The impact of digital transformation on the UK economy

A Cebr report for Virgin Media Business

February 2021

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London, February 2021

Foreword

Throughout history, hard times have been a catalyst for innovation.

Last year was no exception.

Through technology, we reshaped our working lives and overcame barriers that previously seemed insurmountable. We transformed the way we work, how we connect, and how we keep the country moving.

But what is the long-term impact of the innovation we've seen? How could it add up across the whole of our economy? And how could similar digital change projects help to drive our national rebound and future recovery?

We partnered with the Centre for Economics and Business Research (Cebr) to find out.

This report, commissioned by Virgin Media Business, indicates that continued investment in digital change projects could boost the UK economy by £232 billion by 2040.

For context, that's an impact similar in magnitude to the current GDP of countries such as South Africa, or Finland.

These benefits will be felt across the entire economy. We also asked Cebr to look in-detail at how Covid-accelerated adoption of digital transformation would impact six specific areas - health, local government and defence, specialised and digital retail, professional services, education, and construction.

The report validates on a national scale what our private and public sector customers have repeatedly told us over the past year; bringing forward digital investment looks set to generate significant benefits.

I'd like to thank Cebr for producing such a comprehensive and enlightening piece of research. We can all learn from the conclusions and take them forward.

Now is the time for the UK's rebound. The opportunity to improve the lives of people across the UK.

This is the moment to make the right decisions and take action, so that we can achieve this necessary uplift to our economy and set ourselves up for success in the years to come.

With the right change, the right technology and the right investment in people, we have the chance to not simply recover, but to make things even better than before.

Together let's grasp this once-in-a-generation moment and revolutionise the everyday.

Peter Kelly, Managing Director, Virgin Media Business

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Executive Summary

The Covid-19 challenges facing the UK and the entire world are extremely serious. The economic impacts alone fall far short of capturing scale of the pandemic's toll on people's lives and wellbeing.

History does, however, show us that recessions and periods of economic hardship can help to catalyse technological progress and adoption, as businesses and other stakeholders are forced to adapt to new realities.

Within this research we have examined the potential economic impact of a wave of digital transformation, driven by the rollout of new ways of working and interfacing. Such transformation could create an economic high road over the coming decades, helping the UK economy to grow while also having the flexibility to deal with future challenges.

Covid-19 led to an unprecedented shift in the use of digital technologies across the world. The ability to rapidly scale and deploy many of these digital solutions amid a global pandemic suggests that rapid digital transformation contains the 'low hanging fruit' needed for above trend economic growth over the long term.

2020 has seen advances in a multitude of fields from mRNA vaccines,[1] to the mass uptake of remote working solutions, and machine learning solving the hard problem of protein folding.[2] Achievements such as these have led to economists and business leaders such as Peter Thiel describing 2020 as the start of a new period of economic dynamism, [3] [4] while the Economist newspaper predicts a 'roaring 20s' decade ahead.[5] Although digital innovation was ever present in the 2010s and UK productivity remained stubbornly subdued; 2020 could mark an end in that trend.

Faster growth in the 2020s and 30s will be driven by the rapid adoption of digital technologies.

Increased adoption of key digital technologies due to the pandemic could lead to a period of Covid-accelerated Digital Transformation (CADT). **Boosted investment and fast adoption of CADT technologies over the coming decades is set to increase UK GDP by £232bn[6] or 6.9% by 2040**.

Due to the considerable ongoing uncertainties with regard to the short-run dynamics of the UK economic recovery, the focus of analysis is on longer-term outcomes. In light of this, annual forecasts for the immediate period 2021-2025 are not presented.

1 Anthony Komaroff (2020), 'Why are mRNA vaccines so exciting?'

2 The AlphaFold Team, DeepMind (2020), 'AlphaFold: a solution to a 50-year-old grand challenge in biology.'

3 Forbes (2020) 'Peter Thiel Says Covid Marks 21st Century's True Start. SPAC Boom, Surging EV Stocks Are A Sign.'

4 Noah Smith (2020) 'Techno-optimism for the 2020s'

5 The Economist (2020), 'The new era of innovation – Why a dawn of technological optimism is breaking'

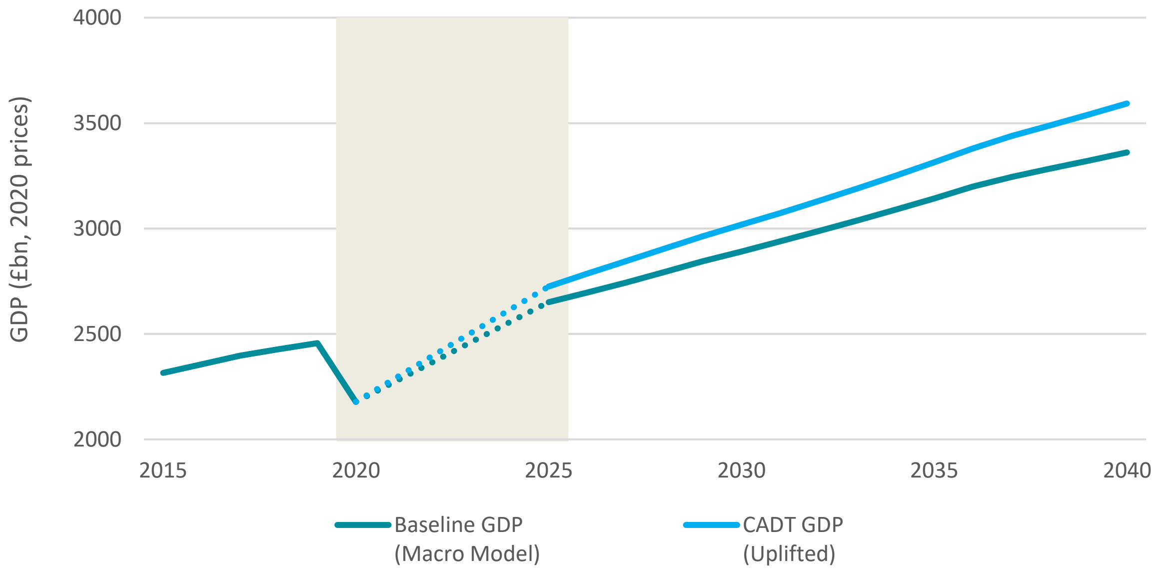
6 All figures are presented in 2020 prices.

Under current assumptions and estimations,[7] **by 2025 digital transformation will have increased GDP by £74bn,** above the baseline scenario. These benefits are driven by three key transformations in the world of work:

- Flexible working;
- Digital delivery of services; and
- The creation larger and richer training sets for machine learning.

Identified via an extensive review of the literature and assessment of data on rapid changes in consumer an employee behaviour, these constitute the core driving forces of CADT. The potential and current spread of these transformations across sectors in the UK economy was further explored in a series of five workshops with industry experts and insiders.

Figure 1: UK GDP, 2015-2040.



Source: Cebr analysis

Figure 1 illustrates the forecasted GDP, both for the baseline scenario and Covid-accelerated Digital Transformation scenario from 2020-2040. It also shows the pre-COVID GDP period from 2015-2020. This provides a point of reference against which the expected boost can be contextualised.

Continued digital transformation will require ongoing investment in physical and digital infrastructure. The viability of remote work was facilitated by recent investments in high-speed broadband networks driven to meet the consumer needs of our society. Continued investment in connectivity will be needed to meet the professional demands of a flexible workforce. Increased investment in **collaboration technologies** will allow flexible work to become the new normal in many industries. As more and more services move to a digital first

7 As of January 2021.

environment, **agile networks** and **smarter enterprises** will be needed to improve quality of service whilst reacting quickly to changing demands.

Specific analysis has been undertaken on the impact of digital transformation in six particular sectors of the economy. The three "in scope" private economy sectors are: Professional Services, Retail and Construction; and three "in scope" public economy sectors are: Education, Health and Central & Local Government and Blue Light Services.[8]

Across the three "in scope" private sectors of professional services, retail and construction, a total of £40bn of additional GVA will be realised in 2040. The importance of the interaction between worker productivity and technological transformation drives the larger impacts in retail and professional services, as digital technologies enable more efficient work.

Table 1: Private Sector GVA Uplift.

(2020 prices)	Digital Transformation Uplift			
Private Sector	2030		2040	
Professional Services	£8bn	3.2%	£16bn	4.8%
Retail	£11bn	3.6%	£21bn	6.2%
Construction	£2bn	1.3%	£3bn	1.8%

Source: Cebr analysis

One third of economywide tech enabled growth will be supported by public sector investment in the specific sub-sets analysed. Investment forms an important part of CADT. As governments and businesses pledge to 'build back better', investing in the technologies, skills, and infrastructure suited to a more digital world will lead to increased productivity and output throughout the 2020s and 2030s. **Public sector investment (across the sectors below) enabled by CADT could increase economywide GDP by 2.3% in 2040.**

Table 2: Public Sector CADT Investment Impacts.

(2020 prices, gain as % of GDP)	Economywide gains attributable to Public Sector investment			
Public Sector	2030		2040	
Education	£7bn	0.2%	£10bn	0.3%
Health	£22bn	0.7%	£33bn	1.0%
Central & Local Government and Blue Light Services	£14bn	0.4%	£32bn	1.0%

Source: Cebr analysis

8 Per the scope of the research, we have specifically considered three sub-sets of the private sector, and three-subsets of the public sector. The activity of these sub-sets should not be seen as the complete extent of activity across the private and public sectors of the economy, respectively. The activity of the six "in scope" sectors has been considered as part of a specific scenario that was modelled for the purpose of the research at hand.

1. Introduction

The Centre for Economics and Business (Cebr) is pleased to present this report to Virgin Media Business in which we estimate the impact of Covid-accelerated adoption of digital transformation across six specific industries in the UK[9]:

- Construction;
- Professional services;
- Specialised and digital retail;
- Health;
- Education; and
- Local government and defence.

This report provides a review of the methods and analysis undertaken to estimate the potential impact in GDP terms for the UK, as well as for the aforementioned "in scope" industries. We also describe the impact and role of digital transformation for employees, companies and organisations, technology and on the economy and local communities.

The outputs of the research are contextualised in terms of the difference relative to a standard baseline – a counterfactual scenario – which does not assume the same degree of accelerated digital transformation. As such, we produce a cumulative economic (GDP) delta over a 20-year time horizon, which can also be seen as the cost of not adopting accelerated digital transformation throughout the economy. Findings are considered in light of other technological waves that have taken place over the last century, such as the tech boom following the global financial crisis and the microcomputer revolution after the stagflation crisis of the early 80s.

In order to conduct the research, Cebr undertook an in-depth literature review in the first instance, from which modelling assumptions could be determined and findings could be contextualised. The assumptions were further validated and verified through a series of semi-structured panel workshops with industry practitioners, as well as with Virgin Media Business, to determine how representative they were of the current landscape of sector-specific technological adoption. These assumptions, together with in-house Cebr data, could then reasonably be used as inputs to the model that was developed in order to derive the estimations.

This report sets out the approach that was taken and provides an overview of findings for each of the sectors. An in-depth analysis of each of the sectors – including the supporting literature and panel evidence will be provided in a series of sector-specific vertical reports. Each of the sector-specific reports will also feature a number of illustrative case studies, created by Virgin Media Business, that set out real world examples of how digital transformation is being rolled out by organisations and individuals across the UK in response to Covid-19. Findings from the

9 We carried out specific analysis on three sub-sets of the private sector, and three-subsets of the public sector. The activity of these sub-sets should not be considered as the complete extent of activity across the private and public sectors of the economy, respectively. The activity of the six "in scope" sectors has been considered as part of a specific scenario that was modelled for the purpose of this research. For completeness, a 'seventh' residual sector of the economy was also estimated. A detailed analysis of this extra sector did not form part of the research scope.

case studies were also used in the analysis to determine the sector-specific impacts that are discussed in this report and in the vertical reports.

This report is structured as follows:

Section 2 sets out background information pertaining to previous digital transformations and their associated impact on the UK economy; **Section 3** provides an overview of the literature that informed the analysis; **Section 4** provides a detailed review of the methodology that was used to undertake this research; **Section 5** sets out a summary of the results which is further expanded upon in the sector-specific vertical reports; and **Section 6** concludes this report.

2. Background

On 23rd March 2020, Boris Johnson announced a 'stay at home' strategy, in order to help slow the spread of Covid-19.[10] Leaving home was permitted only for very limited purposes, including for basic shopping necessities, in response to medical needs and travelling to and from work – but only where absolutely necessary. In other words, if it was possible to work from home, the UK population was asked to do so. This, together with the necessary adaptations that organisations and businesses would be required to make in order to survive the pandemic, would bring about a new and increased dependency on technology.

It has been said that 'the company of the future' seems to have been fast forwarded by the crisis. Productivity gains will be unleashed by the rapid adoption of flexible working, through utilising different tools and technologies to support more efficient working, and through the ability to collaborate and come together in remote ways that remove restrictive barriers such as travel time. The speed at which companies have adopted new technologies and business practices has increased, and some industries have referenced Covid-19 as being the driving force behind the escalation of strategies that might otherwise have taken a number of years to rollout – as opposed to weeks.

Flexible and remote work has further entrenched the use of digital systems throughout the entire workday. More at work interactions and services are being mediated by computer systems. These interactions will form more complete datasets of our work, enabling artificial intelligence systems to be trained. The subsequent insights and solutions generated by the application of artificial intelligence may generate a productivity boom in service functions similar to the productivity gains seen in the further mechanisation and automation of manufacture.

In view of this, and in light of the innovations that have been brought about as a result of the situation presented in 2020, it is necessary to consider previous technological waves – and the events that led to them – with a view to identifying their respective economic impacts. This will enable suggestions about how Covid-accelerated technological adoption might also impact the economy, particularly with respect to indicators such as GDP.

The following section presents an overview of the four industrial revolutions that have brought about technological innovations of importance, against which the findings of this research – and of those arising from Covid-19 more broadly – can be contextualised. Thereafter, the relationship between crises and technological booms is considered.

2.1. The industrial revolutions

There have been four key pivotal developments in the last 250 years that have revolutionised the modern world; the first industrial revolution of the late 18th century, the technological revolution of the late 19th century, Industry 3.0 of the 1950s and 60s and now, Industry 4.0.

Each of these produced new forms of technology that rapidly altered the arrangement of economies and catalysed newer, efficient production methods as well as entirely new industries.

The first industrial revolution catalysed the shifting of economies from agriculture to industry through machine manufacturing. This revolution began in the late 18th century following the

10 Gov.uk. (2020) 'Prime Minister's statement on coronavirus (COVID-19) 23 March 2020'.

invention of the steam engine, allowing for mechanised production lines and development of the rail roads,[11] increasing the connectivity of economies. This shift to industrial production had some significant impacts on those experiencing it. Individuals now had access to a wider, more affordable range of goods, medicine was evolving at a rapid pace, and their overall wealth and wellbeing was improving.[12]

The second industrial revolution, also known as the technological revolution, occurred in the latter part of the 19th century and early 20th. This revolution occurred primarily out of the discovery of electricity, gas and oil, creating sources of energy to drive the economy and the first forms of telecommunications, such as the telephone and telegraph.[13] This revolution furthered mass migration towards cities and a significant increase in the production. This is also the period that saw the invention of the automobile and the assembly line of production.[14]

The third industrial revolution, Industry 3.0, occurred in the 1950s and 60s. This is the period during which electronics, telecommunications and early computers truly entered economies and created entirely new industries, such as biotechnology and robotics.[15] Industry 3.0 was marked by the emergence of automation, allowing for even greater efficiencies and production capabilities. This form of machine automation relied on integrated computer circuits and man-machine interaction to function properly.[16]

One of the key differences between Industry 3.0 and Industry 4.0 is the automation of machines. Industry 4.0 is characterised as truly autonomous machinery and robots, whereby machinery and robots will be able interact with one another and have a greater range of learning capabilities.[17]

For many there is a debate around whether Industry 4.0 is an industrial revolution in its own right, or rather a continuation and development of 3.0.[18] However, the technological advancements since the 50s and 60s and the continuing rate of digitalisation of economies indicates it has grounds to be thought of independently.

Development of smart devices is one of the traits of this newest technological revolution, devices that can interact with us, collect, store and send data. These devices alone have surged in the past two decades; in 2006 it is estimated there were 2 billion smart devices across the globe. By the end of 2020, it is forecast that there will be 200 billion – an increase of 9,900% in 14 years.[19]

Industry 4.0 is expected to be characterised by nine key technological trends over the coming years, some of which are already well integrated in economies:

11 Institute of Entrepreneurship Development. (2019). 'The 4 Industrial Revolutions'.

12 Encyclopaedia Britannica. 'The Rise of the Machines: Pros and Cons of the Industrial Revolution'.

13 Institute of Entrepreneurship Development. (2019). 'The 4 Industrial Revolutions'.

14 History. 'Ford's assembly line starts rolling'

15 Institute of Entrepreneurship Development. (2019). 'The 4 Industrial Revolutions'.

16 Adeyeri. M. (2018). 'From Industry 3.0 to Industry 4.0: Smart Predictive Maintenance System as Platform for Leveraging'.

17 Boston Consulting Group. 'Embracing Industry 4.0 and Rediscovering Growth'.

18 Institute of Entrepreneurship Development. (2019). 'The 4 Industrial Revolutions'.

19 Forbes. (2018). 'How Much Data Do We Create Every Day? The Mind-Blowing Stats Everyone Should Read'.

- Autonomous robots;
- Simulation;
- Horizontal and vertical system integration;
- The industrial Internet of Things;
- Cybersecurity;
- Use of the Cloud;
- Additive manufacturing (3D Printing);
- Augmented reality; and
- The use of Big Data, AI and analytics.[20]

These developments will lead to even greater efficiencies and production capabilities in economies that adopt them.

2.2. The relationship between crises and technological booms

Although it may appear counterintuitive, there is a relationship between economic crises and major technological advancements. The second industrial revolution occurred in the latter part of the 19th century, coinciding with the Long Depression, a period of economic turmoil catalysed by a crash in the financial markets of Vienna and the American Civil War.[21]

Similarly, the Historian Alexander Field states that the 1930s was the most technological progressive decade of the 20th century.[22] Again, the 1930s were a period of serve economic hardship globally as a result of the Great Depression; industrial production in the US fell 47%, and real GDP 30%.[23]

Economic downturns are associated with a general reduction in investment in economies, however. Figure 2, overleaf, highlights the quarters of recession in the UK and the Gross Fixed Capital Formation in the economy (effective investment). This relationship is particularly clear in the 1980-81 recession, 1991 recession and the 2008 Global Financial Crisis.

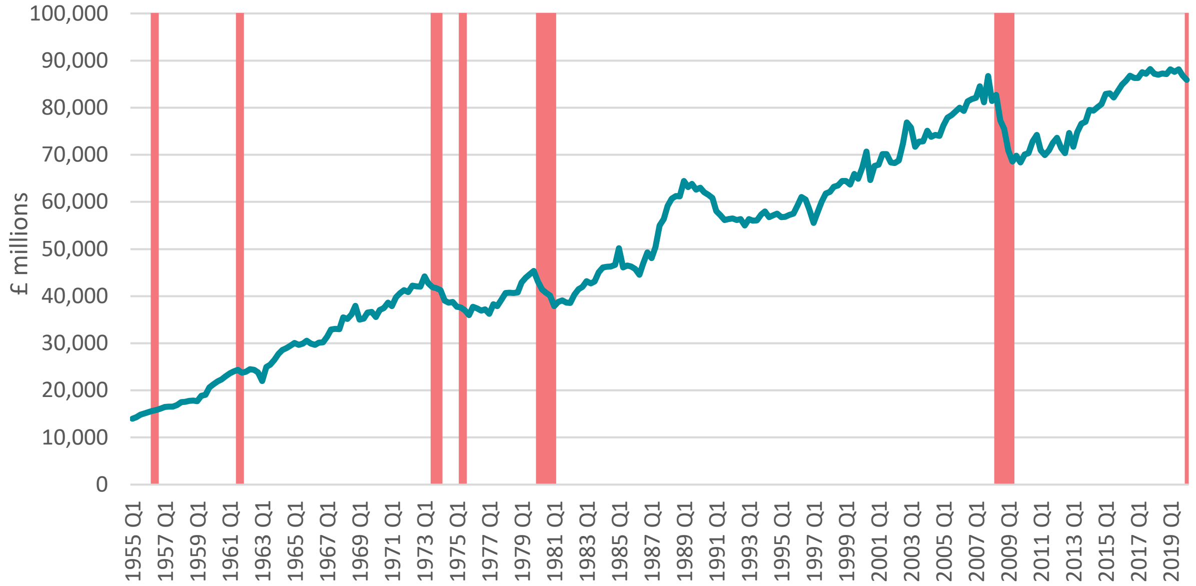
20 Boston Consulting Group. 'Embracing Industry 4.0 and Rediscovering Growth'.

21 History Today. (2012). 'The Long Depression'.

22 Florida. R. (2009). 'Innovation and Economic Crises.'

23 Business Insider. (2020). 'The main causes of the Great Depression, and how the road to recovery transformed the US economy'.

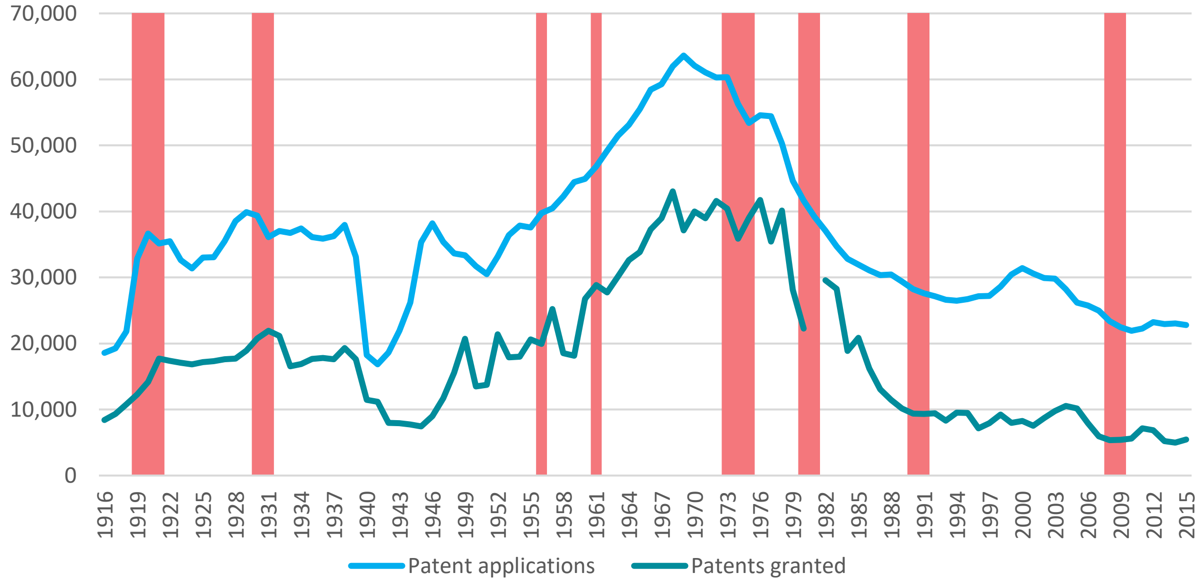
Figure 2: UK Gross Fixed Capital Formation (Seasonally Adjusted) and quarters in recession, Q1 1955 – Q1 2020



Source: ONS and Cebr analysis

What is somewhat surprising is that although there exists a relationship between recessions and investment, there is a less clear relationship between recessions and patent applications and patent grants. This is highlighted in Figure 3 below.

Figure 3: Patent applications in the UK and years in recession, 1916 - 2015



Source: UK Government Intellectual Property Office and Cebr analysis

This implies that innovations must be occurring throughout the business cycle and are influenced by other external factors rather than just recessions. What this means though, is that in times of recession and a downturn in investment, the patent applications are competing for fewer investment resources.[24] Given this increased competition, the patents that achieve funding from investors may be of higher quality during economic crises as funds are limited. This is the phenomenon that was seen during the Great Depression.[25] As such, the higher quality patents and investments in them lead to a technological boom during economic crises that arises due to increased competition for resources.

A second possibility – and one that might be particularly relevant in the context of this piece of research – as to why technological booms often follow economic shocks is the idea of creative destruction. Florida. R. summarises the idea as follows:

"Innovations developed during crises generate the gales of creative destruction that launch new technologies, remake existing industries, and give birth to entirely new ones – setting in motion new rounds of economic growth".[26]

The idea is that during times of economic prosperity, many large businesses dominate and innovate along established technological trajectories. This continuous development helps prevent new entrances into the market, maintaining their profits.[27]

However, it is this process of maintenance as opposed to true innovation that may explain the lack of tech booms during times of economic prosperity. During economic turmoil, new firms are provided with an opportunity to challenge established industries and technological fields through innovations.[28]

In a New York Times article, Amar Bhide, Professor at Columbia Business School, states:

"The deck gets reshuffled in a recession as habits are re-examined and patterns of behaviour are broken, perhaps to greater degree than when things are humming along at a steady state. And that's what creates business opportunities."[29]

To highlight this relationship, Figure 4, overleaf illustrates UK GDP, with economic downturns and recessions above the line, and notable technological advancements below. Although anecdotal, it usefully highlights that some of the world's most ground-breaking inventions to date occurred in the wake of economic turmoil:

- The first microcomputer was invented during the 1970s OPEC and stagflation crises;
- The first form of a global internet was developed in 1981[30] and Microsoft Windows operating system in 1985, both of which occurred during the period of Deflationary Monetarism; and

24 Jaffe. E. (2020). 'How an economic crisis impacts innovation: lessons from the Great Depression'.

25 Ibid.

26 Florida. R. (2009). 'Innovation and Economic Crises.'

27 Archibugi. D., Filippetti. A., & Frenz. M. (2013). 'Economic Crisis and Innovation: Is Destruction Prevailing over Accumulation?'

28 Ibid.

29 The New York Times. (2009). 'Why Bad Times Nurture New Inventions'.

30 OFTEL (2003), 'Events in British Telecomms History'.

- Smartphones and mobile 4G service accelerated development during the 2010s following the Financial Crash.

It would be oversimplifying to state that technological innovations only occur during times of crisis, as the figure below shows, many major inventions occurred during prosperous times:

- 1967 saw the first colour TV broadcast in the UK;
- Men first walked on the moon in 1969; and
- The Human Genome Project began in 1998.

However, there does seem to exist a strong correlation between revolutionary technology and digitalisation and economic crises.

That being said, in the wake of Industry 4.0, the current economic crisis as a result of Covid-19 may see some significant technological and digital transformations occurring in the following years, providing substantial gains in productivity and output to advanced economies. This may be particularly beneficial to the UK, where in recent years it has been in a productivity slump and productivity growth has been slower than other western economies.[31]

Due to the lockdown procedures necessary to combat the spread of the disease, many companies (that were able to) shifted operations to remote working – working from home. This shift in working patterns created a demand for virtual working technologies, such as telecommunications, virtual networks and a general increase in usage of the internet. In December 2020, Virgin Media indicated record-breaking demand for data, with uploads increasing by 64% and with people downloading an additional 2.8Gb of data per day.[32]

Teleconferencing has become a common occurrence for many individuals during the lockdown period and has resulted in a significant increase in value for companies offering the service, such as Zoom whose revenues for its first fiscal quarter more than doubled to $328m, turning a profit of $27m compared to the previous year's £198,000.[33]

It is, therefore, possible that this economic crisis will produce disruptive technologies and change working patterns permanently for many. A survey conducted by Deloitte found that 74% of respondents would like to work from home more frequently in the future, with 52% saying that they would like the majority or more of their working week to be based at home.[34]

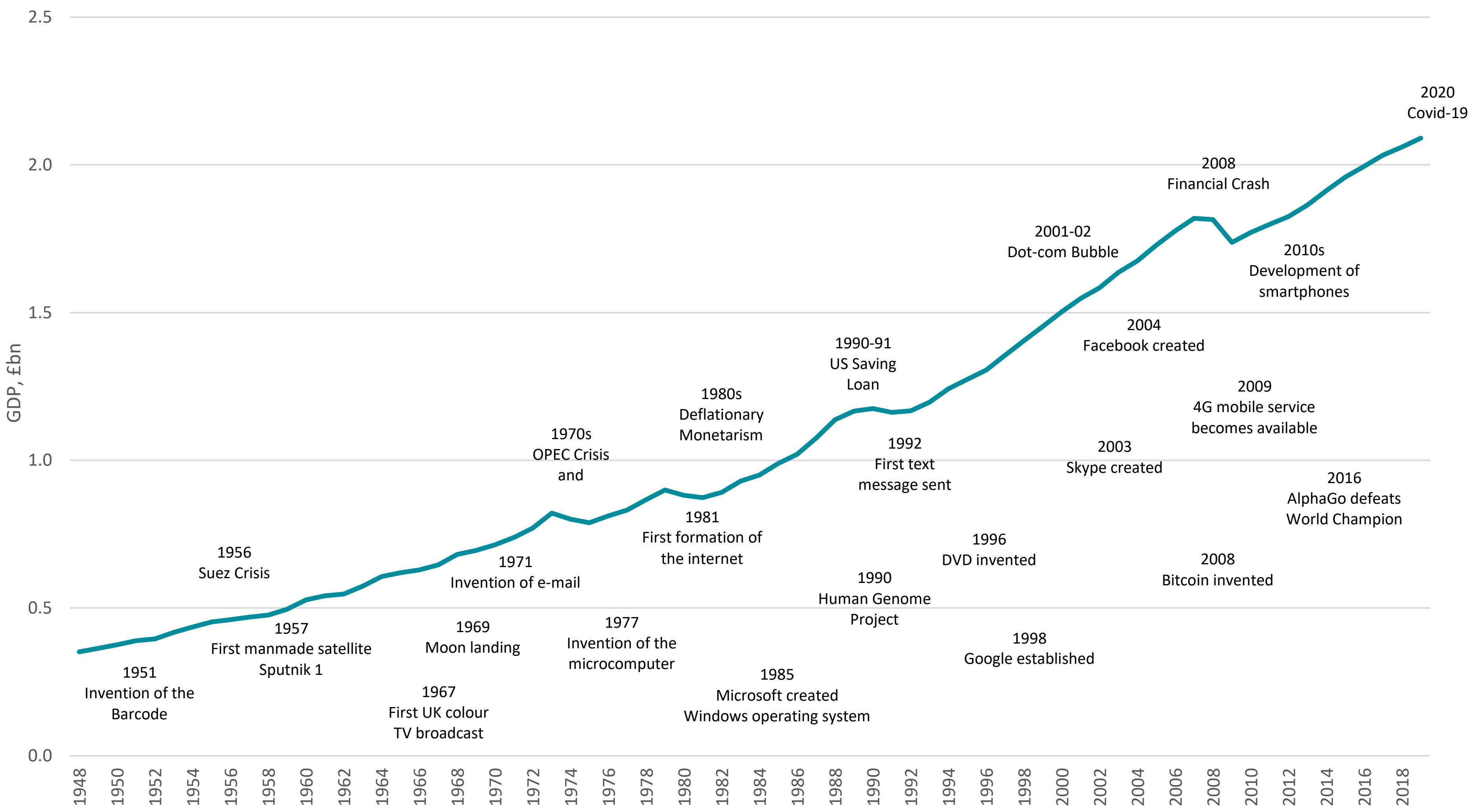
31 Financial Times. (2018). '[Britain's productivity crisis in eight charts](#)'.

32 Virgin Media (2020). '[Virgin Media reveals a record-breaking 2020 as data use surges](#)'.

33 The Guardian. (2020). '[Zoom booms as teleconferencing company profits from coronavirus crisis](#)'.

34 CityAM. (2020). '[Twice as many young people want permeant flexible working post-Covid](#)'.

Figure 4: UK GDP, recessions, economic shocks and notable technological advancements, 1948 - 2019



Source: ONS and Cebr analysis

3. Summary of literature

In order to undertake the analysis, it was first necessary to conduct an in-depth literature review of each industry. This enabled sector-specific assumptions to be made which were then further verified through panel interviews and workshops with industry practitioners. These assumptions were used as modelling inputs in support of estimating the impact of accelerated digital transformation on each of the UK sectors of interest.

This section provides a summary of some of the key pieces of literature that supported the assumptions necessary for the model. The comprehensive and sector-specific literature review for each of the afore – and below – mentioned industries can be found in the respective verticals reports. This is intended to be a summary for reference and context.

Sectoral literature reviews were undertaken to survey the extent of digital transformation throughout the economy to identify the key technologies and transformations that will define Covid-accelerated Digital Transformation. A subsequent review of the impacts of flexible work, increased digital delivery of services, and machine learning was then undertaken.

The literature presented in this section fed into a series of five workshops with industry experts and insiders to inform estimates of the current and future uptake and impact of technological transformation.

3.1. Private sector

Construction

Table 3 below summarises some of the quantitative findings on digitalisation and technology's impact in the construction sector.

Table 3: Quantitative impacts of technology and digitalisation within Construction

Author	Title	Impact	Other key points
Avontus. (2019)	New Scaffolding Robot and the Acceleration of Digital Transformation in Construction	**Use of drones:** • Reduction in time taken to measure the volume of stockpiles at a quarry from two days to 10 minutes **Use of robots**: • SAM10 (semi-automated mason): can lay 2,000 bricks per day, up from 400 bricks per day (as laid by average mason) – 400% increase in productivity • Kewazo scaffolding robot: improves on-site scaffolding assembly by delivering components and materials to workers; reduces labour costs by 33% and increases construction speed by 43%	Since 1945, productivity in manufacturing, retail and agriculture has grown by 1500%, but it has barely increased in construction; using drones for business services has an addressable market, estimated at $127bn, of which $45bn is for construction projects Robotics for construction: reduces scaffolding safety issues on dangerous sites
McKinsey. (2019)	Decoding digital transformation in construction	• Productivity gains of 14% - 15%; • Cost reduction of 4% - 6% **Case studies:**	Review of various engineering and construction (E&C) company experiences; issues preventing full transformation in the construction

		• Mobile app for real-time feedback: 12% reduction in rework hours at the jobs site; • Advanced Analytics: improvement in project margins of 3% - 5%	sector include: - Fragmentation of projects - Lack of replication - Transience - Decentralisation
Roland Berger. (2016)	Digitization in the construction industry	**Hadrian**: a robot for 3D construction plans; the building is constructed in 48 hours rather than 'several weeks' • Reduces construction time by up to 70%; • Reduces manual labour by 80%; • Saving of up to 60% on materials.	The robot is fed with construction plans, in accordance with which it trims, processes and lays each brick

Source: As stated

Professional services

Table 4 below summarises some of the quantitative findings on digitalisation and technology's impact in the professional services sector.

Table 4: Quantitative impacts of technology and digitalisation within Professional Services

Author	Title	Impact	Other key points
Clio. (2019)	How Cloud Computing is Making Low Firms More Efficient and Profitable	On average, cloud computing cuts cost by 30%	Cloud computing enables mobility through syncing data between devices. According to the American Bar Association, 79% of lawyer's telecommute and spend around 25% of their time working outside their offices
Sprout IT. (2019)	Legal cloud technology - how it aids efficiency and productivity	Using a hybrid cloud model cut IT costs by 24%	Hybrid cloud is a cloud computing environment that uses a mix of on-premise servers, private cloud and third-party cloud services
Accountancy Age. (2019)	Technology tools that will drive efficiency for accountants	Automating repetitive tasks could mean 30% of people's time could be freed for other tasks	Estimates that up to 80% of rule-based processes and repetitive tasks could be automated, creating more efficient outputs. Worker's times could be utilised in human activities such as client relations and advertising

Source: As stated

Retail

Table 5 below summarises some of the quantitative findings on digitalisation and technology's impact in the retail services sector.

Table 5: Quantitative impacts of technology and digitalisation within Specialised and Digital Retail

Author	Title	Impact	Other key points
Dunelm. (2020)	Interim Results - Financial Year 2020	33% increase in like for like online sales (only 2% instore) profits increase 20% (but there were also investments in brand awareness at the same time as digital transformation, TV advertising etc)	New cloud native digital platform launched on AWS. 2x mobile speed Better online checkout experience click and collect and mixed channel delivery
ONS. (2020)	Retail sales data	May-June online sales exceeded previous online sale peak (December 2019, £2.07bn per week) April-June sales far higher than expected given the overall trend June's average weekly online sales £2.35bn was a 65% increase over the same time last year	
Hildebrand and Bergner. (2019)	AI-Driven Sales Automation: Using Chatbots to Boost Sales	Chatbots increased willingness to upsell on rental cars from 29% for the standard website to 55% with a personalised chatbot (90% increase)	Chatbots help create a more personalised relationship with the brand, increasing trust and creating upselling opportunities. Personalised chatbots that mirrored consumer characteristics such as gender and having a similar sounding name were particularly effective.

Source: As stated

3.2. Public sector

Health

Table 6 below summarises the quantitative findings from the literature review on digitalisation and technology's impact in the health sector.

Table 6: Quantitative impacts of technology and digitalisation within Health

Author	Title	Impact	Other key points
Matheson. C. (2016)	Implementation of WebGP and E-consultations in Wessex GP practices	• The average length of time to deal with e-consultation was 6 minutes compared to 11.7 for face-to-face: representing a 48.7% gain in efficiency	E-consultations accounted for just 0.87% of all appointments in the first 8 months of use, saving 113 face-to-face appointments and produced an estimated cost saving of £2,147 from saved GP appointments (£19 per appointment)
Bejnordi. B., Veta. M., & Diest. P. (2017).	Diagnostic Assessment of Deep Learning Algorithms for Detection of Lymph Node Metastases in Women with Breast Cancer	• AI was more effective at detection than medical professionals: effectiveness of 0.994 compared to 0.884 – 12.4% more efficient	Misdiagnosing illnesses and medical error account for 10% of all US deaths. The study compared 32 algorithms against 11 pathologists - 7 showed greater efficiency

John Hopkins Medicine (2016)	The John Hopkins Hospital Launches Capacity Command Centre to Enhance Hospital Operations	• 60% improvement in the ability to accept patients with complex medical conditions from other hospitals; • In the emergency department, patients are assigned a bed 30% faster after a decision is made to admit them; • Patients are also transferred 26% faster after they are assigned a bed; • Transfer delays from operating rooms after procedure have been reduced 70%; • 21% more patients are discharged before noon, compared to previous year.	New AI software that better manages patient safety, experience, volume and movement in and out of the hospital. The new centre is giving front-line managers real-time information about their hospital to make the most informed decisions for patient care
NHS Digital (2020)	Coronavirus pandemic prompts a surge in the number of people using NHS tech in 2020	• 257% increase in the use of NHS 111 online. • A tenfold increase in the number of users of the NHS App. • There has been a 25% increase in the use of the Electronic Prescription Service over 2020	There has been a large increase in the usage of NHS Digital Services to access healthcare remotely over 2020. "We're fully expecting the numbers using NHS tech to continue rising in 2021," NHS Digital's Executive Director for Product Development.

Source: As stated

Education

Table 7 below summarises the quantitative findings from the literature review on digitalisation and technology's impact in the education sector.

Table 7: Quantitative impacts of technology and digitalisation within Education

Author	Title	Impact	Other key points
Department for Education. (2019)	Realising the potential of technology in education	• EdTech Challenges to be delivered by 2021, through use of technology: ○ Improve parental engagement and communication, whilst cutting related teacher workload by up to five hours per term: representing an efficiency gain of 1%; ○ Reduce teacher time spent preparing, marking and analysing in-class assessments and homework by two hours per week or more: efficiency gain of 5.3%; ○ Reduce teacher time spent on essay marking for mock GCSE exams by at least 20%.	Key driver for increased use of technology across educational institutions is reduced workload to enable increased student engagement; the biggest barrier to adopting digital technologies is teacher willingness

		Case study impact (UK Institution): savings of 50% on on-premises hardware by moving to the cloud	
Taylor, E. S. (2018)	New Technology and Teacher Productivity	• Computer-aided instruction (CAI) software reduces the variance of teacher productivity by 25% (in mathematics classes); ○ Increase in the share of individual student class time from 38% to 73% (in mathematics classes); ○ Reduction in the share of time for whole-class activities from 61% to 30% (mathematics and reading classes); ○ Reduction in (mathematics) teachers' hours worked by 23.4%; ○ Reduction in lesson planning and grading time by one third.	**CAI** - provides individualized tutoring and practice to students one-on-one with the computer acting as the teacher Measured using student test score gains; reduction comes from improvements for otherwise low-performing teachers and also losses among high-performers
Higher Education Policy Institute (2017)	Rebooting learning for the digital age: What next for technology enhanced higher education?	**Curriculum redesign:** • Technology-enhanced learning through curriculum redesign can achieve savings of 31% • Blended learning can reduce the costs of classes by 15% **Learning analytics**: can reduce university non-retention rates: • Columbus State University (US): retention rose by 4.2% (5.7% for low-income students); • Open University (UK): pilots have shown a 2.1% increase in retention; • University of New England (Australia): drop-out rates fell in pilot schemes from 18% to 12%.	**Curriculum redesign:** Savings achieved whilst simultaneously improving student outcomes in 72% of projects - EdTechnology.co.uk (2020) defines 'blended learning' as: a teaching style that allows students to learn using a combination of technology and online educational exercises or materials to assist in the classroom, whilst having a 'traditional' hands-on and in-person lesson. **Learning Analytics**: correlates patterns of student activity with learning outcomes; enables teachers to identify disengaged and underachieving students;

Source: As stated

Local and Central Government and Blue Light services

Table 8 below summarises the quantitative findings relating to Blue Light Services and Local Government digitalisation.

Table 8: Quantitative impacts of technology and digitalisation within Local and Central Government and Blue Light Services

Author	Title	Impact	Other key points
TechUK. (2016)	Digital Policing: The Future of Modern Crime Prevention	• Police time spent on low-level crime could be reduced by 25% through adoption of range of	Low-level crime costs the UK £130m per year; potential saving of £32.5m per year through adoption of technology. CPS

		technologies (based on case studies); • The CPS estimates that if evidence such as CCTV can be provided earlier in an investigation, 11% additional cases would have an early guilty plea	estimates that a guilty plea costs £60 and not guilty plea £400
IT Pro. (2020)	How coronavirus has accelerated the digital transformation of Britain's public sector	• Swindon Borough Council achieved a 98.3% efficiency gain in processing free school meal applications through robotic process automation (RPA).	Free school meal applications spiked 2000% at the outset of coronavirus which sparked the digital work behind the scenes. The RPA managed to reduce a 583-hour monthly task to 9.6 hours
Local Government. (2014)	Transforming local public services using technology and digital tools and approaches	• Lewisham enabled residents to report issues online, reducing activity in call centres by 33%, saving £500,000 over past 5 years (2009-2014); • London Borough of Dagenham achieved a 100% digital shift for benefits claims, reducing processing time by 30 days and saving £617,000 annually	The report highlights 50 local authorities have used digital technological innovations to improve outcomes for citizens and improve financial savings.
Policy Connect	Crime Prevention through Artificial Intelligence	• Burglaries were reduced by 33% and violent crime by 21%	Pilot of using AI to predict crime in LA. The software used previous data to predict and identify hotspot areas where crime was probable to occur, defined within a 500 square foot area. Police would pre-emptively deploy, deterring crime from occurring
Ministry of Justice. (2010)	Virtual Court Pilot Outcome evaluation	• Average number of cases seen per day was greater in the pilot than in the control at 2.33 vs 2.19 - 6.4% increase in efficiency.	Pilot ran 12 months in two magistrates' courts in London and North Kent. Although more efficient in cases seen per day, the virtual cases were, on net, more costly due to higher set up costs and legal aid costs (this was a 2010 study and virtual technology has been developed significantly since, so this may not be the case currently).
TechUK & Ministry of Justice. (2020)	Evaluation of digital technology in prisons	• Introduction of self-service kiosks in prisons resulted in: ○ An 82% decrease in time taken collating prisoner applications (5,461 min/week); ○ 64% decrease in time taking menu orders (271 min/week);	The self-service kiosks provided basic tools to prisoners so they could manually process their own forms as opposed to staff collecting and returning which was labour intensive.

		○ 89% decrease in time taking canteen orders (634 min/week); and ○ 76% decrease in time distributing notices (76 min/notice).	

Source: As stated

3.3. Flexible working

The benefits of flexible and remote working are varied. They range from increased productivity of workers, to reduced sick leave and a more efficient labour market where the potential pool of candidates is increased. Prior to the pandemic, the proportion of remote workers in the UK was approximately 5% across all industries. However, during the week that the national lockdown was announced, this figure rose to 47.5%. Whilst remote working has since dropped (to approximately 27.4% in early September 2020 – during a period of lessened restrictions), this still represents a substantial rise above the historic typical levels. [35]

Flexible working has been enabled by a multitude of technologies. These include:

- Video Conferencing;
- Collaboration tools;
- Cloud Computing;
- Virtualization;
- VOIP and Cloud Voice; and
- Flexible Network Architecture.

Whilst the initial model adopted during lockdown for many office workers was one of working from home five days a week, the benefits of flexible working do not require a full departure from worker co-location. Many of the benefits can be expected to be realised with a mixed solution, such as working three days per week from home, or allowing employees to choose which days they come into the office.

Table 9: Summary of quantitative literature in flexible work.

Author(s)	Title	Details and Results
Bloom, Liang, Roberts and Ying (2013)	Does Working from Home Work? Evidence from a Chinese Experiment	Experiment in a Shanghai call centre with an average commute of 80 minutes. 131 people in treatment group. 118 in control group. At end of experiment half of the treatment group remained WFH. Loneliness and lower rates of promotion were cited as reasons to return to office. A large proportion performed relatively poorly at home, as such the performance gains of the home workers almost doubled after the experiment (from 13% to 22% due to "learning and reselection"). Two thirds of the control group remained in the office, even though all of them opted to be in the experiment.

35 ONS (2020), Business Impact of COVID-19 Survey (BICS)

Mas and Pallais (2017)	Valuing Alternative Work Arrangements	Experimental evidence from job advertisement for a large and significant preference for the ability to work from home.

Source: As stated

In their 2013 paper on a randomized trial of working from home in a Chinese call centre, Bloom et al. identify a 13% increase in efficiency for home workers.[36] Much of this benefit is due to a 9% increase in time worked due to employees taking fewer breaks and sick days. Additionally, the benefit rose to 22% after a period of "learning and reselection" after the initial experiment had finished and employees could freely choose if they wanted to work from home or not. There was also a halving of attrition in those who worked from home and a saving of $1,250 per employee in reduced office costs over the year-long experiment. Although home workers performed better than their in-office counterparts, they were promoted at a much lower rate, likely due to being less visible to office-based managers. The lower rate of promotion is likely to be minimized in the post-Covid flexible work environment as many managers will also work from home and managing remote employees becomes the norm.

In order to measure the direct economic impacts of flexible working on the UK economy and sectors, a focus has been put on the efficiency gains experienced by those working from home rather than the wider economic benefits such as decreased costs associated with physical offices, such as rents and higher wages.

During the five workshops with members of a representative selection of UK industries, panellists were largely in agreement that there would be at least some lasting shift to working from home, citing evidence of companies not renewing office rentals, reducing total floorspace, investing in employees home working environments and supporting employee relocation away from high cost commuter areas.

3.4. Digital delivery of services

Whilst there has been a sharp rise in the use of online shopping over the course of the pandemic, there has also been a switch to digital customer experiences throughout the wider economy. Although the virtual delivery of services such as primary healthcare and courts had been either widely available[37] or successfully piloted[38] prior to 2020, Covid-19 has rapidly accelerated the transformation to digital delivery.

Digital delivery of services not only allows for services to be delivered more conveniently for the consumer, but critically it also allows efficiencies and economies of scale seen in the tech sector to be applied to a wider segment of the economy. Examples of digital delivery of services could include:

36 Bloom, Liang, Roberts, and Ying. (2013). 'Does Working from Home Work? Evidence from a Chinese Experiment'.

37 Prospect. (2020). 'The inside story of Babylon Health'.

38 Ministry of Justice. (2010). 'Virtual Court pilot Outcome evaluation'.

- Video consultations with lawyers and other professional service professionals;
- Virtual courts;
- Full integration of computer aided instruction in classrooms and lectures; and
- Video consultations with medical and social care professionals.

Table 10: Summary of productivity benefits arising from digital delivery of services

Author(s)	Title	Details and Results
Local Government. (2014)	Transforming local public services using technology and digital tools and approaches	Lewisham enabled residents to report issues online, reducing activity in call centres by 33%, saving £500,000 over past 5 years (2009-2014). London Borough of Dagenham achieved a 100% digital shift for benefits claims, reducing processing time by 30 days and saving £617,000 annually
Ministry of Justice. (2010)	Virtual Court Pilot Outcome evaluation	Average number of cases seen per day was greater in the pilot than in the control at 2.33 vs 2.19 - 6.4% increase in efficiency.
TechUK & Ministry of Justice. (2020)	Evaluation of digital technology in prisons	Introduction of self-service kiosks in prisons resulted in: an 82% decrease in time taken collating prisoner applications (5,461 min/week), 64% decrease in time taking menu orders (271 min/week), 89% decrease in time taking canteen orders (634 min/week) and 76% decrease in time distributing notices (76 min/notice)

Source: As stated

3.5. Machine Learning

The increased mediation of interactions by online devices will generate large amounts of usable data. We have already seen a limited application of machine learning across both public and private sectors. Applications of machine learning to real world problems have typically been limited by two things: computer power and access to good datasets with which one can train and test machine learning systems. The increase in computing power and switch to GPUs rather than traditional CPUs has provided large advances with respect to the first limiting factor. Machine Learning (ML) systems are still restricted to certain data rich problems and are still limited in their application by the necessity of an interface between computer and world.

Increased use of telecommunications and a further reinforcing of digital devices in all aspects of work reduces the distance between computers and people, and therefore makes it easier for ML systems to interface with, learn from and assist humans. Machine learning systems have delivered insights and performance comparable to expert level humans in tasks. For instance, DeepMind's AlphaStar has bested top-10 ranked professional players in StarCraft II, a strategically rich real-time strategy game. The greater and more intensive use of computers in the post-Covid workplace, may allow ML systems to learn from and work with humans in the world of work much as they already do in computer games.

Current applications of machine learning are growing, as readily available large datasets come online. OpenAI recently trained a neural network on a vast dataset of text-image pairs, creating a tool that can generate realistic images based on descriptions, such as *'a loft bedroom with a white bed next to a nightstand. there is a fish tank standing beside the bed.'*[39] Cloud computing has provided a powerful, large and scalable environment for continued application of machine learning.[40] Flexible networks and computer infrastructure such as those found in modern cloud computing environments have allowed companies to rapidly shift business models and work practices. These powerful and flexible networks will continue to host and enable intelligent enterprise solutions, from machine learning to the collection and mining of real time data.

Automation in computers and IT looks set to transform the world of thought just as the spinning jenny transformed manual labour in the Lancashire textiles industry. This can be seen in two 2019 case studies by the UK Government's Government Digital Service and Office for Artificial Intelligence. In both cases, artificial intelligence systems were successfully deployed in order to save large amounts of time on repetitive computer tasks, in the areas of public sector website development and in security and regulatory compliance in financial services.[41,42]

Artificial Intelligence solutions were already predicted by some to be set to disrupt legal services, from speedier evidence discovery processes, to accurate predictions of court case outcomes and automatically generated draft contracts.[43] ML and AI systems will continue to be applied to repetitive tasks, such as those in finance, administration and law.

Table 11: Literature on applications of machine learning solutions.

Author(s)	Title	Details and Results
Government Digital Service and Office for Artificial Intelligence (2019)	Case Study: How GDS used machine learning to make GOV.UK more accessible	Work expected to take multiple years, was completed in 6 months due to application of machine learning. This suggests a 300% increase in speed of repetitive tasks. GDS designed a taxonomy in which to sort webpages and information on the GOV.UK website. Manually tagging each page took a large amount of time as. Approximately 100,000 pages needed to be tagged in order to be sorted into the taxonomological structure.
Government Digital Service and Office for Artificial Intelligence (2019)	Case Study: How a UK-based bank used AI to increase operational efficiency	Reduced duration of compliance by 80% whilst allowing for greater accuracy and standards as 100% of cases can be reviewed instead of a sample and a close to 100% accuracy rate was achieved. Reviewing the sales of financial products for regulatory compliance. Sample of 10-15% of cases are required to be checked, over 10 data sources and 180 data points have to be checked with an audit taking about 4 hours and frequent backlogs and delays to service due to compliance. An artificial intelligence solution was

39 OpenAI. (2021). 'DALL·E: Creating Images from Text'.

40 DeepMind. (2018). 'Predicting eye disease with Moorfields Eye Hospital'.

41 Gov.uk. (2019). 'How GDS used machine learning to make GOV.UK more accessible'.

42 Gov.uk. (2019), 'How a UK-based bank used AI to increase operational efficiency'.

43 The Lawyer Portal. (2017). 'The Artificial Intelligence Law: Is AI Taking Over?'.

		implemented which allows for 100% of the cases to be checked and a closer to real-time processing.
Senior, Jumper, Hassabis and Kohli (2020)	AlphaFold: Using AI for Scientific Discovery	Systems such as AlphaFold have the potential to speed up drug discovery and the development of new medicines. Importantly it serves as a proof of concept of the ability of machine learning systems to 'integrate diverse sources of information to help scientists come up with creative solutions to complex problems at speed.'
Accountancy Age. (2019)	Technology tools that will drive efficiency for accountants.	Automating repetitive tasks could mean 30% of people's time could be freed for other tasks. Estimates that up to 80% of rule-based processes and repetitive tasks could be automated, creating more efficient outputs. Worker's times could be utilised in human activities such as client relations and advertising.

Source: As stated

3.6. Investment

A portion of increased output due to CADT related productivity gains is assumed to be channelled into increased investment.

In an analysis of the role of public and private sector investment in GDP growth in OECD countries, Afonso and St. Aubyn (2018) find that private sector investment is always associated with an increase in GDP. Whilst public sector output is occasionally associated with negative growth, the negative figures are close to zero. The average impact across the entire sample of 17 OECD countries of an additional 1% in private sector investment is a 0.256% increase in output. Whilst the impact of an additional 1% of public sector investment on output was estimated at 0.019%. The closeness of the public investment estimates to zero suggests that the model has identified little, or no effect associated with public sector investment. Similarly, Bassani and Scarpetta (2001) find small negative effect of public sector R&D investment on economic growth, whilst similar private sector investments are associated with an increase in growth.

A failure to identify an impact of public sector investment in the literature is due to a mix of factors. Firstly, public sector investment may not be in productive areas of research. They may be focused in industries such as defence and provide little wider economic benefit, whilst crowding-out growth-enhancing private sector investment. In the case of investments such as R&D, government investment may be focused on more fundamental advancements in knowledge, with large positive spillovers but a long delay until it has a material impact on output. The estimation techniques are unlikely to be able to capture the impact of such long-run investment outcomes. Public sector investment is naturally associated with larger public sector expenditure, which is often associated with lower rates of GDP growth.

In the case of CADT, the increased investment is funded thanks to cost savings associated with increased technological adoption and innovation. As such, there is no negative pressure on GDP growth associated with higher government expenditure. Along with the failure to identify benefits associated with a longer time horizon, the estimates of near zero impact of government investment are not implemented in the model. Instead, we conservatively halve the private sector long run growth relationship, when applying the elasticity to public sector investment.

Table 12: Literature review of the impacts of public and private investment on GDP

Author(s)	Title	Details and Results
Afonso & St. Aubyn (2018)	Economic growth, public, and private investment returns in 17 OECD economies	17 OECD economies assessed with data from 1960 to 2014. Mean private investment output elasticity is 0.256. Mean public investment output elasticity is 0.027.
Bassani & Scarpetta (2001)	The driving forces of economic growth: panel data for the OECD countries	OECD economies assessed with data from 1971 to 1998. Output elasticity of capital is estimated with estimates from 0.14 to 0.39 dependent on the regression specification.
Zou (2006)	Empirical studies on the relationship between public and private investment and GDP growth	Estimates of the impact of public and private investment on growth in Japan and the USA from 1958 and 1997. Increases in both public and private investment are found to *Granger-cause* GDP growth in the USA and Japan.

Source: As stated

4. Methodology

This section outlines the research methodology providing details on each stage of the modelling approach.

As noted in the introduction, the methodology is centred on producing a cumulative economic delta between a baseline scenario, in which there is no accelerated adoption of digital transformation initiatives, and a scenario in which there is. The delta will be presented in GDP terms for the 2020-2040 time horizon and can be examined at any point along that time frame. The impacts will be disaggregated for each sector of interest, and for the UK economy as a whole.

In order to estimate the cumulative economic delta, a number of modelling inputs were required, each with their own method of derivation. Together, these inputs would act as uplifts to the baseline scenario, to depict a situation in which the accelerated uptake of digital transformation is reflected in GDP. The necessary inputs included the following:

- A composite coefficient to capture the productivity impacts associated with the adoption of various forms of technology, namely technologies and tools in support of:
    - Flexible working;
    - Network agility;
    - Collaboration; and
    - Intelligent enterprise.

  For the purpose of this research, the composite coefficient is referred to as the **'Covid-accelerated Digital Transformation' (CADT)** technology uplift coefficient. Before being applied to the baseline, the coefficient is scaled to reflect the proportion of the workforce to whom it applies;

- An estimation of the rate of accelerated technological adoption, derived using the Bass Diffusion Model and calculated using the adoption patterns of similar previous technological adoptions over time; and

- A rate of Private Sector and Public Sector investment for the purpose of developing a transmission channel through which the productivity gains associated with technological adoption can be reinvested back into the economy, and subsequently bring about an additional layer of economic value.

Each of the above elements were estimated using evidence from the literature review, together with information from the panel workshops and the customer case studies.

4.1. Panel workshops and customer case studies

Five panel workshops were undertaken during August, September, and December 2020, involving a number of industry experts across the in scope sectors, as well as a sample of professionals from additional sectors of the economy for context.

The purpose of workshops was to validate the assumptions arising from the literature review in support of the model inputs listed above. The discussions also provided supplementary and supporting insight allowing the results of the model to be contextualised.

The methods of estimation and associated outcomes for each of the aforementioned model inputs are presented in the following three sections, after which the mechanism of the model will be explained for the Private Sector and Public Sector, respectively.

4.2. Covid-accelerated Digital Transformation (CADT)

In the first instance, it was necessary to derive a coefficient that would capture the benefits associated with digital transformation in a post Covid-19 scenario. The findings from the literature review and panel workshops were particularly important in providing evidence for this composite value.

The immediate impact of Covid-19 on digital transformation has been seen with large increases in consumers using online shopping, digital tools enabling tens of millions to work from home and increased digital delivery of services.

Due to the nature of Covid-19 restrictions, digital transformation has been characterised by the replacement of in person interactions with digitally enabled interactions, and the replacement of the physical with the digital. The solutions adopted during and immediately before the Covid-19 lockdown are seen to enable three key transformations, encompassing the technologies that Virgin Media Business directly and/or indirectly helps to deliver. These are:

- Flexible working;
- Digital delivery of services; and
- The creation larger and richer training sets for machine learning.

Each of these transformations has brought about productivity benefits, the estimation of which is detailed in the following sub-sections, and a summary of which is given in Table 13**.**

Flexible Working

With the long term transition to flexible arrangements allows for the process of "learning and reselection", the benefits of working from home are assumed to be higher than the baseline 13% and treating the 22% in Bloom et al as an upper bound, we settled upon a midpoint of **17% as a reasonable estimate of the increase in worker productivity that flexible working and working from home could deliver over the longer term** (see Table 13).

Digital Delivery of Services

A summary of the productivity benefits brought about by through digital delivery of services is given in Table 9. **Taken together, we estimate the productivity benefits of digital delivery of services to be in the region of 28%** (see Table 13).

Machine Learning

Based on evidence in the literature, we estimate **a productivity gain in the region of 90% for tasks that can be enabled by machine learning** (see Table 13). However, it must be noted that the proportion of the workforce to whom this estimate applies is currently quite small, and further, it would not account for all of the tasks undertaken by that proportion of the workforce, and would therefore require further scaling. These scaling factors are reviewed in the following sub-section.

Application of CADT to the workforce

Before each of the productive gains could be used in the CADT composite, it was necessary to determine the proportion of the workforce to whom they each apply, and to scale each benefit accordingly to arrive at a final impact. This estimate would subsequently be apportioned using the wage share for each of the sectors of interest.

In order to scale each benefit, we adopt a method similar to that proposed in Dingel and Neimann (2020)[44], together with data from the O*NET database Work Context Questionnaire and Generalized Work Activities Questionnaire.

As O*NET data is from the US, job categories had to be converted from US Standard Occupational Classification (SOC)'s to UK SOCs with an intermediary step of mapping UK and US SOCs to the international ISCO job classifications.

Matching the resulting 4-digit SOCs with ONS data on annual pay and number of jobs, we find that:

- 46% of jobs can be worked from home, representing 57% of wages;
- 26% of jobs are likely to be highly impacted by the digital delivery of services, representing 31% of all wages; and
- 5% of jobs are likely to be impacted by increased implementation of machine learning, representing 6% of wages.

In all three cases the share of wages is higher than the share of jobs, suggesting that CADT is likely to have a higher impact on higher paid lines of work. This is in line with the common conception that higher paid and 'white collar' professionals have been able to take advantage of digital technologies to remain relatively safe at work during the Coronavirus pandemic, whilst lower paid workers have not been able to shield themselves as effectively from disease in the workplace.

Summary of CADT coefficient inputs

Table 13 sets out a summary of the productivity gains and associated scaling factors that were used in the estimation of the CADT coefficient which is given as 11.9%.

As previously noted, this value was subsequently apportioned using the respective GVA to compensation ratios for each industry before it was multiplied by the cumulative adoption rate (discussed in the following section) and applied as an uplift to the GDP baseline. It can be thought of as an **anchor input**, to which further adjustments were made during the analysis.

Table 13: Summary of CADT coefficient inputs

	Productivity gain	Scalar	Final impact
Flexible working	17.0%	28.7%	4.9%
Digital Delivery of Services	28.0%	15.3%	4.3%
Machine Learnable tasks	90.0%	3.0%	2.7%
		CADT Productivity Input:	11.9%

Source: Cebr analysis

44 Dingel, J and B Neiman (2020), "How Many Jobs Can be Done at Home?".

4.3. Technological Adoption Curves

In addition to estimating the productivity uplift composite (the CADT), it was necessary to estimate the increased adoption of digital technologies over and above the baseline, against which the CADT coefficient could be applied. The following sections outline the steps that were taken to achieve this.

Technological adoption curves have been used to scale the impacts of the CADT over time, and between sectors in the economy. Where levels of adoption are higher than the baseline adoption curve, increases in productivity associated with increased adoption of these technologies are realised.

Baseline Scenario

To estimate the impact of accelerated adoption of transformative technologies brought about by Covid-19, we need a baseline scenario to act as a counterfactual in relation to which results are presented.

Cebr produces regular forecasts of key economic indicators for the UK national and regional economies. One such forecast is the UK macroeconomic model, which is disaggregated by sector. The model takes into account a variety of considerations, including continued technological transformation and long run dynamics. The December 2020 macroeconomic, therefore, serves as our baseline scenario, against which the additional GDP – brought about by accelerated technological adoption – is applied, to yield an uplifted GDP estimate for each year.

Previous Technological Adoption

A diffusion model was chosen to model the adoption curve of technologies. These models typically output an 'S-curve' of adoption, where adoption is initially slow whilst the technology is relatively new and unknow. The rate of adoption then speeds up as the technology is widespread before eventually slowing down as the market is saturated. As with many econometric models, output is minimally impacted by model specification. [45] As such a Bass model is used for simplicity.[46]

Considering this, it was necessary to examine the adoption patterns of previous transformative technologies from which it would be possible to estimate a baseline rate, implicit in the GDP macro model. Subsequently, it would be possible to determine accelerated adoption rate curves based on the evidence presented in the literature and panel workshops.

While a significant body of data and literature exists on the adoption of domestic technologies, it was important to consider technologies that are relevant in the professional and corporate context being explored in this research. In view of this, and given the data constraints, four transformative technologies were selected as suitably representative. These were:

- Adoption of Agile;[47]

45 For instance, with binary regression models, whilst logit and probit models more accurately reflect the economic decision, a simple linear probability model performs similarly well in most scenarios.

46 Bass, F. M. (1969). 'A New Product Growth for Model Consumer Durables'.

47 Source: Stackoverflow, HP, Cebr analysis

- Adoption of spreadsheets; [48]
- Cloud computing market; and
- The number of smartphone users worldwide.

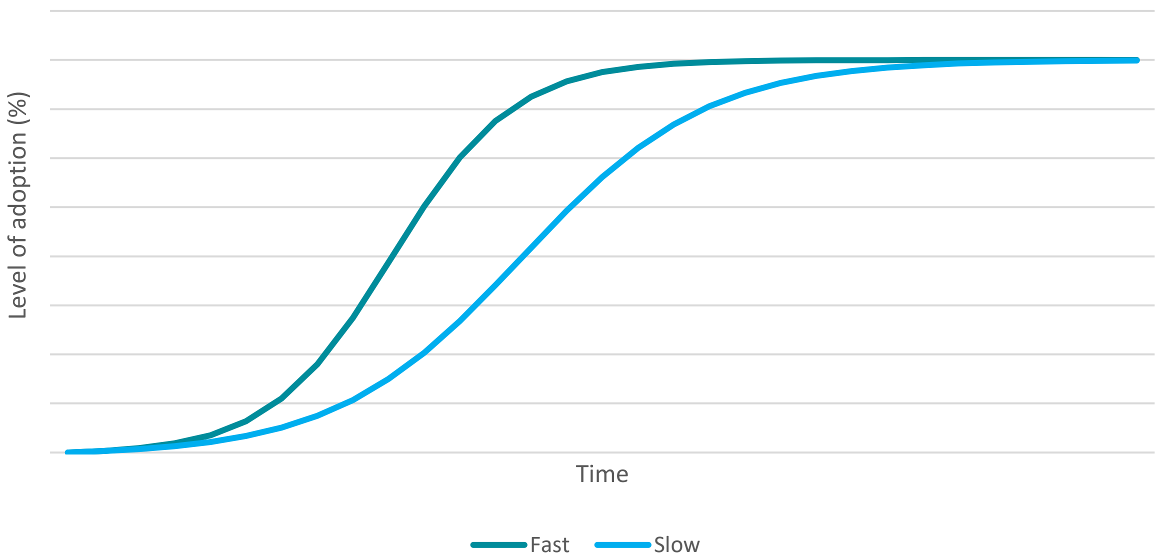
Each of the above technologies has been transformative in the business environment to date. In particular, Cloud Computing was referenced as an important enabler for further digital transformation during the panel workshops.

Available time series data for each of the technologies was examined, revealing the characteristic S-shaped curve of adoption that one would expect. This data was then used to estimates the coefficients associated with a Bass Diffusion model. The average values of coefficients were used to estimates a generalised technological adoption curve.

Covid-accelerated Technological Adoption

Figure 5 presents two adoption curves. The shallower curve assumes a slower rate of technology adoption implicit in the baseline scenario. This represents the counterfactual, in which there is no Covid-accelerated adoption of technology. The steeper curve depicts a scenario in which market participates choose to adopt technologies at an accelerated rate, owing to circumstances presented by Covid-19.

Figure 5: Slow and Fast Technology Adoption Curves



Source: Cebr analysis

As technological adoption of post-Covid technologies is not currently at zero – if it were then mass remote working would not have been possible in early 2020 – modifications were made to each sectors adoption curve to reflect initial rates of adoption. The modifications were informed by evidence presented in the literature and through workshops with industry experts. There was also a divergence in the rates, this was driven both by a three-year time lag in the baseline model (to reflect the observation that technological adoption made a multi-year 'jump'

48 Source: Brancheau, J.C., & Wetherbe, J.C. (1990). The Adoption of Spreadsheet Software: Testing Innovation Diffusion Theory in the Context of End-User Computing

due to Covid-19) and a slower rate of adoption due in the baseline. These changes, again, were driven by evidence from the literature and workshops.

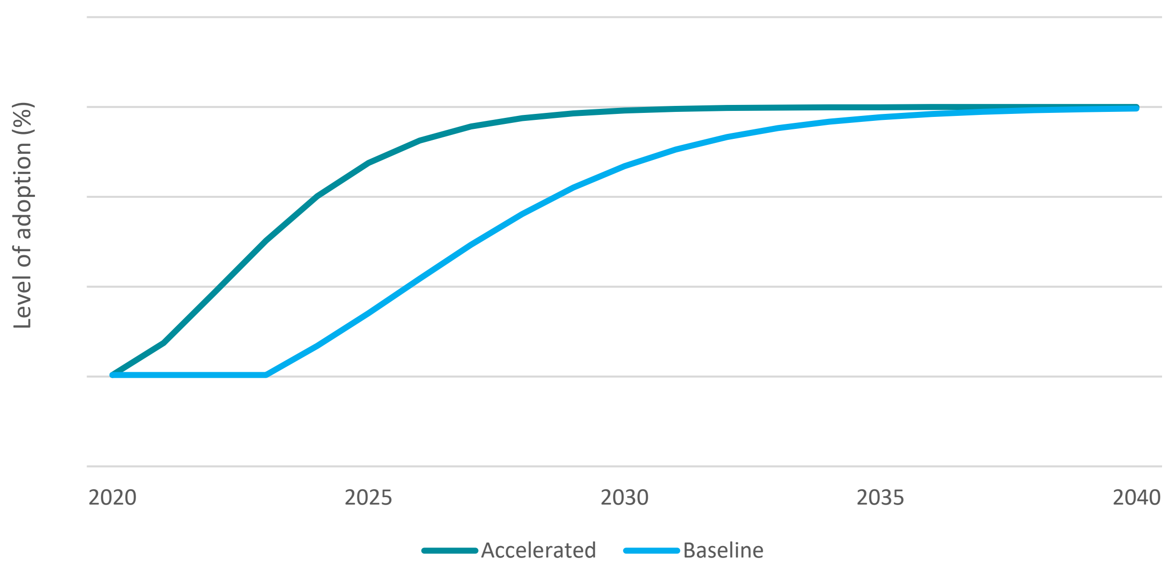
With respect to the time horizon, the model assumes the baseline and the accelerated rates to be level in 2020, and that the divergence will occur in approximately 2021.[49]

Our scenario does not consider the current wave of technological adoption in isolation. Long-run technological progress is formed by sum of these shorter-run technological adoption cycles. The benefits of the bringing forward of subsequent technological adoption cycles are captured in the long run gains we attribute to increased investment. Whilst the adoption rates eventually converge in the adoption curves, through bringing forward future technological advancements and subsequent innovation, there is a lasting benefit to faster adoption.

Figure 6 sets out the scenario in which a sector is assumed to have a high current rate of technological adoption. As seen the baseline curve will eventually reach a similar trajectory at the end of the given time horizon, however, some cumulative benefits realised by the early adopters will not be realized in the baseline scenario of slower adoption. Thus, the accelerated scenario still results in a higher level of economic output in the year 2040.

Sectors operating under the high adoption scenario will reach the point of saturation more quickly than other sectors because they are further along their adoption journeys. Sectors such as professional services (where there is already widespread adoption of CADT technologies) have a smaller journey to full adoption of CADT than the healthcare sector where CADT offers both a larger challenge and a larger opportunity to realise benefits.

Figure 6: Scenario - High current rate of technology adoption



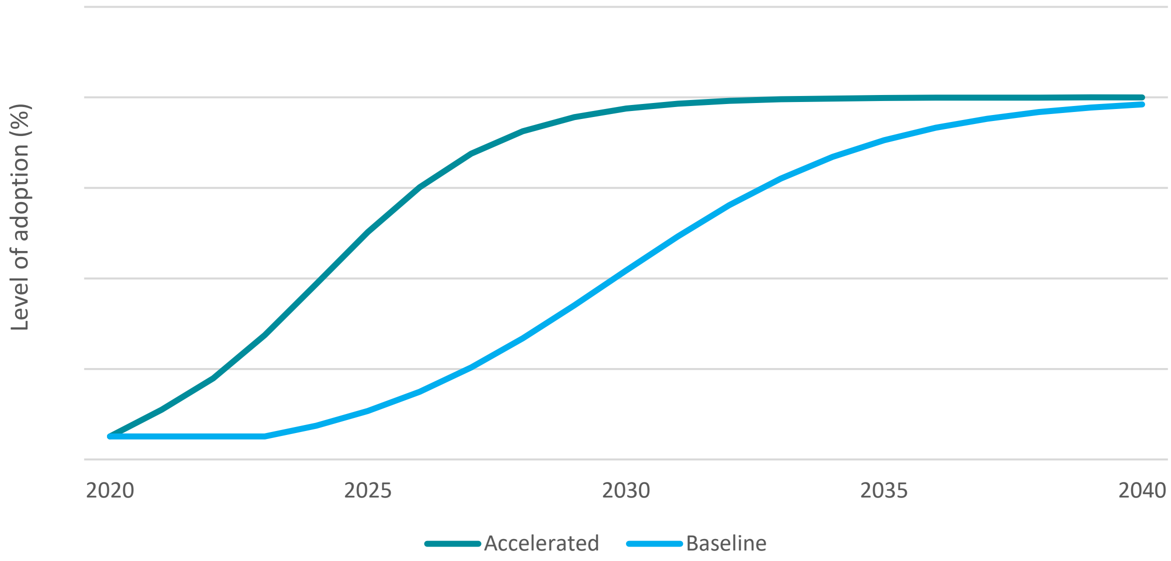
Source: Cebr analysis

49 The divergence in 2021 assumes a gradual return to somewhat ‘normal’ practices by the end of 2020; that is, no further restrictions or lockdowns are imposed. Should further restrictions or lockdown measures be implemented, it is possible that the divergence would take place later.

Figure 7 sets out a scenario in which sectors are assumed to have a 'low' 5% starting rate of adoption.

The baseline in this case continues to assume a three-year lag in uptake, whereas the accelerated curve assumes a Covid-induced increased uptake of technology in the year 2021. As a result of beginning the trajectory from a lower current rate of adoption, there is a greater possibility for the sectors contained in this scenario to realise the benefits brought about by digital transformation to a greater extent than those contained within the 'high' current rate scenario – where technologies are assumed to have been utilised to a greater extent for some time.

Figure 7: Scenario - Low current rate of technology adoption



Source: Cebr analysis

4.4. Investment uplift channel

It is reasonable to assume that the firms benefiting from the productivity gains – brought about by accelerated and increased use of the transformational initiatives discussed thus far – will achieve savings and surpluses that can be re-invested in their respective sectors (and in the case of the public sector – the savings can be disseminated across the wider economy). In order to reflect this likely course of firm-level behaviour, an additional uplift tranche was specified in the model to channel the gains brought about by increased productivity through a re-investment channel.

The decision to include an investment channel forms part of the scenario that we are presenting in this research. There are, of course, a number of alternative ways in which the efficiency gains could be channelled. However, it is reasonable to assume that this approach is adopted in practice. As noted in the Background section, gross fixed capital formation (GFCF) is an accepted measure of investment. More specifically, it is a net investment concept used with in UK national accounts which measures expenditure on non-financial assets from public and non-government sectors.[50] It can be thought of as a useful indicator of long-term

50 ONS. (2017). 'An international comparison of gross fixed capital formation'.

productive capacity.[51] ONS data for the UK indicates that GFCF was approximately 17% of GDP in 2017, and average government spend on GFCF is approximately 2.4% of GDP.[52] More recently, Eurostat indicates that general government gross fixed capital formation in the UK in 2019 was approximately 2.8% of GDP.[53] The Government's Industrial Strategy notes an R&D spending target of 2.4% of GDP by 2028.[54]

Importance of investment

Investment is essential for long run economic growth. It allows for the development of new technologies, capital and infrastructure. Increased investment, especially in the private sector, is seen as a factor in increasing long run economic growth. According to endogenous growth theory, not only is investment central to economic growth, but the level of investment as dictated by market forces is sub-optimal.[55] As such, action by the government to either encourage increased investment or directly providing investment could lead to increased economic performance.

While some of the gains of increased productivity are being modelled as providing long run growth through investment, it should be noted that gains from early technological adoption may increase long run productivity through other similar channels. This could include an increase in both public and private sector R&D as companies and governments react to the rapid rise in demand for high tech solutions or higher quality public services enabling a more dynamic economy. It should be noted that the UK's R&D expenditure is at 1.7% of GDP is well below the OECD average of 2.4%, indicating room for improvement.[56]

Difference between Private and Public sector reinvestment

In calculations of GDP, public services are largely measured at labour cost, due to the absence of markets and subsequent surpluses or profits. Therefore, even if the quality (and hence intrinsic value) of public services were to increase owing to CADT, it is difficult to fully reflect this directly in terms of GDP. As such, we have framed the "gains" somewhat differently.

The direct economic contribution of the government dominated sectors of Health and Social Care, Public Administration and Defence and Education are kept in line with that seen in the baseline macroeconomic model. In order to illustrate the benefits of CADT on the public sector, whilst the direct GDP contribution does not change, cost savings achieved are assumed to be invested through the public sector[57]. This becomes possible because fewer operational resources are needed to provide the same amount of public service operations that we have presently. As noted above, we recognise that there may be alternative conceptualisations for the way in which gains could be channelled. However, for the reasons given earlier – pertaining to GFCF – this is the approach that we have adopted for the purpose of our scenario.

51 ONS. (2017). 'An international comparison of gross fixed capital formation'.

52 Ibid.

53 Eurostat. 'General government gross fixed capital formation'.

54 NHS. 'Research and innovation to drive future outcomes improvement'.

55 Howard Pack (1994) 'Endogenous Growth Theory: Intellectual Appeals and Empirical Shortcomings.'

56 House of Commons Library. (2020). 'Research and development spending'.

57 For the purpose of this research and the scenario that we present, we treat 'investment' as a composite – including R&D and fixed capital – that generates stable, long-term returns as the technological frontier also shifts outwards.

In the private sector, as productivity increases sectoral output, a portion of that increased output is assumed to be channelled into increased investment for that sector. The gains of investment result in a higher GDP from the year after the investment is made and in the case of the private sector, a larger sectoral output.

Taking a view of the elasticities found in the literature (see Table 12), an investment elasticity of output equal to 20% for the private sector has been chosen. This represents a 0.2% increase in long run output for every 1% increase in investment. A conservative halving of this impact has been made in respect to public sector investment, with a 1% increase in investment funded by the public sector increasing long run output by 0.1%. Due to the large increases in the level of investment generated by the macro model, these conservative lower estimates make findings robust to potential decreases in the elasticity as the level of investment increases.

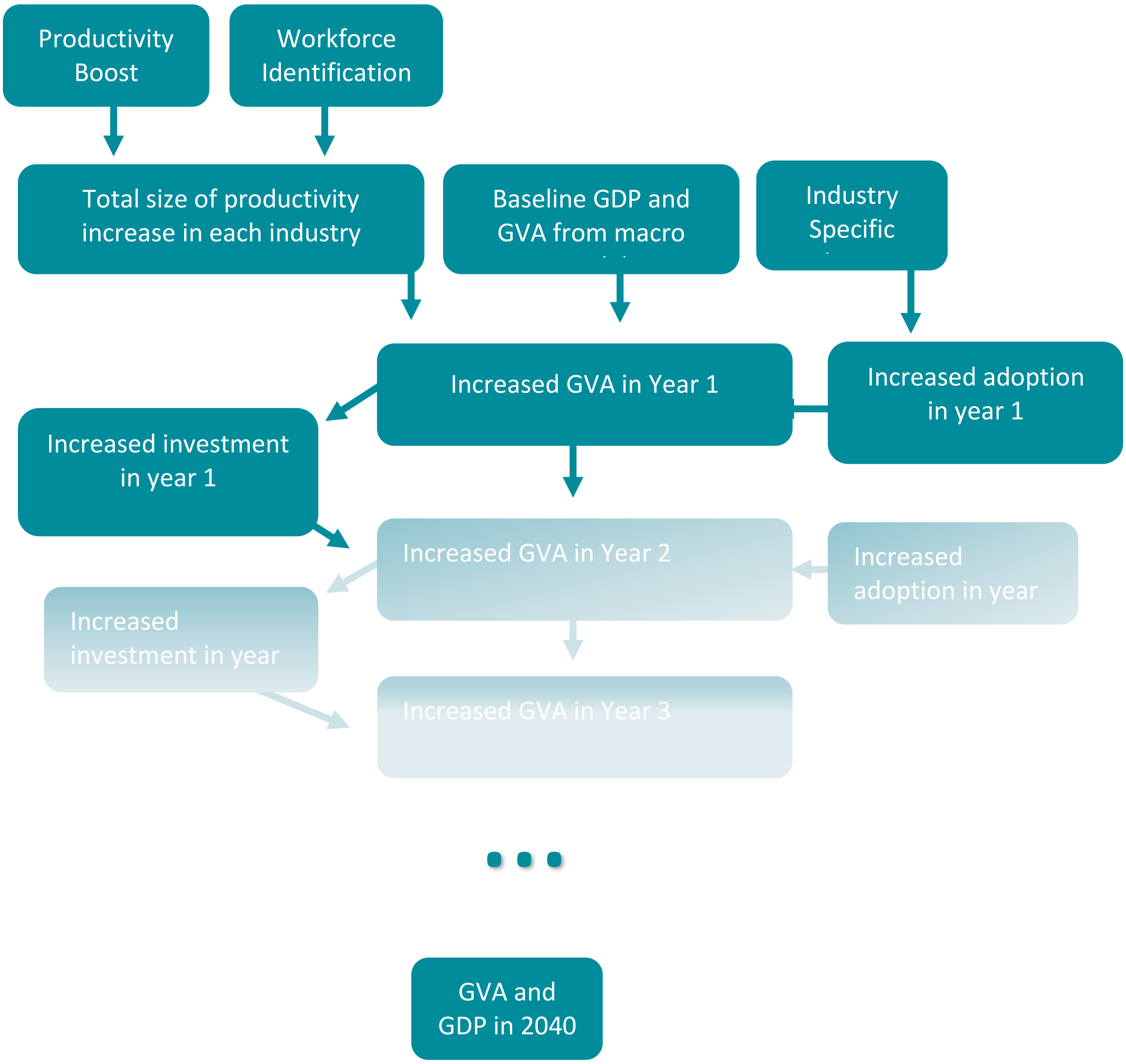
4.5. Private Sector

Having determined values for each of the model inputs, the cumulative economic deltas for each sector of relevance could be estimated.

Per the details provided in the previous section, the uplifts were calculated differently for the private and public sectors, respectively.

Figure 8 summaries the functioning of the model for the private sectors (construction, professional services and retail). It can be seen that the productivity boost, together with the workforce scalar – the CADT uplift – is combined with the industry specific net cumulative rate of adoption and applied to the baseline GDP from Cebr's macro model – which assumes no accelerated rate of adoption. The CADT uplift in employee productivity brings about an increase in sectoral output, a portion of which is reinvested back into the sector at a rate of 10%. The gains of this re-investment result in a higher GDP from the year after the investment is made.

Figure 8: Conceptual illustration of the private sector model methodology



4.6. Public Sector

Of the six sectors assessed in greater detail in this report, three are dominated by the activity of the public sector: health, education and local and central government and blue light services.

Figure 9 summaries the functioning of the public sector model.

Figure 9: Conceptual illustration of the public sector model methodology

The high wage shares in these public sub-sectors provide large potential benefits for technological innovations that save employee time and increase employee productivity. A cost savings perspective was adopted as follows:

1. Productivity boosts provided by CADT were used to generate cost savings whilst maintaining the same level of public service provision (as shown in Figure 9);
2. The additional cumulative level of adoption of CADT technologies found above that in the baseline was used to generate a cost saving in each year for each sector;
3. In order to maintain total sectoral contribution to GDP, the cost savings were assumed to be invested;
4. Therefore, the size of the direct sectoral contribution to GDP does not change due to CADT;
5. As higher levels of CADT occur, cost savings are generated, with increases in investment following a year later.

As investment accrues, the long-run benefits of investment also accrue. The increase in investment is used to calculate a percentage increase in total investment in the economy as measured by Total Capital Formation. This percentage is combined with the 0.1% public sector investment output elasticity in order to estimate the increase in GDP precipitated by the increased investment.[58] The benefits of increased investment are only realised from the calendar year after the investment is initially made.

The boost in GDP due to increased public sector investment are not assigned to any industry. This is done for two reasons. First, there is a wide degree of uncertainty as to which industries would be the beneficiaries of increased public sector investment. Second, if the impacts of increased public sector investment were applied to other industries, the calculated benefit of increased technological investment in said industry would not be separable from the impact of increased public sector investment. The internal dynamics of CADT within each industry, which are of importance to this analysis, would be obscured.

The following chapter provides a summary of the results for each sector. A comprehensive review of each industry's impact is given in the sector-specific vertical reports, together with the illustrative case studies.

58 Increased investment due to CADT from all sectors (both public and private) are added to the baseline forecast Total Capital Formation to create a more accurate estimate of the marginal impact of increased investment.

5. The impact of CADT on the UK economy

This section sets out a summary of the findings, that is: the estimated impact of accelerated adoption of digital and technological initiatives in the UK, in response to Covid-19.

The use of GDP and GVA

When presenting the digital transformation uplifts, we use two measures of economic activity as contextually appropriate: Gross Domestic Product (GDP) and Gross Value Added (GVA). At the UK-level, we present the digital transformation uplifts in terms of additional GDP – which the ONS refers to as a standard measure of the size of a country's economy. [59]

At the individual **private** sector-level, we present the uplifts in terms of GVA, which can be thought of a measure of sectoral contribution to the economy.[60] Owing to the way in which we illustrate the **public** sector gains – that is, as a proportion of the economywide uplift – we use GDP, because we are referring to the economy as a whole, the gains for which are given in terms of GDP.

While the two measures are sometimes used interchangeably, there are some differences to note. GVA is estimated using basic prices; said another way, it is the value of a unit's output, less the value of the inputs used in production.[61] The basic price is the amount that a producer receives for a unit of good or service, inclusive of any subsidies, but excluding taxes that are payable. This relationship is summarised as follows:

GVA (at basic prices) + taxes on products – subsidies on products = GDP (at market prices)[62]

In the context of this research, GDP is considered to be a suitable unit of measurement at the economywide-level, and GVA is more appropriately used at the sector level.

The 2021 – 2025 short run

This research has been carried out in real-time, against an uncertain economic backdrop with particular respect to the long-awaited Brexit deal announcement, and indeed Covid-19 – the surrounding circumstances of which have been subject to frequent and last minute change. Results are estimated using assumptions that are based on the state of the world at the end of 2020, and the near-term forecast might consequently be subject to change.

The shape of 'economic recovery', in the period 2021 – 2025, is unclear.[63] Opinion ranges from a quick 'V-shaped' to a prolonged period of lower output. This uncertainty is largely due to the unpredictable progression of the virus and governmental responses. While a fast and effective rollout of vaccines may allow for a return to normality and a quick economic recovery, prolonged restrictions well into the second half of 2021 would lead to greater scarring in the economy and slower economic growth in the following years.

59 ONS. (2016). What is GDP?'.

60 Gov.uk. (2018). 'Productivity measured by Gross Value Added (GVA)'.

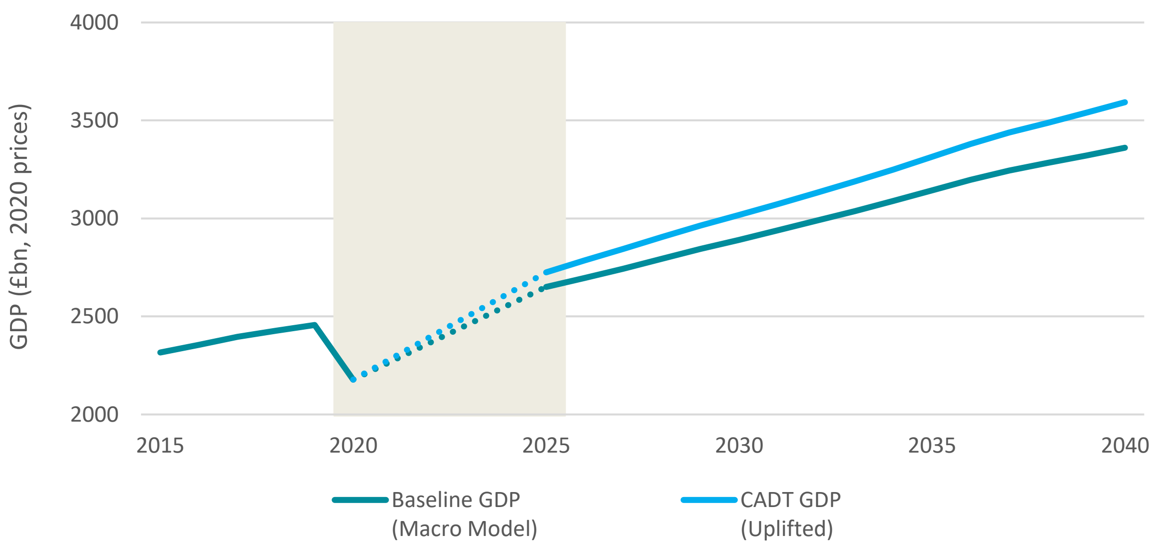
61 ONS. (2018). 'A guide to interpreting monthly gross domestic product'.

62 Ibid.

63 The immediate term between 2021 and 2025 can be thought of as the of the 'economic recovery' period, before the UK transitions into a long term steady state. 2025 has been chosen as a suitable analytical starting point from which to undertake the analysis because that is the nearest steady state marker that is currently identifiable.

We have therefore placed greater focus on the medium and longer-term findings by excluding annual estimates for the years between 2020 and 2025. Longer-term findings are more robust and less likely to be impacted by the current – and ongoing – changes to government policy and pandemic trajectory. By the start of the long term steady state period (currently estimated to be 2025), increased Covid-accelerated Digital Transformation is estimated to have added £74bn to GDP.

Figure 10: UK GDP, 2015-2040



Source: Cebr analysis

Table 14 sets out the results for the UK as a whole. Data from Cebr's in-house macro model (as of December 2020) is used as the baseline, against which the additional GDP – brought about by accelerated technological adoption – is applied, to yield an uplifted GDP estimate for each year.

Under the baseline scenario, sectors operate under normalised, steady-state assumptions, following non-accelerated technological usage trajectories. In this case, GDP across the UK economy as a whole is estimated to be approximately £2,891bn by 2030. However, the results of the model in which we consider an accelerated technological adoption scenario, indicate that GDP could increase to approximately £3,018bn – an uplift of £127bn, or 4.4%.[64]

By 2040, the counterfactual GDP – with normalised assumptions regarding technology adoption – is estimated to be approximately £3,361bn. However, with increased used of digital technologies, it could be uplifted by around 7% to £3,593bn – an increase of £232bn.

Table 14: UK-wide impact of Covid-accelerated Digital Transformation adoption

Year	Baseline GDP (£bn, 2020 prices)	Uplifted GDP (£bn, 2020 prices)	Additional GDP (£bn, 2020 prices)	Percent boost
2020	2178	2178	0	0.0%
2025	**2651**	**2725**	**74**	**2.8%**

64 All figures are given in real terms, based on 2020 prices.

2026	2697	2786	89	3.3%
2027	2744	2845	101	3.7%
2028	2794	2905	111	4.0%
2029	2845	2964	119	4.2%
2030	**2891**	**3018**	**127**	**4.4%**
2031	2939	3073	134	4.6%
2032	2988	3130	142	4.8%
2033	3038	3189	151	5.0%
2034	3090	3250	160	5.2%
2035	3143	3314	171	5.4%
2036	3198	3380	182	5.7%
2037	3244	3438	194	6.0%
2038	3283	3488	205	6.2%
2039	3322	3540	218	6.6%
2040	**3361**	**3593**	**232**	**6.9%**

Source: Cebr analysis

The following section sets out the results for the three in scope private sector: construction, professional services and retail, respectively.

5.1. Private sector

As noted in the previous section, increased productivity in the private sector – attributable to accelerated adoption of technology – raises employee productivity, which manifests itself in the form of increased sectoral output, a portion of which is assumed to be channelled into increased investment. The gains of such investment lead to higher GDP from the year after the investment is made, and in turn bring about a further increase in sectoral GDP.

Our findings indicate that the total digital transformation uplift across the three private sectors is approximately £21bn in 2030, and around £40bn in 2040 – representing a combined GVA uplift of approximately 4.8% above the baseline for the three sectors.

A summary of the digital transformation uplifts for each of the sectors in 2040 is given in Table 15, below.

Table 15: Summary of private sector digital transformation GVA uplifts in 2040

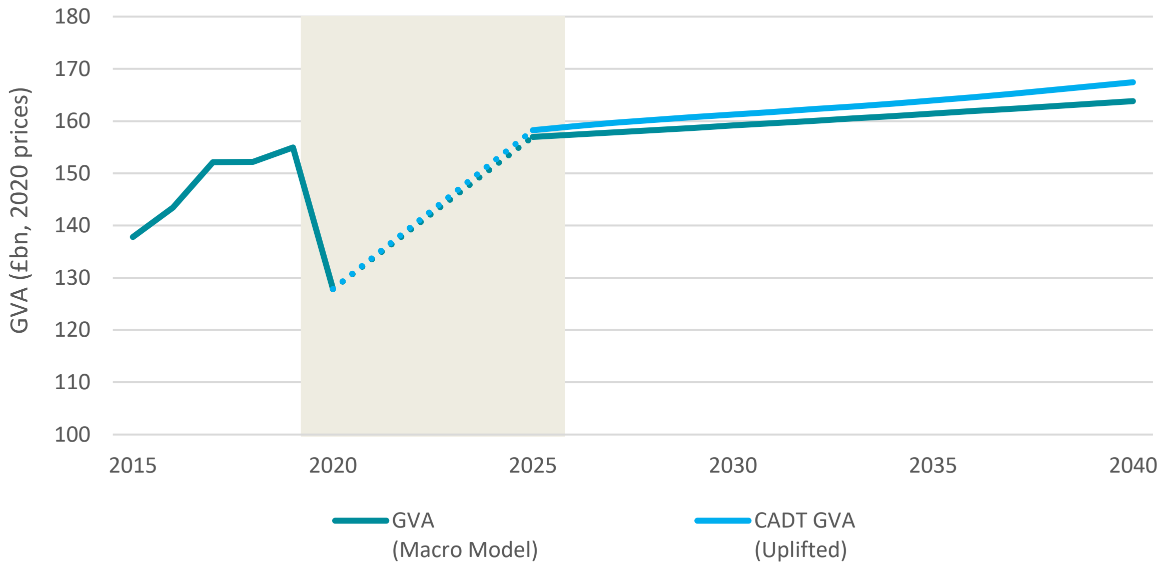
(Real, £bn, 2020 prices)				
Private Sector	**Baseline 2040**	**Size of Uplifted Sector in 2040**	**Digital Transformation Uplift**	**Percent Gain**
Construction	164	167	3	1.8%
Professional & Scientific Services	333	349	16	4.8%
Retail	340	361	21	6.2%

Source: Cebr analysis

Construction

Figure 11 presents the forecasted size of the construction sector under the baseline scenario, together with the forecasted size of the uplifted sector, achieved through accelerated adoption of digital transformation.

Figure 11: UK construction sector GVA, 2015-2040



Source: Cebr analysis

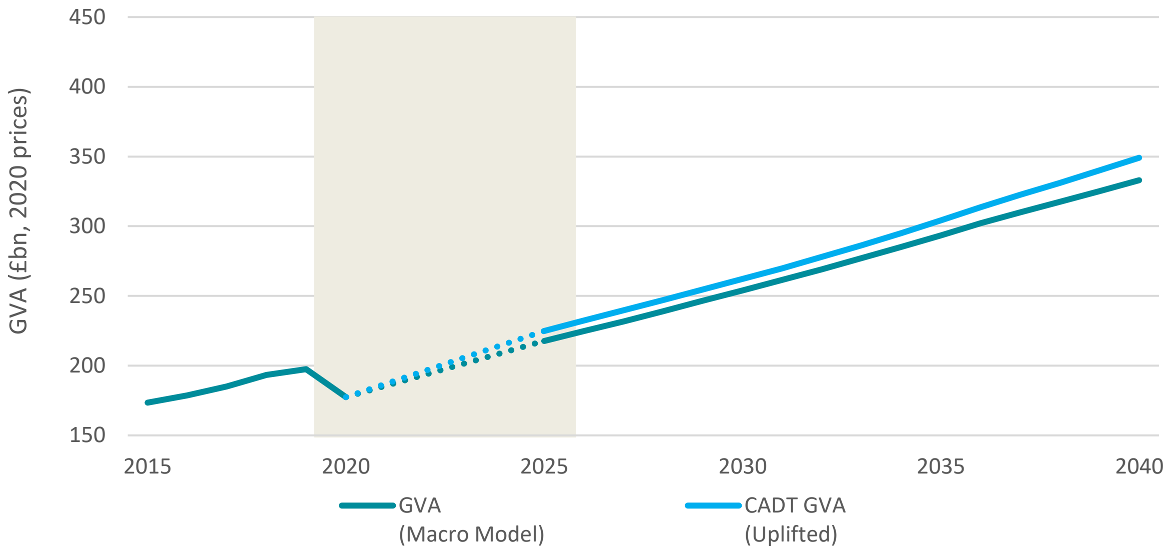
As noted in the literature, the construction sector was found to be slow adopter of digital transformation, owing among other things, to the fragmented nature of the industry. Further to this, and despite the benefits that the sector may theoretically realise in time, findings from the panel workshops suggest that significant transformations (that bring about considerable gains) are not currently taking place across the board. Rather, it is the smaller tasks are currently being digitised and as such, gains can arguably be considered as modest.

In view of this, the digital transformation uplift is estimated to be approximately £3bn in 2040, a gain over the baseline of around 1.8%, bringing the size of the sector to £167bn at the end of the 20-year time horizon.

Professional Services

Figure 12 presents the forecasted size of the professional (and scientific) services sector under the baseline scenario, together with the forecasted size of the uplifted sector, achieved through accelerated digital transformation.

Figure 12: UK professional services sector GVA, 2015-2040



Source: Cebr analysis

In contrast to the construction sector, the professional and scientific services sector was found to have a 'high' current level of digital transformation adoption. This was verified through the panel workshops, where industry practitioners confirmed that many sub-sets within the sector, such as the legal profession, have been using various automation tools for repetitive tasks for a number of years. Such tools have brought about significant productivity gains that can further be realised by additional innovations in the sector, such as increased use of video technology, which was referenced as important in ensuring successful working from home practices.

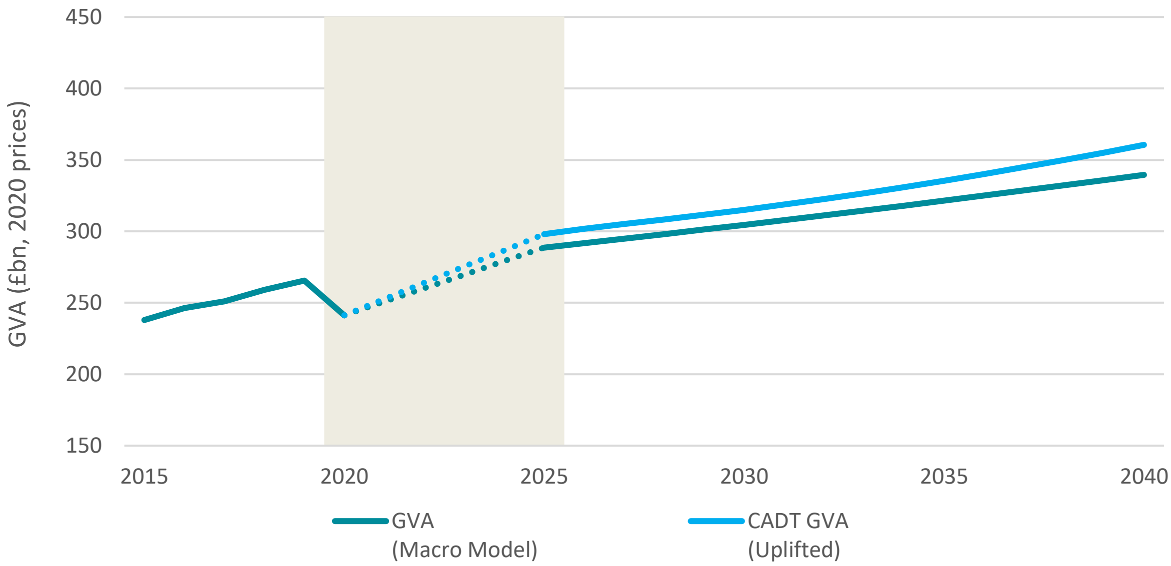
As such, we estimate the size of the professional services sector to be approximately £349bn by 2040 – a cumulative uplift of £16bn, or 4.8%, over the counterfactual baseline.

Specialised and digital retail

As in professional services, the wider retail sector was found to have a high current level of digital adoption. However, further technological transformation is possible, with respect to personalisation of online services, for example through use of chatbots to enhance customer experience. The success of digitally savvy multi-channel retailers in the USA, evidences the potential for continued innovation in the already highly digitized UK retail market where online shopping is already the norm.

Our results indicate that the size of the uplifted retail sector could be approximately £361bn by 2040, an increase of £21bn, or 6.2% over the counterfactual baseline.

Figure 13: UK retail sector GVA, 2015-2040



Source: Cebr analysis

5.2. Public sector

As detailed in the previous section, the public sector is treated differently to the private sector. The uplift accruing due to increased adoption of digital transformation in these government dominated sectors is expressed with respect to its impact on the overall economy. Said another way, the gains *originate* from the “in scope” public sector sub-sets, but are *realised* across the whole economy.

Table 16 provides a summary of economywide gains in 2040, brought about by accelerated adoption of digital transformation in three sub-sets of the public sector.[65]

Table 16: Summary of digital transformation uplifts in three public sectors in 2040

(Real, £bn, 2020 prices)			
Sector	**Size of Sector in 2040**	**Economywide gains attributable to Public Sector investment**	**Gain as a % of GDP**
Health & Social Care	270	33	1.0%
Education	151	10	0.3%
Public Administration & Defence	121	32	1.0%

Source: Cebr analysis

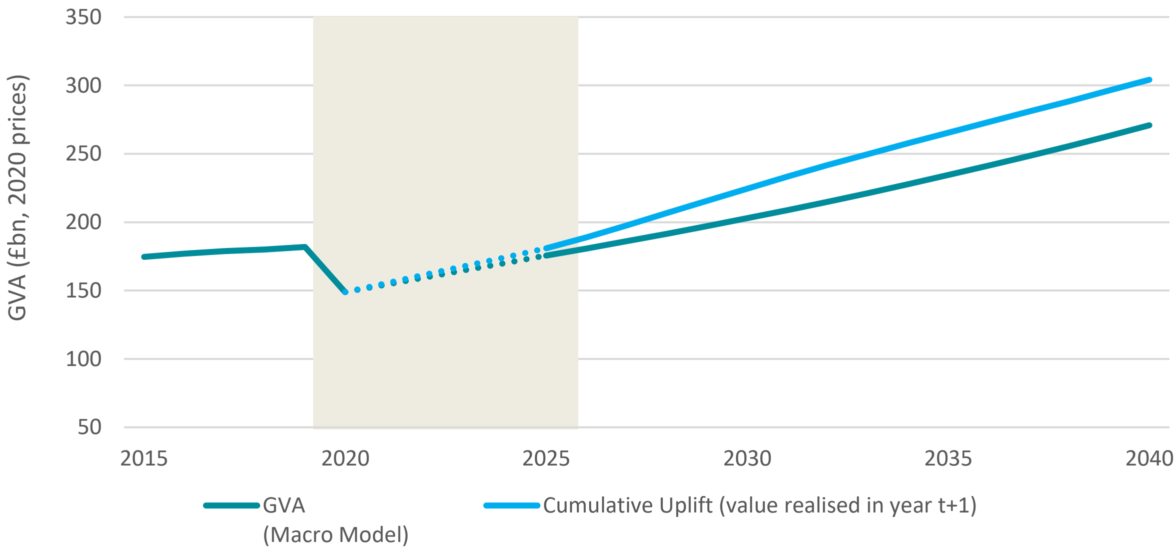
65 Per the scope of the research, we have specifically considered three sub-sets of the broader public sector. It should be noted that the activity of these three sub-sets does not constitute the complete extent of public sector activity.

Health

In the health sector[66], we find evidence of a 'low' current rate of digital transformation adoption – that is, the pre-Covid propensity to adopt technology. However, the literature and insight arising from the panel workshops indicated that the sector could realise significant gains from increased use of technology, with respect not only to employee efficiency, but also more broadly in the improvement of service quality. It is estimated that Covid-19 might have accelerated the rate of digital transformation by between three and five years, as a result of forcing innovation where there has previously been wastage.

As such, GDP gains (to be released across the overall economy), are estimated to be approximately £33bn in 2040, the equivalent of 1% of 2040 baseline GDP for the whole UK economy (£3,361bn – Table 14).

Figure 14: UK health sector GVA, 2015-2040



Source: Cebr analysis

Education

Figure 15 sets out the forecasted size of the education sector under the baseline scenario using estimates from Cebr's macro model. It also illustrates the estimated size of the cumulative gain which will be released across the whole UK economy, as a result of accelerated digital transformation in the education sector.

Approximately 70% of the UK education sector is directly funded by the government.[67] Digitally aided instruction will continue to increase in importance, throughout the coming decade. Further digitisation and efforts to close the digital divide will play an important role in an educational catch up.

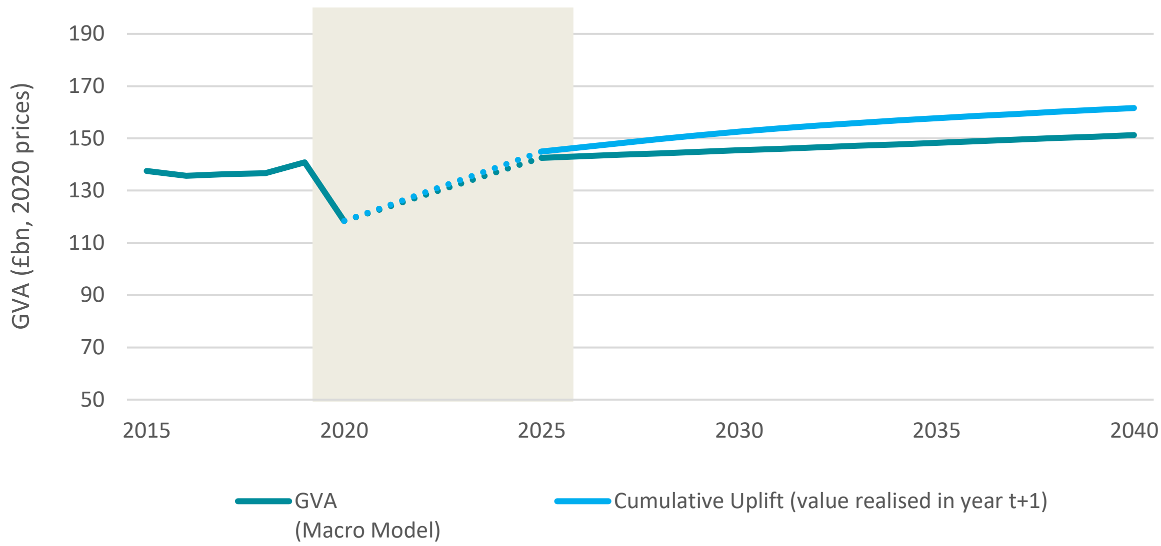
66 On the basis that the health sector is substantively government-run, our scenario employs a simplifying assumption in which we treat the whole sector as a public sector sub-set.

67 On the basis that the education sector is substantively government-run, our scenario employs a simplifying assumption in which we treat the whole sector as a public sector sub-set

More radical transformations may be realised in higher education, as the digital first model becomes more commonplace.

We find that by 2040, economywide gains attributable to investment in the education sector are approximately £10bn, around 0.3% of total UK GDP.

Figure 15: UK education sector GVA, 2015-2040



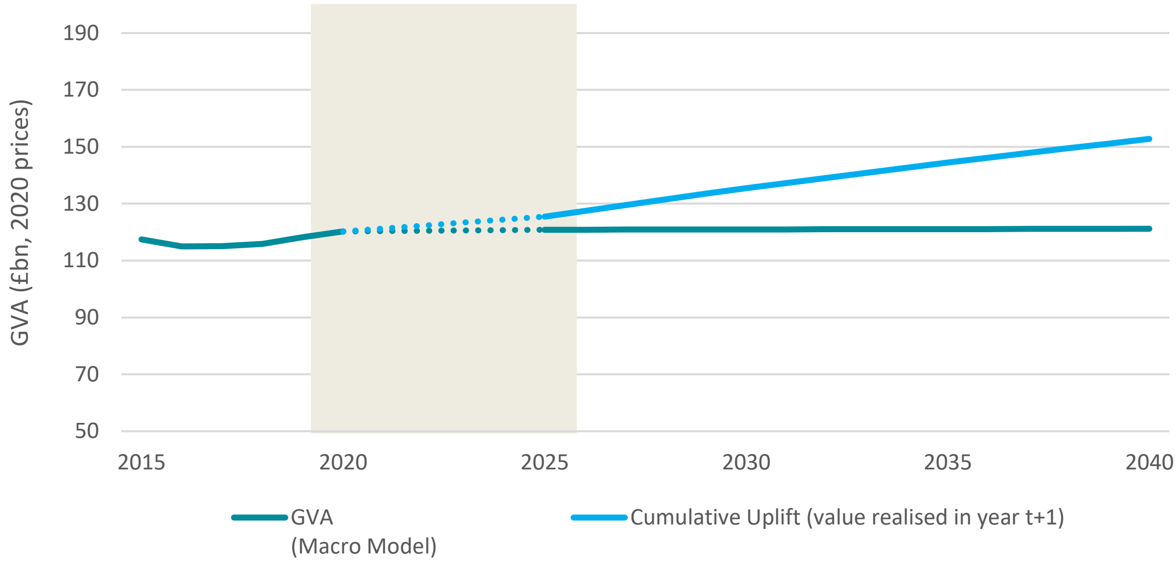
Source: Cebr analysis

Local and Central Government and Blue Light services

Across local and central government, the GDP uplift is estimated to be £32bn, or around 1% of UK GDP in 2040 – in line with the estimated gain arising from digital transformation in the health sector.

The large wage share of government services allows CADT to have a sizable impact in the sector. Additionally, public demand for government services to be made available digitally and proof of concept realised during Covid-19 will drive accelerated digital transformation through the coming decades.

Figure 16: UK local and central government sector GVA, 2015-2040



Source: Cebr analysis

Cebr