

# THE UK DIGITAL SECTORS AFTER BREXIT

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An independent report commissioned by  
**techUK**

24 January 2017

**tech**<sup>UK</sup>





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## FOREWORD

### Julian David, CEO of techUK

Ahead of the referendum on the European Union, the UK tech sector was clear on its overwhelming preference for the UK to remain a member of the EU. techUK set out the positive case to remain and its concerns on the negative impact of leaving. However, the British public voted to leave the EU on 23 June 2016 and the business community fully respects that decision. Our job now is to focus on ensuring the best possible outcome for the UK tech sector, the wider economy and UK citizens.



As the Prime Minister said in her speech at Davos in January 2017, Brexit represents a ‘momentous change’. This is as true for the UK tech sector as it is for the UK as a whole. The UK’s digitally-intensive producing and using businesses have highly integrated supply chains across European and global markets. Twenty per cent of all the goods and services produced by these firms are bought by businesses and consumers around the world; two-fifths of these in the EU. The day-to-day operations of the sector depend upon a highly complex and broadly effective set of rules, regulations and standards that have been developed over decades at European level. The success and growth of the UK’s digitally-intensive businesses has been fuelled by talent, expertise and entrepreneurialism that has flowed to the UK thanks to the free movement of people. The UK’s universities have benefited more than any other country from EU research funds, whilst the European Investment Fund has been a vital source of venture capital for the UK’s world-leading tech start-up ecosystem. Taken together the UK’s digitally-intensive producing and using firms account for 16% of GVA, 24% of all exports and three million jobs.

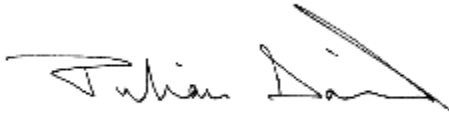
Leaving the EU will disrupt all of this. The challenge for all of us is to find a path that ensures the transition between EU membership and what follows is as smooth as possible.

That is why techUK commissioned Frontier Economics to provide this independent analysis on the UK Digital Sectors after Brexit, to shed further light on the implications of potential changes to an industry which by its very nature is global and deeply integrated with other markets.

As this report sets out, it is in the strong interests of the UK’s digitally-intensive sectors that a new comprehensive free trade agreement is reached with the EU that can enable continued growth in the UK and innovation and digital transformation across the EU. However, with the best will of all parties it is highly unlikely that such an agreement could be implemented within the two year deadline set out for the completion of the UK’s withdrawal from the EU. To avoid potentially significant demand- and supply side-shocks there will need to be some form of comprehensive transitional arrangements that allow businesses to

adapt. This will also be in the interests of digitally-intensive businesses across Europe that are highly integrated with the UK.

As this report outlines, in many ways, the UK's digitally-intensive sectors are a model for what a new Global Britain should be: open, fast moving, innovative, and most importantly globally successful. The tech sector did not seek Brexit, but it is dependent upon the UK making a success of it and is committed to making it work.

A handwritten signature in black ink, appearing to read "Julian Dan". The signature is fluid and cursive, with a long horizontal stroke at the end.

*Alongside this independent analysis from Frontier Economics, techUK has published a set of priorities for the UK Government in forthcoming negotiations, available at [www.techuk.org/brexit](http://www.techuk.org/brexit).*

## EXECUTIVE SUMMARY

The UK digital technology sector, like others, is confronted with a changing business environment as government prepares for an exit from the European Union. This report helps by building an evidence base around three major sector priorities—access to markets, talent, and data flows—in support of decision-making among the various stakeholders ahead of negotiations.

Last summer, techUK’s members prioritised five key areas for the digital sectors after Brexit, and have asked Frontier Economics to further inform those positions with additional evidence. This analysis demonstrates why access to cross-border markets, skilled labour, and data flows were prioritised by Britain’s leading digital companies—because these factors are fundamental to the sector’s international orientation and to its performance in a global marketplace. Our primary finding is that the digital sectors are vulnerable to disruptions on the supply and demand sides from Brexit, particularly when compared with the UK economy overall.

### Key findings:

- The “digital sector”—the group of 12 industries that produce or intensively use digital goods, services, and labour in production—accounts for 16 per cent of domestic output, 10 per cent of employment, and 24 per cent of exports. It contributes disproportionately to growth, productivity, and innovation, directly and indirectly, and its development has been a stated national priority.
- The digital sectors have a strong international orientation. On the supply side, half of inputs in production for the “digital-producing” segment are imported. Twenty per cent of final demand of goods and services for the entire digital sector—the digital producing segment plus the “digital-using” segment—is exported. Many of these linkages are with European suppliers and customers.
- The digital sector is primarily services: 96 per cent of sector output and 81 per cent of sector exports are spread across services activities. Tariffs on digital goods are broadly low and bounded by WTO rules. As a result, the primary trade-related risks for the digital sector *overall* from Brexit will be through non-tariff barriers, in particular for the regulation of services activities.
- The digital sector relies on global talent: 18 per cent of the sector’s 3 million workers are foreign-born. One-third of those are from EU countries. Foreign-born workers accounted for 45 per cent of net employment *growth* between 2009 and 2015. EU-born workers contributed the most, in relative terms. Brexit potentially risks access to skills by disrupting a vital talent pipeline.
- Cross-border data flows underpin a modern, services-oriented economy, and the UK is a global leader: accounting for 11.5 per cent of global cross-border flows (three-quarters are between the UK and EU countries). It is estimated that half of all trade in services are enabled by digital technologies. Brexit places the value of cross-border data flows at risk by introducing uncertainty

on EU data protection regulations, and the UK’s “adequacy” of compliance with those laws.

A more detailed summary of our report follows.

## About the digital sectors



### Defining digitally-intensive industries

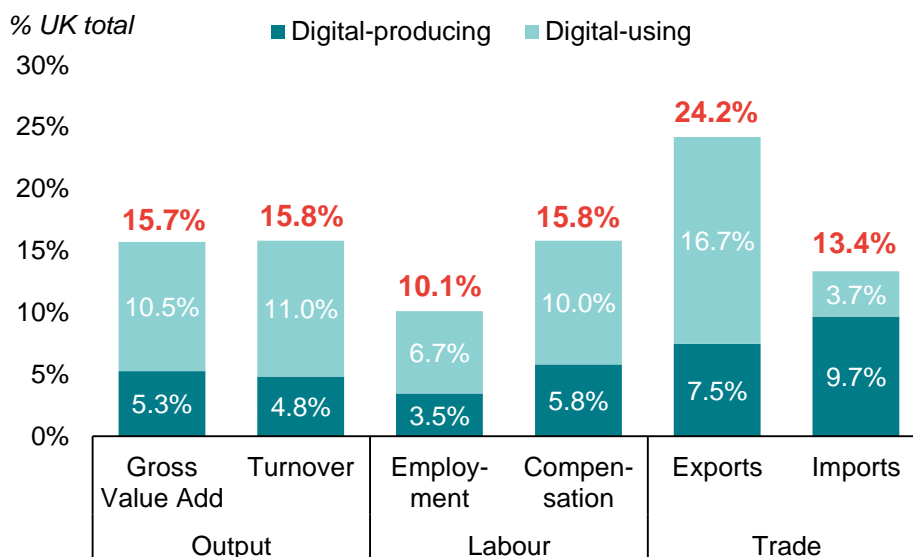
Twelve of 105 industries analysed use very high shares of digital inputs (capital, labour, goods, and services) relative to non-digital inputs to production. Five of these also produce digital goods and services.

There are 12 “digitally-intensive” industries in the UK economy—they have very high shares of digital inputs in production. Five are also “digital-producing” industries (computer hardware, software, and services; telecommunication and information services), while the seven “digital-using” industries are spread across financial activities, media, advertising, and other business services.

The digital sector accounts for 16 per cent of domestic output, 10 per cent of employment, and 24 per cent of total UK exports. The sector employs high-skilled workers and boosts productivity—directly and indirectly.

The digital sector has some additional characteristics: it plays an outsized role in entrepreneurship and high-growth firm generation, has a preponderance of both very small and very large firms, has an internationally-oriented business structure (significant presence of foreign-owned firms in the UK and UK-owned firms in Europe), and is geographically concentrated in high-skilled regions of the UK.

**Figure E1 Digital Sector Share of Total UK Economic Activity (2014)**



Source: Frontier analysis of ONS data  
 Note: Figures may not sum to totals due to rounding

## The single market and digitally-enabled trade

The digital sectors have strong international linkages on both the supply side (imports) and the demand side (exports). The digital-producing industries are significantly reliant on international supply chains—49 per cent of inputs of goods and services in production are imported, compared with 28 per cent for the entire economy.



### Global suppliers

Half of inputs of goods and services in production for the digital-producing segment are imported.

On the demand side, 20 per cent of final demand for digital sector goods and services is exported—16 per cent for the digital-producing segment, and 23 per cent for the digital-using segment. Nine of the 12 digitally-intensive industries have export shares of final demand above the economy-wide average of 13 per cent.



### Global customers

20 per cent of final demand for digital sector goods and services are exported.



### EU linkages

About half of digital sector goods exports and one-third of services exports are with EU countries.

Compounding these linkages with suppliers and customers abroad, the digital sectors have strong linkages in particular with European partners. About half of imported goods and one-third of imported services in the digital sectors are from EU member states. The EU/non-EU splits are similar for exports of UK-produced goods and services in the digital sectors.



### Services trade

81 per cent of digital sector exports are in services—representing 46 per cent of total UK services trade.

Trade in services potentially represents a major, immediate risk. To begin with, 81 per cent of digital sector exports are in services—or 46 per cent of total UK services exports—and approximately one-third or more of these flow to European trading partners. Services trade presents a unique challenge in negotiations because EU services trade policy with third-countries is fragmented, complex, and traditionally has not fully liberalised in agreements outside the framework of the European Economic

Area. Similarly, digital services are less well-defined under existing WTO rules.

In our view, trade in goods with Europe represents less of a risk for the digital sector as a whole, firstly because tariffs are relatively low for digital products and are bounded by WTO commitments, and secondly because non-tariff measures (e.g. product standards and environmental regulations) are unlikely to deviate significantly from the status quo, at least in the near term.



## The digital sectors and skilled migrants

Of the 3 million workers employed in the digital sectors, 18.4 per cent or more than a half million, are foreign-born—compared with 15.8 per cent for the UK economy as a whole. About one-third of foreign-born workers in the digital sector are from the EU.

The contribution of foreign-born workers to employment *growth* in the digital sectors has been even larger—accounting for 45 per cent of net growth between 2009 and 2015. EU-born workers comprised 4 per cent of digital sector employment in 2009 but 17 per cent of its growth through 2015. Non-EU foreign-born workers accounted for 10 per cent of digital sector employment in 2009, but 28 per cent of growth through 2015.

Brexit places access to these workers at risk—the ability of digital technology companies to secure adequate talent under the existing Tier 2 visa scheme has become increasingly challenging in recent years, and the evidence clearly shows that firms are looking to Europe to fill growing demand for global talent.

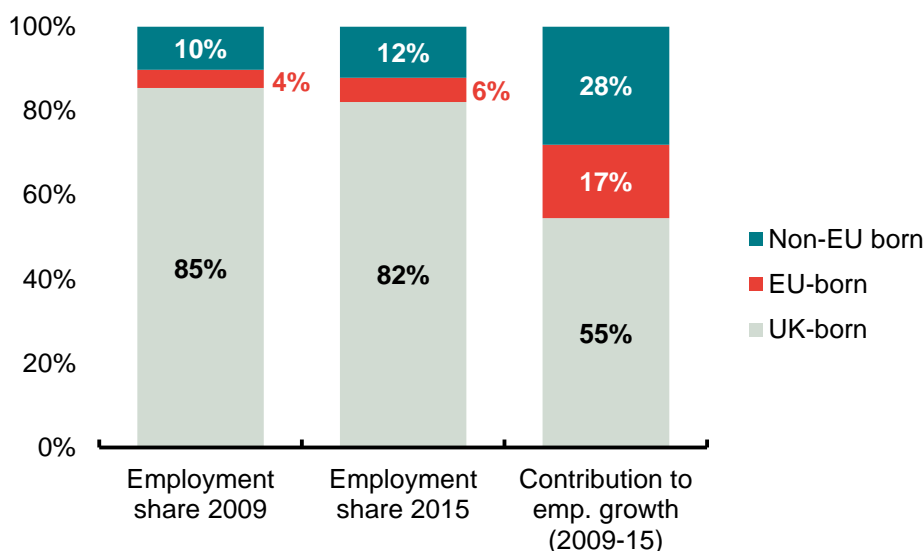
# 552,600

Foreign-born workers in the digital sectors in 2015, or 18.4 per cent of total sector employment. One-third are from the EU.

# 45% of growth

Net employment growth in the digital sectors from 2009-2015 accounted for by foreign-born workers.

**Figure E2 Digital Sector Employment and Growth by Birth Region**



Source: Frontier analysis of ONS data

Note: Figures include digital-occupations in non-digital-intense industries

## Cross border data flows



### Data flows

The UK accounts for 11.5 per cent of global cross-border data flows versus 3.9 per cent of global GDP. Three-quarters are with EU countries.

Data flows underpin a modern, services-oriented economy. It is estimated that about half of all trade in services is enabled by digital technologies and the related data flows. A recent McKinsey study estimates that cross-border data flows account for 3.8 per cent of global GDP. As a relatively services-oriented economy and a leading digital adopter, this likely represents a conservative, lower bound estimate for the impact of cross-border data flows on the UK.



### “Adequate” data protection regulations

The determination of third-country adequacy is fuzzy, and would be decided by the European Commission.

The UK is a global leader in cross-border connectivity, accounting for 11.5 per cent of global cross-border data flows in 2015—compared with 3.9 per cent of global GDP and 0.9 per cent of global population. Cross-border data flows for the UK increased 28 times between 2005 and 2015 and are expected to grow another 5 times through 2021. A full 75 per cent of the UK’s cross-border data flows are with EU countries.

Brexit potentially poses risks in disrupting the benefits of cross-border data flows, due primarily to new EU data protection regulations and the need for third-countries to demonstrate “adequate” compliance with those laws. The determination of third-country “adequacy” is fuzzy, and would be decided by the European Commission. The ambiguity of the situation makes it difficult to assess the potential impacts, but previous estimates of “data localisation” policies are in the range of a decline of a one-half to one full per cent of GDP for European Union nations.

## POLICY IMPLICATIONS

From an overall policy perspective, the findings reinforce the importance of the UK’s participation in the EU single market for the digital sectors. In her 17 January statement, the Prime Minister indicated an intention to exit the single market, and to negotiate a bespoke arrangement between the UK and the EU. The most obvious template for such an arrangement is a comprehensive free trade agreement. In principle, such an agreement could replicate many elements of the single market, depending on the depth of commitments undertaken by both parties. An agreement that meets the requirements of the digital sectors would be one that includes deep commitments on the movement of labour in the context of services trade, and specific commitments in areas such as audio-visual and media services, financial services, and data flows, which cover both market access issues and regulatory cooperation.

## INTRODUCTION

Following the vote on 23 June last year to leave the EU, British businesses must determine the implications for themselves—for their customers, suppliers, and employees. Unwinding more than two decades of deepening economic integration will be disruptive to UK digital businesses, and must be informed by a robust evidence base. This report aims to help in that regard.

Shortly following the referendum, techUK interviewed hundreds of its members to form a collective opinion on priorities for the digital sectors ahead of negotiations with the European Union. Given the complexity of the matter, the issues affecting individual companies, industries, and markets are potentially endless. However, techUK's member engagement prioritised five broad areas: access to the single market, access to talent, free flows of data, a commitment to digital infrastructure, and a fresh look at the UK's digital strategy.<sup>1</sup>

To support decision-making ahead of the upcoming negotiations, techUK asked Frontier Economics to help develop an evidence base around the first three of these five key issues—placing them in an economic framework and putting some estimates around the potential scope of challenges.

Our methodology is straightforward: we objectively define and then measure the “digital sectors” in terms of scope, growth dynamics, exposure to international commerce (particularly linkages with Europe), reliance on skilled migrants, and assess the importance of cross-border data flows (which underpin a digital, services-based economy) between the UK and the EU. Our work is also informed by conversations with stakeholders across the digital sectors.

To be clear, this brief is not exhaustive. Naturally, our limited scope means that a number of important issues are not fully addressed, and will require future work—such as the impact of Brexit on innovation and start-ups, on access to capital and foreign investment, and on regulatory divergence, among others. Even so, the evidence presented here makes clear why these three broad areas were prioritised by Britain's leading voices in digital technology to begin with.

This document answers the following questions:

- For the purpose of understanding the economic impact of Brexit, what are the digital sectors, their characteristics, and their importance to the UK economy?
- How interconnected are the digital sectors—on both the supply and demand sides—with the European economy and the global economy more broadly?
- How critical is access to skilled labour for the digital sectors, and how does migration factor into filling demand for those roles?
- What is the importance of cross-border data flows to the UK economy, and how dependent are those flows on linkages with Europe?

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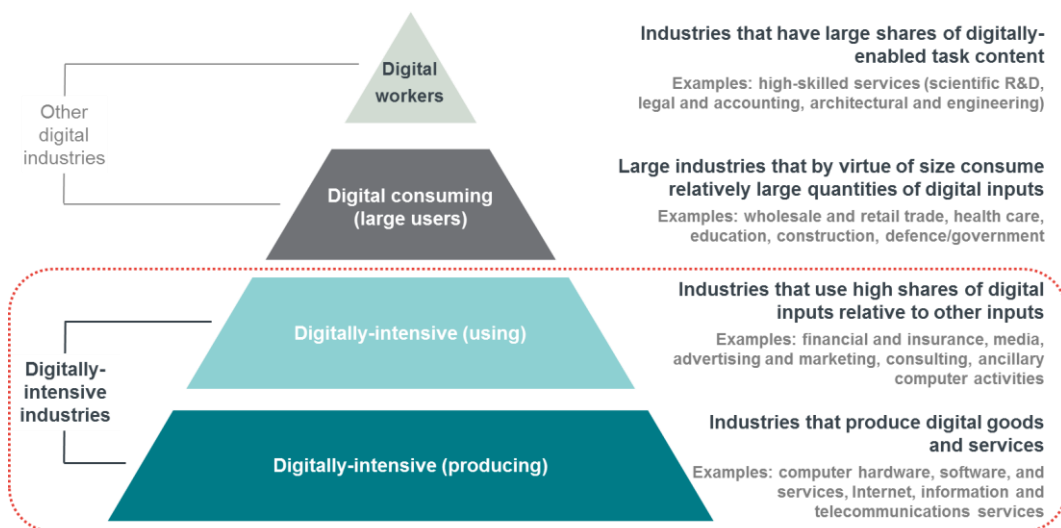
<sup>1</sup> techUK (2016a)

## THE DIGITAL SECTORS

Digital technology is central to modern economies—touching nearly every industry, firm, and worker in some meaningful way. Sectors that produce or intensively use digital technologies account for a sizable portion of the UK economy—driving growth, innovation, and international competitiveness.

### Defining the digital sectors

The central challenge to defining the “digital sectors” is that digital technologies are ubiquitous—they are deeply embedded in all sectors of the economy, within many businesses, and are critical tools for most workers. It’s an increasingly futile task to separate the digital economy from the non-digital economy. But we must draw the line somewhere in assessing how the *especially digital* sectors might be impacted by a United Kingdom departure from the European Union.



To bring objectivity to understanding how the “digitally-intensive” sectors might be affected by Brexit, here we focus on the degree to which each industry utilises digital inputs (computer and information hardware, software, telecommunications, and IT services) in production (as labour, capital, and intermediate inputs).

We analysed more than 100 industries spanning the UK economy, and found that 12 intensively use digital goods and services (very high shares of digital capital, labour, and intermediate inputs relative to total inputs).<sup>2</sup> Five of these 12 digitally-intensive industries also produce digital goods or services. The remaining seven produce services—in media, finance, advertising, and businesses services—but

<sup>2</sup> Based on the measure, this meant some combination of a scalar from the mean (2 times the average) or placing within a certain percentile (say, above the 85<sup>th</sup> percentile). For more, see Annex A: Methodology

intensively use digital technologies in the course of production. Collectively, these 12 constitute the “digital sector” for analysis here.



## The digitally-intensive industries

Twelve of 105 industries analysed use very high shares of digital inputs (capital, labour, goods, and services) relative to non-digital inputs to production. Five of these also produce digital goods and services.

But first, two additional groups are worth mentioning. The first is a group of industries that are sizable and account for large shares of the total use of digital goods and services in production, but fail to meet our “digitally-intensive” standard because they also use many other inputs. These include wholesale and retail trade, health care, education, and government. While these fall outside of the analysis here, they are likely to be impacted by and impact on the digital sectors from Brexit—both directly and indirectly. These sectors account for one-third of total consumption of digital inputs to production. The digitally-intensive industries consume another 35 per cent.

The second is a group of highly-skilled services industries that have a large share of employment in “digitally-intensive occupations” (roles that have a high share of task content involving human interaction with digital devices), but fall short as digitally-intensive industries here because of relatively low shares of digital inputs overall.<sup>3</sup> These include scientific R&D, legal and accounting, and architecture and engineering services. These industries may be impacted by Brexit in similar ways to the services-oriented, high-skilled, digital sectors—particularly in terms of demand for access to export markets and high-skilled migrants.

## Scoping the digital sectors

### Economic output

Figure 1 lists the twelve digitally-intensive industries in the UK economy, along with figures for nominal levels, shares, and growth of gross value add (the industry equivalent of GDP), and turnover (or revenue). Also included are aggregates for the entire economy, as well as the “digital-producing” and “digital-using” groupings.

16% of output

The digitally-intensive sectors account for 16 per cent of gross value add

Objectively, the digital sectors constitute about 16 per cent of the UK economy, with around one-third of that coming from the digital-producing sector and two-thirds from the digital-using sector. Whether measured as GVA or turnover, *96 per cent of digital sector output is concentrated in services activities*—with computer and electronics manufacturing, and software

<sup>3</sup> Frontier built a model of “digital intensity” across occupations at the level of 3-digit ISCO codes for 11 countries, including the United Kingdom. For more details, see Annex A.

publishing being the exceptions. About half of the digital-producing segment is concentrated in computer programming and consulting services, while almost three-quarters of activity in the digital-using segment is concentrated in finance, insurance, and related services activities.

**Figure 1. Output (GVA and Turnover) by Sector (2014)**

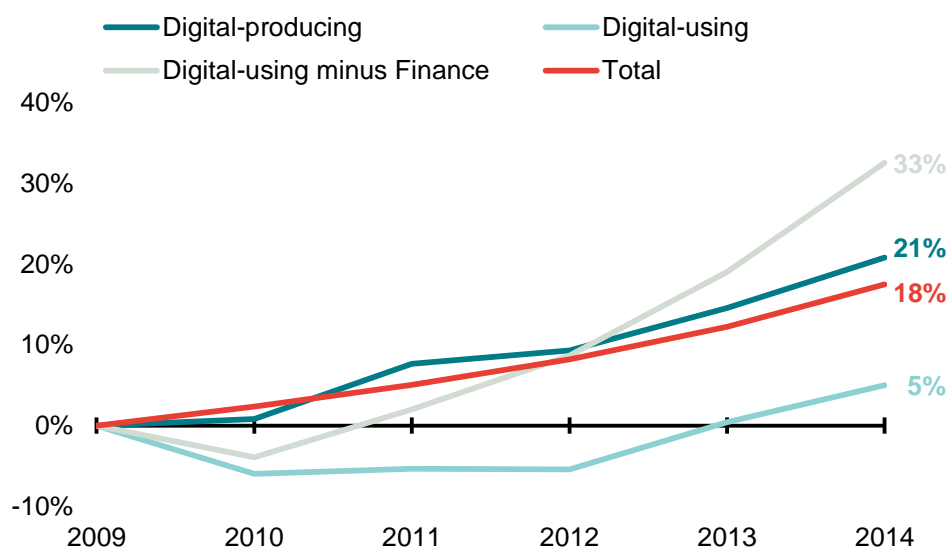
Code	Industry	Group	GVA (2014)		Turnover (2014)	
			£b	% Total	£b	% Total
--	Total		1,624.3	100.0%	3,143.9	100.0%
--	Digital-producing		85.5	5.3%	151.4	4.8%
--	Digital-using		169.8	10.5%	346.3	11.0%
26	Manufacture of computers and electronics	Producing	8.6	0.5%	21.2	0.7%
58.2	Software publishing	Producing	1.3	0.1%	2.6	0.1%
59-60	Media (TV, film, audio)	Using	14.4	0.9%	28.0	0.9%
61	Telecommunications	Producing	29.1	1.8%	55.0	1.7%
62	Computer programming, consultancy and related	Producing	40.8	2.5%	63.7	2.0%
63	Information services	Producing	5.7	0.4%	9.0	0.3%
64	Financial services	Using	64.8	4.0%	135.5	4.3%
65	Insurance	Using	36.0	2.2%	86.7	2.8%
66	Activities auxiliary to financial services and insurance	Using	21.1	1.3%	36.1	1.1%
70	Management consulting	Using	20.0	1.2%	37.0	1.2%
73	Advertising and market research	Using	11.4	0.7%	19.3	0.6%
95.1	Repair of computers and communication equipment	Using	2.1	0.1%	3.5	0.1%

Source: Frontier analysis of ONS data

## Economic growth

The digital sectors have been a key source of economic growth in recent years. The digital-producing segment achieved a (compounded) average annual growth rate of 3.9 per cent between 2009 and 2014.

**Figure 2. Change in Nominal GVA compared with 2009 by Sector**



Source: Frontier analysis of ONS data

During the same period, GVA across the economy grew 3.3 per cent. Growth in the digital-using segment was slowed by the decline in financial services during this period (an industry that is both large and underwent a historic contraction). The digital-using sectors still grew in spite of this. However, netting financial services out, the average annual growth rate (compounded) was 5.8 per cent.

Growth in nine of the 12 digitally-intensive industries outpaced growth in the total economy—software publishing, computer repair, advertising and marketing, and insurance lead the way. Telecommunications, financial services, and activities auxiliary to financial activities lagged behind the UK economy overall.

## International trade

The digital sectors are exposed to international trade and compete on a global basis more so than the rest of the economy—particularly for exports. Evidence broadly confirms a positive impact on GDP growth from trade in goods and services—not just from market access and income generation, but from imports that increase competition and consumer choice.<sup>4</sup>



The digital sectors are exposed to international trade and compete on a global basis more so than the rest of the economy—particularly for exports

**Figure 3. Trade (Exports and Imports) and Growth by Product Sector**

Product	Exports (2014)		Imports (2014)		Annual Growth ('09-14)	
	£b	% Total	£b	% Total	Exports	Imports
Total	511.7	100.0%	547.9	100.0%	5.1%	4.8%
Digital-producing	38.2	7.5%	53.0	9.7%	2.8%	1.9%
Digital-using	85.6	16.7%	20.2	3.7%	3.8%	1.8%
Manufacture of computers and electronics	23.1	4.5%	43.2	7.9%	0.7%	1.6%
Software publishing	0.3	0.1%	0.4	0.1%	0.1%	-1.2%
Media (TV, film, audio)	4.5	0.9%	1.6	0.3%	3.4%	-1.6%
Telecommunications	6.5	1.3%	4.3	0.8%	10.0%	1.2%
Computer programming, consultancy and related	6.3	1.2%	4.4	0.8%	5.7%	5.4%
Information services	2.0	0.4%	0.7	0.1%	0.6%	1.5%
Financial services	26.0	5.1%	9.8	1.8%	1.3%	5.0%
Insurance	18.6	3.6%	2.0	0.4%	7.0%	-10.2%
Activities auxiliary to financial services and insurance	23.4	4.6%	2.8	0.5%	1.7%	9.4%
Management consulting	6.4	1.2%	0.8	0.1%	10.5%	-0.7%
Advertising and market research	5.7	1.1%	2.4	0.4%	10.4%	0.8%
Repair of computers and communication equipment	0.9	0.2%	0.7	0.1%	9.0%	2.8%

Source: Frontier analysis of ONS data

The digital sectors comprise 24 per cent of total UK exports, compared with 16 per cent of GVA. Both the digital-producing and digital-using segments contribute to exports well in excess of their contributions to GVA. Individual sectors that are especially engaged in exports include computer and electronics manufacturing,

<sup>4</sup> Frankel and Romer (1999); Busse and Koeninger (2012)

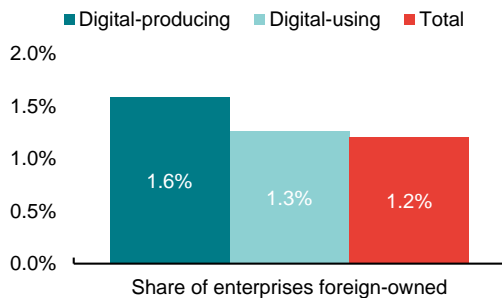
financial and insurance services, and advertising and marketing. Software and computer consulting services are more domestically focused.

Import competition is lower vis-à-vis exports, where the digital sector accounts for 13 per cent of total UK imports. The two goods-producing segments—computer and electronics manufacturing, and software publishing—face the stiffest import competition. The computer repair industry faces imports at about the rate of the economy-wide average. The remaining industries face below average import competition. Overall, the digital sectors contribute positively to the trade balance.

### International business structure

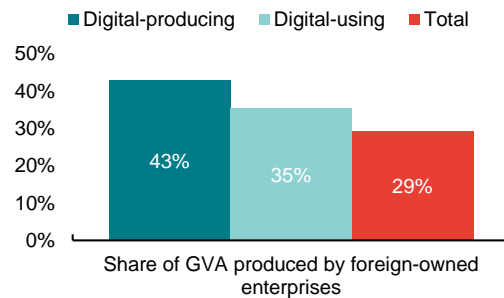
The digital sectors tend to be concentrated in global sectors engaged with global markets and suppliers. The UK is known as being a favoured choice of location for the European (and global) operations of large, foreign multi-nationals.

**Figure 4. Foreign-owned share of UK businesses (2013)**



Source: Frontier analysis of Eurostat data

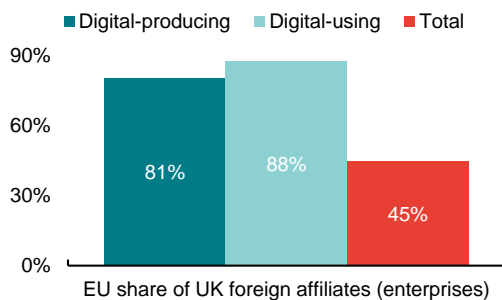
**Figure 5. Foreign-owned business share of GVA (2013)**



Source: Frontier analysis of Eurostat data

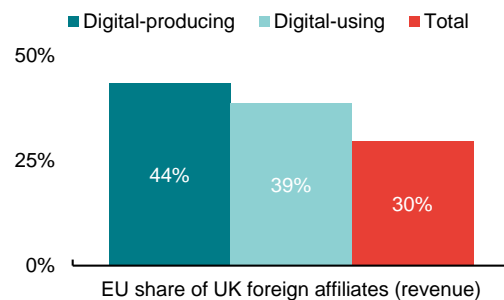
This appears to be especially true in the digital sectors. The information services industry has two-thirds of its GVA produced by foreign-owned firms, compared with 29 per cent for the economy as a whole. Computer manufacturing, computer services, software publishing, and media (especially film production), all have shares around half. As the figures show, these same companies make up a small number of total sector businesses, yet constitute a large portion of economic value creation—they are large, impactful, and globally oriented.

**Figure 6. EU share of UK foreign affiliate firms (2013)**



Source: Frontier analysis of Eurostat data

**Figure 7. EU share of UK foreign affiliate revenue (2013)**



Source: Frontier analysis of Eurostat data

Similarly, many UK-owned firms have foreign operations abroad. Nearly half (45 per cent) of business establishments abroad were located in the EU—but for the



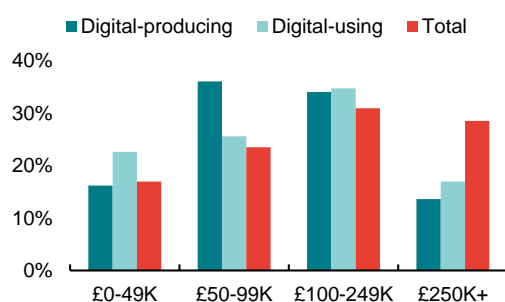
digital sectors, that figure is much higher (81 per cent and 88 per cent). Forty-four per cent of global revenue produced by UK-owned digital-producing businesses came from EU countries in 2013. That same figure for the digital-using segment was 39 per cent, and for the total economy it was 30 per cent.

## Business sizes

The digital sectors are characterised as having both a high proportion of very small businesses (by turnover) and a high share of very large businesses. Eighty-six per cent of business enterprises in the digital-producing segment had annual revenue of less than £250,000 in 2015, while the same was true for 83 per cent of the digital-using segment. For the private sector as a whole, that same figure was 71 per cent.

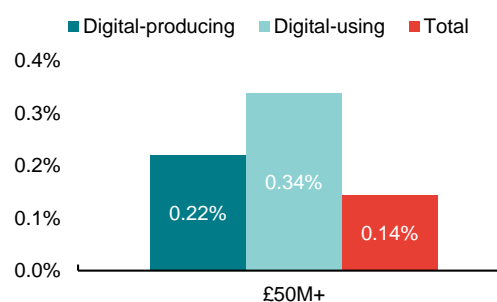
At the other end of the spectrum, digital-producing industries are about twice as likely as the private sector as a whole to fall into the £50 million and above category. Digital-using industries are three times as likely.

**Figure 8. Distribution of businesses by sector and turnover size group (2015)**



Source: Frontier analysis of ONS data

**Figure 9. Share of sector firms with at least £50m in annual turnover (2015)**



Source: Frontier analysis of ONS data

These figures square with anecdotal evidence on three dimensions. First, these sectors are concentrated in high-skilled, services activities. Since the universe of enterprises included in the figures above includes sole proprietors, one would expect a high share of very small “businesses” to be picked up. Secondly, many of the companies in these sectors are innovation-driven—meaning that in the early stages, they may have little to no revenue. Finally, with regard to very large firms, we know that some of the largest businesses globally are concentrated in these industries—accounting for a high share of very large firms.

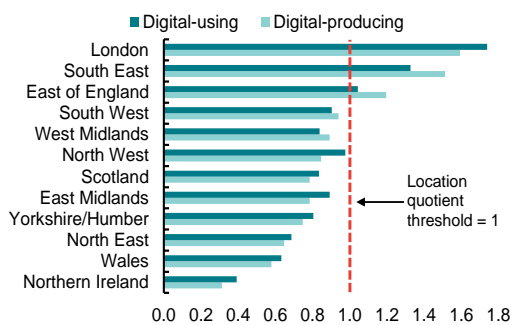
## Regional concentration

The digital sectors are concentrated by geography. Fifty-eight per cent of digital sector businesses are seated in three regions—London (28%), South East (20%) and East of England (10%). These are the only regions with location quotients—measures of geographic concentration—above average.<sup>5</sup>

<sup>5</sup> For location quotients, a value of one indicates an average concentration relative to the entire UK; values above one indicate higher concentrations; those less than one are less concentrated than the average.

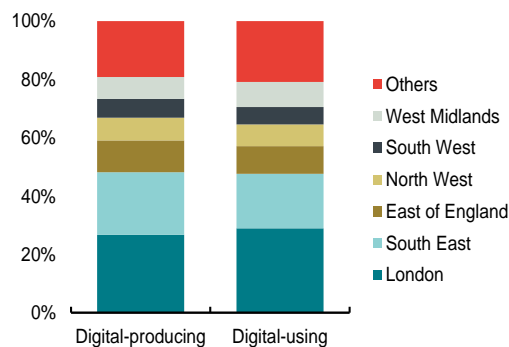
Even within these regions, digital technology companies tend to cluster together. In London, they tend to coalesce in East London’s Tech City, Camden, King’s Cross, and near Paddington. For the South East, pockets are found in Brighton, Oxford, Reading, and Southampton, while for the East of England, activity is centred in Cambridge, Ipswich, and Norwich.<sup>6</sup>

**Figure 10. Regional location quotients for digital sector enterprises (2015)**



Source: Frontier analysis of ONS data

**Figure 11. Regional distribution of digital sector enterprises (2015)**

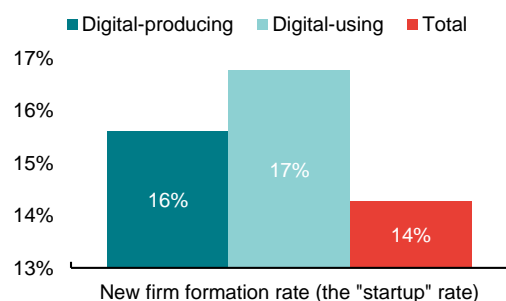


Source: Frontier analysis of ONS data

## Firm dynamics: entrepreneurship and high-growth firms

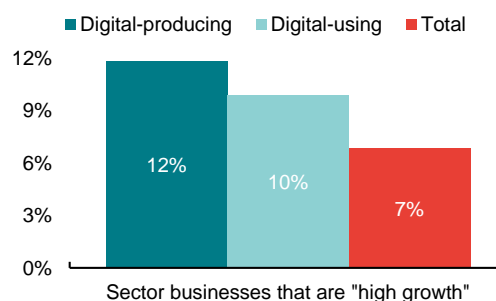
Business dynamics is the study of the growth and decay of individual firms. The constant state of business churn in the economy is healthy, and an important source of job creation, productivity, and innovation.<sup>7</sup> The role of new firm entry or business “start-ups,” is the single most important aspect of business dynamism in terms of the benefits just described—particularly for innovation-driven firms that seek to disrupt established incumbents.<sup>8</sup> Additionally, there is a wide distribution of performance among firms, and a small number of “high-growth” businesses account for most net job creation and revenue growth across the economy.<sup>9</sup>

**Figure 12. Firm entry rate by sector (2014)**



Source: Frontier analysis of Eurostat data

**Figure 13. Rate of “high-growth” (by revenue) firms by sector (2012-2015)**



Source: Frontier analysis of Eurostat data

Note: Businesses with 10 or more employees

<sup>6</sup> For a more thorough regional analysis of the digital technology sectors, see Tech City UK (2016)

<sup>7</sup> Svyerson (2011), Haltiwanger (2011)

<sup>8</sup> Haltiwanger, et al (2013); Acemoglu, et al (2013); Litan and Schramm (2012)

<sup>9</sup> Decker, et al (2014); Andrews, et al (2015)

The digital sectors contribute disproportionately on both measures. The rate of new firm entry—the share of newly launched businesses as a share of total businesses—was nearly 16 per cent in the digital-producing sector in 2014, and nearly 17 per cent in the digital-using segment that same year. The rate for the entire economy was 14 per cent. The most active industries include finance and insurance, consulting, and computer services.

The rate of “high-growth” firms—those with at least 10 employees and achieve 20 per cent average annual compound growth in revenue over a three-year period (or 72.8% over three years)—is higher in the digital sectors. Nearly 12 per cent of businesses with at least 10 employees in the digital-producing segment, and nearly 10 per cent in the digital-using segment fit this definition, compared with just 7 per cent for the entire UK business sector. The leading industries include telecommunications, computer and information services, and insurance.

### HIGH-TECH JOBS MULTIPLIER

Businesses in the digital sector have a big impact on the broader economy. In 2013, Frontier partnered with academics in Belgium to measure the scope, growth dynamics, and broader economic impact of the “high-tech” sector in the European Union. Among other findings, our research showed that the creation of one high-tech job in a region lead to the creation of more than four additional jobs in the local services economy of the same region over the long run.<sup>10</sup> This result was identical to similar work carried out among US metropolitan regions.

## Key takeaways

- There are twelve digitally-intensive industries in the UK economy—they have very high shares of digital inputs in production. Five are also digital-producing industries (computer hardware, software, and services, Internet, information and telecommunications services), while the other seven are spread across financial activities, media, advertising, and other business services.
- The digital sector accounts for 16 per cent of domestic output, whether it is measured as turnover or gross value-add, or respectively £498 billion and £258 billion in 2014. The digital-producing segment accounts for about one-third of digital sector output, with the digital-using contributing the rest. Aside from the financial services industry, which experienced a historic contraction in recent years, the digital sector has been a driver of economic growth.
- The digital sector has some key characteristics. It competes in international markets (accounting for one-quarter of UK exports), plays an outsized role in entrepreneurship and high-growth firm generation, has a preponderance of both very small and very large firms, has an internationally-oriented business structure (high proportion of foreign-owned firms in the UK and UK-owned firms in Europe), and is geographically concentrated in high-skilled regions of the UK (particularly, London and the South East), and has important spillover effects for broad-based economic growth.

<sup>10</sup> Goos, et al (2013); Similar results were found in the US, see Moretti (2010) and Hathaway (2012)

## KEY ISSUE #1: SINGLE MARKET ACCESS AND DIGITAL TRADE

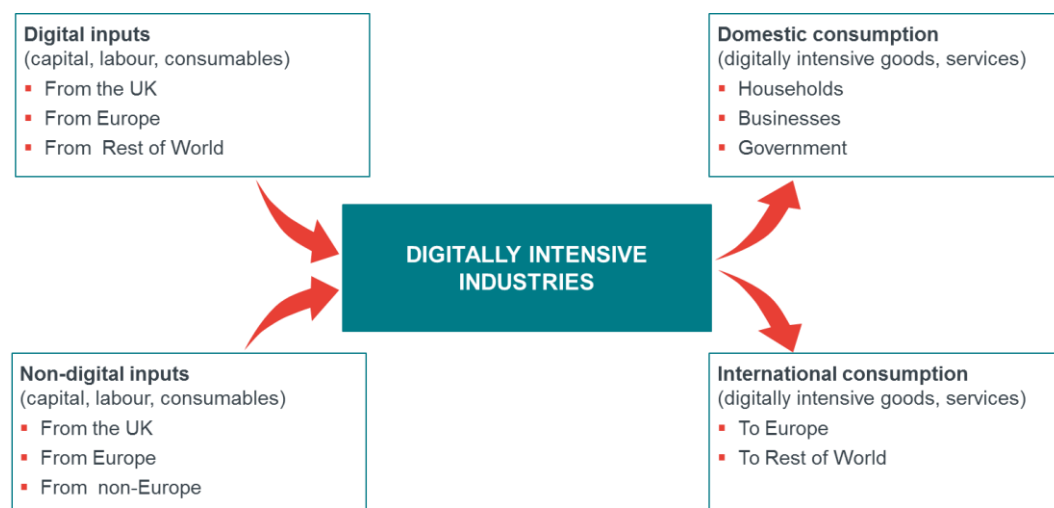
The digital sectors trade in goods and services—both as inputs to production and as exported final products. These links are strongest for UK exports in services, where market access is governed more by regulation than by tariffs. Brexit puts these value chains at risk by disrupting linkages between the digital sector and their suppliers and customers in the EU.

### Cross-border value chains

Like other sectors, the digital sectors also have many linkages with the rest of the economy, both through the goods and services they supply and through the goods and services they use as inputs into their own production. The economic value created by the digital sectors can thus be broken down into direct measures (value of goods and services produced) and indirect measures (activity generated in other sectors that are linked to the digital sectors)

Figure 14 below provides a schematic representation of the sector, highlighting the role of cross-border linkages. The digitally-intensive sectors consume and supply goods and services on both a domestic and a cross-border basis, and are therefore susceptible to changes in trade policy.

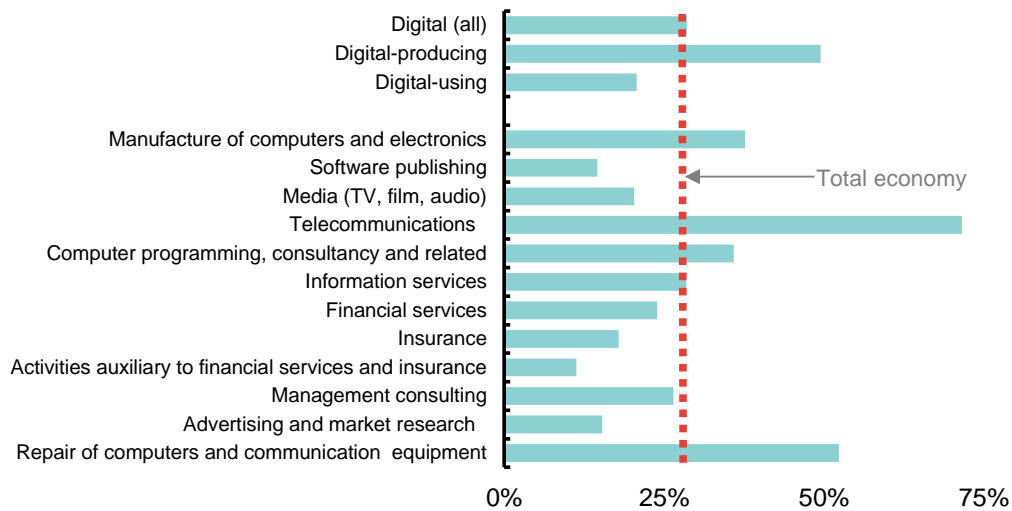
**Figure 14 Supply and Demand Value Chain in an Open Economy**



Figures 15 and 16 below report measures of the reliance of the digital sectors on cross-border value chains—respectively, the share of intermediate inputs used in production that are imported (supply-side), and the share of final demand for a product that is exported (demand-side). The first of these measures captures the

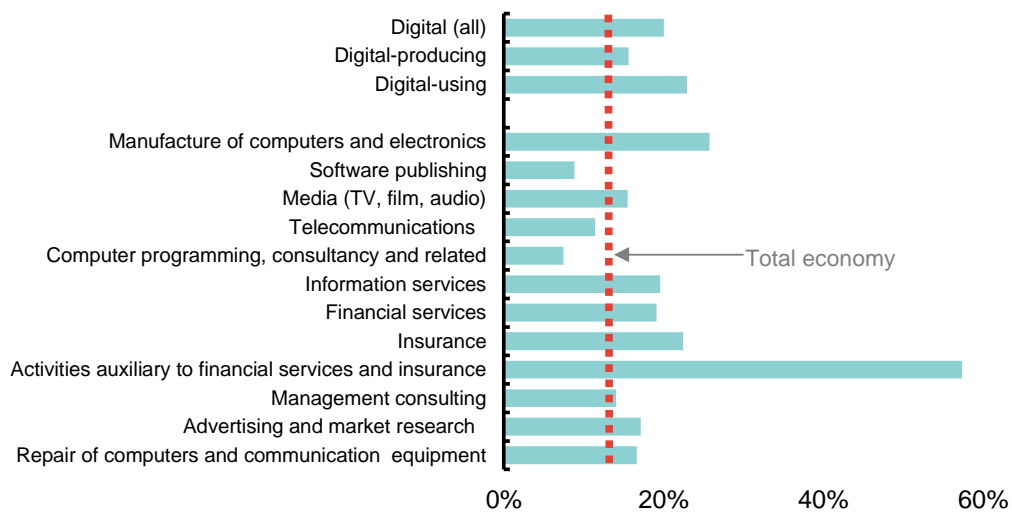
exposure of the digital sectors to shocks affecting the cost of internationally-sourced inputs. The second of these captures the exposure of the digital sectors to shocks in demand through changes in conditions of market access abroad. In both cases the red dashed line is the average for the economy as a whole.

**Figure 15 Import Share of Intermediate Inputs (2014)**



Source: Frontier analysis of ONS data

**Figure 16 Export Share of Final Demand for Goods and Services (2014)**



Source: Frontier analysis of ONS data

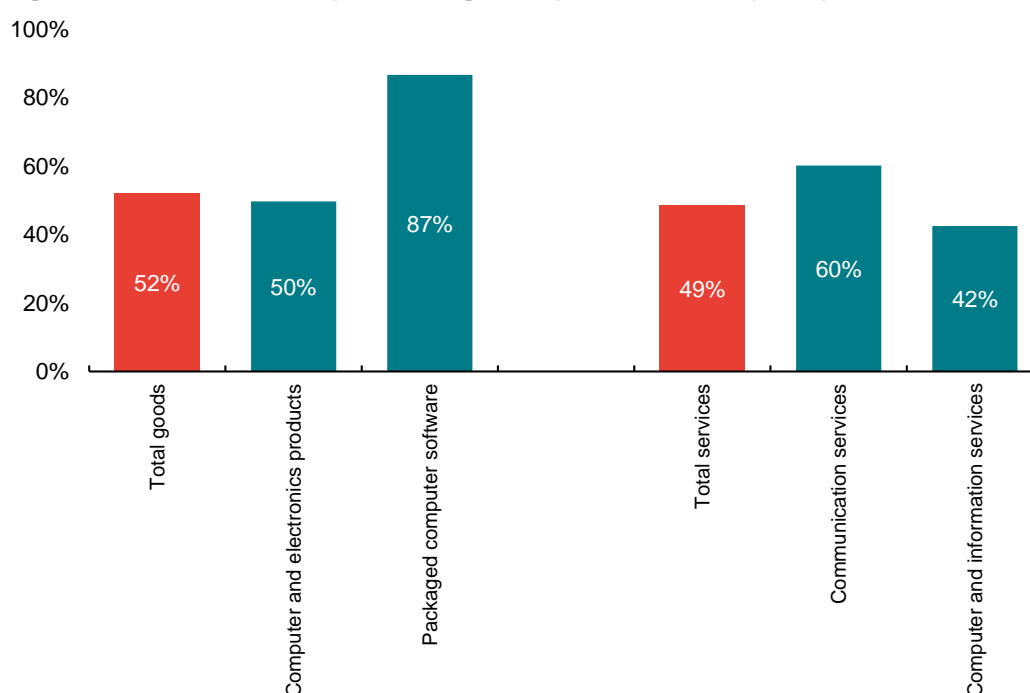
Digital-producing sectors rely on imports of intermediate goods and services to a much greater extent than the economy as a whole—49 per cent of inputs of goods and services for this segment are imported, compared with 28 per cent for the economy as a whole and 21 per cent for the digital-using segment. For the goods producing industries, these inputs are primarily equipment and materials. On the services side, however, it is much more diversified—businesses rely not just on computing equipment, but also a sizable portion of inputs are imported for services in computer and information, telecommunications, business advisory, and office and administrative support.

The trade exposure of the digital sectors is more consistently pronounced on the export side, with all but three industries exhibiting a higher share of exports in final demand than the average for the whole economy. Exports constitute 16 per cent of final demand for the digital-producing segment, 23 for digital-producing industries, and 20 for the digital sector overall, compared with 13 for the economy as a whole. This in turn suggests that the potential of policy changes to market access, whether negative or positive, will be of more critical interest to the digital sectors when compared with the rest of the economy.

## Linkages with Europe

The importance of the EU single market can be better understood by considering measures of the intensity of trade for the sectors of interest with the EU. Figure 17 below reports the splits between EU and non-EU imports for each of the digital-producing sectors—which we have defined as being of critical importance as inputs to production for all of our digitally-intensive industries. The role of the EU as a source of digital inputs in these sectors points to particular vulnerabilities if Brexit leads to the imposition of Most Favoured Nation (MFN) tariff duties under global World Trade Organisation (WTO) arrangements (less favourable vis-à-vis the single market), or leads to an increase in the incidence of non-tariff barriers (e.g. product and service regulations).<sup>11</sup>

**Figure 17 Share of Imported Digital Inputs from EU (2013)**



Source: Frontier analysis of ONS and OECD data

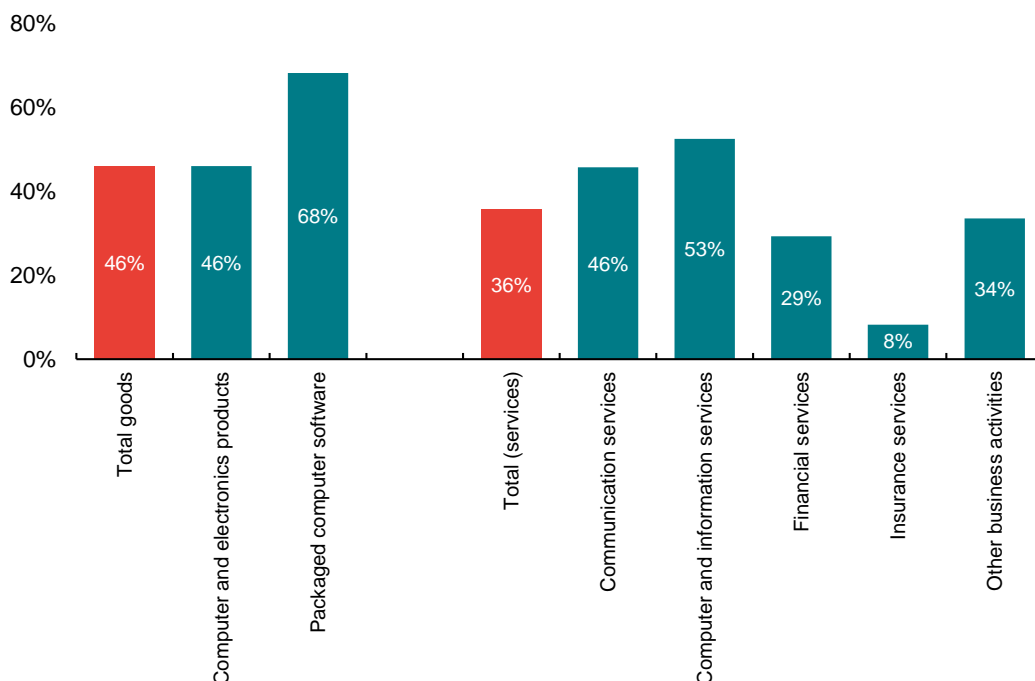
Generally speaking, the most important digital imports are goods—particularly computers and electronics—when compared with their contributions to domestic output. The above figures show that they are also reliant on imports from European trading partners—about average for computer and electronics and

<sup>11</sup> In the case of tariffs, specifically, we assume that the MFN rates are current applied MFN tariff rates.

above average for packaged software. Communications services are more weighted towards EU versus non-EU, but imports are of relatively minor importance to final demand for communications services in the UK overall.

Figure 18 below reports the split for the digital sectors between EU and non-EU export markets. The extent of exposure to the EU varies across different sectors (*note that data here are less-granular on an industry-by-industry basis compared with the rest of the analysis—these data limitations reduce our ability to make wholly direct comparisons with previous data sources on cross-border linkages*). The greater the exposure, the greater risks associated with the imposition of MFN tariffs on trade with the EU or the implementation of non-tariff measures.

**Figure 18 Share of Exported Digital Sector Outputs to EU (2013)**



Source: Frontier analysis of ONS and OECD data

If we consider individual sectors, we note that the manufacturing of computers and related electronic equipment has degree of exposure to the EU that is about average for both imports and exports. Communication services exhibit a similar pattern of exposure, but this is partly moderated by the relatively low importance of exports in final demand for these services.

The overall impact of Brexit and trade with these sectors is a function of overall exposure to trade in final demand (explored earlier), and the extent of that exposure with Europe (as above). Though data limitations here require some caveats, it does appear that computer and electronic goods, and services in telecommunications, computer and, information, and financial services may be the most vulnerable. At minimum, these are industries that rely on digital trade and are substantively linked to the EU for exports.

## Trade and Brexit

The data allow us to draw some inferences on the consequences of various Brexit scenarios (the degree and arrangements of a future relationship between the UK and EU), based on projected effects on the demand and supply sides. Adverse effects will be a function of the degree of exposure to the EU and the extent to which trade restrictiveness—through tariff or non-tariff barriers—will increase under a particular Brexit pathway.

### Trade in goods

An increase in tariffs could affect either the supply side (by increasing the cost of imported inputs) or the demand side (by restricting market access), but only to the extent to which the MFN tariff rates committed to by the UK and the EU in the WTO exceed zero.

In general, we do not expect tariffs to be a major issue for the digital sectors overall on either the supply side or the demand side.

This is because the EU (and the UK, by virtue of being a member of the EU when the EU negotiated its WTO commitments) has bound most of the tariff lines at zero-duty or low rates, meaning they cannot be increased post-Brexit. Figure 19 below reports trade-weighted average tariffs by major product codes relevant to the digital sectors.



In general, we do not expect tariffs to be a major issue for the digital sectors overall on either the supply side or the demand side.

**Figure 19 Trade-weighted average tariffs (2015)**

Code	Description	Trade-Weighted Average Tariff
37	Photographic / cinema goods	0.0%
84	Mainly office equipment (i.e. computers)	0.3%
85	Mainly audio-visual goods	1.6%
90	Medical and precision instruments	1.7%
95	Toys and games (games consoles)	0.0%

Source: *Frontier analysis of United Nations and World Bank data*

The weighted average statistics for product divisions can mask individual tariff “peaks” applying at a more disaggregated product level. For example, certain specific types of radio appliances and monitors attract MFN duties of up to 14 per cent. But there has been very little trade within the EU, even at duty-free rates, in these types of products. This suggests little or no effect from a re-imposition of MFN duties under a “hard Brexit” scenario.

An analysis of non-tariff measures for trade in goods by digital-producing sectors also suggests *mostly* negligible impacts under a hard Brexit scenario, at least in



the short term. Trade in computers and consumer electronics are regulated by certain product standards, though the existing regulatory regimes are unlikely to change immediately after Brexit. Customs delays and checks could be translated into lost sales by slowing the flow of goods, and where supply chains are heavily dependent on ‘just-in-time’ logistics management practices this could reduce productivity and competitiveness. However, new technology solutions to manage customs processes, such as e-records systems, could help to reduce these effects. Further, many digital goods are imported into Europe from third-countries. Many firms in the business of digital goods production that have operations in the UK tend to be engaged in services-related activities here—such as for consumer electronics firms that have European sales, marketing, customer support, and enterprise service operations based in the UK. These wouldn’t be subjected to such product regulations, but would be under the trade in services directive and the free movement of professionals in services trade.

## Trade in services

The primary trade-related impact on the digital sector from Brexit overall will be through non-tariff barriers related to the regulation of services activities. For some activities, specific sector regulation has a direct bearing on market access in the EU’s single market, and falling outside the scope of such regulation would impede access to the single market. This is most notably the case for audio-visual and media services, financial services, and data flows (the regulation of data flows is an issue we consider in a subsequent section).

Regulation in audio-visual and media services, and in financial services, operates on some variation of the country of origin principle. This means that an entity whose centre of commercial interest is in a national jurisdiction of the EU and has demonstrated compliance with regulatory requirements of that jurisdiction is not required to jump through further regulatory hoops in other national jurisdictions and facilitates ease of commercial operation across borders.

In the specific case of audio-visual and media services, a further issue is the existence of local content requirements that stipulate threshold-broadcasting levels of “European content”, based on the country of origin principle. Should UK-based producers of audio-visual and media content be unable to meet the definition of European content post-Brexit, they would no longer qualify for preferential access under local content requirements in EU markets.

As reported before, around 40 per cent of digital sector GVA is accounted for by the 1.3 per cent of its firms that are controlled by foreign entities. The decision to establish a presence in the UK reflects the country’s competitive advantages, and in part, the fact that these advantages can be exploited to serve the EU market. Losing eligibility to qualify as “European” could reduce the attractiveness of the




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The primary trade-related impact on the digital sector from Brexit overall will be through non-tariff barriers related to the regulation of services activities.

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UK as a location for content providers, financial institutions, and other services providing firms.

# 81% of exports

## Digital-sector exports are primarily services

Under a “hard” Brexit scenario, such service providers are likely to fall outside the scope of regulations operating on a country of origin principle. As a result, they are likely to at least partially reconsider the extent of their operations in the UK. The extent of this effect will depend partly on whether non-UK locations can match other factors that have

given the UK a competitive edge as an investment location to begin with, and how far servicing EU markets as opposed to global markets remains an objective.

It is possible, however, to meet concerns about access to the EU single market by negotiating specific commitments in the digital sectors under a free trade agreement between the UK and the EU. For this to be the case, the EU would need to be willing to enter into negotiations on subjects that it has traditionally not engaged on in the context of trade discussions with countries outside the European Economic Area (EEA). For example, audio-visual and media services are specifically excluded from the EU’s free trade agreements—including the most comprehensive to date, the recently concluded Canada-EU Comprehensive Economic and Trade Agreement (CETA). Prudential regulations in the area of financial services are also carved out from the scope of commitments.

A wide collection of cross-cutting regulation (i.e. that is non-sector specific) will also impact these sectors via the demand and supply sides. The foremost example of this lies in the effect of EU treaty provisions on the free movement of labour. EU member states often retain specific national restrictions on the movement of labour that apply to non-EU services suppliers, while EU service suppliers in general benefit from the principle of free movement (we consider the effects of restrictions on the movement of labour and access to talent in greater detail in the next section).

Generally, UK-based digital businesses navigate a complex regulatory environment—from health and safety regulations to data protection rules (discussed later). Regulatory conformity is essential for products to be made available across all EU member states, due to the benefits of scale that these harmonised regulations provide. The sentiment of UK digital sector businesses is for UK law to remain harmonised with EU rules following Brexit. Otherwise, they would face additional compliance costs and uncertainties. The cost of divergence could be significant, yet requires further study.

The indirect effects of regulatory measures reflect spillovers from sectors affected by a change in regulation to others that are suppliers or purchasers of inputs. For



It is universally accepted that dropping out of the, albeit imperfect, Single Market for services and trading under the EU’s provisions for third countries will cut access considerably.

*National Institute Economic Review (2016)*

example, a shock to the UK's financial sector will affect its use of inputs supplied by other sectors, notably business services such as consulting, computer, and information services. Similarly, a shock to market access for broadcasters could adversely affect advertisers and digital platform service providers.

## A LOSS OF INFLUENCE?

One issue that came up again and again in our discussions with sector experts, across industries and disciplines, was the issue of a loss of British influence on European policymaking. Two factors motivate this.

The first is the UK as a liberalising voice in regional economic and regulatory policymaking—as a needed counter-balance to what is viewed as regulatory tendencies of unelected bureaucrats in Brussels. Recall, gaining control over regulatory “sovereignty” was one of the reasons motivating the Leave campaign (along with curbing European migration and payments into the EU budget).<sup>12</sup>

Second was the dynamic nature of regulation. If a post-Brexit UK were to adopt a wide range of EU regulations in order to maintain access to the single market (in whole or in part), it would face the risk of continuing to comply with rules that become less favourable over time. In other words, the UK would be complying with regulations that it has no influence over shaping.

These concerns were voiced in a number of different digital sectors, from cyber security and data protection, to regulation of digital platforms and copyright protections for content providers, to setting the funding agenda on scientific research under Horizon 2020, among others.

## Key takeaways

- The digital sectors have strong international linkages on both the supply side and the demand side. The digital-producing industries are significantly reliant on international supply chains—49 per cent of inputs of goods and services in production are imported, compared with 28 per cent for the entire economy and 21 per cent for the digital-using industries.
- On the demand side, 20 per cent of final demand for digital sector goods and services is exported—16 per cent for the digital-producing segment, and 23 per cent for the digital-using segment. Nine of the twelve digitally-intensive industries have export shares of final demand above the economy-wide figure of 13 per cent.
- Compounding these linkages with suppliers and customers abroad, the digital sectors have strong linkages in particular with European partners. Among the imports of digital goods and services—key inputs for the digitally-intensive industries—approximately half of goods and one-third of services are sourced from EU nations. For exports, the split is roughly the same—about half of all exported goods and one-third of exported services are destined for the EU.

<sup>12</sup> Holmes, et al (2016)

- Trade in goods with Europe does not represent a major risk for the digital sector immediately after Brexit. First, tariffs are very low for digital products and are bounded by WTO commitments. Second, non-tariff measures—such as product standards and environmental regulations—will likely not deviate significantly from the status quo, at least in the short term.
- Trade in services represents a potentially much larger, immediate risk. To begin with, 81 per cent of digital sector exports are in services—representing 46 per cent of total UK services exports. Though we face data limitations to arrive at firmer split between EU/non-EU trade in these product categories, we can safely say that a sizable portion of digital sector exports in services—approximately one-third or more—is with European trading partners.
- Trade in services present a significant challenge in upcoming negotiations, as EU services trade policy with third-countries is highly fragmented, complex, and traditionally has not been fully liberalised in agreements outside the framework of the European Economic Area—see for example the CETA trade agreement with Canada, the most comprehensive deal between the EU and a third-country to date, which still contains sector-specific carve-outs (notably, for audio-visual and media services).

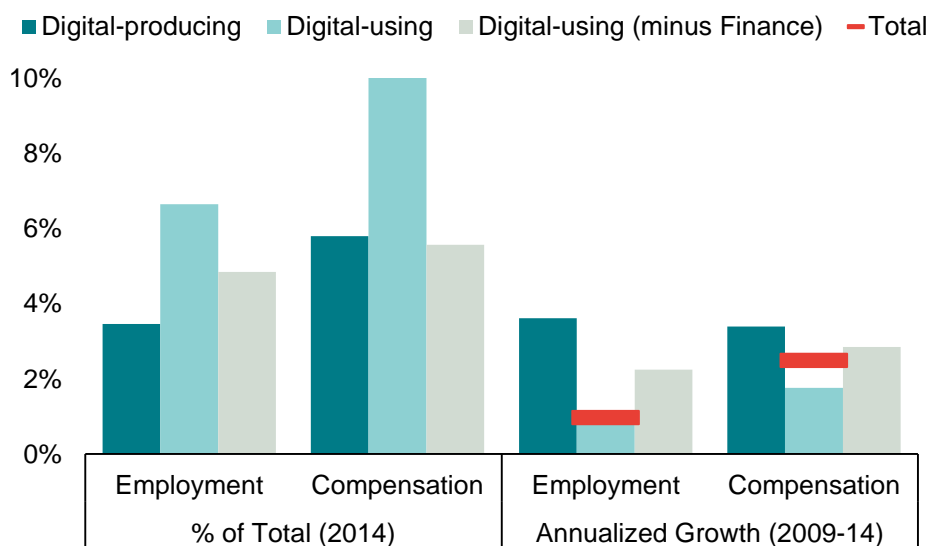
## KEY ISSUE #2: ACCESS TO TALENT

In knowledge-based, services-oriented, and globalised sectors, access to talent is vital. The digital sectors rely on high-skilled labour to accommodate growth, and increasingly depend on migrants—from the EU and elsewhere—to fill demand for skills. Brexit potentially puts access to skills at risk by limiting the flow of a critical talent pipeline—European migrants.

### Employment and wages in the UK digital sectors

Of the 29 million employed workers in the UK in 2014, nearly 3 million—10.1 per cent—were employed in the digital sectors. Of these, one-third were in the digital-producing segment, with the remaining two million in the digital-using segment. There were another nearly half-million workers employed in high-skilled “digital occupations” (i.e. IT engineers, specialists, managers, and designers) in other industries. The largest individual contributors in the digital sectors in terms of employment are computer programming and consulting, followed by financial services (despite large employment declines in recent years).

**Figure 20. Employment and Compensation by Sector**



Source: Frontier analysis of ONS data

Workers in the digital sectors are paid well, as evidenced by their 15.8 per cent share of total employment compensation (compared with 10.1 per cent of total employment). At 1.7, the ratio of compensation share to employment share for the digital-producing sector was highest, followed by the digital-using sector with a ratio of 1.5 (the ratio falls to 1.1 when removing financial services). The largest individual ratio was 3.9 in the information services industry, followed by 2.5 each for telecommunications and financial services.

In terms of growth, the digital-producing segment saw impressive gains in both employment and compensation between 2009 and 2014. The digital-using sectors performed at or slightly below the economy as a whole. This was driven by declines in the financial services sector (large and in contraction during this period). Excluding financial services, those figures change to 2.3 and 2.7 per cent, respectively—each of which are in excess of the economy as a whole.

**Figure 21. Labour (Employment and Compensation) and Growth by Sector**

Industry	Employment (2014)		Compensation (2014)		Annual Growth ('09-14)	
	000s	% Total	£b	% Total	Emp.	Comp.
Total	29,643.6	100.0%	899	100.0%	1.0%	2.5%
Digital-producing	1,027.3	3.5%	52	5.8%	3.6%	3.4%
Digital-using	1,971.9	6.7%	90	10.0%	0.9%	1.8%
Manufacture of computers and electronics	178.5	0.6%	6.4	0.7%	2.7%	2.0%
Software publishing	22.9	0.1%	0.6	0.1%	0.1%	6.5%
Media (TV, film, audio)	167.0	0.6%	6.6	0.7%	3.3%	3.7%
Telecommunications	185.4	0.6%	14.1	1.6%	0.8%	3.9%
Computer programming, consultancy and related	610.1	2.1%	27.5	3.1%	5.2%	3.2%
Information services	30.3	0.1%	3.6	0.4%	1.0%	5.0%
Financial services	534.1	1.8%	40.0	4.4%	-2.3%	0.5%
Insurance	234.4	0.8%	7.8	0.9%	0.2%	1.3%
Activities auxiliary to financial services and insurance	391.4	1.3%	15.8	1.8%	0.1%	1.2%
Management consulting	432.3	1.5%	12.1	1.4%	4.7%	4.1%
Advertising and market research	177.0	0.6%	6.4	0.7%	5.3%	5.2%
Repair of computers and communication equipment	35.8	0.1%	1.3	0.1%	-3.2%	8.4%
Digital occupations in non-digital industries	479.9	1.6%	--	--	0.3%	--

Source: Frontier analysis of ONS data

## Migration in the UK digital sectors

Global migration is a fundamental aspect of the UK economy. In 2015, foreign migrants accounted for 16 per cent of employment, up from 10 per cent in 2005—increasing by 2 million employed workers, or 76 per cent during this ten-year period.<sup>13</sup> Slightly more than half of these workers came from EU countries. By comparison, the UK-born workforce fell slightly during this same period by 56,900. In other words, growth in the UK economy during the last decade has been supported—in no small part—by the foreign-born workforce. Similar trends can be observed in the digital sectors over the last decade, though a major difference is that the UK-born workforce continued to expand—along with growth from workers from abroad.

# 552,600

Foreign-born workers in the digital sectors in 2015, or 18 per cent of total sector employment. One-third are from the EU.

<sup>13</sup> Source: Frontier analysis of LFS microdata. For more, see Annex A.

To remain consistent with the rest of our analysis, here we observe the period from 2009 forward—though the findings are broadly similar when looking over a longer time horizon.<sup>14</sup> The figures below demonstrate the distribution of digital sector employment by region of birth—for UK-born, EU-born, and non-EU-born workers—in 2009 and 2015. It also shows the contribution of each of those three categories to net employment gains in the digital sectors during this period.

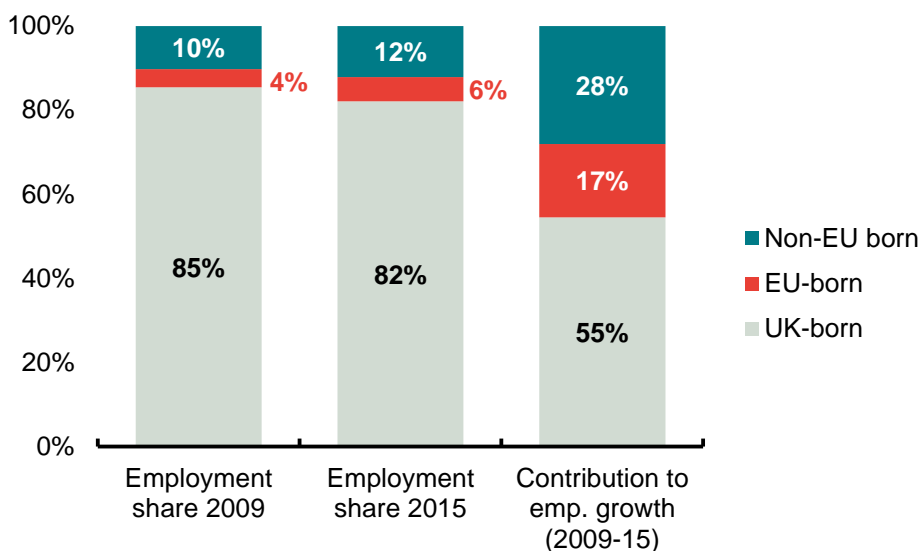
# 45%

Net employment growth in the digital sectors from 2009-2015 accounted for by foreign-born workers

The data reveal some intriguing insights. First, UK-born workers constitute the clear majority of digital sector employment—82 per cent at last count. Even so, the fact that nearly 1 in 5 employed workers in the UK digital sectors were born abroad shows the importance of migration to these sectors.

Secondly, the non-EU-born worker share of the foreign-born workforce exceeds that of the EU-born. Of the 552,600 foreign-born workers in the digital sectors in 2015, 181,300 or 33 per cent were born in EU countries. Additionally, the digital-producing segment has a higher foreign-born share—21.3 per cent versus 16.3 per cent—compared with the digital-using segment, as well as a higher split of non-EU-born vis-à-vis EU-born (2.4 to 1 versus 1.9 to 1). The software publishing and computer services industries have foreign-born shares above 23 per cent. Financial services and computer services have EU-born shares above 6 per cent; for the software publishing industry that figure is nearly 10 per cent. These numbers mask variation across firms—some businesses told us that as many as half of their UK-based employees were non-British nationals, and as many as half of those are from EU countries.

**Figure 22 Digital Sector Employment and Growth by Birth Region**



Source: Frontier analysis of ONS data

Note: Figures include digital-occupations in non-digitally-intense industries

<sup>14</sup> Note that most of our economic accounts data are available through 2014; however our labour force data are available through 2015. In instances where we present just labour force data, we look at 2015.

Third, and perhaps most critically, the foreign-born workforce—in particular, the EU-born workforce—disproportionately drove employment growth in the digital sectors over the half decade. EU-born workers accounted for 4 per cent of digital sector employment in 2009, but 17 per cent of net growth—four times its weight at the beginning of the period. For non-UK-born workers outside of the EU, their 28 per cent contribution to net employment growth in the digital sectors from an initial share of employment of 10 per cent is nearly three-times its initial weighting. The UK-born labour force *still grew* during this period—in fact a healthy 7.6 per cent during the six-year period. However, these gains were dwarfed—in percentage terms—by the growth fuelled by foreign-born workers.

**Figure 23. Foreign-Born Employment by Region of Birth and Sector**

Industry	EU Born (2015)		Non-EU Born (2015)		Total Foreign Born (2015)	
	000s	% of Sector	000s	% of Sector	000s	% of Sector
Total	1865.2	6.2%	2890.7	9.6%	4755.8	15.8%
Digital-producing	65.6	6.3%	156.1	15.0%	221.6	21.3%
Digital-using	115.7	5.7%	215.2	10.6%	331.0	16.3%
Manufacture of computers and electronics	11.1	6.6%	16.0	9.6%	27.1	16.3%
Software publishing	1.9	9.8%	3.0	15.5%	4.9	25.4%
Media (TV, film, audio)	9.2	5.1%	16.6	9.2%	25.8	14.2%
Telecommunications	8.3	4.5%	22.4	12.1%	30.7	16.6%
Computer programming, consultancy and related	43.0	6.5%	112.0	16.9%	155.1	23.4%
Information services	1.2	4.1%	2.6	8.9%	3.9	13.1%
Financial services	37.5	6.6%	67.3	11.9%	104.9	18.6%
Insurance	8.0	3.4%	12.0	5.1%	20.0	8.5%
Activities auxiliary to financial services and insurance	24.6	6.0%	47.7	11.7%	72.3	17.7%
Management consulting	25.4	5.9%	49.1	11.5%	74.5	17.4%
Advertising and market research	9.5	5.1%	19.8	10.6%	29.2	15.7%
Repair of computers and communication equipment	1.6	5.0%	2.7	8.7%	4.2	13.7%
Digital occupations in non-digital industries	21.6	4.3%	40.9	8.2%	62.5	12.5%

Source: *Frontier analysis of ONS data*

Note: “Total Foreign Born” is the sum of the left two categories; the remainder are UK-born (not shown)

## Labour migration and Brexit

These numbers have important implications for policy. The digital sectors rely on foreign-born workers today—18 per cent of employment is a substantial share. Encouragingly, government has signalled its intention to preserve the right of these workers to stay in the UK.<sup>15</sup> Government must still address the status of workers that arrive(d) in the period between the 23 June 2016 vote and the eventual exit from the EU, whenever that occurs.



The evidence is clear that the UK faces a digital skills crisis.

*House of Commons, Science and Technology Committee (2016)*

What is most critical, then, looking ahead, is where future growth will come from. Our analysis demonstrated that employment gains in the digital sectors have been filled disproportionately by foreign-born workers—those born outside the

<sup>15</sup> <https://www.gov.uk/government/news/statement-the-status-of-eu-nationals-in-the-uk>

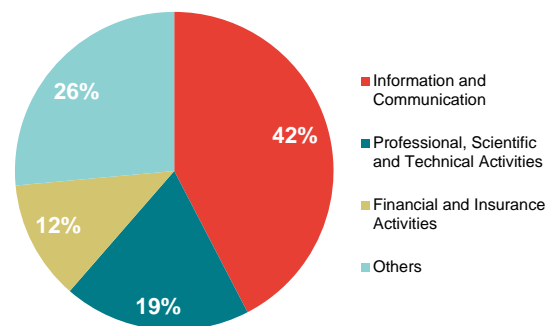


EU have contributed the most to growth overall, but in relative terms, the EU-born segment is contributing the relatively largest (compared to its employment) share. We don't know for sure what the future holds, but if the recent past is any indication, digital sector companies would continue to look to foreign-born talent to scale and grow—perhaps increasingly so.

If that's true, it leaves the question of how demand for future migrants will be met within British law—will government create special arrangements for European nationals, or will they compete with global talent for a fixed number of visas under the Tier 2 (high-skill) visa scheme (or for entrepreneurs, under Tier 1)?

As Figure 24 illustrates, the clear majority of demand for Tier 2 visas currently comes from the three major industry groups most closely associated with the digital sectors. It seems unlikely that incorporating EU migrants under this scheme could be accommodated as it currently stands. Furthermore, restrictions on Tier 2 visas have already been announced earlier this year, which would compound the problem of an adequate number of visas for highly-skilled migrants; nearly two thirds of “data-intensive” companies reported significant challenges in filling vacancies for technical roles, while more than 90 per cent of digital technology companies stated that a perceived skills gap materially affects commercial operations.<sup>16</sup> A reduction in the pool of available talent would exacerbate this. In addition, the process of obtaining a Tier 2 visa is time-consuming, costly, and uncertain—three things that disadvantage small and medium enterprises (SMEs) relative to large, global firms.

**Figure 24. Tier 2 Visa Applications by Major Industry Group (2015)**



Source: Frontier analysis of Home Office data



The clear majority of demand for Tier 2 visas currently comes from the three major industry groups most closely associated with the digital sectors.

The reliance of the digital sectors on a high-skilled, global workforce may be at odds with public sentiment, who at least in part want to curb immigration—it is undeniable that migration was a major factor in the decision to leave the EU.<sup>17</sup> That said, recent public polling indicates that these views are focused more on low-skilled migrants, whereas a substantial majority are favourable to increasing or at least maintaining current levels of high-skilled migrants.<sup>18</sup>

<sup>16</sup> House of Commons (2016)

<sup>17</sup> For more on public sentiment on immigration and Brexit, see Portes (2016)

<sup>18</sup> Katwala, et al (2016)

## Key takeaways

- The digital sectors employ 3 million workers, or 10 per cent of the UK total. The digital-producing industries account for one-third of those. An additional half-million workers are employed in digital-specialist occupations in industries outside of the digitally-intensive ones.
- Employment growth in the digital sectors averaged 1.8 per cent per year on a compounded basis between 2009-2014, versus 1 per cent for the entire UK economy as a whole.
- Workers in the digital sectors are high-skilled—accounting for 16 per cent of total employment compensation, compared with 10 per cent of employment. This difference reflects wages that are much higher than average across the entire UK economy.
- Foreign-born workers account for 18.4 per cent of employment in the digital sector today, compared with 15.8 per cent for the economy as a whole. About one-third of foreign-born workers in the digital sector are from EU countries.
- The contribution of foreign-born workers to net employment growth between 2009 and 2015 has been much greater—accounting for 45 per cent of digital sector net employment growth during this period. EU-born workers increased the most in relative terms, comprising 4 per cent of digital sector employment in 2009 but 17 per cent of the sector's growth through 2015. Non-EU foreign-born workers accounted for 10 per cent of digital sector employment in 2009, but contributed to 28 per cent of net employment growth through 2015.
- In terms of policy, Brexit places access to these workers at risk—the ability of digital technology companies to secure adequate talent under the existing Tier 2 visa scheme has come under pressure in recent years. As the analysis shows, firms in the digital sector have been increasingly looking to European talent to accommodate growth, and depending on the future arrangement with the EU, may fall into an already tightening general immigration pool.

## KEY ISSUE #3: FREE FLOW OF DATA

The UK has a digitised, information-driven, services-oriented economy that relies on free flow of data across borders. These cross-border data flows raise productivity and national income. Brexit potentially puts these flows at risk, creating a regulatory fragmentation of information and communication links between the UK and Europe—its largest trading partner for data flows.

### The economic value of cross-border data flows



About half of all trade in services is “digitally-enabled”—they have the potential to be delivered remotely via information and communication links.

Like international flows of goods, services, capital, and people, the flow of information and data helps power modern economies. Businesses depend on data flows to access markets, facilitate supply chains, and enable transactions around the globe.<sup>19</sup> This fact is especially true in an open, services-oriented economy like the UK—service industries account for 79 per cent of output and 43 per cent of trade exports across the country. For the digital sectors, those same figures are 96 per cent and 81 per cent. Economists

estimate that about half of all trade in services is “digitally-enabled”—they have the potential to be delivered remotely via information and communication links.<sup>20</sup>

But, measuring the economic value of cross-border data flows is challenging for a few reasons. The first is the nature of data flows, which are easy to witness but difficult to observe and measure in the statistical sense. Second, is the “pricing” of many data flows. Some are associated with transactions where money is changed hands and a market price is attached—such as digital platform services, online advertising, or data processing and hosting services. Others, such as data shared between or within businesses, or digital services that are transacted with end-users at a zero market price, fall outside of standard measurement mechanisms for market-based economic exchange. Looking at cross-border data flows within affiliated enterprises, one study found that UK firms are among the largest traders globally.<sup>21</sup>

## 3.8 % of GDP

McKinsey estimates that cross-border data flows accounted for 3.8% of global GDP in 2014.

<sup>19</sup> Nicholson and McHenry (2016)

<sup>20</sup> See UNCTAD (2009), Lee-Makiyama (2014), and Nicholson (2016)

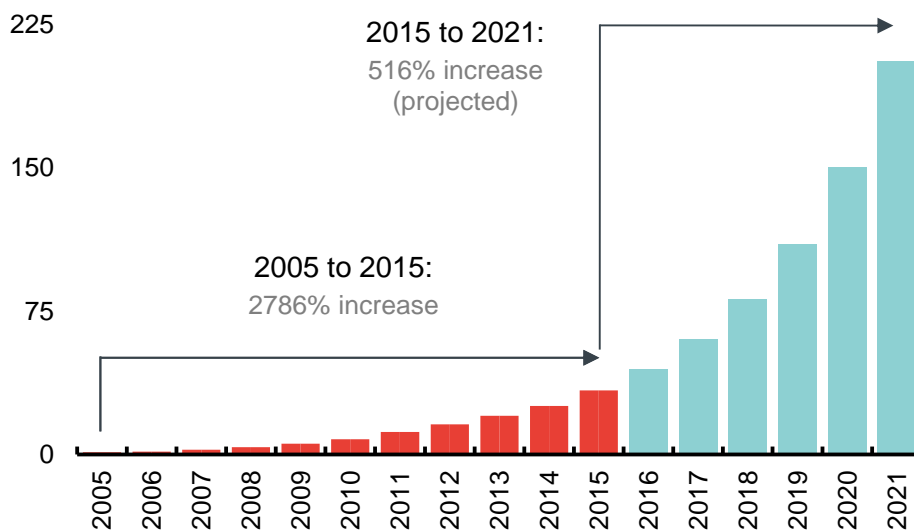
One way to get around these conceptual and measurement challenges is to estimate the indirect impact that data flows have on innovation and efficiency—or how data flows improve productivity. The McKinsey Global Institute recently took this approach, measuring the “spillover” benefits of cross-border data flows on GDP growth for 139 countries.<sup>22</sup> Their analysis estimated these benefits simultaneously with other international flows—of goods, services, people, and capital—and controlled for other confounding factors. Their main conclusion was that cross-border data flows accounted for a 3.8 per cent uplift of global GDP in 2014, and the primary channels through which this manifests is productivity improvement and increased capital and labour inputs. As a relatively services-oriented economy and a leading digital adopter (as noted in the same report), this figure likely represents a conservative, lower bound estimate for the impact of cross-border data flows on the UK economy.

These estimates are aligned with a U.S. government study that calculated a 3.4 to 4.8 per cent increase in GDP from “digital trade,” in addition to an increase in wages of 4.5 to 5.0 per cent, and the creation of 2.4 million jobs.<sup>23</sup>

## UK cross-border data flows

The UK is a leader in cross-border connectivity, accounting for 11.5 per cent of global cross-border data flows in 2015. By comparison, the UK accounted for 3.9 per cent of global GDP and 0.9 per cent of global population.<sup>24</sup>

**Figure 25. UK International Bandwidth in Terabytes per Second**



Source: Frontier analysis of Telegeography, Cisco and McKinsey data

Note: Figures are capacity, not actual flows; figures from 2016 to 2021 are forecasts

Figure 25 shows the growth in cross-border data flows for the United Kingdom from 2005 to 2015, with forecasted figures through 2021. Cross-border data flows

<sup>21</sup> van der Marel (2015)

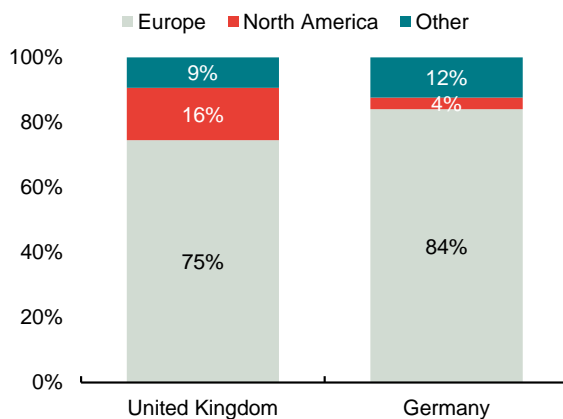
<sup>22</sup> Manyika, et al (2014)

<sup>23</sup> USITC (2014)

<sup>24</sup> Frontier analysis of Telegeography data and World Bank Open Data, <http://data.worldbank.org/>

between the UK and partner countries have achieved explosive growth in the last decade, and are now 28 times what they were in 2005. We forecast flows will continue to increase over the next have decade and will be a factor of 6 times in 2021 compared with what they were last year.

**Figure 26. Distribution of International Bandwidth by Country and Partner Region (2015-16)**



Source: Frontier analysis of Telegeography data

Note: Figures are International Bandwidth, which measure capacity for—not actual—data flows

As Figure 26 shows, 75 per cent of UK cross-border data flows are with EU partner countries. These flows are generally for information, communications, search, audio and video, transactions, inter- and intra-company traffic, and machine-to-machine links (smart connected devices and logistics), and are due to strong links between UK-EU households and consumers, but also businesses. It is not possible to disaggregate data flows among these groups with the information we have available. As stated before, 43 per cent of total UK exports are services-related, more than one-

third of these trade flows are with European partners, and the majority of trade in services is underpinned by cross-border data flows.

By comparison, 84 per cent of cross-border data flows for a European mainland country—Germany—are with EU partners. Much of this difference is made up through stronger links between the UK and North America (primarily the US).

## Data flows and Brexit

So clearly, cross-border data flows are increasing rapidly for the UK, are heavily linked with European countries, and are important in driving economic activity—particularly for an open, services-driven economy like the UK. But what does that mean with regard to Brexit? A few points are worth making briefly.

The biggest challenge is the upcoming implementation of the EU’s General Data Protection Regulation (GDPR)—a new personal privacy law that goes into effect in May 2018. The GDPR expands and unifies the protection of personal data on individuals within the EU, and restricts the flow of that data outside the EU. It has wide-reaching effects on individuals and businesses.<sup>25</sup>

Notably, the GDPR will require full implementation in the UK ahead of exiting the EU, as the regulation will apply in May 2018, almost certainly prior to the completion of Article 50 negotiations and the UK’s formal exit from the EU. Even if the UK were to maintain data protection regulations identical to GDPR—for purposes of continuity, EU market access, or other reasons—risks remain. Adoption still leaves open the question of the secure legal basis on which

<sup>25</sup> For a summary, see Allen & Overy (2016)

companies can transfer data in and out of the EU. GDPR adoption does not ensure “adequacy”, which can apply to third-countries and is decided by the European Commission.<sup>26</sup>

An “adequacy” decision determines that a third country offers an equivalent level of protection compared to provisions laid out in EU law, satisfies recent EU court case law and matches the expectations of the Article 29 Working Party’s templates for adequacy decisions. Any UK adequacy decision would be based on the Commission’s full review of the UK’s domestic data regime to determine how the UK’s data protection landscape matches the requirements of EU law.

An assessment of such issues is outside the scope of this analysis, but ensuring adequacy will be something the UK government will need to consider ahead of upcoming negotiations.



If we don’t get data passporting—so that effectively a UK data centre can only hold the information of UK nationals—this would be a really poor outcome for the UK, and a poor outcome for everyone else in Europe.

*techUK member*

Failure to secure adequacy may force the “localisation” or redirection of data flows on EU citizens (that requires storage and/or processing outside the UK), risking fragmented communications links and data flows between the UK and European partners. In addition, many UK businesses will need to implement costly alternative legal mechanisms, many of which are subject to ongoing legal challenge and uncertainty. Continued uncertainty over EU-UK data flows could also see companies restrict the amount and type of data processed in the UK. Such an outcome could impact data infrastructure and in particular data centres in the UK, which are among the region’s and the world’s most active.<sup>27</sup>

Data localisation may also have impacts on the UK economy; acting as a barrier to trade in data services that increases costs, and reduces investment, competition and innovation. According to one study, the economic impacts of data localisation on the EU as a whole would be a reduction in GDP of 0.4-1.1%, in private investment of 3.9-5.1%, and in services exports of 1%.<sup>28</sup>

<sup>26</sup> techUK (2017)

<sup>27</sup> CBRE (2016) and techUK (2016b)

<sup>28</sup> USITC (2014); Bauer (2014)

## DATA FLOWS AND EMERGING DIGITAL TECHNOLOGIES

One risk to impeded data flows is reduced innovation. Emerging digital technologies—cloud computing, advanced analytics, the internet of things and artificial intelligence—hold significant economic potential. They also require vast quantities of data—along with seamless links of distributed computing, high-speed communications, and mobile and autonomous digital equipment.

Frontier partnered with Accenture to estimate the impact of the internet of things and artificial intelligence (separately) on economic performance for a number of advanced and emerging countries, including the UK.<sup>29</sup> Our models project that IoT could raise GDP by as much as 2 per cent in the UK by 2030, and AI could raise annual GDP growth by as much as 50 per cent by 2035.

Our models adjust for the ability of countries to fully absorb the benefits of these technologies—accounting for stark differences between potential and realised economic benefits. Issues like free flowing data can accelerate—or deter—this technology-driven growth. Similarly, future trade agreements must recognise the digitisation of many goods become services, as smart, connected devices begin to blur the line between what is a good and what is a service.

### Key takeaways

- Data flows underpin a modern, services-oriented economy. It is estimated that about half of all trade in services are enabled by digital technologies and the related data flows. The quantification of the economic impact of cross-border data flows is in its nascence, though a recent McKinsey study estimates that cross-border data flows account for 3.8 per cent of global GDP. As a relatively services-oriented economy and leading digital adopter, this likely represents a conservative estimate for the UK.
- The UK is a leader in cross-border connectivity, accounting for 11.5 per cent of global cross-border data flows in 2015. By comparison, the UK accounted for 3.9 per cent of global GDP and 0.9 per cent of global population. Cross-border data flows for the UK increased 28 times between 2005 and 2015, and are expected to grow another 5 times through 2021. A full 75 per cent of the UK's cross-border data flows are with European Union countries.
- Brexit poses major risks in potentially disrupting the benefits of cross-border data flows, due primarily to new EU data protection regulations and the need for third-countries to demonstrate “adequate” compliance with those laws. The determination of third-country “adequacy” is less than clear, and would be the purview of the European Commission to make such a decision.

<sup>29</sup> Purdy and Davarzani (2015); Purdy and Daugherty (2016)

## CONCLUSION

The main finding from this analysis is that the digital sectors are vulnerable to disruptions on the supply-side and particularly the demand-side after Brexit. The areas of greatest risk include access to export markets in digital and digital-enabled services trade, access to skilled migrants, and unencumbered cross-border data flows with European partners. The extent of these effects will depend on negotiated arrangements with the EU, which remain unknown at this time.<sup>30</sup>

### Summary

The digitally-intensive industries cover a range of digital-producing (computer, information and communications hardware, software, and services) and digital-using (media, financial activities, advertising and marketing, consulting, and other professional services) activities. In terms of output, the sector is almost entirely services-based (96 per cent), constitutes £1 in every £6 in economic value creation across the entire UK economy, and plays an integral role to growth.

The digital sector also competes in international markets, plays an outsized role in entrepreneurship and high-growth firm generation, has a preponderance of both very small and very large firms, is reliant on foreign investment and global operations, and is geographically concentrated in high-skilled regions of the UK.

The digital sectors have strong linkages with Europe and the rest of the world on both the supply side and the demand side. In terms of inputs, the digital sectors predominantly rely on locally sourced services and imported digital equipment—both from the EU and the rest of the world. We are less immediately concerned about the impact of tariff and non-tariff measures for digital goods on the digital sector *overall* post-Brexit, primarily because of the weighting of digital goods in the sector and the low average tariffs on digital goods products under WTO rules.

Trade in services, on the other hand, are a much bigger risk. To begin with, the digital sectors are responsible for an outsized share of exports overall, and 81 per cent of digital sector exports are in services. Though we face data limitations to arrive at firmer numbers, it is safe to say that a sizable portion of digital sector exports in services—approximately one-third or more—is with European trading partners. This presents a significant challenge in upcoming negotiations, as EU services trade policy with third-countries is highly fragmented and complex.

The digital sectors are not just services-based and internationally open, but are also highly skilled—trading on knowledge capital. Taken as a whole, this requires digital sector businesses to compete on a global basis for talent. The foreign-born workforce constitutes 18 per cent of employment in the digital sectors today—but has contributed to 45 per cent of net job growth in the digital sectors over the last

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<sup>30</sup> For a more detailed discussion of policy priorities, see [www.techuk.org/Brexit](http://www.techuk.org/Brexit)



half decade. Within the foreign-born digital sector workforce, European workers account for one-third of employment, and an even larger share of its recent growth. A future relationship with the EU will factor heavily onto the performance of the digital sectors, which are increasingly reliant on foreign migrants to accommodate their growth—in particular those from the EU.

Underpinning the services economy and its links to international commerce is the free flow of data. Cross-border data flows have exploded in the UK in just a short time, and are expected to continue on an exponential growth path for some time. To no surprise, data flows with Europe are by far the largest among all cross border data flows involving the UK. Preserving a free flow of data with Europe will be essential for cross-border commerce in services and the emergence of new digital technologies, though Brexit places this at least partially at risk.

Overall, the British economy has strong ties to the EU economy—links that were by design under the deep integration that occurred during the last few decades, and from a natural geographic proximity. The UK's next five trading partners—United States, China, India, Canada, and Australia—combined are less than half of cross-border commerce that occurs between the UK and EU, and EU linkages are equally strong for labour migration and data flows.

## Policy implications

The future architecture of the relationship between the EU and the UK is as yet unclear. We can conceive of outcomes as lying on a spectrum between (i) an agreement that is close to the status quo, essentially preserving single market access and its principal pillars, including on movement of labour, and (ii) a “hard” exit in which the UK and the EU essentially revert to trading with each other on most favoured nation terms.

An intermediate outcome would require a bespoke arrangement between the UK and the EU. This appears to be the direction of travel favoured by the government, judging from the Prime Minister's speech on 17 January. Such a bespoke arrangement would be based on a free trade agreement that is comprehensive in its coverage of goods and services. It could replicate many existing elements of the current single market, depending on the depth of commitments undertaken by the negotiating parties. From the perspective of the digital sectors, the key question is what instruments would such a negotiated, bespoke arrangement need to contain to ensure that the economic contribution of these sectors to the UK is preserved, if not enhanced.

The instruments would need to address the potential for demand and supply side shocks that could affect the UK's digital sectors. A demand side shock would arise from a loss of market access, which in turn would reflect the possibility that the UK digital sectors could face regulatory and other non-tariff barriers. In principle, these could be addressed through a deep free trade agreement that contained specific provisions guaranteeing market access for UK-based entities. This would need to include participation in common regulatory frameworks—for example, the audio-visual and media services directive—that provide unrestricted access to EU markets. It would also need to include provisions on mutual recognition regarding data protection.

A free trade agreement could also be used as a vehicle to address supply side shocks, notably the question of access to skills. For this to happen, the agreement would need to have specific commitments on the movement of labour in relation to services and investment, where the commitments could be tailored to meet the requirements and sensitivities of specific sectors. The advantage of such an approach is that it could be differentiated from immigration policy more generally.

*Whether* such an agreement could be negotiated is not something on which it is possible to speculate within the confines of this report. It is worth noting, however, that for a future agreement to contain the elements discussed above, the EU and the UK would need to negotiate a trade agreement of a scope and depth that surpasses any agreement in place between the EU and non-EEA members at present.

## ANNEX A: METHODOLOGY

### Industry accounts and digital intensity

The main dataset used in this analysis is the Input-Output tables produced by the Office for National Statistics (ONS). In the first instance, these tables provide the primary inputs to our “digital intensity” analysis to identify the digitally-intensive industries—the intensity of intermediate and capital inputs from computer goods and services, information services, and telecommunications (the remaining two inputs to the digital intensity analysis are described below). To be identified as digitally-intensive, industries needed to have very high concentrations of digital inputs relative to total inputs—above the 85<sup>th</sup> or 90<sup>th</sup> percentile, depending on the measure—in at least two of the four measures (many were high in all four).

For consistency across various measures and because other sources of industry analysis don’t include key segments of the digitally-intensive industries (such as the Annual Business Survey), we utilise the ONS Input-Output tables as our main source of industry accounts data—including for output (turnover and revenue) and employment compensation by industry, and international trade (imports and exports of goods and services) by product. We also use Input-Output tables to assess the reliance of imports as inputs to production (supply chain) and of the importance of exports in final demand (market access). Figures are published in nominal Pounds and are available annually through 2014.

Data for the digital sectors are generally available at the level of two-digit industry and product codes, with a few exceptions. Film, television, and audio industries for production (59) and broadcasting (60) were available only in a single industry, which we dubbed “media.” Two industries—publishing activities (58) and repair of computers and personal and household goods (95)—required further refinement, as certain components fall outside of the digital sectors. Figures for the three-digit industries within these two-digit industries—software publishing (582) and repair of computers and communication equipment (951)—were estimated by applying within two-digit shares from other data sources (e.g. ABS, Trade in Goods).<sup>31</sup>

### Miscellaneous

#### Trade in goods and services by product and partner country

The Input-Output tables described above as our main dataset for industry accounts includes data on trade in goods and services by product category in nominal Pounds. However, these data don’t identify trading partners, which for the purposes of this analysis, fall into two categories: “EU” and “Non-EU”. To estimate the splits of EU and Non-EU imports and exports of goods and services for the digital sector, we rely on two datasets. First, for trade of goods by direction (imports or exports) and partner region (EU or Non-EU) we utilised the UK Trade in Goods CPA (Classification of Product by Activity) series. For these data, the

<sup>31</sup> Because of the limitation of data for software publishing, it was not used as a “digital producing” industry for the purposes of the digital intensity analysis.

product codes match with the product codes used in our main industry accounts series. Secondly, for services trade, we relied on the OECD Balance of Payments, Trade in Services by Partner Country statistics. As noted before, the product codes are not available at the level of granularity used throughout the rest of the report, and are therefore, less precise estimations.

## Employment

The main dataset for labour market analysis (employment) is the ONS Labour Force Survey between 2009 and 2015. We utilised micro-level data to construct various aggregates of employment of the civilian population between ages 16 and 64 by industry, occupation, and country of birth. Annual figures are constructed as four-quarter averages for each calendar year.

Aside from the “digitally-intensive” industries listed above at the 2-digit and 3-digit industry code level, we also estimate employment in “digital occupations” outside of these industries. The DCMS lists 11 such occupations at the level of 4-digit occupation codes (SOC)—those occupations were used here.<sup>32</sup> These roles don’t capture the degree of digital engagement, but rather, are a list of roles that are primarily involved with producing digital goods and services—irrespective of the industry of employment.

Finally, these “digital occupations” were used as one of the four measures to identify the digitally-intensive industries. Namely, the “digital occupation” share of industry employment was used. This measure identifies the intensity of primary-digital occupations in an industry.

## Digital intensity of occupations

In previous work, Frontier collaborated with Accenture and the OECD to assess the “digital intensity” (values between 0% and 100%) for each occupation in the economy (at the level of 3-digit ISCO, the international standard occupation code scheme). Using the cross-country Survey of Adult Skills (PIAAC) from the OECD and the Occupational Information Network (O\*NET) from the US Department of Labor on workplace task content, we assessed the degree (relative frequency) workers used digital tools (interacting with computing equipment, send/receive email, Internet search, use of word processors and spreadsheets, use computer programming language, and engage in real-time discussions digitally) on average for a given occupation in a particular country. Figures used in this analysis map OECD-derived digital intensity of occupations with employment by industry and occupation (LFS) to estimate the “digital intensity of task content” for industries.<sup>33</sup>

## Trade-weighted tariffs

To calculate trade-weighted tariffs—the ratio of total tariff revenue to total value of imports for digital goods products—we utilised data from the United Nations and World Bank. The ISIC 4 hierarchy is consistent with the SIC codes used in input-output tables. In the ISIC 4 hierarchy we flag the relevant digital industries.

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<sup>32</sup> See, DCMS (2016) at Table 6.

<sup>33</sup> See, Spiezia (2015).

We then map these to HS12 product codes using the following two concordances: ISIC4-CPC2.1, and then CPC2.1-HS12. This gives a list of the corresponding digital products in the HS12 hierarchy. We can then pull in import and export volumes at HS12 level from Comtrade (United Nations), together with the corresponding EU MFN tariff data from the World Integrated Trade Solution database (WITS) (World Bank). This allows weighted average tariffs to be calculated at different levels of aggregation (2-, 4-, and 6-digit levels). We also looked for estimates of non-tariff measures in the Kee non-tariff measures dataset (World Bank). Across EU countries there were no non-zero non-tariff measures in any of the 2-digit product codes in which digital goods appear.

### Data flows

Data for cross-border data flows for the UK and Germany was provided by Telegeography. The plotted figures are for international bandwidth, which represent data flow capacity, between partner countries. For forecasts, we utilised data from Cisco's Visual Networking Index (VNI) and from McKinsey (2016), to estimate figures for the UK through 2021.

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