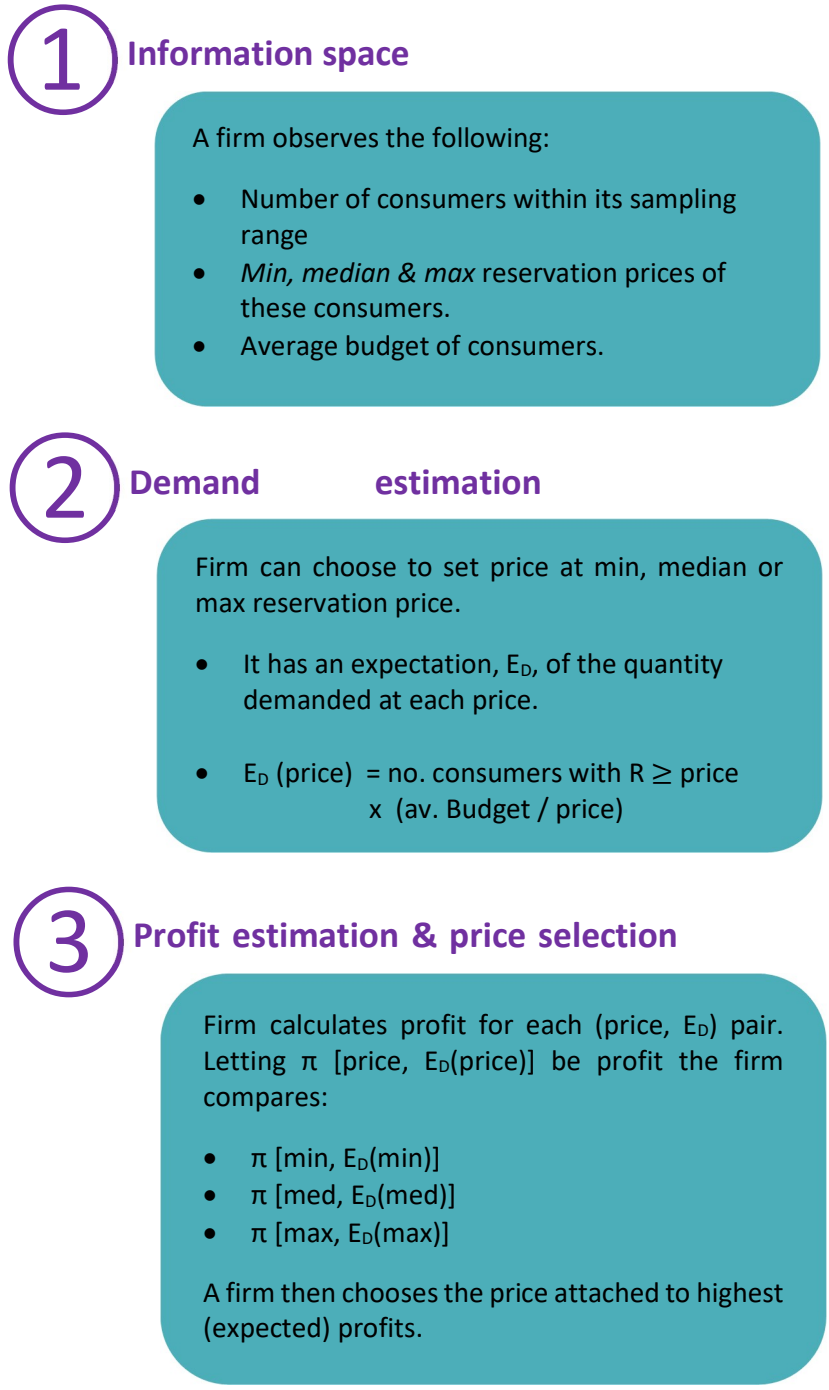


Notes: The firm must choose what price-per-unit to charge for its product. This will be a function of the demand that it perceives, and so its perception of the reservation prices that consumers have. We assume that any given firm is unable to observe the specific reservation prices of consumers, but only able to observe a set of summary statistics concerning the reservation prices and budget of consumers in a circular area around it. The size of this circular area is determined by the radius parameter "firm-sampling".
Source: Cebr analysis

Firm price setting rule

Firms aim to maximise their profits, given limited information on the preferences (reservation prices) of

Figure 43: Firm price setting



Source: Cebr analysis

individual consumers. The price-setting process is depicted in Figure 44. As stated above, a firm is in general unable to observe the specific reservation prices of consumers, but can instead observe a set of summary statistics about these consumers: namely the minimum, median and maximum reservation

prices, in addition to the average budget of these consumers. Given this information, a firm is able to form an expectation of the quantity of their product that would be demanded at a given price. Formally, the demand a firm would expect to face at a given price is:

$$E_D(price) = (\ no.of\ consumers\ with\ R \geq price\ ) \times \left({}^{av.budget}/_{price}\right)$$

For simplicity, a firm can set its price at one of three levels: the *min*, *median*, or *max* reservation price. If it sets its price at the minimum reservation price then it would expect to have demand from all consumers within its sampling range, with the total quantity demanded being the product of (i) the total number of consumers and (ii) the ratio of average budget to price. Conversely, if a firm sets its price at the maximum reservation price it can only expect to have demand from those consumers with the highest reservation price. Its expected demand is then the product of (i) only those consumers with the highest reservation price and (ii) the ratio of average budget to price.

A firm will compare the expected profits across the three price options (min, median and max) and choose that which yields the highest expected profit.

We are here implicitly assuming that a given firm is unaware of the price charged by other firms in the market: it effectively assumes that all the consumers near it will choose to purchase from it whenever the price that it charges falls below the reservation price of consumers. However, a firm may be inadvertently "undercut" by other firms that charge a lower price and attract away some of these consumers. Going forwards, a richer version of the model would allow for strategic interactions between firms when setting their price.

A4.6. The cost function and economies of scale

Analogous to Krugman (1979)[30], each firm faces a cost function, $c(q)$, of the form

$$c(q) = FC + MVC \times q$$

where q denotes the quantity produced, FC is a fixed cost that is incurred independent of the quantity of output produced; and MVC is a constant marginal variable cost (such that variable costs are linearly proportional to the quantity of output produced.)[31]

Economies of scale arise when the average cost of production falls with output; it can be readily demonstrated that this arises with the functional form adopted here. The average cost per unit of production is

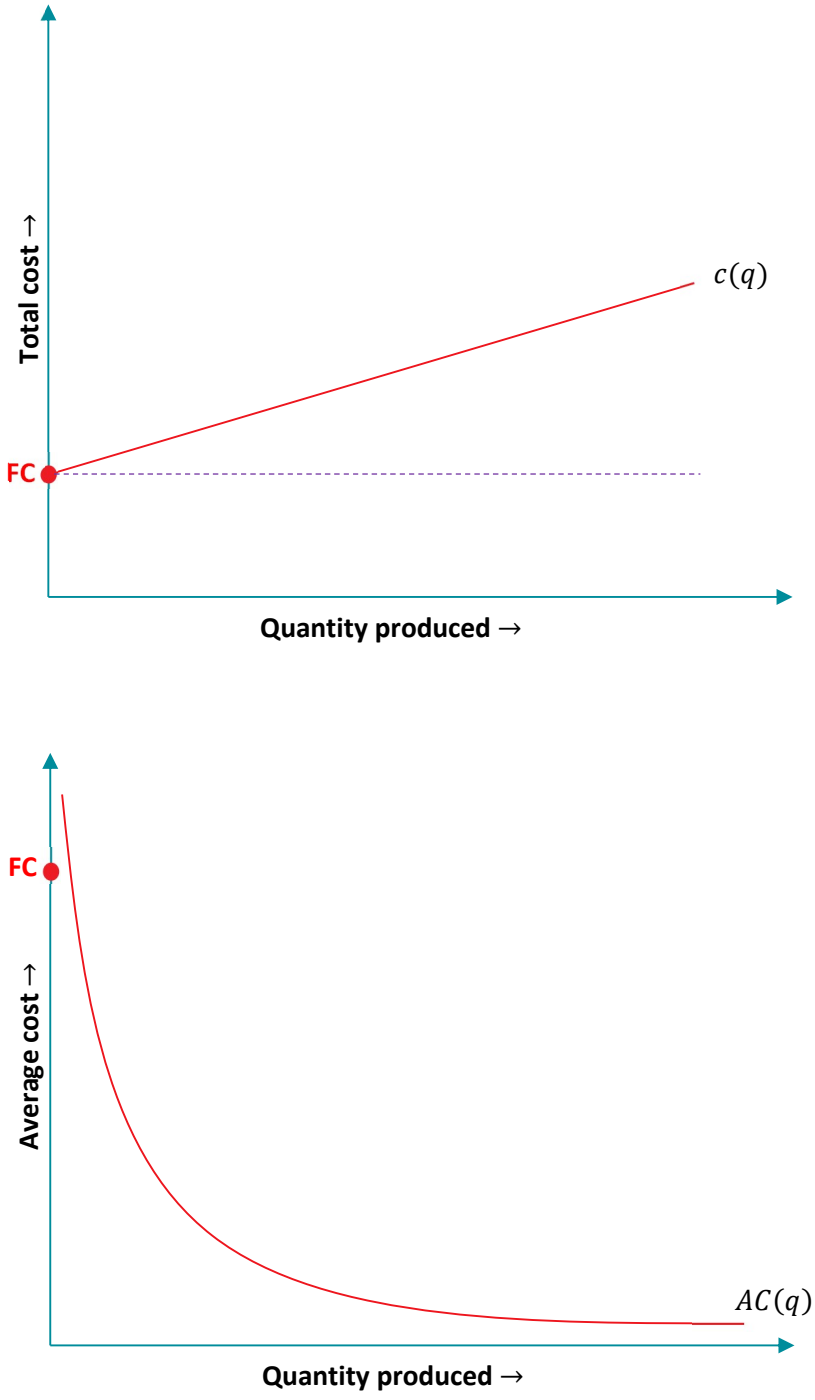
$$AC(q) = \frac{c(q)}{q} = \frac{FC}{q} + MVC$$

Given the constant marginal variable costs, average cost falls unambiguously with the quantity produced.

[30] Krugman, P.R. (1979) "Increasing returns, monopolistic competition, and international trade", *Journal of International Economics*, 9, pp. 469-479.

[31] The constant marginal variable cost is a simplification. A more general cost function with fixed and variable costs would take the form $c(q) = k\left(FC, VC(q)\right)$; where the function k is increasing in both the fixed and variable costs, but where the variable costs need not be linearly increasing in the quantity of output produced.

Figure 44: The cost function



Notes: FC denotes A "fixed cost" of production (a cost that is incurred independent of the quantity produced), whilst VC denotes a variable cost that is proportional (increasing in) the quantity of output produced. As depicted, an implication of the fixed cost and constant marginal variable cost is that average costs fall monotonically with the quantity produced. Note that average cost falls monotonically precisely because the marginal variable cost is constant; were the marginal variable costs instead increasing in the quantity produced then average cost would only fall over a range of quantities.
Source: Cebr analysis

The properties of the cost function are depicted graphically in Figure 45.

Capturing average cost within the ABM

Within a dynamic ABM, one must think carefully about how average cost of production is measured and recorded. As economies of scale will arise when a firm increases its output and the average cost falls, it is important that average costs are recorded at firm level and subsequently averaged across all firms within a country or globally. We therefore consider the following measures of average cost.

- *Average cost conditioned by country and time.*
  This measure takes the mean value of the average cost faced by firms in a given country at a given point in time.
- *Average cost conditioned by time.*
  This measure takes the average value across countries, of the average cost conditioned by country and time. It this therefore conditional on time.
- *Average cost conditioned by country.*
  This measures takes the average value over time, of the average cost conditioned by country and time. It is therefore conditional on time.
- *Unconditional Average cost.*
  This is the mean value of the average cost faced by all firms in the model, averaged across time.

A4.7. Discussion of the results

This section presents the key outputs from the ABM. Results are generated through systematically varying the extent of one of the trade distortions, all else held constant.

To facilitate discussion, we throughout compare results with the following benchmark case:

> **Benchmark case:** *The model outcomes that arise when "between-country trade distortions" = 0%; "within-country trade distortions" = 0%; and "consumer-vision" = 2 patches.*

The analysis is structured as follows: sections a and b assess the effects of between-country and within-country trade distortions; section c illustrates the joint effects of these distortions (i.e. when both occur); and finally, section d discusses some of the implications of information distortions.

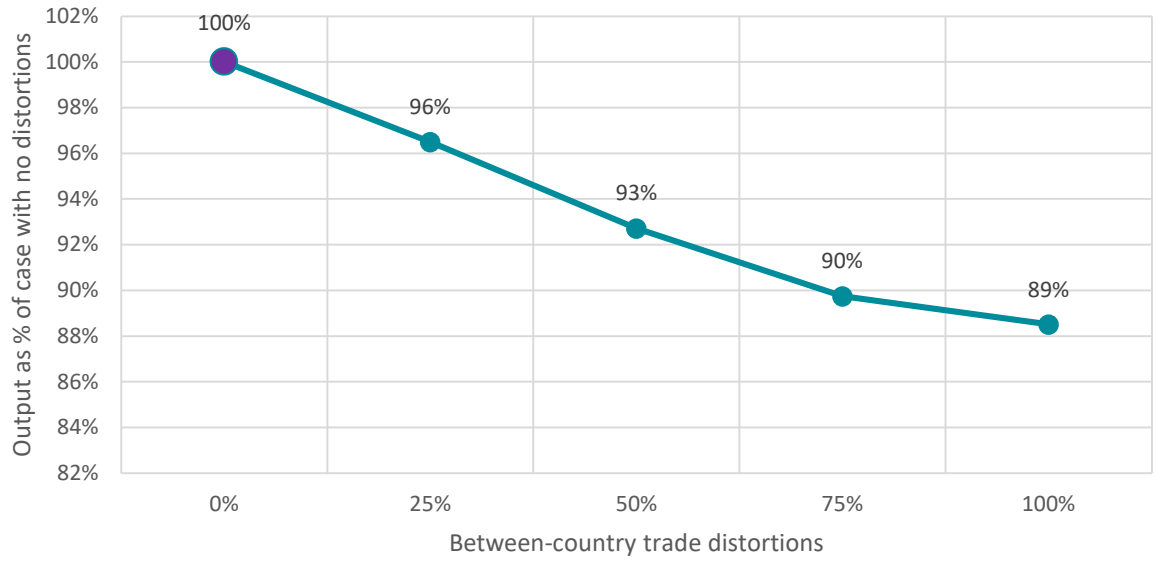
a) Between-country trade distortions

In all that follows we establish how output and average cost are affected by the between-country trade distortions.

Output

Figure 46 expresses the global output that arises with between-country trade distortions as a percentage of global output in the benchmark case. The direction of travel is clear: global output (averaged over time) is falling with the degree of between-country trade distortion. Output is 4% lower when 25% of consumers are unable to access foreign markets; 7% lower when half of consumers are unable to access foreign markets; and 10% lower when 75% of consumers are unable to access foreign markets.

Figure 45: The effect of between-country trade distortions on global output



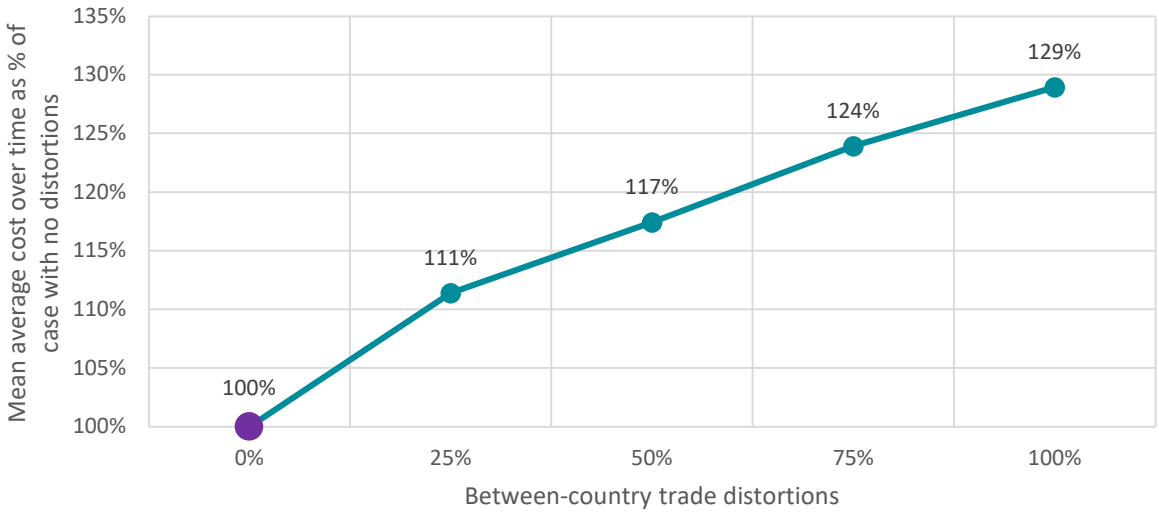
Notes: This figure presents global output as a percentage of the global output achieved when there are no trade distortions (the larger marker). *Source:* Cebr analysis

Note that these percentage falls in output also hold for changes in output in both country A and B, respectively. This is unsurprising given that the distribution of consumers and firms is assumed to be identical in both countries. As stated, our focus is with the effects on global output, rather than any distributional implications across countries.

Mean average cost over time

Given the increase in average global output over time, one may expect to see a fall in the average cost of production across firms that produce. We capture this through examining how the unconditional average cost – i.e. the mean average cost across firms, averaged over time – varies with the degree of between-country trade distortion. Figure 47 expresses the unconditional average cost that arises with distortions as a percentage of the unconditional average cost with no distortions (the benchmark case). Average cost is 11% higher when 25% of consumers are unable to access foreign markets; 17% higher when half of consumers are unable to access foreign markets; 24% higher when 75% of consumers are unable to access foreign markets; and finally 29% higher when consumer-firm trade is entirely "autarkic".

Figure 46: The effect of between-country trade distortions on average cost

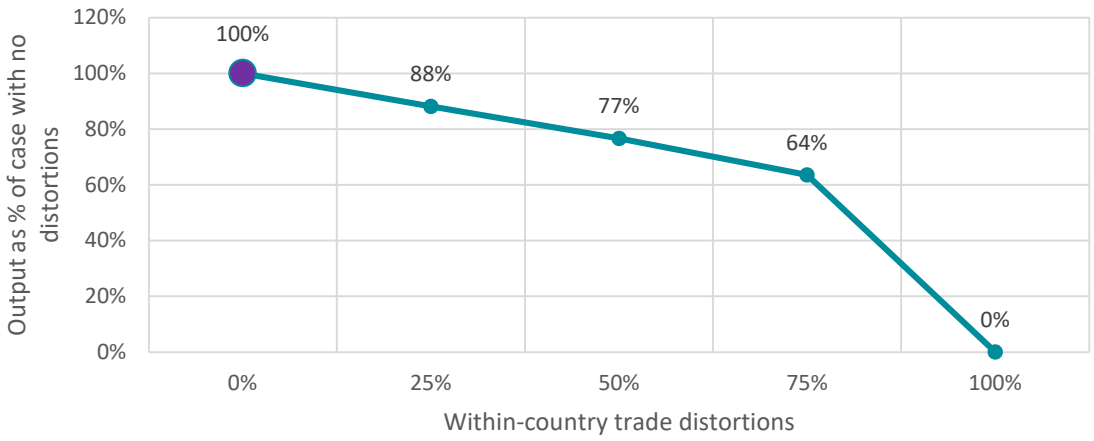


Notes: This figure presents how the average cost of firms (the average cost of a firm being averaged across firms and over time) varies with the degree of between-country trade distortion.
Source: Cebr analysis

b) Within-country trade distortions

Figure 48 expresses the global output that arises with within-country trade distortions as a percentage of global output in the benchmark case. Unsurprisingly, global output is falling with these distortions because they prevent mutually beneficial trades from taking place. Output is 12% lower when approximately 25% of transactions between consumers and firms that would otherwise go ahead do not due to distortions. Output largely falls linearly with the distortion, ultimately falling to zero (an extreme case) when no transactions can take place.

Figure 47: The effect of within-country trade distortions on global output



Source: Cebr analysis

While a comparison between the results in Figure 48 and Figure 46 has to be treated with some caution given the difference in how the distortions are modelled, it is interesting to note that that the within-

country distortion has a much more marked affect average output over time than does the between-country distortion.

To some extent, however, the intuition is clear: the within-country distortion prevents transactions that would otherwise *certainly* take place from occurring, while the between-country distortion prevents consumers and firms accessing foreign markets, in which they *may subsequently* choose to trade. For example, the lowering of between-country distortions does not in general guarantee that additional trade will take place, whereas lowering within-country distortions should.

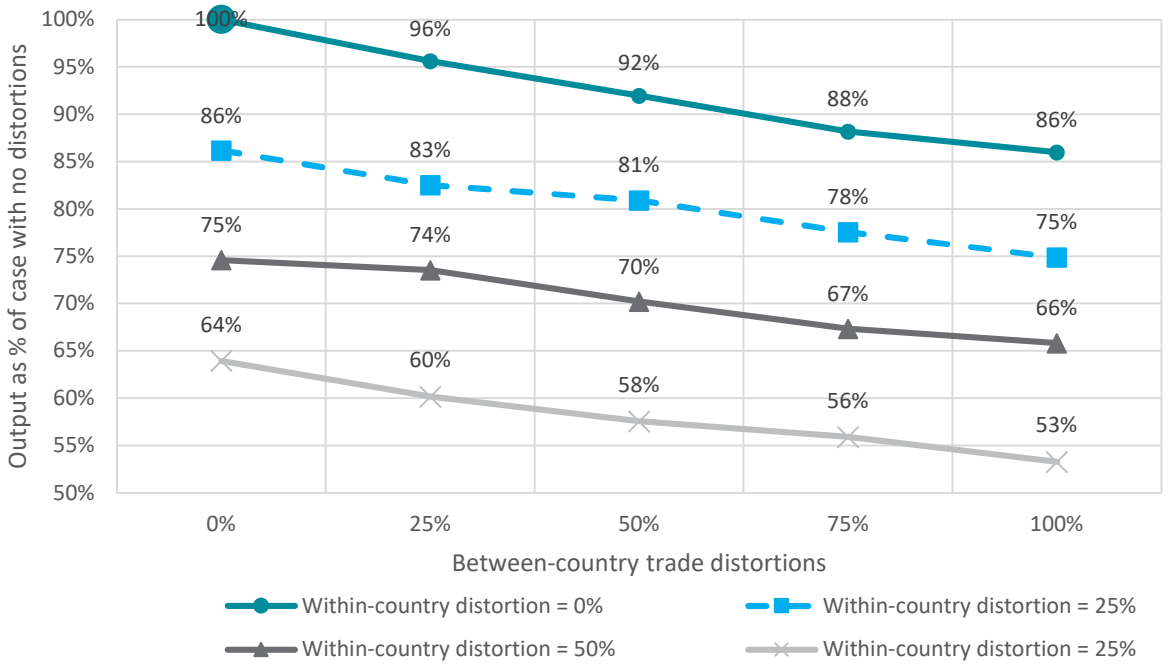
However, the impact of this distortion is not just linearly due to the prevented number of transactions. As with the trade distortion case, there are scale transmissions which come through in instances where a firm may observe multiple potential customers – but yet trade cannot take place with all those counterparts, thus lowering the achievable scale for each firm.

c) Joint effects of between- and within-country distortions

Our examination has thus far been "partial", exploring the implications of between- or within-country distortions relative to the benchmark case, all else held constant. It is, however, interesting to explore how output is affected in the presence of both types of distortion. It is not a priori clear whether the joint effects will simply be the linear sum of the two partial effects, or whether there will be any multiplier effects whereby the overall effect is more than the sum of the two effects.

The results are presented in Figure 49, below. There are four curves, with each generated for a different level of within-country trade distortions. Movements along a given curve provide the partial effects of a between-country trade distortions, while movement across curves (for a given level of between-country distortion) provide the partial effect of within-country distortions.

Figure 48: The joint effects of between- and within-country trade distortions



Source: Cebr analysis

The key results are as follows:

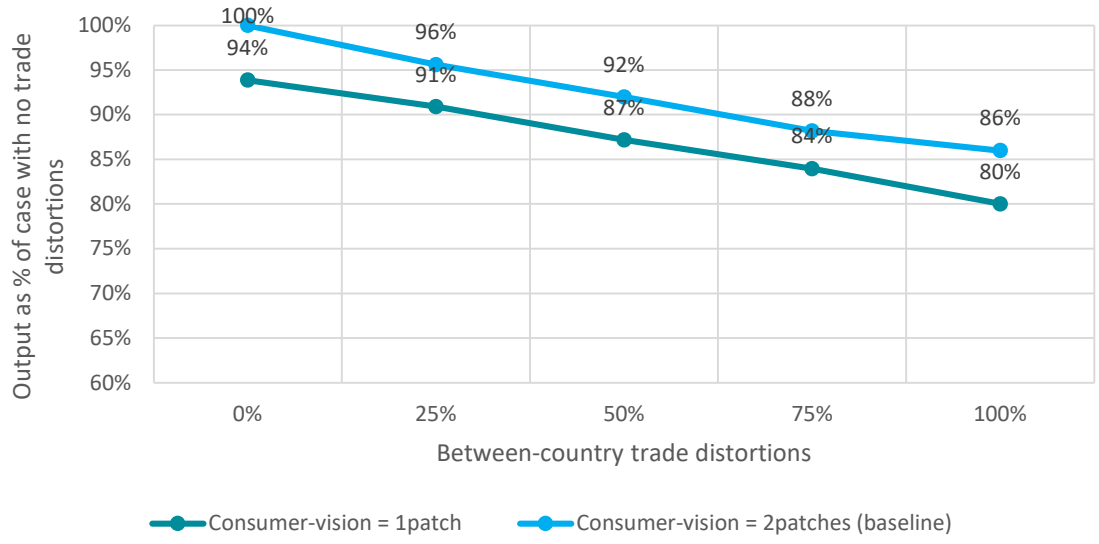
- When between- and within-country distortions are both set at 25%, global output is approximately 17% lower than in the benchmark case. The partial contribution of between-country trade distortions is 4%, while the partial contribution of within-country trade distortions is 14% (the sum of the two partial effects is therefore 18%).
- When between-and within-country distortions are both set at 50%, global output is approximately 30% lower than the benchmark case with no distortions. The partial contribution of between-country trade distortions is 8%, while the partial contribution of within-country trade distortions is 25% (the sum of the two partial effects is therefore 33%)
- When between-country- and within-country trade distortions are both set at 75%, global output is approximately 44% lower than in the benchmark case with no distortions. The partial contribution of between-country trade distortions is 12%, while the partial contribution of within-country trade distortions is 36% (the sum of the two partial effects is therefore 48%)

Further investigation is required to understand whether there are any additional effects at work that mean the joint effects of distortions are more than the sum of the two partial effects. The most we can say at the moment is that that joint effects appear to be "broadly" in line with the sum of the two partial effects.

d) Informational distortions

This section briefly explores the implications of the extent of consumer vision on the level of global output. Figure 50 below illustrates how global output is affected when the vision of consumers is effectively halved, from 2 patches to 1 patch. Intuitively, this acts to reduce the menu of firms that a consumer can choose to purchase from in a given period; all else held constant this may mean that the consumer pays more for a given good and purchases less (though this requires further investigation).

Figure 49: The effect of informational distortions on consumers on output



The key results are as follows:

- A reduction in the extent of consumer vision from 2 patches to 1 patch reduces global output by 6% relative to the benchmark case.
- The *joint effect* of (i) a reduction in consumer vision from 2 patches to 1 patch; and (ii) a between-country trade distortion of 25% is to reduce global output by approximately 9% relative to the benchmark case.

While efforts to reduce informational distortions are likely to play an important role in facilitating trade, the analysis of these distortions has only been afforded a modest amount of attention in this report; with focus largely placed on between- and within-country distortions. The results presented here provide a specific example whereby a reduction in informational distortion unambiguously increases output. However, further investigation is required to understand the extent to which this holds universally for producers and consumers.[32]

A4.8. Equations in the ABM modelling system

Deriving aggregate and average costs within the model

Consider a global economy composed of $\boldsymbol{I}$ countries, with $\boldsymbol{N_i}$ firms in each country.

Aggregate costs

Letting $q_{n,i,t}$ denote the quantity of output produced by firm n in country i at time t, the cost of production of a given firm is

$$c_{n,i,t} = FC + MVC \times q_{n,i,t}$$

Where FC denotes a fixed cost of production and MVC is the marginal variable cost associated with producing an additional unit of output.

We can readily establish that the aggregate costs of production in country i at time period t are:

$$\begin{aligned} C_{i,t} \equiv C(Q_{i,t}) &= \sum_{n=1}^{N_i} \{FC + MVC \times q_{n,i,t}\} \\ &= N_i \times FC + MVC \times \sum_{n_i=1}^{N_i} q_{n,i,t} \\ &= N_i \times FC + MVC \times Q_{i,t} \end{aligned}$$

Where $Q_{i,t}$ is the aggregate output in country i at time t.

It immediately follows that aggregate costs across all countries at time t are given by

$$C_t \equiv C(Q_t) = \sum_{i=1}^{I} C_{i,t}$$

[32] Early inspection suggests there may be some non-monotonicity in the effect of increasing consumer vision on overall output.

Average costs

The average cost of production for firm n in country i at time t is

$$AC_{n,i,t} = c_{n,i,t}/q_{n,i,t}$$

It follows that the average cost of production in a given country is given through aggregating and averaging the average cost of production across the individual firms. It is therefore:

$$AC_{i,t} = \left(\frac{1}{N_i}\right)\sum_{n=1}^{N_i}\left(c_{n,i,t}/q_{n,i,t}\right)$$

The average cost of production in country i across time is therefore

$$\begin{aligned} AC_i &= \left(\frac{1}{T}\right)\sum_{t=1}^{T} AC_{i,t} \\ &= \left(\frac{1}{T}\right)\sum_{t=1}^{T}\left\{\left(\frac{1}{N_i}\right)\sum_{n}^{N}\left(c_{n,i,t}/q_{n,i,t}\right)\right\} \end{aligned}$$

The average cost of production across all countries at time t is

$$\begin{aligned} AC_t &= \left(\frac{1}{I}\right)\sum_{i=1}^{I} AC_{i,t} \\ &= \left(\frac{1}{I}\right)\left\{\left(\frac{1}{N}\right)\sum_{n}^{N}\left(c_{n,i,t}/q_{n,i,t}\right)\right\} \end{aligned}$$

Finally, the average cost across both countries and time is

$$\begin{aligned} AC &= \left(\frac{1}{T}\right)\sum_{t=1}^{T}\left\{\left(\frac{1}{I}\right)\sum_{i=1}^{I} AC_{i,t}\right\} \\ &= \left(\frac{1}{T}\right)\sum_{t=1}^{T}\left\{\left(\frac{1}{I}\right)\sum_{i=1}^{I}\left(\left(\frac{1}{N}\right)\sum_{n=1}^{N} c_{n,i,t}/q_{n,i,t}\right)\right\} \end{aligned}$$

Appendix 5 Macro Model Structure

The model is based upon the familiar national accounting framework. It uses the standard ONS data. We do not provide the coefficients here for intellectual property reasons.

Core identity

The core identity for the model is:

Real gross domestic product (GDP) equals the sum of real consumption (C), real investment (I), real government current expenditure (G) and real exports (X), minus real imports (M).

[1] $GDP \equiv C + I + G + X - M$

Consumption

Consumption is modelled as a function of real personal disposable income (RPDI) and perceived wealth (PW), subject to households' propensity to save. The latter is determined by the real interest rate (r).

[2] $C = f(RPDI, PW, r)$

RPDI is defined as total personal income (TPI) minus total deductions (D).

[3] $RPDI = TPI - D$

Total personal income is the sum of: income from employment (IE); income from self-employment (ISE); rent, dividends and net interest (R); social security benefits and other current grants from general government (B); imputed charge for capital consumption of private non-profit making bodies (ICCC); current transfers from overseas plus current transfers to charities from companies (TO).

[4] $TPI = IE + ISE + R + B + ICCC + TO$

Income from employment equals the average wage rate for employees in employment (WEE) multiplied by the number of employees in employment (EE). Similarly, income from self-employment is the average wage for the self-employed (WSE) multiplied by the number of self-employed (ESE).

[5] $IE = WEE \,.\, EE$

[6] $ISE = WSE \,.\, ESE$

Rents, dividends and net interest are modelled as a lagged function of savings (S) and the interest rate. Savings are defined as RPDI minus consumption.

[7] $R = f(S_t, S_{t-1}, S_{t-2}, ..., r)$

[8] $S = RPDI - C$

Social security benefits and other current grants from general government are a function of: (i) exogenous benefit rates (b); (ii) claimant unemployment (U); (iii) the number of economically inactive people (PEI); and (iv) the ratio of regional wage rates (W^{NW}) to national wage rates (W^{UK}).

[9] $B = f(b, U, PEI, W^{NW}/W^{UK})$

where:

[10] W = (IE + ISE) / (EE + ESE)

ICCC and TO are treated as exogenous variables which are forecast on the basis of trend.

Deductions are defined as the sum of: income tax (DIT); social security contributions (DSS); council tax and community charge (DCT); and other deductions (DOT).

[11] D = DIT + DSS + DCT + DOT

Income tax is modelled as a joint function of total personal incomes and the exogenous tax rate (t). Similarly, social security contributions is a function of TPI and the exogenous contribution rate (tss).

[12] DIT = f (TPI, t)

[13] DSS = f (TPI, tss)

The variables DCT and DOT are treated as exogenous.

Perceived wealth is represented by a lagged and weighted index of UK house prices (P_{house}) and share values (SSE).

[14] PW = f ($P_{house, t}$, $P_{house, t-1}$, ..., SSE_t, SSE_{t-1}, ...).

The interest rate - a national economic variable - is determined exogenously but is adjusted to keep inflation at the relevant national target rate. Currently the UK inflation target is 2%.

Investment

Investment is defined as gross domestic fixed capital formation (GDFCF) plus changes in inventories (CINV).

[15] I = GDFCF + CINV

GDFCF can be conducted by three groups: general government; companies; households. There are also three types of fixed capital: infrastructure; machinery and equipment; buildings.

[16] GDFCF = $\sum GDFCF_{group, type}$ $\forall$groups, types

All government GDFCF is treated as exogenous and forecast on the basis of expenditure plans. Company expenditure on infrastructure is also treated as exogenous (and negligible).

Company capital expenditure on machinery and equipment (CEME) is forecast by industry as a lagged function of: regional and national GDP; UK exports (X^{UK}); profits (Þ); and the interest rate.

[17] $CEME_i$ = f ($GDP^{NW}_{i, t}$ $GDP^{NW}_{i, t-1}$, ...,

$GDP^{UK}_{i, t}$, $GDP^{UK}_{i, t-1}$, ...,

$X^{UK}_{i, t}$, $X^{UK}_{i, t-1}$, ...,

$Þ_{i, t}$, $Þ_{i, t-1}$, ...,r)

where i is an industry under the two-digit Standard Industrial Classification (92)

Company GDFCF expenditure on buildings (CEB) is modelled as a function of property prices (P_{prop},) and construction prices ($P_{construct}$).

[18] $CEB = f(P_{prop}, P_{construct})$

Household capital expenditure on infrastructure and on machinery and equipment are taken as exogenous and are assumed to be negligible. Household capital formation expenditure on buildings (HEB) is taken as a joint function of house and construction prices.

[19] $HEB = f(P_{house}, P_{construct})$

Business property prices are modelled as a function of: interest rates; output; and the size of the commercial property stock ($K_{prop,}$). Residential property prices are modelled as a function of: the interest rate; RPDI, perceived wealth and the stock of residential property (K_{house}).

[20] $P_{prop} = f(r, GDP, K_{prop.})$

[21] $P_{house} = f(r, PW, RPDI, K_{house})$

The stocks of property are functions of property capital formation.

[22] $K_{prop} = f(CEB)$

[23] $K_{house} = f(HEB)$

It is assumed that only companies have inventories. Changes in inventories are modelled as a cycle based upon current and lagged GDP and stock levels.

[24] $CINV_t = f(GDP_t, GDP_{t-1}, ..., INV_t, INV_{t-1}, ...)$

where

[25] $INV = f(CINV)$

Government Current Expenditure

Government current expenditure is taken as an exogenous variable based upon official plans.

Exports

Exports are all goods and services produced in the UK which are consumed outside the country.

Exports of a given product are a function of: world trade in that product (WT); and the relative price of the product - i.e. the ratio of UK prices (P^{UK}) to world prices (P^{WORLD}) .

[26] $X_i = f\ WT_i, P^{UK}_i/P^{WORLD}_i)$

And,

[27] $X = \Sigma X_I$

Imports

Imports are all goods and services produced outside the UK which are consumed inside the country.

Imports of a given product are modelled as a function of the total final expenditure on that product (TFE).

[28] $M_i = f(TFE_i)$

where,

[29] $TFE_i = C_i + I_i + G_i + X_I$

And,

[30] $M = \Sigma M_i$

Labour Market

The labour market is important both as a determinant of GDP and in its own right. UKMOD incorporates a labour market sub-model which forecasts employment, unemployment, wage rates and the level of self-employment.

Employment (E) is modelled as a lagged function of employee wage rates and GDP.

[31] $E = f (WEE_t, WEE_{t-1}, ..., GDP_t, GDP_{t-1}, ...)$

The share of total employment which is accounted for by self-employment is modelled as a lagged function of unemployment.

[32] $ESE / E = f (U_t, U_{t-1}, ...)$

[33] $E = EE + ESE$

Unemployment is defined as the number of members of the labour force (L) who are not in employment or self-employment. The size of the labour force is modelled as a joint function of exogenous demographic change (DEM) and real national wage rates.

[34] $U = L – E$

[35] $L = f (DEM, WEE^{UK})$

Employee wage rate inflation (and, hence, wage levels) is determined by the rate of change of employment and the level of short-term unemployment (UST).

[36] $dWEE/dt = f (dE/dt, UST)$

The level of long-term unemployed (ULT) is modelled as a lagged function of unemployment.

[37] $ULT = f (U_t, U_{t-1}, ...)$

[38] $U = ULT + UST$

Self-employed wage rates are modelled as a function of employee wage rates and GDP.

[39] $WSE = f (WEE, GDP)$

Appendix 6 Sectors in the Input Output Model

This appendix lists the 104 sectors that comprise the latest UK input output matrix with their sector codes. It also includes the full versions of Tables 10 and 11 in the report with the estimated economic impact of standards for all 104 sectors. Table 10 gives the listing by order of percentage impact and Table 11 by order of absolute impact.

CPA_A01	Products of agriculture, hunting and related services
CPA_A02	Products of forestry, logging and related services
CPA_A03	Fish and other fishing products; aquaculture products; support services to fishing
CPA_B05	Coal and lignite
CPA_B06 & B07	Extraction Of Crude Petroleum And Natural Gas & Mining Of Metal Ores
CPA_B08	Other mining and quarrying products
CPA_B09	Mining support services
CPA_C101	Preserved meat and meat products
CPA_C102_3	Processed and preserved fish, crustaceans, molluscs, fruit and vegetables
CPA_C104	Vegetable and animal oils and fats
CPA_C105	Dairy products
CPA_C106	Grain mill products, starches and starch products
CPA_C107	Bakery and farinaceous products
CPA_C108	Other food products
CPA_C109	Prepared animal feeds
CPA_C11.01-6 & C12	Alcoholic beverages & Tobacco products
CPA_C1107	Soft drinks
CPA_C13	Textiles
CPA_C14	Wearing apparel
CPA_C15	Leather and related products
CPA_C16	Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials

CPA_C17	Paper and paper products
CPA_C18	Printing and recording services
CPA_C19	Coke and refined petroleum products
CPA_C20A	Industrial gases, inorganics and fertilisers (all inorganic chemicals) - 20.11/13/15
CPA_C20B	Petrochemicals - 20.14/16/17/60
CPA_C20C	Dyestuffs, agro-chemicals - 20.12/20
CPA_C203	Paints, varnishes and similar coatings, printing ink and mastics
CPA_C204	Soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
CPA_C205	Other chemical products
CPA_C21	Basic pharmaceutical products and pharmaceutical preparations
CPA_C22	Rubber and plastic products
CPA_C23OTHER	Glass, refractory, clay, other porcelain and ceramic, stone and abrasive products - 23.1-4/7-9
CPA_C235_6	Cement, lime, plaster and articles of concrete, cement and plaster
CPA_C241_3	Basic iron and steel
CPA_C244_5	Other basic metals and casting
CPA_C25OTHER	Fabricated metal products, excl. machinery and equipment and weapons & ammunition - 25.1-3/25.5-9
CPA_C254	Weapons and ammunition
CPA_C26	Computer, electronic and optical products
CPA_C27	Electrical equipment
CPA_C28	Machinery and equipment n.e.c.
CPA_C29	Motor vehicles, trailers and semi-trailers
CPA_C301	Ships and boats
CPA_C303	Air and spacecraft and related machinery
CPA_C30OTHER	Other transport equipment - 30.2/4/9
CPA_C31	Furniture
CPA_C32	Other manufactured goods
CPA_C3315	Repair and maintenance of ships and boats

CPA_C3316	Repair and maintenance of aircraft and spacecraft
CPA_C33OTHER	Rest of repair; Installation - 33.11-14/17/19/20
CPA_D351	Electricity, transmission and distribution
CPA_D352_3	Gas; distribution of gaseous fuels through mains; steam and air conditioning supply
CPA_E36	Natural water; water treatment and supply services
CPA_E37	Sewerage services; sewage sludge
CPA_E38	Waste collection, treatment and disposal services; materials recovery services
CPA_E39	Remediation services and other waste management services
CPA_F41, F42 & F43	Construction
CPA_G45	Wholesale and retail trade and repair services of motor vehicles and motorcycles
CPA_G46	Wholesale trade services, except of motor vehicles and motorcycles
CPA_G47	Retail trade services, except of motor vehicles and motorcycles
CPA_H491_2	Rail transport services
CPA_H493_5	Land transport services and transport services via pipelines, excluding rail transport
CPA_H50	Water transport services
CPA_H51	Air transport services
CPA_H52	Warehousing and support services for transportation
CPA_H53	Postal and courier services
CPA_I55	Accommodation services
CPA_I56	Food and beverage serving services
CPA_J58	Publishing services
CPA_J59 & J60	Motion Picture, Video & TV Programme Production, Sound Recording & Music Publishing Activities & Programming And Broadcasting Activities
CPA_J61	Telecommunications services
CPA_J62	Computer programming, consultancy and related services
CPA_J63	Information services
CPA_K64	Financial services, except insurance and pension funding
CPA_K65.1-2 & K65.3	Insurance, reinsurance and pension funding services, except compulsory social security

CPA_K66	Services auxiliary to financial services and insurance services
CPA_L68BXL683	Real estate services, excluding on a fee or contract basis and imputed rent
CPA_L68A	Owner-Occupiers' Housing Services
CPA_L683	Real estate services on a fee or contract basis
CPA_M691	Legal services
CPA_M692	Accounting, bookkeeping and auditing services; tax consulting services
CPA_M70	Services of head offices; management consulting services
CPA_M71	Architectural and engineering services; technical testing and analysis services
CPA_M72	Scientific research and development services
CPA_M73	Advertising and market research services
CPA_M74	Other professional, scientific and technical services
CPA_M75	Veterinary services
CPA_N77	Rental and leasing services
CPA_N78	Employment services
CPA_N79	Travel agency, tour operator and other reservation services and related services
CPA_N80	Security and investigation services
CPA_N81	Services to buildings and landscape
CPA_N82	Office administrative, office support and other business support services
CPA_O84	Public administration and defence services; compulsory social security services
CPA_P85	Education services
CPA_Q86	Human health services
CPA_Q87 & Q88	Residential Care & Social Work Activities
CPA_R90	Creative, arts and entertainment services
CPA_R91	Libraries, archives, museums and other cultural services
CPA_R92	Gambling and betting services
CPA_R93	Sports services and amusement and recreation services
CPA_S94	Services furnished by membership organisations
CPA_S95	Repair services of computers and personal and household goods

CPA_S96	Other personal services
CPA_T97	Services of households as employers of domestic personnel

Sectoral impact

Table 12 Sectors listed by order of percentage impact

	Percentage	£ millions
Computer programming, consultancy and related services	1.6%	594
Scientific research and development services	1.4%	536
Computer, electronic and optical products	1.1%	161
Architectural and engineering services; technical testing and analysis services	1.1%	196
Real estate services on a fee or contract basis	1.0%	94
Legal services	1.0%	119
Construction	1.0%	1600
Other chemical products	0.9%	37
Weapons and ammunition	0.8%	7
Services of head offices; management consulting services	0.8%	200
Information services	0.8%	32
Employment services	0.8%	26
Accounting, bookkeeping and auditing services; tax consulting services	0.8%	15
Advertising and market research services	0.8%	53
Air and spacecraft and related machinery	0.8%	147
Vegetable and animal oils and fats	0.8%	3
Services auxiliary to financial services and insurance services	0.8%	203
Products of forestry, logging and related services	0.8%	0
Ships and boats	0.7%	20
Security and investigation services	0.7%	2
Other professional, scientific and technical services	0.7%	36
Office administrative, office support and other business support services	0.7%	174
Machinery and equipment n.e.c.	0.7%	114
Publishing services	0.7%	135
Fish and other fishing products; aquaculture products; support services to fishing	0.6%	4
Fabricated metal products, excl. machinery and equipment and weapons &	0.6%	65
Paints, varnishes and similar coatings, printing ink and mastics	0.6%	5
Financial services, except insurance and pension funding	0.5%	349
Other transport equipment - 30.2/4/9	0.5%	7
Electrical equipment	0.5%	24
Petrochemicals - 20.14/16/17/60	0.5%	23
Rubber and plastic products	0.5%	43
Dyestuffs, agro-chemicals - 20.12/20	0.5%	3
Soap and detergents, cleaning and polishing preparations, perfumes and toilet	0.5%	33
Air transport services	0.5%	48
Basic iron and steel	0.5%	13
Other food products	0.5%	33
Wholesale trade services, except of motor vehicles and motorcycles	0.5%	353
Alcoholic beverages & Tobacco products	0.4%	23
Industrial gases, inorganics and fertilisers (all inorganic chemicals) - 20.11/13/15	0.4%	4
Products of agriculture, hunting and related services	0.4%	43
Grain mill products, starches and starch products	0.4%	8
Telecommunications services	0.4%	94
Leather and related products	0.4%	3
Paper and paper products	0.4%	10
Motion Picture, Video & TV Programme Production, Sound Recording & Music	0.4%	102
Processed and preserved fish, crustaceans, molluscs, fruit and vegetables	0.4%	13

Wood and of products of wood and cork, except furniture; articles of straw and	0.4%	2
Postal and courier services	0.4%	9
Mining support services	0.4%	2
Accommodation services	0.4%	49
Water transport services	0.3%	39
Creative, arts and entertainment services	0.3%	33
Repair and maintenance of aircraft and spacecraft	0.3%	5
Rest of repair; Installation - 33.11-14/17/19/20	0.3%	2
Other mining and quarrying products	0.3%	4
Textiles	0.3%	18
Extraction Of Crude Petroleum And Natural Gas & Mining Of Metal Ores	0.3%	65
Rental and leasing services	0.3%	45
Prepared animal feeds	0.3%	11
Glass, refractory, clay, other porcelain and ceramic, stone and abrasive products -	0.3%	9
Wearing apparel	0.3%	12
Insurance, reinsurance and pension funding services, except compulsory social	0.3%	162
Dairy products	0.3%	16
Coke and refined petroleum products	0.3%	48
Basic pharmaceutical products and pharmaceutical preparations	0.3%	44
Furniture	0.3%	23
Cement, lime, plaster and articles of concrete, cement and plaster	0.3%	1
Libraries, archives, museums and other cultural services	0.3%	11
Preserved meat and meat products	0.3%	23
Repair services of computers and personal and household goods	0.2%	4
Soft drinks	0.2%	6
Warehousing and support services for transportation	0.2%	16
Bakery and farinaceous products	0.2%	14
Motor vehicles, trailers and semi-trailers	0.2%	103
Services to buildings and landscape	0.2%	3
Other manufactured goods	0.2%	13
Wholesale and retail trade and repair services of motor vehicles and motorcycles	0.2%	64
Land transport services and transport services via pipelines, excluding rail transport	0.2%	13
Waste collection, treatment and disposal services; materials recovery services	0.1%	17
Travel agency, tour operator and other reservation services and related services	0.1%	19
Real estate services, excluding on a fee or contract basis and imputed rent	0.1%	97
Retail trade services, except of motor vehicles and motorcycles	0.1%	123
Food and beverage serving services	0.1%	91
Gambling and betting services	0.1%	11
Other personal services	0.1%	22
Sports services and amusement and recreation services	0.1%	15
Services of households as employers of domestic personnel	0.1%	5
Rail transport services	0.1%	9
Veterinary services	0.1%	4
Printing and recording services	0.1%	1
Owner-Occupiers' Housing Services	0.1%	151
Education services	0.1%	80
Other basic metals and casting	0.1%	1
Services furnished by membership organisations	0.1%	7
Coal and lignite	0.1%	0
Electricity, transmission and distribution	0.1%	7
Gas; distribution of gaseous fuels through mains; steam and air conditioning supply	0.0%	6
Natural water; water treatment and supply services	0.0%	2
Sewerage services; sewage sludge	0.0%	2
Residential Care & Social Work Activities	0.0%	14
Public administration and defence services; compulsory social security services	0.0%	32
Human health services	0.0%	13

Table 13 Sectors listed by order of their total absolute impact

	Percentage	£ millions
Construction	1.0%	1600
Computer programming, consultancy and related services	1.6%	594
Scientific research and development services	1.4%	536
Wholesale trade services, except of motor vehicles and motorcycles	0.5%	353
Financial services, except insurance and pension funding	0.5%	349
Services auxiliary to financial services and insurance services	0.8%	203
Services of head offices; management consulting services	0.8%	200
Architectural and engineering services; technical testing and analysis services	1.1%	196
Office administrative, office support and other business support services	0.7%	174
Insurance, reinsurance and pension funding services, except compulsory social	0.3%	162
Computer, electronic and optical products	1.1%	161
Owner-Occupiers' Housing Services	0.1%	151
Air and spacecraft and related machinery	0.8%	147
Publishing services	0.7%	135
Retail trade services, except of motor vehicles and motorcycles	0.1%	123
Legal services	1.0%	119
Machinery and equipment n.e.c.	0.7%	114
Motor vehicles, trailers and semi-trailers	0.2%	103
Motion Picture, Video & TV Programme Production, Sound Recording & Music	0.4%	102
Real estate services, excluding on a fee or contract basis and imputed rent	0.1%	97
Telecommunications services	0.4%	94
Real estate services on a fee or contract basis	1.0%	94
Food and beverage serving services	0.1%	91
Education services	0.1%	80
Fabricated metal products, excl. machinery and equipment and weapons &	0.6%	65
Extraction Of Crude Petroleum And Natural Gas & Mining Of Metal Ores	0.3%	65
Wholesale and retail trade and repair services of motor vehicles and motorcycles	0.2%	64
Advertising and market research services	0.8%	53
Accommodation services	0.4%	49
Coke and refined petroleum products	0.3%	48
Air transport services	0.5%	48
Rental and leasing services	0.3%	45
Basic pharmaceutical products and pharmaceutical preparations	0.3%	44
Products of agriculture, hunting and related services	0.4%	43
Rubber and plastic products	0.5%	43
Water transport services	0.3%	39
Other chemical products	0.9%	37
Other professional, scientific and technical services	0.7%	36
Soap and detergents, cleaning and polishing preparations, perfumes and toilet	0.5%	33
Creative, arts and entertainment services	0.3%	33
Other food products	0.5%	33
Public administration and defence services; compulsory social security services	0.0%	32
Information services	0.8%	32
Employment services	0.8%	26
Electrical equipment	0.5%	24
Alcoholic beverages & Tobacco products	0.4%	23
Petrochemicals - 20.14/16/17/60	0.5%	23
Furniture	0.3%	23
Preserved meat and meat products	0.3%	23
Other personal services	0.1%	22
Ships and boats	0.7%	20
Travel agency, tour operator and other reservation services and related services	0.1%	19
Textiles	0.3%	18
Waste collection, treatment and disposal services; materials recovery services	0.1%	17
Dairy products	0.3%	16

Warehousing and support services for transportation	0.2%	16
Sports services and amusement and recreation services	0.1%	15
Accounting, bookkeeping and auditing services; tax consulting services	0.8%	15
Residential Care & Social Work Activities	0.0%	14
Bakery and farinaceous products	0.2%	14
Human health services	0.0%	13
Basic iron and steel	0.5%	13
Land transport services and transport services via pipelines, excluding rail transport	0.2%	13
Other manufactured goods	0.2%	13
Processed and preserved fish, crustaceans, molluscs, fruit and vegetables	0.4%	13
Wearing apparel	0.3%	12
Libraries, archives, museums and other cultural services	0.3%	11
Prepared animal feeds	0.3%	11
Gambling and betting services	0.1%	11
Paper and paper products	0.4%	10
Postal and courier services	0.4%	9
Glass, refractory, clay, other porcelain and ceramic, stone and abrasive products -	0.3%	9
Rail transport services	0.1%	9
Grain mill products, starches and starch products	0.4%	8
Services furnished by membership organisations	0.1%	7
Electricity, transmission and distribution	0.1%	7
Weapons and ammunition	0.8%	7
Other transport equipment - 30.2/4/9	0.5%	7
Soft drinks	0.2%	6
Gas; distribution of gaseous fuels through mains; steam and air conditioning supply	0.0%	6
Paints, varnishes and similar coatings, printing ink and mastics	0.6%	5
Services of households as employers of domestic personnel	0.1%	5
Repair and maintenance of aircraft and spacecraft	0.3%	5
Industrial gases, inorganics and fertilisers (all inorganic chemicals) - 20.11/13/15	0.4%	4
Fish and other fishing products; aquaculture products; support services to fishing	0.6%	4
Other mining and quarrying products	0.3%	4
Repair services of computers and personal and household goods	0.2%	4
Veterinary services	0.1%	4
Dyestuffs, agro-chemicals - 20.12/20	0.5%	3
Leather and related products	0.4%	3
Services to buildings and landscape	0.2%	3
Vegetable and animal oils and fats	0.8%	3
Wood and of products of wood and cork, except furniture; articles of straw and	0.4%	2
Natural water; water treatment and supply services	0.0%	2
Security and investigation services	0.7%	2
Mining support services	0.4%	2
Rest of repair; Installation - 33.11-14/17/19/20	0.3%	2
Sewerage services; sewage sludge	0.0%	2
Cement, lime, plaster and articles of concrete, cement and plaster	0.3%	1
Printing and recording services	0.1%	1
Other basic metals and casting	0.1%	1
Products of forestry, logging and related services	0.8%	0
Coal and lignite	0.1%	0

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