Cloud services market study

Call for inputs

Welsh overview available

CONSULTATION:

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Annex

1. Overview

Cloud computing is being rapidly adopted by businesses across the economy and has become an essential part of how digital services are delivered to consumers, including in the telecoms and broadcasting sectors. Ofcom is launching a market study into the supply of cloud services in the UK to explore if these markets are working well and whether any action is required.[1] We are doing this as part of a new programme of work to ensure that digital communications markets are working well for people and businesses in the UK.

This document sets out our initial understanding of cloud services in the UK and explains how we plan to undertake our study. We are seeking stakeholders' input on how the market is developing and the nature of competition, particularly in cloud infrastructure services and cloud ecosystems.

What we are doing – in brief

We are undertaking a market study into the supply of cloud services in the UK using our powers under the Enterprise Act 2002.

'Cloud computing' is the provision of remote access to computing resources (compute, storage and networking) on demand and over a network. 'Cloud services' are all services involved in the provision of cloud computing. The main suppliers of cloud services in the UK are Amazon Web Services (AWS), Microsoft and Google, who are referred to collectively as the hyperscalers.

Cloud services are increasingly important to many businesses across the economy, including the telecoms and broadcasting sectors. They play a critical role in the delivery of a range of communications services to consumers over the internet. As demand for cloud services continues to grow, competition in these markets will be increasingly relevant for our duties as the UK communications regulator. It is important that we understand how these markets function and establish whether they are working well for consumers.

Our study will explore whether any feature of the markets for cloud services, or the behaviour of providers, could dampen competition and harm consumers through higher prices, lower quality products or less innovation. We will consider two themes in depth:

- **cloud infrastructure services**, which include services that provide access to raw computing resources, i.e. basic compute, storage and networking (often referred to as infrastructure as a service, or IaaS), as well as services that can be used to develop, test, run and manage applications in the cloud (platform as a service, or PaaS). These are the foundational elements of the cloud stack on which other cloud services are built, and where we currently see the greatest concentration of supply and factors that may pose a risk to effective competition.
- **cloud ecosystems,** which are the portfolios of services that the hyperscalers and some other vertically integrated cloud providers supply across the cloud value chain (i.e. also including software as a service, or SaaS). These include cloud marketplaces, which offer access not just to the marketplace owners' services but to those of other cloud providers. We want to understand

[1] We have published a market study notice in accordance with section 130A of the Enterprise Act 2002 as amended and applied by section 370 of the Communications Act 2003 alongside this document.

how these ecosystems may develop and the impact this could have on competition in cloud services.

We are embarking on this study with an open mind and may find that the markets for cloud services are working well. If we do identify any competitions concerns, either present today or that could arise in the future, we will assess the most appropriate route for addressing them.

We have one year from today to complete our study. We expect to publish a consultation on our interim findings in spring 2023.

Cloud computing is important to the wider economy and the markets Ofcom regulates

1.1 Cloud computing has been widely adopted by UK businesses across the economy. Compared to the traditional model, where businesses purchase and maintain their own physical computing resources and software, cloud computing is faster to deploy, more flexible and potentially cheaper. This supports innovation and growth, for example by allowing businesses offering digital services to scale up quickly and cost effectively.

1.2 Cloud computing is an increasingly important input to the different elements that make up the internet, which means it is essential for providing online services used by many UK consumers including social media, streaming, and communications services.

1.3 Cloud computing is also changing how services in the telecoms and broadcasting sectors are being produced and delivered to consumers. In broadcasting we already see extensive use of the cloud by public service and commercial broadcasters, including growing use in the production of TV and video content. And cloud computing is expected to play an increasing role in the delivery of fixed and mobile telecoms, with partnerships emerging between cloud providers and telecoms providers in the UK and elsewhere.

1.4 If the markets for cloud services are not working well, there could be negative impacts for the businesses that rely on them through higher prices, lower service quality and reduced innovation, that would in due course be passed on to UK consumers. In particular, given the importance of the cloud as an input in the different sectors under our remit, there is a risk of negative impacts for UK consumers of communications services.

1.5 Ofcom's work in this area will complement ongoing work by other UK and international regulators including other market wide studies.

Cloud computing is a complex and evolving sector led by the hyperscalers

1.6 The three hyperscalers – AWS, Microsoft and Google – provide cloud services at massive scale. Their infrastructure is built on millions of physical servers and virtual machines hosted in huge data centres around the world.

1.7 The hyperscalers are the main providers in the UK of cloud infrastructure services, which include access to raw computing resources, i.e. basic compute, storage and networking

(often referred to as infrastructure as a service, IaaS), as well as services that can be used to develop, test, run and manage applications in the cloud (platform as a service, PaaS). Estimates suggest they accounted for about 81% of UK public cloud infrastructure services sales in 2021.[2]

1.8 Cloud infrastructure services are then used to run software that is managed by software providers (software as a service, SaaS). SaaS encompasses a wide range of business software including operations, customer relationship management, and productivity. There is much greater diversity of supply in this part of the market and the hyperscalers' share is significantly smaller, as discussed in Section 3.

1.9 The cloud services sector is still growing as customers continue to migrate to the cloud and new applications and services are developed. For example, one analyst expects spending on public cloud to rise to 45% of global business IT spend by 2026, up from less than 17% in 2021.[3] This means that the situation we see today may not reflect the position when the sector matures, so it is important that we take a forward-looking approach that takes into account key market trends. These include the increasing role of multi-cloud, where customers use more than one cloud provider to meet their needs, and edge cloud, where computing is deployed closer to the user. As the market evolves we could see a shift in companies' strategies for customer acquisition, with fewer customers new to cloud, and more focus on winning business from other providers.

Our approach to the market study

1.10 The purpose of our market study is to explore if the market is working well for consumers. We want to investigate whether any feature of the market, or the behaviour of providers, could dampen competition between suppliers and therefore have an adverse effect on businesses and ultimately consumers. We will examine the extent of competition between the leading firms, how much of a constraint smaller firms impose, and the potential for market entry.

1.11 An area of potential concern is the presence of features and behaviours that could leave customers locked into relationships with particular suppliers and their ecosystems. This could make it more difficult for new firms to enter and expand their share or dampen competition between the hyperscalers. In particular, we will be exploring the extent of interoperability between services of different providers, how easy it is for customers to move their workloads and data between suppliers, and how easy it is for customers to change suppliers or use more than one supplier.

1.12 We are starting the study with an open mind, not with a presumption that there are problems which need to be tackled through regulation. We want to understand where competition concerns exist today or could arise in the future and, at a high level, to consider how any such concerns could be addressed. As noted above, the sector is still

[2] Synergy Research Group, 4Q 2021 Cloud Infrastructure Services United Kingdom Market Share Report, March 2022.
[3] Gartner, 2021. Press release. Gartner Says Four Trends Are Shaping the Future of Public Cloud [accessed 29 September 2022].

evolving and so there may be scope to identify potential competition issues before they become embedded.

Scope and structure

1.13 We plan to focus on public cloud (where cloud services offer access to a shared pool of computing resources, rather than being reserved for a single customer), as these represent the biggest transformation to the way that businesses buy computing resources.

1.14 We will focus on cloud infrastructure services (IaaS and PaaS). These are the foundational parts of the cloud stack on which other services (like SaaS) are built and where we see more risks to effective competition. Competition concerns in this part of cloud could have far-reaching effects for the wider economy, particularly where vertically integrated cloud providers act both as a supplier of cloud infrastructure services and a competitor to third party SaaS providers.

1.15 While we are taking a broad view across the different types of cloud customers, we will have a particular focus on any implications for outcomes in the telecoms and broadcasting sectors.

1.16 It is not feasible to examine all aspects of cloud services in this study. We will not, for example, be looking at the resilience of cloud services, which is of relevance not only for Ofcom but other regulators, particularly in relation to financial services. However, our deeper understanding of cloud services will complement and support wider policy work on resilience.

1.17 We plan to organise our study around two themes, which we believe will get at the heart of how competition is working.

Theme one: cloud infrastructure services competition

1.18 We will examine how competition is working for cloud infrastructure services. This will involve assessing competition between suppliers, and whether there are indications of market power, either for cloud infrastructure services overall or for specific categories of services. We will also explore how the hyperscalers compete with independent software vendors (ISVs)[4] that provide PaaS, given the dual role of hyperscalers as both suppliers and competitors of ISVs.

1.19 We will work to understand the extent to which any market features may favour the hyperscalers and make it difficult for other providers to enter and expand. These could include, for example, high capital costs and economies of scale, network effects and technical barriers to switching and multi-cloud.

1.20 We will also assess whether there are any business practices that could promote customer lock-in. In particular, we want to identify practices that make it harder for cloud customers

[4] Independent software vendors (ISVs) are providers of cloud services, typically PaaS and/or SaaS, that do not own any of the underlying raw computing resources.

to switch providers or use multiple providers, for example by charging them to move their data or limiting interoperability.

1.21 We will examine whether these features or business practices combine in ways that could dampen competition and lead to higher prices, lower service quality or less innovation. This could be the case if they limit the ability of smaller providers to compete effectively with hyperscalers, and dampen competition among hyperscalers (particularly for existing customers). This may be of particular concern if ISVs crucially rely on hyperscalers' IaaS, while also competing with them in the supply of PaaS.

Theme two: cloud ecosystems

1.22 In our second theme we will examine cloud ecosystems, which are the portfolios of services that the hyperscalers[5] provide and include marketplaces which offer access to the hyperscaler's services and those of other providers. This will allow us to take a broader perspective, recognising that the hyperscalers compete across the whole cloud stack and appear to be building separate ecosystems of cloud services.

1.23 In this theme, we will assess the extent to which hyperscalers are competing on the basis of their ecosystems and how this might shape competition in the future. We will examine the ways in which the hyperscalers design, support and price their offerings, and the risks that customers could be locked into one cloud ecosystem or that third-party providers become reliant on the hyperscalers as their route to market. This could potentially dampen competition across the value chain, for example by reinforcing the market position of the hyperscalers in cloud infrastructure services or distorting competition in the SaaS layer.

Possible outcomes

1.24 At the moment, we do not have a view on the likely outcome of the market study. We may conclude that cloud services in the UK can be given a clean bill of health. However, we may find that the market is not working well for consumers. If we were to find competition concerns or potential consumer harms, then we will explore potential policies or interventions that would seek to mitigate those harms. Having assessed the nature of concerns and potential solutions, we will review the best mechanism at our disposal to implement them.

1.25 Should we find evidence of potential anti-competitive arrangements or conduct which relate to "activities connected with communications matters", we have the power to pursue potential enforcement action using our concurrent powers under the Competition Act 1998.[6]

1.26 Alternatively, if we find that there are features of the market that lead to dampening of competition, which in turn lead to adverse effects for consumers we may make a market

[5] While other vertically integrated cloud providers offer portfolios of services that could be considered ecosystems, we will focus on the impact of the hyperscalers' ecosystems.
[6] Section 371 of the Communications Act 2003.

investigation reference to the Competition and Markets Authority (CMA), or accept remedies in lieu of such a reference.

1.27 We could also issue advice to the Government, other regulators, or businesses who may be best placed to put interventions in place.

1.28 This market study will also support the work of the Digital Markets Unit in the CMA, including its ongoing preparation for its oversight of the proposed new pro-competition regime for digital markets.[7]

1.29 Finally, we believe that our focus on public cloud will also allow us to consider if there are any issues now or the potential for issues to emerge in the future in relation to broadcasting and telecoms. If we were to find potential concerns that have specific implications for the telecoms and broadcasting markets within our remit, we would consider what further work Ofcom should pursue as part of our duty to further the interests of citizens and consumers in relation to communications matters.

Next steps

1.30 We will conduct our market study over the next year, gathering evidence from a wide range of stakeholders both informally and using our formal powers.

1.31 We expect to publish an interim report for consultation in around six months' time setting out our provisional findings, which will be followed by our final report which will set out our findings and recommendations for any further work.

1.32 We welcome input from stakeholders by 3 November 2022. In particular, we welcome responses to the questions set out in Annex 4. We are keen to hear from all cloud providers, ISVs, suppliers of professional services and customers on their experiences of the market and any concerns they have about cloud services either now or for the future.

[7] Please see Digital Markets Unit (www.gov.uk) [accessed 29 September 2022].

2. Introduction

2.1 In this section, we set out the context of the market study and why we have decided to examine the markets for cloud services. We then outline our legal powers to carry out a market study and the process we will follow.

Context for the market study

What is cloud computing?

2.2 'Cloud computing' is the provision of remote access to computing resources (compute, storage and networking) on demand and over a network (public internet or a private connection), instead of a personal computer or local server that are not part of the cloud.

2.3 Cloud computing is defined by the National Institute of Standards and Technology (NIST)[8] as "a model for enabling ubiquitous, convenient, and on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."[9] The UK Government offers a similar definition of cloud services: "a digital service that enables access to a scalable and elastic pool of shareable computing resources".[10]

2.4 These definitions focus on the **public cloud** deployment model, where cloud services offer access to a shared pool of computing resources. However, alongside public cloud, there are two additional deployment models: **private cloud**, where the computing resources are not shared between customers, and **hybrid cloud**, which combines aspects of public and private cloud. Whatever the delivery model, cloud computing is distinct from traditional IT where assets are located on site and are not part of the cloud.

2.5 In this market study, by 'cloud services' we mean all services involved in the provision of cloud computing. As discussed in Section 4, we focus mainly on public cloud, which is consistent with the NIST and UK Government definitions.

2.6 The main suppliers of cloud services in the UK are Amazon Web Services (AWS), Microsoft and Google,[11] which provide a full range of cloud services at scale and are often referred to (in this document and more widely) as hyperscalers. There are a number of relatively smaller suppliers of cloud services, some offering a full range of cloud services while others are more specialised. We discuss suppliers in more detail in Section 3.

[8] NIST is a non-regulatory agency within the US Department of Commerce. The NIST definition of cloud computing is widely adopted.
[9] NIST, 2011. The NIST Definition of Cloud Computing [accessed 29 September 2022].
[10] DCMS, 2022. Policy paper. Data storage and processing infrastructure security and resilience - call for views [accessed 29 September 2022].
[11] We use AWS, Microsoft and Google as they are the direct owners of the three hyperscaler clouds in the UK: AWS, Azure and Google Cloud. AWS is a subsidiary of Amazon and Google is a subsidiary of Alphabet.

The importance of cloud services in the UK

2.7 Cloud services are increasingly important inputs to many businesses across the economy, including the telecoms and broadcasting sectors which are central to our remit. Cloud computing supports not only the communications sector, but all other sectors, for example manufacturing, retail, hospitality and financial services.

2.8 Compared to traditional IT, cloud computing offers flexibility which enables customers to quickly scale up or down the computing resources that support their business. This allows them to potentially reduce their IT costs, transform capex into opex[12], increase their innovation potential, increase their quality of service, and achieve baseline security and resilience. Cloud services could also help businesses become more sustainable by lowering their IT energy consumption.[13] Many UK businesses are at some stage of modernising their IT through the adoption of cloud services. Increasingly, cloud services are a fundamental input for all businesses, and ensuring cloud services markets are working well for consumers is vital for future UK productivity and growth.

2.9 In telecoms, cloud services are an important input to electronic communications networks and services. All major UK telecoms providers are using private cloud deployments to operate their fixed and mobile networks and deliver communications services. As well as specialised private cloud deployments, telecoms providers are increasingly exploring ways of using public cloud in their networks, and we are already seeing examples of 5G networks being built on public cloud.[14] Telecoms providers are also competing with cloud providers who are using cloud technology to offer localised connectivity directly to customers and to transfer large files across the UK and the world.[15]

2.10 Cloud services are also an important input for broadcasting and video on demand services. UK broadcasters already use cloud services in content production, for example to set up remote artist workstations, editorial workflows, collaboration platforms and rendering, as well as in content distribution, for example via broadcast video on demand (BVoD) services like BBC iPlayer and content distribution networks (CDNs). UK broadcasters compete with providers of subscription video on demand (SVoD) services like Netflix, but also Amazon (Prime Video) which is the parent company of AWS. In addition, UK broadcasters are becoming increasingly dependent on providers of operating systems for connected TVs like Samsung, but also Google (Android TV) which is another leading cloud provider.[16]

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[12] Capex or capital expenditures are major purchases a company makes that are intended to be used over the long term. Opex or operating expenses are the routine expenses a company incurs to remain operational.

[13] AWS claims that customers moving to the cloud can achieve on average 80% reduction in IT carbon emissions. Amazon's public messaging on sustainability, including more detail on the 80% figure, is available at https://aws.amazon.com/about-aws/sustainability/ [accessed 29 September 2022].

[14] In the US, DISH, has entered into a strategic partnership with AWS to provide a cloud-based network (Amazon, 2021. Press release. DISH and AWS Form Strategic Collaboration to Reinvent 5G Connectivity and Innovation [accessed 29 September 2022]). In addition, AT&T, has moved its 5G core to Microsoft Azure after Microsoft acquired AT&T's network cloud business (Microsoft, 2021. AT&T to run its mobility network on Microsoft's Azure for Operators cloud, delivering cost-efficient 5G services at scale [accessed 29 September 2022]).

[15] For example, AWS has launched AWS Private 5G [accessed 29 September 2022].

[16] See Media nations: UK 2022, pages 41-42.

Ofcom's role

2.11 In September 2022, we published a document setting out our approach to competition and consumer issues in internet-based communications markets.[17] Our programme of work includes four targeted projects that are of particular importance to UK consumers and the functioning of communications markets. This market study is the first of those projects to be launched.

2.12 Demand for cloud services is growing and is expected to continue as the benefits become clearer and more widely accessible. We anticipate that dynamics in the markets for cloud services will be increasingly relevant for our duties in relation to competition, consumer protection, and network security and resilience in the communications sector. It is therefore important that we understand how these markets function and establish whether they are working well for consumers. This is reflected in our market context and competition themes, described in Section 4.

2.13 As noted above, many businesses are in the early stages of their transition to cloud. It may be that competition to date has been focused on gaining new customers, while switching between cloud providers is a consideration customers will face in the future. This potential development is reflected in our ecosystems theme, described in Section 4.

Wider UK policy and regulatory context

2.14 Our market study will provide the Government and other UK regulators with a robust evidence base and a broad understanding of the markets for cloud services, supporting collaboration on regulatory approaches for the UK. Ofcom, together with other regulators, has established the Digital Regulation Cooperation Forum (DRCF), which aims to facilitate knowledge sharing between regulators working on similar issues in digital services.[18] One way that the DRCF aims to achieve this is by ensuring that there are knowledge sharing networks between its members, and potentially other regulators, on topics of common interest, including cloud services.[19]

2.15 The Government has proposed a new pro-competition regime for digital markets.[20] In advance of the statutory regime, a non-statutory Digital Markets Unit (DMU) has been established within the Competition and Markets Authority (CMA) to promote competition in digital markets.[21] This market study will support the work of the DMU, including its

[17] Ofcom, 2022. Digital markets in the communications sector.
[18] Please see The Digital Regulation Cooperation Forum (www.gov.uk) [accessed 29 September 2022].
[19] See DRCF, 2022. Policy paper. Digital Regulation Cooperation Forum: Plan of work for 2022 to 2023 [accessed 29 September 2022].
[20] HM Government, 2022. Government response to the consultation on a new pro-competition regime for digital markets [accessed 29 September 2022].
[21] In 2021, the Government issued a consultation on a new pro-competition regime for digital markets which aims to actively boost competition and innovation by tackling the harmful effects and sources of substantial and entrenched market power. Following this, the Government reaffirmed its plans in its consultation response published on the 6 May 2022. In the Queen's Speech, the government committed to publish draft legislation in this parliamentary session as part of the Digital Markets, Competition and Consumers Bill. The CMA is the lead agency on digital markets. In 2021, it established a Digital Markets Unit (DMU) on a non-statutory basis to begin work to operationalise the future pro-competition regime for digital markets. See A new pro-competition regime for digital markets - GOV.UK (www.gov.uk) [accessed 29 September 2022].

ongoing preparation for its oversight of the new regime. We have consulted with the CMA as we developed our plans to carry out a market study on cloud services and will continue to do so during the course of the market study. We will lead the market study, drawing on our strong expertise in communications markets and reflecting that cloud is increasingly becoming an important element of the infrastructure of the internet (see Section 3).

2.16 This market study sits alongside other reviews of cloud services in the financial sector in the UK. The Bank of England, the Financial Conduct Authority and the Prudential Regulation Authority are considering the systemic risks that the reliance of UK financial institutions upon a small number of cloud providers raises to the stability or market integrity of the financial system of the UK. In July 2022, the UK financial authorities published a discussion paper on the potential introduction of new regulatory measures, including the designation of certain providers as critical third parties.[22] In June 2022, HM Treasury also published a policy statement detailing proposals for reducing the risks of systemic disruption from critical third parties to the finance sector.[23]

2.17 In May 2022, the UK Government issued a call for views on the security and resilience of data centre infrastructure and cloud platform infrastructure.[24] Although this market study will not focus on cloud security and resilience, we anticipate that our work will be complementary in building the UK's public policy position.

2.18 More broadly, the UK Government has set out its ambition to be a "Science and Tech Superpower", supporting UK businesses through digital adoption and improving public services through digital improvements.[25] It has also set out its plans to encourage innovation, competition and investment in digital infrastructure and digital technologies in its recent Digital Strategy.[26] In many cases, cloud services will likely underpin these ambitions, and therefore a clear picture of the cloud services market will provide useful context for these wider policy objectives.

International context

2.19 Cloud services are of interest to a number of jurisdictions around the world given their role in the global digital economy. A brief summary of relevant regulatory developments outside the UK is provided below. We will continue to monitor such developments over the course of the market study and factor them into our analysis as appropriate.

[22] Discussion paper, 2022. Operational resilience: Critical third parties to the UK financial sector [accessed 29 September 2022].
[23] HM Treasury, 2022. Policy paper. Critical third parties to the finance sector: policy statement [accessed 29 September 2022].
[24] DCMS, 2022. Policy paper. Data storage and processing infrastructure security and resilience - call for views [accessed 29 September 2022].
[25] Cabinet Office, 2021. Policy paper. Global Britain in a Competitive Age: the Integrated Review of Security, Defence, Development and Foreign Policy [accessed 29 September 2022].
[26] DCMS, 2022. Policy paper. UK Digital Strategy [accessed 29 September 2022].

European Union

2.20 The cloud sector is affected by both existing and emerging legislative developments within the EU. Notable examples include:

- **Digital Markets Act (DMA):** this imposes a suite of ex ante regulatory obligations on large digital platforms that meet the requirement of a "gatekeeper" for one or more "core platform services", which includes "cloud computing services". Designated gatekeepers will be subject to a mixture of obligations such as a duty to ensure data portability to their users and a prohibition of self-preferencing. The Council and European Parliament reached provisional political agreement on 25 March 2022, and the DMA is expected to come into force in October 2022.
- **Data Act:** this draft legislation is currently under negotiation and seeks to set out the rules on who can use and access what data (and on what terms) generated across all economic sectors in the EU. The proposed rules include allowing customers to switch effectively between different cloud "data processing service providers" and putting in place safeguards against unlawful data transfer.

France

2.21 On 27 January 2022, the French competition authority, the Autorité de la concurrence, launched a sector inquiry into the competitive functioning of the cloud sector.[27] The Autorité published an interim document for public consultation on 13 July 2022, and stated that the inquiry will mainly focus on public or hybrid cloud, and more specifically on the IaaS and PaaS models.[28] The Autorité is expected to issue its final conclusions in early 2023.

Netherlands

2.22 On 5 September 2022, the Dutch competition authority, Authority for Consumers and Markets (ACM), published its market study into cloud services.[29] ACM found that it was difficult for smaller players in the Dutch market to compete effectively with large integrated providers.[30] This was perpetuated by "vendor lock-in",[31] in part reinforced by "poor interoperability"[32] and other barriers to switching.

2.23 ACM said that it believes that the proposed EU Data Act should make interoperability easier and has made suggestions for changes to the text to this effect. In addition, ACM has announced that it will, in the coming months, further investigate the extent to which switching barriers such as egress fees cause competition concerns.[33]

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[27] Autorité de la concurrence, 2022. Press release. The Autorité de la concurrence starts proceedings ex officio to analyse competition conditions in the cloud computing sector [accessed 29 September 2022].
[28] Autorité de la concurrence, 2022. Press release. The Autorité de la concurrence opens a public consultation until 19 September 2022 as part of its cloud sector inquiry [accessed 29 September 2022].
[29] ACM, 2022. Market Study Cloud services [accessed 29 September 2022].
[30] Ibid, page 6.
[31] Ibid, page 5.
[32] Ibid, page 5.
[33] Ibid, page 6.

Japan

2.24 On 28 June 2022, the Japanese competition authority, the Japan Fair Trade Commission (JFTC), published the findings of its fact-finding survey regarding both trade practices and the state of competition in the cloud services sector.[34] The report highlighted the type of conduct that might restrain competition in the market, and made some recommendations to both suppliers and customers of cloud services with respect to actions that they could respectively take to encourage a competitive market.

Question 2.1: How do you see developments in the international context impacting the provision of cloud services in the UK?

The market study process

2.25 Ofcom has concurrent functions with the CMA pursuant to section 370 of the Communications Act 2003. This includes the power to undertake a market study to consider the extent to which a matter in relation to commercial activities connected with communications matters has or may have effects adverse to the interests of consumers. Communications matters includes services made available by means of or to facilitate the provision of electronic communications networks (ECN) and/or electronic communications services (ECS).[35] Cloud services are commonly made available by means of ECNs and also facilitate the provision of ECNs and ECSs (see 2.9 paragraph above). As noted at paragraph 2.15 above, Ofcom and the CMA consulted one another on our plans,[36] and will continue to do so during the course of the project.

2.26 Market studies are examinations into the causes of why particular markets may not be working well and in the interests of consumers, taking into account any regulatory and economic drivers, and patterns of suppliers' and customers'[37] behaviour.

2.27 We have started this market study with the publication of our market study notice alongside this document.[38] This announces the market study and starts the clock for the statutory deadlines specified in the notice.

2.28 We will now gather evidence through responses to this call for inputs, statutory information requests, stakeholder meetings and market research. We have identified a broad range of relevant stakeholders, including suppliers of cloud services, customers, technical experts and others. This will inform our analysis of how well the market is working and how to proceed.

2.29 Around the first six months of the market study, we aim to publish a market study consultation. This will announce our provisional findings and consult on our proposed course of action.

[34] Japan Fair Trade Commission, 2022. Report Regarding Cloud Services [accessed 29 September 2022].
[35] Within the meaning given by section 369(1) of the Communications Act 2003.
[36] As provided for by section 370(5) of the Communications Act 2003.
[37] "Customers" include businesses as well as residential consumers. See section 183(1) the Enterprise Act 2002.
[38] The market study notice is published on our website.

2.30 Following the market study consultation, we will review responses, collect any necessary additional information, and decide on our findings. These findings will be set out in a market study report which we are required to publish by 5 October 2023.

2.31 This market study could lead to a range of outcomes. We may conclude that the markets for cloud services in the UK can be given a clean bill of health and that any initial concerns about consumer detriment are not substantiated by the information collected over the course of the study.

2.32 If we find that the markets for cloud services are not working in the interests of consumers, we may consider:

- making recommendations to the Government to change regulations or policy;
- taking enforcement action;
- encouraging businesses in the market to self-regulate;
- taking steps to improve the quality and accessibility of information to customers or promoting customer awareness;
- making a market investigation reference to the CMA;[39] and/or
- accepting undertakings in lieu of making a market investigation reference.

2.33 Further information on market studies can be found in the following guidance documents: Market Studies: Guidance on the OFT Approach (OFT519)[40] and Market Studies and Market Investigations: Supplemental Guidance on the CMA's Approach (CMA3).[41]

[39] Where the findings of a market study give rise to reasonable grounds for suspecting that a feature or combination of features of a market or markets in the UK prevents, restricts or distorts competition, and a market investigation appears to be an appropriate and proportionate response, Ofcom may make such a reference to the CMA.
[40] Office of Fair Trading, 2010. Market studies: Guidance on the OFT approach [accessed 29 September 2022].
[41] CMA, 2017. Market Studies and Market Investigations: Supplemental guidance on the CMA's approach [accessed 29 September 2022].

3. Cloud services

3.1 This section explains what cloud services are, describes the key types of cloud services, their suppliers, and sets out important future trends.

What are cloud services?

3.2 Cloud services provide access to computing resources on demand, via a network. The customer buys access to the computing resources as a service and typically does not own the underlying hardware and software. There are three key elements to this definition:

- **Computing resources** – these include hardware (servers and network equipment) and software (applications) which are used to process workloads[42] and store data.
- **On demand** – the computing resources are available on a scalable and elastic basis. This typically involves the dynamic provision of virtualised computing resources. Users are often billed for the amount of resource used.
- **Via a network** – the transit of data to and from the cloud provider may be over the public internet or a private connection. This allows location-independent access to the cloud.

3.3 Cloud services started to be used at scale when they were launched by AWS, Microsoft and Google. Originally, AWS cloud services were used internally to support Amazon's online retail services. In 2006, AWS officially launched its cloud services for third party use.[43] Some years later Microsoft followed suit with Microsoft Azure in 2010 and Google with Google Cloud in 2011.[44]

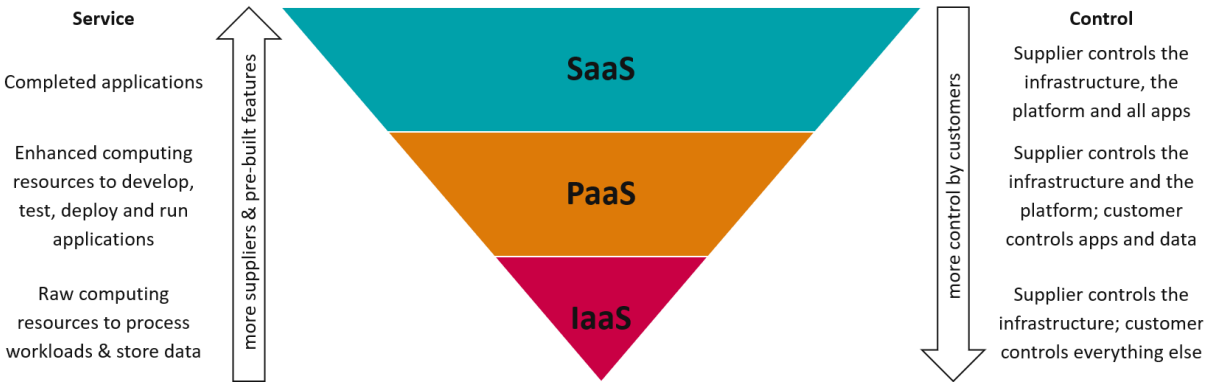
3.4 The adoption of cloud services has been steadily increasing. In 2018, less than 10% of all businesses' IT spend globally was for public cloud services.[45] In 2020 and 2021, public cloud services saw exponential growth due to the COVID-19 pandemic and the need to work from home, with public cloud spend rising to 17% of all business IT spent globally.[46] There is still the potential for significant growth, with some analysts expecting 45% of businesses' IT spend globally to be on public cloud by 2026.[47]

[42] A workload is a specific application, service, capability or a specific amount of work that can be run on a cloud resource.
[43] AWS website. About AWS [accessed 30 September 2022].
[44] AWS, Microsoft and Google offered some cloud services in beta version before the official launch of their clouds.
[45] Gartner, 2018. IT Key Metrics Data 2019: Executive Summary [accessed 30 September 2022].
[46] Gartner, 2021. Press release. Gartner Says Four Trends Are Shaping the Future of Public Cloud [accessed 30 September 2022].
[47] Ibid.

Service models

3.5 Cloud services are typically classified according to their service models: IaaS, PaaS and SaaS.[48] These are differentiated by the level of control[49] the customer has over the management and maintenance of the computing resources. IaaS, PaaS and SaaS form a vertical stack, where each layer is notionally built on top of the previous one(s). This is shown in Figure 3.1 below.

Figure 3.1: The cloud computing stack



Source: Ofcom.

3.6 **Infrastructure as a service (IaaS)** are cloud services that provide access to raw computing resources for processing workloads and storing data. These computing resources are in the form of servers and networking equipment owned and managed by the IaaS provider (and typically held on racks in a remote data centre). To allow and manage that access, IaaS also includes some necessary software, including networking (e.g. firewall) and virtualisation.[50] The customer has the highest level of control over the cloud stack, including over the operating system, applications and data. Examples of IaaS include AWS EC2, Microsoft Azure Virtual Machines and Google Compute Engine – which can be used by business customers, for example, to store data and install software.[51] IaaS should be distinguished from **bare metal** services, which offer access to dedicated servers with no or limited software installed (e.g. no operating system or virtualisation). The UK market for public

[48] These three service models have been recognised by the US National Institute of Standards and Technology (NIST). NIST, 2011. The NIST Definition of Cloud Computing [accessed 30 September 2022].
[49] Control refers to the involvement the customer has in the management and maintenance of the computing resources themselves, as opposed to the freedom it affords them to, for example, choose between providers. We will assess this separately as discussed elsewhere in this document.
[50] Virtualisation is the process of using software to create an abstraction layer over servers that allows the hardware elements of a single server (e.g. CPUs central processing units, RAM random access memory and storage) to be divided into multiple virtual servers, commonly called virtual machines. Each virtual machine runs its own operating system and behaves like an independent server, even though it is running on just a portion of the actual underlying server hardware. The software that creates, runs and manages virtual machines is called a hypervisor.
[51] AWS website. Amazon EC2 [accessed 30 September 2022]; Microsoft Azure website. Virtual Machines [accessed 30 September 2022]; and Google Cloud website. Compute Engine [accessed 30 September 2022].

IaaS was worth an estimated £1.2 billion in 2018 and £2.8 billion in 2021, equivalent to a growth of 133% over three years.[52]

3.7 **Platform as a service (PaaS)** are cloud services that provide access to a virtual environment for customers to develop, test, deploy and run applications. These include application development computing platforms and pre-built application components and tools which customers can then use to build and manage full applications. Key types of PaaS services include containers[53], functions, data management, data analytics, AI/ML (artificial intelligence and machine learning and IoT (internet of things). The overall virtual environment and the underlying raw computing resources are typically owned and managed by the same service provider.[54] However, the individual PaaS services (computing platforms, and/or pre-built application components and tools) may be supplied by the service provider or by independent software vendors (ISVs). The customer has less control over the cloud stack compared to IaaS: they still manage applications and data, but not the PaaS computing platform (including its operating system) or the pre-built application components and tools. Examples of PaaS include AWS Elastic Beanstalk, Microsoft Azure DevOps and Google App Engine – which can be used, for example, to build SVoD services.[55] The UK market for public PaaS was worth an estimated £0.9 billion in 2018 and £2.4 billion in 2021, equivalent to a growth of 175% over three years.[56]

3.8 **Software as a service (SaaS)** are complete applications hosted in the cloud. These cloud applications can be offered by the cloud provider that owns the underlying raw computing resources or by an ISV. The service provider(s) manages all hardware and software. In general, most modern consumer- and business-facing applications are SaaS, including communications services (e.g. Gmail and WhatsApp), BVoD services (e.g. BBC iPlayer), productivity software (e.g. Microsoft Office 365 and Google Workspace) and customer relationship management software (e.g. Salesforce Sales Cloud). Estimates of the size of the UK market for SaaS vary given difficulties determining the boundaries of SaaS, but it is likely to be larger than public IaaS and public PaaS combined.

3.9 The above service models should be distinguished from **traditional IT** where customers only have on-premises access (as opposed to remote access) to computing resources. Traditional IT involves dedicated computing resources typically owned by, and located on

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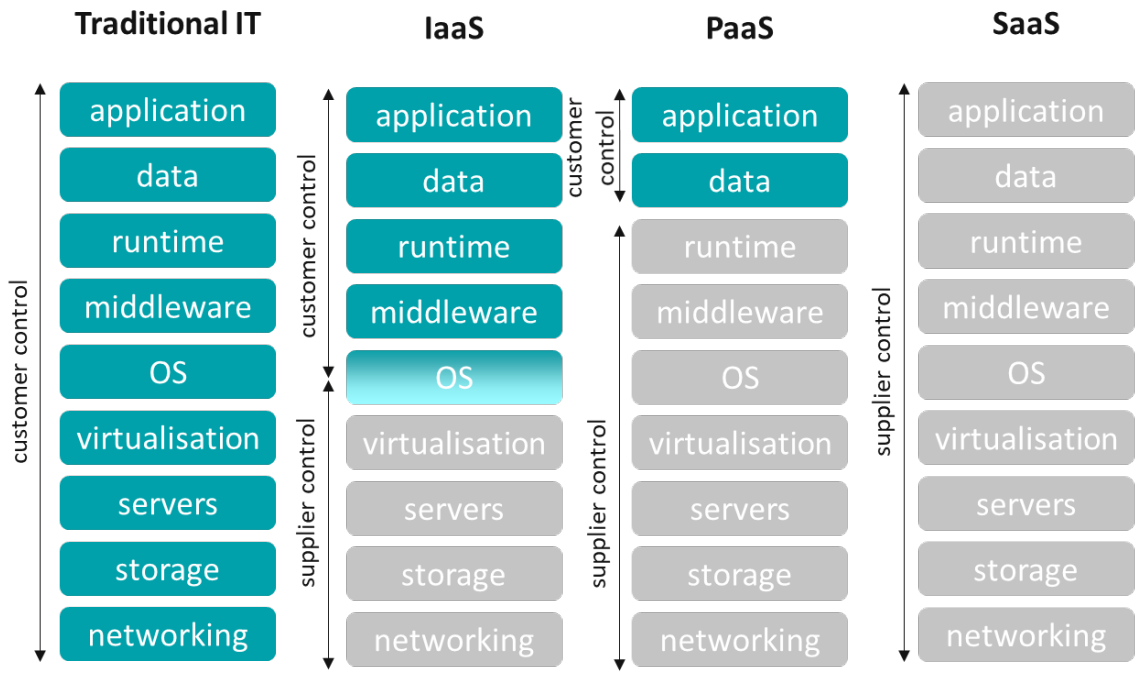
[52] Synergy Research Group, 4Q 2021 Cloud Infrastructure Services United Kingdom Market Share Report, March 2022. We have used ONS exchange rate data to convert Synergy's data from US dollars to Pound sterling (we have used the 2018 annual average exchange rate for 2018 datapoints, and the 2021 annual average exchange rate for 2021 datapoints).
[53] A virtual machine is a a software-defined computer that is created by running a guest operating system on top of the host operating system of the physical server. A container is a package of software that bundles an application's code with any necessary software required for the application to run (e.g. configuration files and libraries). Virtual machines and containers offer similar functionalities but containers are typically lighter because they do not need to run a full operating system.
[54] There are examples of PaaS where the service provider owns the virtual environment but not the underlying raw computing resources. For example, IBM Red Hat OpenShift and VMware Tanzu are PaaS virtual environments that can integrate with many clouds, including those of the hyperscalers.
[55] AWS website. AWS Elastic Beanstalk [accessed 30 September 2022]; Microsoft Azure website. DevOps solutions on Azure [accessed 30 September 2022]; and Google Cloud website. App Engine [accessed 30 September 2022].
[56] Synergy Research Group, 4Q 2021 Cloud Infrastructure Services United Kingdom Market Share Report, March 2022. We have used ONS exchange rate data to convert Synergy's data from US dollars to Pound sterling (we have used the 2018 annual average exchange rate for 2018 datapoints, and the 2021 annual average exchange rate for 2021 datapoints).

the premises of, the customer. Most businesses are currently in the process of identifying and migrating suitable workloads and data from traditional IT to cloud computing.

Figure 3.2: Vertical stack for traditional IT and cloud computing



Source: Ofcom.

3.10 Some suppliers of cloud services avoid using service models in their commercial offerings to customers, and instead, group their services by the type of computing capability that they offer. This reflects the fact that, within layers, there can be varying applications with different levels of control. Potentially, anything can be offered as a service, leading to the designation 'anything as a service.' This way cloud services can be split into many categories, including virtual machines, storage as a service, container as a service (CaaS), database as a service (DBaaS) and disaster recovery as a service (DRaaS) – all of which comprise a combination of cloud services from across the three service models set out above.[57]

3.11 At this stage we see the IaaS, PaaS and SaaS designations as a useful starting point for our analysis because they reflect important differences in the features of the services and types of suppliers. We therefore want to explore whether this translates into different competitive dynamics between these layers. However, we recognise that these boundaries can blur, and that customers typically focus on buying capabilities rather than by reference to these terms. We refer to IaaS and PaaS collectively as 'cloud infrastructure services'. We

[57] Microsoft Azure website. Virtual Machines [accessed 30 September 2022]; IBM website. IBM Storage as-a-Service [accessed 30 September 2022]; Red Hat website. What is CaaS? [accessed 30 September 2022]; Oracle Cloud Infrastructure (OCI) website. What is DBaaS? [accessed 30 September 2022]; and VMware website. What is disaster recovery as a service (DRaaS)? [accessed 30 September 2022].

welcome input from stakeholders if there is a better way to categorise cloud that captures these dynamics.

Deployment models

3.12 As noted in Section 2, cloud services are also typically classified according to their deployment models: **public**, **private** and **hybrid**.

- **Public cloud** is the most common cloud deployment model, where cloud services are open to all customers willing to pay and computing resources are shared between them. Public cloud servers are typically located in an off-premises data centre and accessed remotely over the public internet or via dedicated connections. Customers of public cloud services are typically businesses whose demands vary over time and buy cloud services on a pay-as-you-go basis.
- **Private cloud** is a cloud deployment model where computing resources are dedicated to (as opposed to shared between) individual customers. It combines many of the benefits of cloud computing with the security and control of traditional IT.[58] Customers may chose to use private cloud for various reasons, including in cases where legacy IT is not easily transferable to public cloud and for running latency-sensitive workloads close to the end-user. Private cloud comes in many forms: it could involve the exclusive allocation of physical or virtual computing resources; it could be deployed in remote data centres or on the premises of the customer; it could be provided by a third party or self-supplied.
- **Hybrid cloud** is a combination of public and private clouds. It allows applications and data to be shared between them. Hybrid cloud allows clients to use public and private cloud as if they were a single cloud service, offering a greater variety of deployment options.

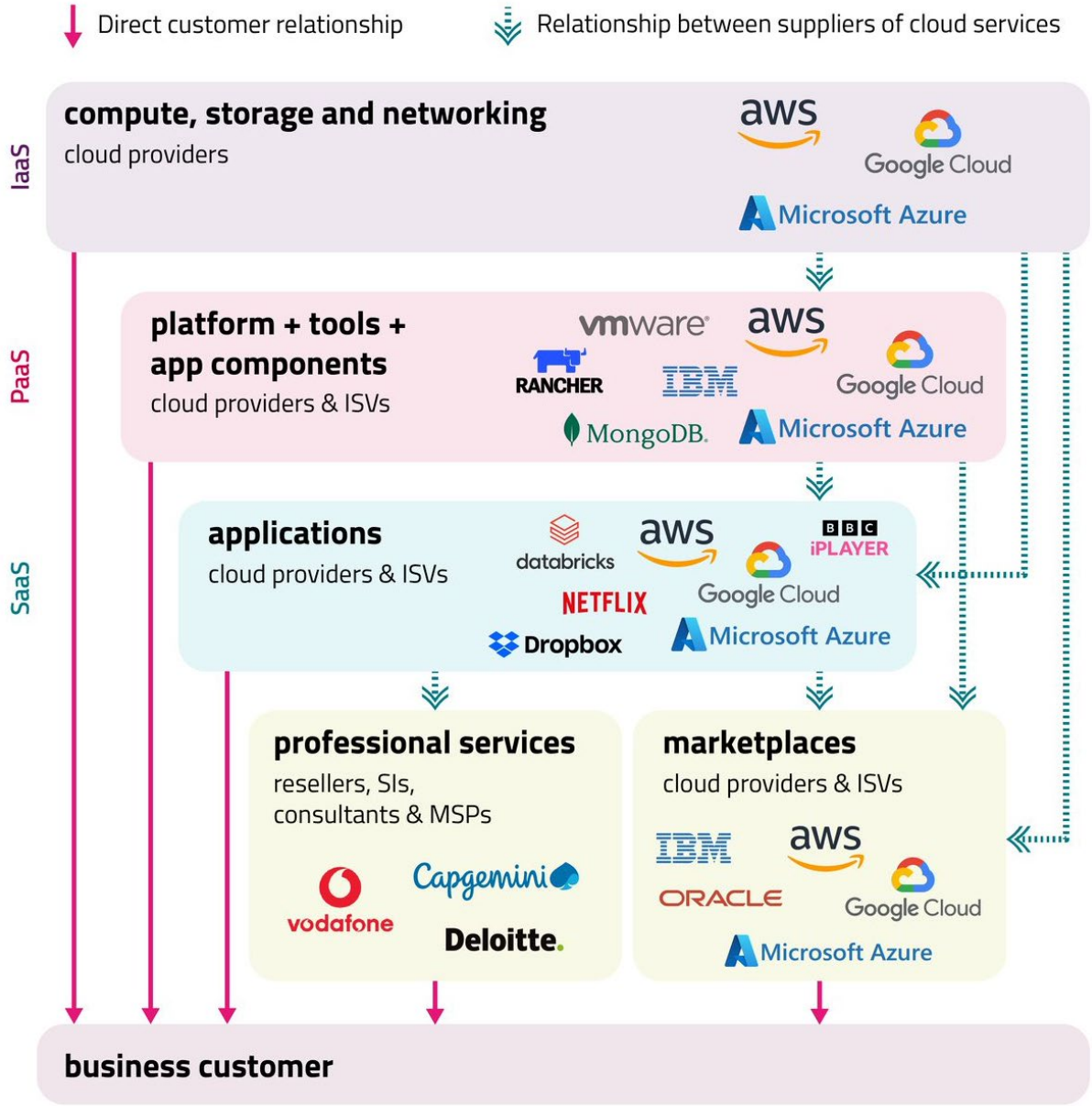
3.13 We intend to focus mainly on public cloud, although as discussed in Section 4 there are aspects of our analysis that will also be informed by private cloud and by different combinations of deployment models (see for example the discussion of multi-cloud below).

Suppliers of cloud services

3.14 The cloud services supply chain is complex, involving different types of suppliers at some or all levels of the cloud stack. Overall, the hyperscalers supply cloud services in all service and deployment models and, in effect, integrate the cloud supply chain in its entirety. This is illustrated in Figure 3.3 below.

[58] For example. IBM website. Private Cloud [accessed 30 September 2022] and Microsoft Azure website. What is a private cloud? [accessed 30 September 2022].

Figure 3.3: The cloud services value chain



Source: Ofcom.

Cloud providers

3.15 Cloud providers are vertically integrated suppliers of cloud services that operate their own cloud infrastructure, i.e. they own the underlying raw computing resources. These include the hyperscalers and a number of smaller companies.

3.16 In the UK, the three hyperscalers – AWS, Microsoft and Google – currently offer cloud services across the cloud stack and at scale.[59] In terms of revenues generated from the

[59] Globally there are other hyperscalers, such as Alibaba, Huawei and Tencent. However, they do not offer cloud services across the cloud stack and at scale in the UK.

supply of public cloud infrastructure services in the UK, AWS accounted for 40%, Microsoft for 25%, and Google for 16% of the total revenues in 2021.[60]

3.17 The remaining 19% of revenues associated with the supply of public cloud infrastructure services is made up of dozens of smaller cloud providers, including telecoms providers like BT and Colt. Some of these compete with hyperscalers across the cloud stack by offering cloud services from all three service models, e.g. Cloudera, OVHcloud and Oracle. Others keep their cloud infrastructure purely for their own use, and offer commercial services on one or two service models, e.g. Salesforce in customer relationship management PaaS.

3.18 For the three hyperscalers, cloud services sit within their wider business structure and each has different specialisms.

3.19 AWS is one of the operating segments of Amazon, the parent company of AWS. While AWS is Amazon's smallest operating segment by revenue, representing about 13% of Amazon's revenue in 2021,[61] it is the most profitable, accounting for almost 75% of Amazon's operating profits in 2021.[62] AWS revenue grew by 37% in 2021. AWS is perceived as the overall market leader in cloud, offering the cheapest price for access to raw computing resources (i.e. IaaS) and the widest ecosystem of services and partners.[63] We also understand that AWS is used by a number of broadcasters as it has a rich range of services to support this sector.[64] AWS is continuously launching new cloud services and partnerships, with an increasing focus on AI/ML.[65]

3.20 Microsoft Azure is part of Microsoft's Intelligent Cloud operating segment.[66] In the year to June 2022, Intelligent Cloud was Microsoft's largest operating segment by revenue and profit, ahead of Microsoft's Productivity and Business Processes and More Personal Computing segments.[67] Microsoft reported that revenue for Azure and other cloud services grew by 45% in the year to June 2022.[68] Microsoft is generally considered to be the second largest cloud provider and Azure is often perceived as the best cloud for running Microsoft software.[69] This has led many organisations that run non-cloud Microsoft software (e.g.

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[60] Synergy Research Group, 4Q 2021 Cloud Infrastructure Services United Kingdom Market Share Report, March 2022. Synergy's definition of cloud infrastructure services includes public cloud services (IaaS and PaaS) and managed private cloud services (bare metal, IaaS and PaaS). The figures quoted above do not include managed private cloud services.
[61] Amazon's other operating segments are North America (60% of revenue in 2021) and International (27%). These segments largely consist of revenues from retail sales of consumer products.
[62] Amazon, 2021. Annual Report [accessed 30 September 2022].
[63] For example. Datamation, 2021. AWS vs. Azure vs. Google Cloud: 2022 Cloud Platform Comparison [accessed 30 September 2022].
[64] AWS website. Netflix Case Study [accessed 30 September 2022]; AWS website. BBC Uses Shared File Storage to Migrate Red Button Application to the AWS Cloud [accessed 30 September 2022]; and AWS website. ITV Case Study [accessed 30 September 2022].
[65] For example. AWS website. AWS Named a Leader in 2022 Gartner Magic Quadrant for Cloud AI Developer Services [accessed 30 September 2022].
[66] Microsoft 10-K for year ending June 2022 says that its Intelligent Cloud segment primarily comprises of i) server products and cloud services, including Azure, SQL Server, Windows Server, Visual Studio, System Center and related Client access licences, Nuance and GitHub and ii) Enterprise Services, including Enterprise Support Services, Nuance Professional Services and Microsoft Consulting Services.
[67] Microsoft 10-K for year ending June 2022. Intelligent Cloud represented 38% of revenue and 39% of Microsoft's operating profit in the year to June 2022.
[68] Microsoft 10-K for year ending June 2022, page 42.
[69] For example. Datamation, 2021. AWS vs. Azure vs. Google Cloud: 2022 Cloud Platform Comparison [accessed 30 September 2022].

Microsoft Office) to migrate to their Azure alternatives (e.g. Microsoft Office 365). Microsoft is also popular among large enterprises with about 95% of Fortune 500 businesses using Azure.[70]

3.21 Google Cloud is one of the operating segments of Alphabet, the parent company of Google. It has so far been loss-making, representing just over 7% of Alphabet's total revenue in 2021. However, Google Cloud has been growing fast, with 47% growth in 2021 (faster than any other Alphabet business reported that year).[71] Google is perceived to be a market leader in the provision of AI/ML and data analytics in the cloud,[72] which may be reflected in its 20% share of UK revenue from public PaaS for analytical purposes.[73]

3.22 Compared to IaaS and PaaS, the SaaS segment is significantly more fragmented. There is much more diversity across SaaS services, market features and suppliers, and the segment is not characterised by the same level of concentration that we see in IaaS and PaaS. In 2021 the hyperscalers' share of global revenue in the 'SaaS – Applications' market (i.e. the SaaS segment as we define it) was under 18%.[74]

3.23 Smaller cloud providers may also partner with hyperscalers by offering complementary cloud services. For example, IBM, Oracle and VMware compete with hyperscalers by offering public cloud services across the stack but at the same time partner with them to offer multi-cloud capabilities.[75] We note that, in this configuration, such cloud providers may also be considered ISVs.

3.24 Other companies – including Apple and Meta – also own cloud infrastructure (alongside using third-party cloud services) and offer SaaS (e.g. iCloud and Facebook). However, their services are mostly directed to individual customers, rather than business consumers, and they are not generally active in the supply of IaaS or PaaS.

Independent software vendors

3.25 ISVs are suppliers of cloud services, typically PaaS and/or SaaS, that do not own any of the underlying raw computing resources. ISVs may complement the services of vertically integrated cloud providers, including hyperscalers, and/or directly compete with them.

3.26 ISVs typically use IaaS from other cloud providers in order to develop one or more downstream cloud services. For example:

- ISVs may use third-party IaaS to provide an independent PaaS virtual environment, e.g. IBM and VMware;

[70] Forbes, 2022. Microsoft Stock: Azure Growth Proves Resilient [accessed 30 September 2022].
[71] Aphabet 2021 Annual Report [accessed 30 September 2022].
[72] For example. Datamation, 2021. AWS vs. Azure vs. Google Cloud: 2022 Cloud Platform Comparison [accessed 30 September 2022].
[73] Synergy Research Group, 4Q 2021 Cloud Infrastructure Services United Kingdom Market Share Report, March 2022.
[74] IDC Worldwide Semmiannual Public Cloud Services Tracker, 2H 2021 [accessed 30 September 2022]. The 'SaaS – Applications' market is defined by IDC and is distinct from the 'SaaS – System Infrastructure Software' market.
[75] IBM website. Modernize infrastructure for increased agility with cloud services [accessed 30 September 2022]; OCI website. Oracle and Microsoft Strategic Partnership FAQ [accessed 30 September 2022]; and VMware website. What Is Hyperconverged Infrastructure? [accessed 30 September 2022].

- ISVs may use third-party IaaS to provide individual PaaS services (computing platforms and/or pre-built app components and tools), e.g. MongoDB and Redis Labs; or
- ISVs may use third-party IaaS (and potentially PaaS) to provide SaaS, for example some data lakes offerings by Databricks and some data warehouses offerings by Snowflake.[76]

3.27 Some ISVs only use IaaS and/or PaaS from one specific third-party cloud provider (e.g. Engine Yard's PaaS and Guidewire's PaaS integrate with AWS only[77]), while others are positioning themselves as 'cloud-agnostic' as their services can integrate with several clouds to offer multicloud capabilities (including IBM and VMware, which we discuss above).

Suppliers of professional services

3.28 Suppliers of professional services support the whole process of using cloud services, including developing a cloud strategy, choosing providers, implementation and ongoing management. They bring value to customers particularly those whose IT needs are more complex. There are different types of such suppliers (although a single supplier may use more than one route to market):

- **License approved resellers** resell cloud services from cloud providers, e.g. Optima Connect.
- **Service integrators (SIs)** offer services from various cloud providers, typically hyperscalers, via an online portal that acts as a one-stop-shop for customers, e.g. Vodafone.
- **Consultants** provide advice to business customers on their use of the cloud, e.g. Capgemini, Deloitte. This may include advice on any aspect of using cloud services, including choice of supplier, migration of traditional IT , security, and ongoing management and support.
- **Managed service providers (MSPs)** provide IT services, such as app development and app management, e.g. Capgemini, Deloitte. MSPs may be considered ISVs that only offer services on request as opposed to launching public offerings.

Key trends in cloud services

3.29 As discussed, above, we expect that take-up of cloud services will continue to grow and accelerate.

3.30 An increasing proportion of businesses and other organisations globally are using cloud computing in some form.[78] Spend on cloud is also increasing as a proportion of total IT spend. As noted above, in 2018, less than 10% of all businesses' IT spend globally was for

[76] A data lake typically holds unstructured data and is used for discovering and modeling relationships among data. A data warehouse typically holds structured data and is optimised for gaining insights from data that is well-understood. The two design types are starting to overlap, for example with the emergence of data lake houses. See GoldenSource website. GoldenSource 101: Data Lake vs Data Warehouse [accessed 30 September 2022].
[77] Engine Yard website. Easy Application Deployment to AWS [accessed 30 September 2022]; and Guidewire website [access 30 September 2022].
[78] For example, see Flexera 2022. State of the Cloud Report [accessed 30 September 2022]. Figures 16-23.

public cloud services.[79] There is still the potential for significant growth, with one analyst expecting 45% of businesses' IT spend globally to be on public cloud by 2026.[80]

3.31 In addition, cloud services continue to evolve, including in relation to technology, services and customers' strategies. This highlights the importance of taking a forward-looking approach for this market study.

3.32 In relation to market trends, so far we observe an acceleration of public cloud take-up as businesses become more comfortable with using public cloud over using private cloud deployments (e.g. as security concerns are addressed).[81] At the same time, hybrid cloud is growing due to the continuing importance of private cloud for specific workloads and/or data (e.g. for migrating some traditional IT to the cloud, or for running latency-sensitive workloads close to the end-user).[82] We also observe an acceleration of SaaS take-up as businesses seek to outsource more of their IT.[83]

3.33 In relation to new technologies, there is new hardware emerging such as quantum computers[84] and new cloud services emerging such as the PaaS called Function as a Service.

3.34 Most analysts consider two ongoing trends to be key for the future of cloud services: multi-cloud and edge cloud.[85] We discuss these below before we consider how developments in cloud impact on our core markets of telecoms and broadcasting.

Multi-cloud

3.35 Multi-cloud involves the use of more than one cloud provider by a single customer. This can be in any combination of the deployment models: public, private, and hybrid – including using multiple providers of the same model, and mixing and matching between models. Multi-cloud can be facilitated by the use of open standards and open source software. They make cloud services more interoperable by disclosing information necessary for the integration of cloud services, such as the application programming interfaces (APIs).[86]

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[79] Gartner, 2018. IT Key Metrics Data 2019: Executive Summary.
[80] Gartner, 2021. Press release. Gartner Says Four Trends Are Shaping the Future of Public Cloud [accessed 30 September 2022].
[81] Flexera, 2022. State of the Cloud Report [accessed 30 September 2022]. Figures 15-17 and 23.
[82] Flexera, 2022. State of the Cloud Report [accessed 30 September 2022]. Figures 9-10 and 14.
[83] Flexera, 2022. State of the Cloud Report [accessed 30 September 2022]. Figures 25-26 and 75.
[84] In a recent paper, the Financial Stability Institute of the Bank for International Settlements said that "Big techs' investments in emerging technologies such as quantum computing are likely to deepen their critical role in the financial system. While this technology is at an early stage, it has huge promise." It noted that "experts envisage that few companies will be able to build or own quantum computers in the near term and see a cloud computing-style model emerging where companies rent access to quantum machines hosted by a relatively small number of specialist providers". Financial Stability Institute, 2022. Big tech interdependencies – a key policy blind spot [accessed 30 September 2022].
[85] For example. Gartner, 2021. Press release. Gartner Says Four Trends Are Shaping the Future of Public Cloud [accessed 30 September 2022]; Gartner, 2021. Gartner Predicts the Future of Cloud and Edge Infrastructure [accessed 30 September 2022]; and Frost & Sullivan, 2021. Top 4 Growth Opportunities in the Cloud Industry for 2022 [accessed 30 September 2022]. Also Flexera, 2022. State of the Cloud Report [accessed 30 September 2022]. Figures 9-14 and 58..
[86] ACM, 2022. Market Study Cloud services [accessed 30 September 2022]. Section 2.4.

3.36 Multi-cloud use may be driven by several factors. Businesses may use multi-cloud to ensure higher resilience by avoiding reliance on a single cloud provider. Or, multi-cloud may offer them greater flexibility in deploying the most relevant cloud solutions across different departments and functions.[87]

3.37 It is not clear to us at this stage to what extent businesses are able to take advantage of multi-cloud to gain these benefits, or do so in practice. The most common implementation of multi-cloud has different applications running on different clouds, as opposed to a single application working across multiple clouds.[88] This type of multi-cloud use is less likely to facilitate switching, particularly where there is limited meaningful choice for each category of services.

Edge cloud

3.38 Edge cloud refers to processing workloads and storing data close to the edge of the telecoms network, i.e. the physical location where users connect with the telecoms network and so within the local access network, reducing data travel time and thereby reducing latency. In the context of a mobile telecoms network, this is known as mobile edge computing (MEC).[89]

3.39 Edge computing has been highlighted as a major future trend in the cloud sector by most analysts and industry players. This is connected to two other technology trends: the rollout of 5G connectivity and IoT. Edge computing will benefit from the low latencies offered by 5G networks. This will lead to the deployment of new services, including IoT, which could involve the expansion of data storage and processing at the network edge.

3.40 At the forefront of edge computing is the Industrial IoT (IIoT), impacting numerous sectors and industries, including healthcare, transportation, defence, energy, aviation, manufacturing, mining, oil and gas, natural resources, telecoms and utilities. These sectors and industries generate large quantities of data that are more efficiently filtered, analysed and acted on using edge cloud services.[90] As IoT activity increases, the volume of data and the need for processing will extend rapidly requiring major developments in edge cloud services.

3.41 All hyperscalers currently offer edge cloud products and services, including Amazon Outpost, Microsoft Azure Stack and Google Anthos.[91] These are essentially bundles of servers and software that can be deployed at the edge with minimum IT skills and infrastructure management.

[87] Gartner, 2019. Why Organizations Choose a Multicloud Strategy [accessed 30 September 2022].
[88] Flexera, 2022. State of the Cloud Report [accessed 30 September 2022]. Figure 11.
[89] Also known as multi-access edge computing. See Discussion paper: Ofcom's future approach to mobile markets, pages 44-47.
[90] Gartner, 2018. The Edge Completes the Cloud: A Gartner Trend Insight Report. Pages 21-22.
[91] AWS website. AWS Outposts Family [accessed 30 September 2022]; Microsoft Azure website. Azure Stack [accessed 30 September 2022]; and Google Cloud website. Anthos [accessed 30 September 2022].

Implications for the communications sector

3.42 In relation to telecoms, we expect telecoms providers to increase their use of cloud infrastructure to run network functions that have been virtualised (virtualised network functions or VNFs).[92] This way they can deliver a more flexible, scalable and cost-efficient network. As noted above, all major UK telecoms providers are using private cloud deployments to operate their fixed and mobile networks and deliver communications services. For example, Three has launched a virtualised core network running from 20 of its own data centres[93] and Vodafone is self-supplying its 5G core network in partnership with VMware.[94]

3.43 As the public cloud sector matures, we expect telecoms providers to move some or all of their network functions to the public cloud. Indeed, some telcoms providers in other countries are already using hyperscalers' public cloud infrastructure, such as the partnership between mobile network operator Dish Wireless and AWS in the USA.[95] We may also see telecoms providers sourcing their VNFs from suppliers of cloud services, including hyperscalers. For example, Microsoft has recently acquired two companies that supply VNFs: Affirmed Networks and Metaswitch Networks.[96]

3.44 We also expect telecoms providers to increasingly deploy edge cloud infrastructure to support retail services (as opposed to VNFs). For example, they may be able to leverage their telco cloud deployments for this purpose, or expand their business model to include potentially leasing access to other suppliers of cloud services. In doing so, some may choose to partner with hyperscalers. For example, in June 2021, AWS and Vodafone made their mobile edge cloud services available to mobile users in London.[97]

3.45 In relation to broadcasting, we see an increasing use of cloud in live broadcasting. As noted above, UK broadcasters already use cloud services in content production and distribution. However, cloud services are not widely used in live broadcasts because the traditional software used in this process is not designed to work efficiently in the cloud. As the cloud matures, we expect broadcasters to increasingly move their live broadcast workloads to the cloud, either by adopting new cloud services tailored for broadcasters or by redesigning and migrating their traditional software to the cloud.

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[92] Network virtualisation decouples the network functions, for example policy control, from the underlying hardware by converting them into software (i.e. VNFs) which can run on general-purpose servers such as the ones used in the cloud. Current network virtualisation typically refers to the core network being implemented in software but increasingly network virtualisation will be used for parts of the radio access network (RAN).
[93] ISPreview, 2019. Three UK Launch Live Fully Integrated Cloud Core Network – 5G Ready [accessed 30 September 2022].
[94] Vodafone, 2021. Technology news. Vodafone and VMware extend strategic partnership to accelerate release of new network features using one scaled platform [accessed 30 September 2022].
[95] In the US, DISH, has entered into a strategic partnership with AWS to provide a cloud-based network (Amazon, 2021. Press release. DISH and AWS Form Strategic Collaboration to Reinvent 5G Connectivity and Innovation [accessed 29 September 2022]). In addition, AT&T, has moved its 5G core to Microsoft Azure after Microsoft acquired AT&T's network cloud business (Microsoft, 2021. AT&T to run its mobility network on Microsoft's Azure for Operators cloud, delivering cost-efficient 5G services at scale [accessed 29 September 2022]).
[96] Microsoft website. Microsoft announces agreement to acquire Affirmed Networks to deliver new opportunities for a global 5G ecosystem [accessed 30 September 2022] and Microsoft announces definitive agreement to acquire Metaswitch Networks, expanding approach to empower operators and partner with network equipment providers to deliver on promise of 5G [accessed 30 September 2022].
[97] AWS website. Announcing general availability of AWS Wavelength in London [accessed 30 September 2022].

4. Scope and structure of the market study

4.1 The objective of this market study is to examine whether the markets for cloud services in the UK are working in the interests of consumers. We want to understand where competition concerns exist today, or could arise in the future, that may lead to consumer harm. We will then, at a high level, consider how any such concerns could be addressed, while recognising that a full examination of potential remedies would be the subject of separate further work.

4.2 We will look at how the market is working today and how we expect it to develop in the future. Taking future developments into account is particularly important in this study given the sector is still evolving, and there may be scope to identify potential competition issues before they become embedded.

High-level scope and structure

4.3 The cloud is a complex and varied sector encompassing many different complementary services and modes of deployment. Our objective is to shed light on how competition works in this evolving area and concentrate on where we see greatest potential for concern.

4.4 We plan to focus on public cloud, and specifically on **public cloud infrastructure services**, as it is this set of cloud services that form the basis of so many services delivered over the internet. Cloud infrastructure services include all IaaS and PaaS supplied to business customers. Those customers include ISVs, which rely on cloud infrastructure services to build their own offerings. Any competition concerns in this segment have the potential to have far-reaching effects across a wide range of services in the economy to the detriment of UK consumers.

4.5 The adoption of these services represents the biggest transformation to the way that businesses buy computing resources, one which is still ongoing. Public cloud services mean businesses no longer need to own and operate their own data centres, and as discussed in paragraph 3.32, there is further scope for businesses that currently use private cloud on their own data centres to shift some or all of their activity into public cloud. This means that the importance of public cloud infrastructure services can only grow further as the sector matures.

4.6 The public cloud infrastructure services segment also exhibits a distinct set of market features that can raise barriers to entry and expansion. These include economies of scale in relation to IaaS, and network effects associated with PaaS. Relatedly, we observe that the public cloud infrastructure services segment is where economic activity is most concentrated, with the hyperscalers accounting for the majority of sales. We therefore believe that there is merit in focusing our efforts on public cloud infrastructure services as a priority.

4.7 At this stage we believe the market features and players in public cloud infrastructure services are sufficiently distinct that we can focus our analysis of any competitive concerns here. The SaaS segment is much more diverse in terms of services, market features and

suppliers. The private cloud segment also seems to exhibit different market features and is expected to remain a small proportion of all cloud services, as businesses become more comfortable with using public cloud for sensitive workloads and data (e.g. as security concerns are addressed).[98] Accordingly, we do not plan to look specifically at competition in the supply of particular types of SaaS or private cloud products.

4.8 That said, we acknowledge that many of the same suppliers, including the hyperscalers, offer all types of cloud. While we will be led by the evidence, at this stage we anticipate reflecting on other services as follows:

- We will explore the extent to which SaaS-only or private cloud-only providers may provide an entry constraint on existing public cloud providers, as well as any scope for potential competition concerns in public cloud to have an impact on either of these segments.
- We will look at the SaaS layer where it is relevant to a hyperscaler's position in cloud infrastructure services, as well as its relevance to the development of cloud ecosystems and the impacts this has on competition across all cloud services.
- While we are taking a broad view across the different sectors that make use of cloud services, we will have a particular focus on any implications for outcomes in the telecoms and broadcasting sectors.

4.9 We will structure our assessment as follows:

- **Competitive dynamics in cloud services:** a review of how competition works, by examining customers' preferences and behaviour and how suppliers compete for these customers across the cloud value chain.
- **Assessment of possible competition concerns:** building on our understanding of the cloud value chain and competitive dynamics, we will examine whether the markets for cloud services are working well for consumers by focusing on two interrelated themes: cloud infrastructure services competition and cloud ecosystems competition.
- **Potential outcomes and remedies:** outlining the possible outcomes of this market study and the potential next steps should our assessment indicate intervention is necessary.

Question 4.1: Do you agree with the scope of the market study?

Competitive dynamics in cloud services

4.10 In this section we will look at competitive dynamics in cloud services, initially assessing the current situation in terms of how customers decide to use cloud, how they choose between providers and how cloud services are bought and sold. We will examine the presence of the main cloud providers across the value chain, and whether they have particular strengths or different areas of focus, including the impact of cloud ecosystems on the competitive landscape.

[98] Flexera, 2022. State of the Cloud Report [accessed 30 September 2022]. Figures 15-17 and 23.

Customer use of cloud

4.11 Businesses across the UK economy use cloud in many different ways. Our initial engagement with stakeholders suggests that customers may consider some of the following aspects when deciding to use cloud services:

- **Business requirements.** Customers may need to consider which cloud services could meet the specific needs of their use-cases. For some customers, the cost of storage is a priority consideration because workloads will generate large amounts of data. While many of these different requirements will be catered for by the cloud providers within their standard offerings, some customers may need to engage with cloud providers to understand their needs and identify the types of services that would support their use-cases.
- **Deployment model.** Customers may need to identify the IT functionalities they need and whether these can be delivered through a specific deployment model (private cloud, public cloud or hybrid cloud). This decision may be influenced by factors such as the capacity of their in-house hardware, the skills of their staff and whether they are already using cloud services.
- **Level of control.** Customers need to choose the level of control they would like to have over the cloud service they will use. For example, cloud storage can be provided as IaaS (e.g. a virtual machine with certain storage capacity) in which case the customer needs to deploy and manage its own software for data management. At the other end of the scale, cloud storage can be provided as SaaS (e.g. Snowflake's Data Cloud) in which case the customer does not need to deploy and manage any software. This decision may be influenced by factors such as the need for bespoke features (e.g. if there are no appropriate SaaS available they may develop their own using PaaS), their end-user needs (e.g. if they want to offer SaaS to end-users they are more likely to use PaaS) and the availability of IT skills in-house.
- **Number of cloud providers.** Customers may wish to decide on whether they follow a multi-cloud strategy. Customers will likely need to consider trade-offs between a centralised approach where there may be efficiencies to using a single provider for most of their cloud usage, versus a diversified approach where they use multiple providers which may provide more choice or flexibility.

4.12 As part of our analysis, we will examine how cloud usage may vary with the size, use case or technical sophistication of the customer. For example, we will consider the importance of having skilled employees or existing relationships with providers in deciding to use cloud infrastructure services (IaaS and/or PaaS).

4.13 We will also consider how the maturity of customers' businesses may affect their cloud usage. For example, we will examine whether newer businesses may find it easier to use public cloud for all of their IT needs, whereas businesses that have existed for some time may be more likely to continue to run traditional IT alongside cloud.

4.14 Finally, we are keen to understand the various points of entry different customers have when buying public cloud services and how this might affect their choice of supplier.

How customers choose cloud providers

4.15 We will examine how suppliers of cloud services compete to inform our assessment of how well markets are working for customers and help us to identify potential competition issues. This will involve a consideration of the parameters of competition, which are the features that customers are concerned with when choosing suppliers. Based on our review of existing research and international market studies, we think these features are likely to include:

- **Pricing/costs:** the potential to reduce costs by moving to usage-based pricing is commonly cited by customers as a key motivation for using public cloud. The potential to optimise costs is also important as customers continue to increase their spend on cloud.[99] Studies indicate that transparency and predictability of costs for different levels of cloud usage may also be an important factor for some customers.
- **Ease of integration:** research suggests that the ability to easily integrate cloud services with existing IT infrastructure (i.e. traditional IT or private cloud environments) may be another relevant factor for customers when choosing cloud providers. In addition, the ability to run software that interoperates with other cloud services or requires data to be exchanged with another cloud platform may be important.
- **Reputation and existing relationships:** customers must trust that their data and workloads will be secure and accessible. The ability of cloud providers to handle large amounts of data and their track record of service availability may be an important factor for some customers. The level of customer service being offered and established relationships between customers and providers in other markets may also be a consideration. For example, in the Dutch market study, the ACM found that the majority of businesses interviewed tended to choose a particular cloud provider due to a previously established relationship.[100]
- **Geographic reach:** some customers may value the global reach of larger providers' cloud infrastructure where this reduces the need to use multiple providers in different territories. The ability to host and process data in certain regions may be important for legal, regulatory or for technical reasons (e.g. data centres located close to end-users to provide low latency services).
- **Range of services:** this is the choice of services a customer has when using a particular cloud provider. Some customers may particularly value 'must-have' services that only certain cloud providers offer, whilst others may particularly look out for the breadth of cloud providers' service catalogues as they value the convenience of being able to purchase all of their cloud services from a single provider.

[99] Flexera suggest that companies expect their spend to further increase on average by 29% in the next year. Flexera, 2022. State of the Cloud Report [accessed 30 September 2022]. Figure 37.
[100] ACM, 2022. Market Study Cloud services [accessed 30 September 2022]. Page 26-27.

How cloud services are bought and sold

4.16 We will also examine how cloud services are sold and any buying patterns. This includes the factors that determine whether customers purchase from suppliers of professional services or directly from cloud providers.[101]

4.17 In addition, we will consider customer usage of the various pricing options cloud providers make available. These can include:

- **On-demand:** where customers pay for compute/storage capacity on a 'pay-as-you-go' basis by the hour or second.
- **Spot instances:** where customers use spare computing capacity at the discretion of the cloud provider at a cheaper rate than on-demand.
- **Reserved instances:** where customers receive cheaper rates compared to on-demand for committing to a certain configuration or amount of usage for a specified term, typically one to three years.

4.18 Our initial understanding is that, in general, most customers do not negotiate with cloud providers to alter how their services are constructed or to make engineering changes. However, we are keen to understand the extent to which customers can negotiate other aspects such as price or terms and conditions. In the Dutch market study, the ACM found that in practice companies often hardly have any scope for negotiating conditions and tariffs, and therefore to protect themselves from the potential consequences of lock-in.[102]

Nature of competition

The market position of different cloud providers

4.19 We will then examine the presence of the main cloud providers along the value chain, and whether they have particular strengths or different areas of focus. We will also explore where cloud providers supply inputs to ISVs, and the extent to which these same providers compete with ISVs in PaaS or SaaS. For example, Databricks provides data lake services that integrate with AWS IaaS and PaaS services. AWS in turn offers its own data lake services with its Redshift offerings.

4.20 This will inform whether we should assess competition for cloud infrastructure services as a whole or separately for each of the IaaS and PaaS segments. We anticipate that such a distinction will prove relevant as we understand that several cloud providers specialise only in PaaS (e.g. IBM and VMware), suggesting that there may be different competitive dynamics in each of these segments. We will also assess the extent to which PaaS-only providers can self-supply cloud infrastructure as opposed to relying on IaaS providers, to understand how competition in IaaS may shape outcomes in PaaS.

4.21 Separately, we will examine whether there are any differences in providers' areas of strength that indicate a need to segment our competitive assessment according to

[101] Flexera state that 57% of all organisations use MSPs for at least some public cloud usage, with 26% using MSPs for most of their public cloud usage. Flexera, 2022. State of the Cloud Report [accessed 30 September 2022].
[102] ACM, 2022. Market Study Cloud services [accessed 30 September 2022]. Page 64.

customer needs. For example, we understand that AWS currently accounts for most cloud sales to UK broadcasters, while smaller customers are more likely to favour Microsoft. We will explore whether such differing areas of strength indicate that some providers are better suited to designing bespoke solutions for customers with more specific use-cases, or offer must-have cloud services for a significant number of customers with a particular use-case. We anticipate that such an assessment is likely to focus on a few sectors or use-cases only, rather than cover the wide variety of customers comprehensively.

4.22 Finally, we want to assess the impact of suppliers of professional services in shaping competition in public cloud infrastructure services. We want to explore to what extent these professional services may have a role in facilitating competition between cloud providers, for example by providing the relevant technical skills and know-how a customer may lack to help them switch or multi-source, and whether this is relevant for all cloud customers or only some.

Ecosystems competition

4.23 One of the main themes of our study will be the impact of cloud ecosystems on the competitive landscape for cloud services. In general terms, an ecosystem can be understood as a collection of complementary products and services that work together to create utility for customers. Ecosystems also typically include an interface or gateway that intermediates multiple sides of the market, such as customers, hardware producers and software developers. For example, in the mobile ecosystems market study, the CMA identified several gateways between users and businesses – mobile devices and operating systems, app stores, and mobile browsers and browser engines – that Apple and Google control.[103]

4.24 We will consider how ecosystems may operate in cloud. Recognising that smaller cloud providers also offer their own ranges of complementary services, we will focus on the more comprehensive offerings of AWS, Microsoft and Google and how the various components of their cloud businesses work together to form their own ecosystems. These components are likely to include:

- The full-stack service offerings that each of the hyperscalers provides. These include the hardware that the hyperscalers operate to provide customers with the necessary raw computing resources to run workloads and store data (provided as IaaS), together with their PaaS suites, and SaaS including both first-party hyperscaler services and third-party ISV services.
- The unique cloud environments that each of the hyperscalers operate, i.e. the collections of programming languages, application frameworks and APIs that allow services across the cloud stack to work together. Similar to an operating system, it performs an intermediary function between ISVs who develop services for the cloud environment, and customers who use those services in combination with first-party hyperscaler services.
- The distribution channels for third-party services that the hyperscalers control. For example, each of the hyperscalers operate their own marketplace where customers

[103] CMA, 2022. Mobile ecosystems market study final report [accessed 30 September 2022].

can purchase third-party services that are compatible with their cloud environments (similar to mobile app stores). We understand that sales through marketplaces are currently relatively small compared to direct sales. Beyond marketplaces, hyperscalers may also have a role in controlling distribution in other ways, for example, by including third-party services in packaged solutions offered to customers.

4.25 We will examine how cloud providers, and hyperscalers in particular, offer a range of services across the cloud stack (IaaS, PaaS, SaaS), and the extent to which they are complementary. A feature of the sector is the emergence of solutions that bring together portfolios of services across the service and deployment models of cloud.[104] We will also explore how the cloud businesses of the main suppliers fit into their wider business strategies and the focus and strategies of any cloud ecosystems that are developing. As the French Autorité de la concurrence discussed, the major players could take advantage of their well-established position in digital markets to promote their own expansion in cloud.[105]

Question 4.2: Are there other ways to those listed in paragraphs 4.11 to 4.14 in which customers use cloud services, and factors which determine their cloud usage, that we should examine?

Question 4.3: Do you agree that the features set out in paragraph 4.15 are the most important features for customers when choosing cloud services?

Question 4.4: Is our characterisation of how cloud services are sold and buying patterns correct at paragraphs 4.16 to 4.18? Are there other methods?

Question 4.5: Do you agree with our characterisation of competition for different types of services and customers? Are there any other aspects where competition may vary?

Question 4.6: What are your views on our characterisation of cloud ecosystems?

Assessment of possible competition concerns and consumer impact

4.26 We want to investigate whether any feature of the market, or the behaviour of providers, could dampen competition between suppliers and therefore have an adverse effect on business customers through higher prices, lower quality products or less innovation. This can be detrimental to UK consumers if this affects the quality or range of consumer products and services that are built on cloud, it may also lead to higher consumer prices if business customers were to pass on any higher costs they face to source cloud services.

4.27 We will focus our assessment on public cloud infrastructure services first, and capture the wider set of cloud services by analysing competition amongst cloud ecosystems.

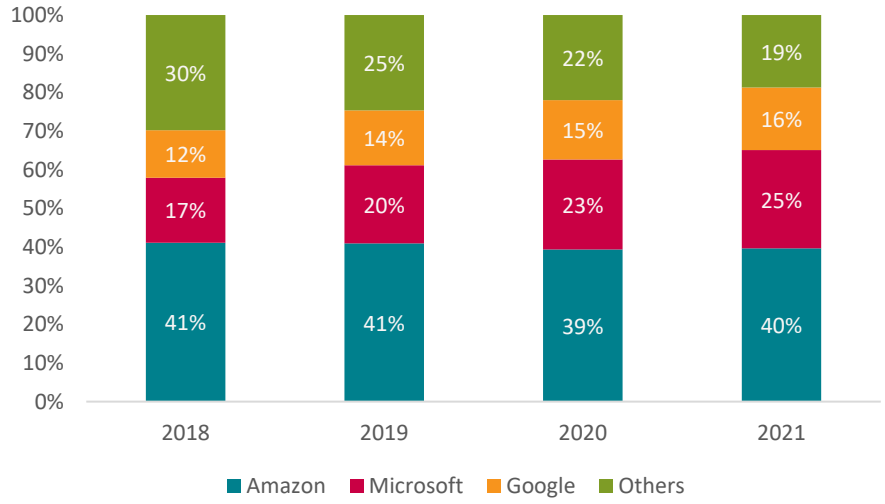
[104] As observed through the products offerings of AWS, Google Cloud, and Microsoft Azure [accessed 30 September 2022].
[105] Autorité de la concurrence, 2022. Public consultation paper on the operation of competition in the cloud computing Sector [accessed 30 September 2022].

Theme 1: cloud infrastructure services competition

4.28 Cloud infrastructure services include processing, storage, networking, and other fundamental computing resources (i.e. IaaS) as well as any services and tools that can be used to develop, test, run and manage applications in the cloud (i.e. PaaS).

4.29 Hyperscalers are present across IaaS and PaaS, and are the main providers of cloud infrastructure services. Figure 4.1 below provides a high-level view of the way in which the hyperscalers' positions in public cloud infrastructure services (by which we mean public IaaS and public PaaS services) have developed in recent years. These shares of supply[106] indicate that AWS has maintained its position as the largest provider. In contrast, Microsoft and Google have been building their shares of supply, resulting in smaller providers losing share in aggregate.

Figure 4.1: Shares of supply (by revenue) in public cloud infrastructure services, UK, 2018-2021[107]



Source: Synergy Research Group.

4.30 Under Theme 1, we will assess the strength of competition between cloud providers, and whether there are any indications of market power, either for cloud infrastructure services in general or for specific subsets of services (e.g. for IaaS and/or PaaS, or for specific service types such as compute, storage or databases, etc.). As part of this, we are particularly interested in understanding the strength of competition between hyperscalers, as well as the competitive constraints from smaller providers and potential new entrants.

[106] Based on Synergy UK revenue data. We recognise that the categorisation of services into IaaS/PaaS/SaaS has an important bearing on market share conclusions, and that categorisation is not always easy as some services will be on the boundary of more than one category. However we note that the Synergy UK market shares are broadly consistent with global market shares from Synergy and Gartner which indicate that hyperscalers represent c.70% of revenues. We plan to collect further information (e.g. through our statutory information gathering powers) to understand UK market shares during the course of the market study.

[107] Synergy Research Group, 4Q 2021 Cloud Infrastructure Services United Kingdom Market Share Report, March 2022. This analysis focuses on public cloud infrastructure and only includes public IaaS and public PaaS services. It does not include managed private cloud services, which is the other component of Synergy's Cloud Infrastructure Services dataset.

4.31 This will include examining the extent to which we should take account of any competitive constraints from outside cloud infrastructure services. This will include understanding constraints from the potential entry of private cloud providers, particularly where they already hold significant customer relationships that would afford them the scale to compete with hyperscalers in the public cloud infrastructure services segment.

4.32 To inform our assessment, we will consider whether there are any market features that can raise barriers to entry and expansion. These include:

- High capital costs together with economies of scale and scope to build and operate the necessary global cloud infrastructure may limit entry and/or expansion of smaller providers into cloud infrastructure services.
- Nature and scope of any network effects, whereby the more widely adopted a cloud service is, the more valuable it becomes as more customers become familiar with it and complementary services are designed to integrate with it.
- Barriers to multi-cloud and/or switching may reduce the intensity of competition for customers already buying cloud services. Such barriers may be related to the environments used by different cloud providers and the time and cost customers incur when migrating their workloads and data.

4.33 We will also assess whether there are any business practices that could raise further barriers to entry and expansion. The types of issues we propose to explore include:

- Whether barriers to moving data between cloud providers make it difficult for customers to switch or multi-source, or strengthen network effects. For example, egress fees, where cloud providers charge customers for extracting their data from their environments, have been identified in the Dutch,[108] French[109] and Japanese[110] cloud market studies as potentially significant barriers. We are also interested in understanding any technical barriers to moving data between different cloud providers that may arise due to, for example, the data formatting or APIs used by the hyperscalers.
- Whether a lack of interoperability between the hyperscalers' cloud services and those of others represents a significant barrier to switching or strengthens network effects. We will examine evidence on the possible factors that might limit interoperability, including the aspects of software or hardware that are specifically tailored to each hyperscaler's cloud platform, such that customers would need to extensively reconfigure their workloads to switch to (or multi-source from) another cloud platform.
- The extent to which hyperscalers can increase barriers to entry and expansion by tying-in desirable software with their clouds or limiting the ability to access such software on other clouds. For example, this may include examining the use of any exclusive partnerships between the hyperscalers and ISVs for certain desirable PaaS services.
- Whether the hyperscalers could use their vertical presence in IaaS to favour their PaaS businesses at the expense of ISVs who only offer PaaS services. This could include, for

[108] ACM, 2022. Market Study Cloud services [accessed 29 September 2022].
[109] Autorité de la concurrence, 2022. Public consultation paper on the operation of competition in the cloud computing Sector [accessed 30 September 2022].
[110] Japan Fair Trade Commission, 2022. Report Regarding Cloud Services [accessed 29 September 2022].

example, a hyperscaler self-preferencing where it directs its customers to its own PaaS services (rather than ISV services), or not providing the ISV with adequate access to its cloud environment.[111]

4.34 We will assess whether a combination of market features and business practices could favour the hyperscalers by making it difficult for other providers to enter the market and expand, and lead to a dampening of competition among these hyperscalers.

4.35 Concerns in relation to the intensity of competition in cloud infrastructure services, or any specific subsets, may lead to harm. This could include, for example:

- Customers who have an existing relationship with a cloud provider becoming locked-in due to significant barriers to switching/multi-cloud, limiting the ability of rival providers to exert a competitive constraint on the existing provider.[112] This may result in customers facing higher prices or lower quality of service.[113] It may also limit the ability for new entry, leading to reduced choice for customers. Existing providers may also have less incentive to innovate and improve existing products or introduce new ones.
- Ineffective competition in IaaS may increase the input costs of ISVs or in the worst case undermine their business cases. This could distort competition in PaaS, leading to higher prices or lower quality. It could also reduce entry and innovation in PaaS, further reducing the amount of choice available to customers.

4.36 We will look at both how the market is operating today and how we expect it to develop in future in recognition that the market is growing, with a fast pace of technological development which could result in the market positions of providers changing over time.

Theme 2: cloud ecosystem competition

4.37 Under our second theme, we will seek to develop a better understanding of how the hyperscalers might develop and grow their cloud ecosystems, and the impact that this could have on competitive intensity as the sector matures.

4.38 Customers can benefit from the development of cloud ecosystems. They can result in a better customer experience, where customers can purchase all their services across the cloud stack from a single provider and expect that different products will be seamlessly integrated. Being able to research and purchase services in one place (which could be a marketplace) can also reduce search costs and potentially be pro-competitive as it allows customers to compare and choose from multiple third-party offerings. It could also

[111] For an ISV to gain adequate access to a hyperscaler's cloud environment, their service is likely to need a certain level of interoperability with the other services in the hyperscaler's environment, and the ISV may need the ability to distribute their service through the hyperscaler's sales channels (e.g. its marketplace).
[112] We note that the Dutch market study identifies cases of strong competition where customers make their initial choice of cloud infrastructure with providers offering incentives (e.g. credits to trial cloud services), but difficulties faced by customers in switching provider, either partially or wholly, once that path has been chosen. ACM, 2022. Market Study Cloud services [accessed 29 September 2022]. Page 55.
[113] Weakened competition in IaaS could also result in customers experiencing lower resilience and security for the data they store with cloud providers, as a lack of competitive pressure could reduce the incentives for providers to continue to invest in the resilience and security of their infrastructure. In the long term, this could result in security breaches or outages becoming more common.

potentially result in lower prices for solutions if hyperscalers pass any realised efficiencies onto customers.

4.39 However, the development of cloud ecosystems could also distort competition and result in harm to customers. The features that might make an ecosystem attractive (e.g. seamless interoperability, cost efficiencies, product discovery centralisation) can also make it more difficult for customers to switch. Cloud ecosystems may also result in the creation of gatekeepers, with ecosystem owners controlling the entry point to reach cloud customers, as the CMA found with mobile ecosystems.[114] This could have implications for ISVs who may become reliant on the hyperscalers as their route to market, and for customers as a whole, who may find themselves locked into commercial arrangements that no longer offer the best value or do not best meet their requirements.

4.40 Building on our knowledge of the business models of the hyperscalers, we will explore how cloud ecosystems are influencing the way customers buy cloud services. This includes understanding whether hyperscalers' ecosystems are built around a particular core service or strength, which brings customers on to their ecosystem. For example, we want to understand the role of the hyperscalers' SaaS services such as Microsoft's Office 365 or Google's provision of AI/ML and data analytics offerings, in bringing customers into their ecosystems and selling complementary cloud services that run on their respective cloud infrastructures.[115] AWS's strength appears to be in cloud infrastructure, where it has the largest share of supply, and we will explore the extent to which this allows it to sell complementary products across the cloud stack.[116]

4.41 We will also examine whether the way in which the hyperscalers design, support and price their services enhances the attractiveness of purchasing solutions exclusively from them, as opposed to customers building their own solutions from different suppliers, including ISVs. For example, in an 'open' ecosystem design, multiple cloud services from different suppliers could be seamlessly used within a hyperscaler system, whereas a more 'closed' ecosystem might involve a hyperscaler offering superior pricing or technical support if the customer runs the service on their cloud infrastructure, or limiting interoperability with third party products in various ways.

4.42 We will look at how the impact of ecosystems on customers' choice might in turn shape competition by:

- Increasing barriers to switching if customers want to switch a larger number of services. This may also impact future purchasing decisions, by encouraging customers to stay within the ecosystem and discouraging multi-cloud use.

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[114] In the mobile ecosystems market study, the CMA found that Apple and Google are the gatekeepers to everything coming through mobile phones, which places them in a powerful position. Both firms are well placed to leverage their position into other markets linked to their ecosystems and that it was very hard for firms to enter and compete effectively.
[115] A report by Gartner found that "enterpises often have strategic alignments with Micosoft, giving Azure significant sales advantages" and that "clients continue to associate Google Cloud with its big data and data science capabilities". Gartner, 2020. Magic Quadrant for Cloud Infrastructure and Platform Services.
[116] Gartner notes that "AWS has the skills, resources and motivations to veritically integrate and deliver solutions to customers end to end". Gartner, 2020. Magic Quadrant for Cloud Infrastructure and Platform Services.

- Making ISVs dependent on hyperscalers' ecosystems as a key route to market, requiring ISVs to develop solutions for particular hyperscalers in order to access customers at scale. This might reinforce the ecosystem as customers are then more inclined to remain with the ecosystem that provides access to a range of third-party offerings.
- Limiting the ability of suppliers of professional services to facilitate switching or multi-cloud use. We will explore whether cloud ecosystems could restrict the role of third parties in shaping competition if the hyperscalers are able to control access to customers (either through marketplaces or directly).

4.43 We will then explore the extent to which any of the above features may raise competition concerns.

4.44 First, we will explore whether the development of cloud ecosystems might risk dampening competition across the cloud stack. In particular, the individual impacts on customers and ISVs identified in paragraph 4.42 may become mutually reinforcing and may keep them locked into a particular ecosystem, reducing competitive intensity across different cloud ecosystem providers. In the extreme, this could result in the market tipping towards a single ecosystem provider or we may find that several ecosystems emerge in different segments of the market with limited competition between them.

4.45 Second, we plan to assess whether the development of cloud ecosystems may further strengthen the position of hyperscalers in cloud infrastructure services. This could happen if core SaaS products of the hyperscalers are bundled together with their cloud infrastructure services or if the ability of third-party cloud providers to access core SaaS products is restricted in some way, either through technical or financial means.[117] As the Autorité de la concurrence noted, these restrictions may be technical or pricing-related.[118] Such restrictions could also raise barriers to entry in cloud infrastructure services as entrants may have to provide services across the full cloud stack to compete effectively against the hyperscalers.

4.46 Finally, we will assess whether the vertically integrated hyperscalers have the potential to distort competition in the SaaS and PaaS layer. For example, SaaS-only suppliers may find it difficult to compete effectively against the bundled cloud offering of the hyperscalers. The Dutch market study found that customers often find it attractive to purchase multiple services from a single cloud provider because discounts depended on the number of different services purchased from the cloud provider.[119] To the extent that the hyperscalers gain control over the route to market, this might give rise to other concerns. For example, the hyperscalers may benefit from information advantages (such as gaining

[117] For example, in early 2022, competitors of Microsoft claimed that Microsoft's software licensing terms made it difficult and costly to run its products on rival cloud services. In response to this, Microsoft announced plans to change the terms of its software licensing agreements. Bloomberg UK, 2022. Microsoft Changes European Cloud-License Terms After Complaints [accessed 30 September 2022].
[118] Autorité de la concurrence, 2022. Public consultation paper on the operation of competition in the cloud computing Sector [accessed 30 September 2022]. Page 30.
[119] ACM, 2022. Market Study Cloud services [accessed 29 September 2022]. Page 62.

an understanding of which products perform well and which are in demand),[120] or potentially engage in self-preferencing of their own products over those of others.

4.47 These areas of concern have the potential to exacerbate some of the risks that we have identified under Theme 1, by influencing consumer choice and laying the foundations for a less competitive market in future. This could result in harm to cloud customers, for example:

- Lower competitive intensity amongst cloud ecosystem providers could lead to customers facing higher prices, lower quality of service and less incentives to innovate.
- Lowering the competitive threat faced by the hyperscalers from ISVs could limit the entry of new cloud providers. This can in turn lead to lower quality and less choice for customers.

4.48 We recognise that cloud ecosystems are still developing and will work to understand what market developments (e.g. Microsoft's recently announced European Cloud Principles[121]) mean for any potential competition concerns associated with the development of ecosystems.

Question 4.7: Do you agree with our proposed approach for considering the dynamics in cloud infrastructure services competition, and what do you think are the most important issues to examine?

Question 4.8: Do you agree we should examine cloud ecosystem competition? How do you see cloud ecosystems currently developing, including around core areas set out in paragraphs 4.40 and 4.45?

Question 4.9: Do you have any concerns regarding any conduct or activities of any provider(s) that may adversely affect market dynamics now or in the future?

The impact on UK consumers

4.49 Cloud computing is an increasingly important input to the different elements that make up the internet and how online services are developed and delivered to UK consumers. This includes every type of consumer activity which takes place online, covering services such as social media, streaming, and communications services.

4.50 Cloud services are also an input in sectors that produce products and services that are not (entirely) digital. This is the case particularly for cloud products that can be relevant to any type of business, such as SaaS products for employee and customer management or PaaS products which can power AI/ML solutions.

[120] ACM cite Elastic's Elasticsearch and AWS' Elasticsearch Service as an example of this. AWS' service was introduced after Elastic and created confusion amongst customers due to the similarities with Elastic's service. ACM, 2022. Market Study Cloud services [accessed 29 September 2022]. Page 63.
[121] Microsoft website. Microsoft responds to European Cloud Provider feedback with new programs and principles [accessed 30 September 2022] and Making European Cloud Providers More Competitive [accessed 30 September 2022].

4.51 This means that competition issues in cloud services can have wide-ranging effects across both online and other products and services that UK consumers buy. Such effects could take different forms:

- Where business customers face higher costs to source the cloud services they need, they may pass these on in ways that will ultimately lead to higher prices for the products and services UK consumers buy.
- Limits on entry and innovation can directly affect the quality and range of choice UK consumers have of online services powered by the cloud.

Potential areas for action we plan to investigate

4.52 There are a number of areas where regulators and or the industry could take action that we believe may merit investigation as part of the market study. We plan to look at these alongside our assessment on how well the market is working. Clearly whether there is a case for any intervention will depend on our findings regarding the functioning of the market, and the detailed analysis of the nature and shape of interventions would be the subject of subsequent work.

4.53 We have identified these areas from our initial research, international studies, and consideration of the EU Commission's proposals (see Section 2). We plan to consider how interoperability between cloud services and facilitating switching between providers could be promoted. These have been recommended by others as potential methods of addressing the risk of customer lock-in to higher-cost, lower-quality services, and of high barriers to entry and expansion for innovative challengers. We also expect to consider if further information could be published to allow customers to compare suppliers of cloud services more effectively. Finally, we plan investigate measures addressing information asymmetry, for example the role that issuing guidelines on acceptable contract terms including contract length and pricing transparency.

Potential outcomes

4.54 At the moment, we do not have a view on the likely outcome of the market study. We may conclude that cloud services in the UK can be given a clean bill of health. However, we may find that the market is not working well for consumers. If we were to find competition concerns or potential consumer harms, then we will explore potential policies or interventions that would seek to mitigate those harms. Having assessed the nature of concerns and potential solutions, we will review the best mechanism at our disposal to implement them. There are a range of available options, as set out in Section 2.

4.55 Should we find evidence of potential anti-competitive arrangements or conduct which relate to "activities connected with communications matters", we have the power to pursue potential enforcement action using our concurrent powers under the Competition Act 1998.

4.56 Alternatively, if we find that there are features of the market that lead to dampening of competition, which in turn lead to adverse effects for consumers we may make a market investigation reference to the CMA, or accept remedies in lieu of such a reference.

4.57 We could also issue advice to the Government, other regulators, or businesses who may be best placed to put interventions in place.

4.58 This market study will also support the work of the DMU, including its ongoing preparation for its oversight of the proposed new pro-competition regime for digital markets.

4.59 Finally, we believe that our focus on public cloud will also allow us to consider if there are any issues now or the potential for issues to emerge in the future in relation to broadcasting and telecoms. If we were to find potential concerns that have specific implications for the telecoms and broadcasting markets within our remit, we would consider what further work Ofcom should pursue as part of our duty to further the interests of citizens and consumers in relation to communications matters.

Question 4.10: Are there any remedies that you believe we should investigate further to mitigate some of the potential risks we've identified in this document or concerns you have with the market?

5. Next steps

5.1 We will conduct our market study over the next year, gathering evidence from a wide range of stakeholders. Following evidence gathering and analysis, we will publish a report which sets out our findings, any concerns we identify and our proposed recommendations or remedies to those concerns. Our final report will be published no later than 5 October 2023.

5.2 We will aim to publish an interim report with our initial findings, including whether a market investigation reference is needed, in about six months' time. Where we find issues of particular concern, we may also take action during or at the end of the study, such as opening consumer or competition enforcement cases.

5.3 Ofcom welcomes submissions on the market study from interested parties by no later than 3 November 2022. We consider a four week consultation period to be appropriate for responding to this call for inputs.

5.4 In this call for inputs, we have set out two themes that we propose to investigate. We would welcome comments and views, supported with evidence where available, in particular on the questions set out in Annex 4.

5.5 We set out how to respond to this consultation, Ofcom's consultation principles and a consultation coversheet in annexes 1-3.

A1. Responding to this consultation

How to respond

A1.1 Ofcom would like to receive views and comments on the issues raised in this document, by 5pm on 3 November 2022.

A1.2 You can download a response form from www.ofcom.org.uk/consultations-and-statements/category-3/cloud-services-market-study. You can return this by email or post to the address provided in the response form.

A1.3 If your response is a large file, or has supporting charts, tables or other data, please email it to cloudservices@ofcom.org.uk, as an attachment in Microsoft Word format, together with the cover sheet. This email address is for this consultation only, and may not be valid after November 2022.

A1.4 Responses may alternatively be posted to the address below, marked with the title of the consultation:

Cloud services team
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.5 We welcome responses in formats other than print, for example an audio recording or a British Sign Language video. To respond in BSL:

- send us a recording of you signing your response. This should be no longer than 5 minutes. Suitable file formats are DVDs, wmv or QuickTime files; or
- upload a video of you signing your response directly to YouTube (or another hosting site) and send us the link.

A1.6 We will publish a transcript of any audio or video responses we receive (unless your response is confidential)

A1.7 We do not need a paper copy of your response as well as an electronic version. We will acknowledge receipt of a response submitted to us by email.

A1.8 You do not have to answer all the questions in the consultation if you do not have a view; a short response on just one point is fine. We also welcome joint responses.

A1.9 It would be helpful if your response could include direct answers to the questions asked in the consultation document and evidence where you can. The questions are listed at Annex 4. It would also help if you could explain why you hold your views, and what you think the effect of Ofcom's proposals would be.

A1.10 If you want to discuss the issues and questions raised in this consultation, please contact Warwick Izzard on 020 7783 4127, or by email to warwick.izzard@ofcom.org.uk.

Confidentiality

A1.11 Consultations are more effective if we publish the responses before the consultation period closes. In particular, this can help people and organisations with limited resources or familiarity with the issues to respond in a more informed way. So, in the interests of transparency and good regulatory practice, and because we believe it is important that everyone who is interested in an issue can see other respondents' views, we usually publish responses on the Ofcom website at regular intervals during and after the consultation period.

A1.12 If you think your response should be kept confidential, please specify which part(s) this applies to, and explain why. Please send any confidential sections as a separate annex. If you want your name, address, other contact details or job title to remain confidential, please provide them only in the cover sheet, so that we do not have to edit your response.

A1.13 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and try to respect it. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.14 To fulfil our pre-disclosure duty, we may share a copy of your response with the relevant government department before we publish it on our website. This is the Department for Business, Energy and Industrial Strategy (BEIS) for postal matters, and the Department for Culture, Media and Sport (DCMS) for all other matters.

A1.15 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's intellectual property rights are explained further in our Terms of Use.

Next steps

A1.16 Following this consultation period on our call for inputs, we expect to publish an interim report for consultation in around six months' time. We will publish a final report no later than 5 October 2023.

A1.17 If you wish, you can register to receive mail updates alerting you to new Ofcom publications.

Ofcom's consultation processes

A1.18 Ofcom aims to make responding to a consultation as easy as possible. For more information, please see our consultation principles in Annex 2.

A1.19 If you have any comments or suggestions on how we manage our consultations, please email us at consult@ofcom.org.uk. We particularly welcome ideas on how Ofcom could more effectively seek the views of groups or individuals, such as small businesses and residential consumers, who are less likely to give their opinions through a formal consultation.

A1.20 If you would like to discuss these issues, or Ofcom's consultation processes more generally, please contact the corporation secretary:

Corporation Secretary
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA
Email: corporationsecretary@ofcom.org.uk

A2. Ofcom's consultation principles

Ofcom has seven principles that it follows for every public written consultation:

Before the consultation

A2.1 Wherever possible, we will hold informal talks with people and organisations before announcing a big consultation, to find out whether we are thinking along the right lines. If we do not have enough time to do this, we will hold an open meeting to explain our proposals, shortly after announcing the consultation.

During the consultation

A2.2 We will be clear about whom we are consulting, why, on what questions and for how long.

A2.3 We will make the consultation document as short and simple as possible, with an overview of no more than two pages. We will try to make it as easy as possible for people to give us a written response.

A2.4 We will consult for up to ten weeks, depending on the potential impact of our proposals.

A2.5 A person within Ofcom will be in charge of making sure we follow our own guidelines and aim to reach the largest possible number of people and organisations who may be interested in the outcome of our decisions. Ofcom's Consultation Champion is the main person to contact if you have views on the way we run our consultations.

A2.6 If we are not able to follow any of these seven principles, we will explain why.

After the consultation

A2.7 We think it is important that everyone who is interested in an issue can see other people's views, so we usually publish the responses on our website at regular intervals during and after the consultation period. After the consultation we will make our decisions and publish a statement explaining what we are going to do, and why, showing how respondents' views helped to shape these decisions.

A3. Consultation coversheet

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

Please tick below what part of your response you consider is confidential, giving your reasons why

Nothing ○

Name/contact details/job title ○

Whole response ○

Organisation ○

Part of the response ○

If there is no separate annex, which parts? _____

_____

If you want part of your response, your name or your organisation not to be published, can Ofcom still publish a reference to the contents of your response (including, for any confidential parts, a general summary that does not disclose the specific information or enable you to be identified)?

DECLARATION

I confirm that the correspondence supplied with this cover sheet is a formal consultation response that Ofcom can publish. However, in supplying this response, I understand that Ofcom may need to publish all responses, including those which are marked as confidential, in order to meet legal obligations. If I have sent my response by email, Ofcom can disregard any standard e-mail text about not disclosing email contents and attachments.

Ofcom aims to publish responses at regular intervals during and after the consultation period. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here.

Name Signed (if hard copy)

A4. Consultation questions

Question 2.1: How do you see developments in the international context impacting the provision of cloud services in the UK?

Question 4.1: Do you agree with the scope of the market study?

Question 4.2: Are there other ways to those listed in paragraphs 4.11 to 4.14 in which customers use cloud services, and factors which determine their cloud usage, that we should examine?

Question 4.3: Do you agree that the features set out in paragraph 4.15 are the most important features for customers when choosing cloud services?

Question 4.4: Is our characterisation of how cloud services are sold and buying patterns correct at paragraphs 4.16 to 4.18? Are there other methods?

Question 4.5: Do you agree with our characterisation of competition for different types of services and customers? Are there any other aspects where competition may vary?

Question 4.6: What are your views on our characterisation of cloud ecosystems?

Question 4.7: Do you agree with our proposed approach for considering the dynamics in cloud infrastructure services competition, and what do you think are the most important issues to examine?

Question 4.8: Do you agree we should examine cloud ecosystem competition? How do you see cloud ecosystems currently developing, including around core areas set out in paragraphs 4.40 and 4.45?

Question 4.9: Do you have any concerns regarding any conduct or activities of any provider(s) that may adversely affect market dynamics now or in the future?

Question 4.10: Are there any remedies that you believe we should investigate further to mitigate some of the potential risks we've identified in this document or concerns you have with the market?

A5. Glossary of terms

Term	Definition
API (application programming interface)	A software interface that allows two or more pieces of software to communicate with each other.
AWS (Amazon Web Services)	A subsidiary of Amazon Inc that provides a full range of cloud services at scale to UK customers.
Bare metal services	Services which offer access to dedicated servers with no or limited software installed (e.g. no operating system or virtualisation).
Cloud computing	The provision of remote access to computing resources (compute, storage and networking) on demand and over a network (public internet or a private connection), instead of a personal computer or local server that are not part of the cloud. It is also defined as "a model for enabling ubiquitous, convenient, and on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."
Cloud ecosystem	A portfolio of services across the service and deployment models of cloud, including a marketplace.
Cloud infrastructure	Data centres and hardware such as servers and networks.
Cloud infrastructure services	Services that provide access to processing, storage, networking, and other raw computing resources (often referred to as infrastructure as a service, IaaS) as well as services that can be used to develop, test, run and manage applications in the cloud (platform as a service, PaaS).
Cloud marketplace	A website operated by a cloud provider where customers can purchase services (supplied by the marketplace owner and third parties) that are compatible with their cloud environments.
Cloud services	All services involved in the provision of cloud computing.
Computing resources	Hardware (servers) and software (applications) which are used to process workloads and store data. In cloud, the computing resources are connected with network equipment and software to allow remote access.

Term	Definition
Container as a service (CaaS)	A layer where applications or parts of applications run separately in a container but sections of the operating system and storage are shared.
Container	A package of software that bundles an application's code with any necessary software required for the application to run (e.g. configuration files and libraries).
Data centre	Buildings that house hardware needed for cloud computing such as servers and network equipment.
Database as a service (DBaaS)	A cloud service that provides customers with access to a database.
Disaster secovery as a service (DRaaS)	A cloud computing service model that allows an organisation to back up its data and applications (for example, in another region served by the cloud provider), and provide disaster recovery orchestration through a SaaS solution.
Edge cloud	Processing workloads and storing data close to the edge of a telecoms network, i.e. the physical location where users connect with the telecoms network.
Egress fees	Fees charged by cloud providers to customers for extracting their data from the cloud.
Google	A subsidiary of Alphabet inc that provides a full range of cloud services (Google Cloud Platform) at scale to UK customers.
Hybrid cloud	A combination of public and private clouds.
Hyperscalers	AWS, Microsoft and Google.
IaaS (infrastructure as a service)	Cloud services that provide access to raw computing resources for processing workloads and storing data. These computing resources are in the form of servers and networking equipment owned and managed by the IaaS provider (and typically held on racks in a remote data centre). To allow and manage that access, IaaS also includes some necessary software, including networking (e.g. firewall) and virtualization.
Independent software vendor (ISV)	Supplier of cloud services, typically PaaS and/or SaaS, that does not own any of the underlying raw computing resources.
Industrial internet of things (IIoT)	IoT used to enhance industrial and manufacturing business processes and applications.

Term	Definition
Internet of things (IoT)	The network of devices that contain the hardware (including sensors and actuators), software and firmware which allow the devices to connect, interact, and freely exchange data and information.
Interoperability	The ability of computer systems or software to communicate with one another.
Microsoft	Microsoft Corporation, a company that provides a full range of cloud services (Azure) at scale to UK customers.
Multi-cloud	The use of more than one cloud provider by a single customer.
Open source software	Software with a public source offered under an open source licence.
PaaS (platform as a service)	Cloud services that provide access to a virtual environment for customers to develop, test, deploy and run applications. These include application development computing platforms and pre-built application components and tools which customers can then use to build and manage full applications. The overall virtual environment and the underlying raw computing resources are typically owned and managed by the same service provider.
Private cloud	A cloud deployment model where computing resources are dedicated to (as opposed to shared between) individual customers.
Public cloud	A cloud deployment model where cloud services are open to all customers willing to pay and computing resources are shared between them.
SaaS (software as a service)	Complete applications hosted in the cloud. They can be offered by the cloud provider that owns the underlying cloud infrastructure or by an independent software vendor.
Stack	A set of hardware and software components that work together to create a computing platform for running applications.
Traditional IT	Dedicated physical computing resources that are not part of the cloud. These are typically owned by, and located on the premises of, the customer.
Unique cloud environment	A collection of programming languages, application frameworks and APIs that allow services across a provider's cloud stack to work together.

Term	Definition
Usage commitments	Where customers receive cheaper rates compared to on-demand for committing to a certain configuration or amount of usage for a specified term, typically 1-3 years.
Vertically integrated providers	All cloud providers, i.e. the hyperscalers and smaller cloud providers.
Virtualisation	The process of using software to create an abstraction layer over servers that allows the hardware elements of a single server (e.g. CPUs, RAM and storage) to be divided into multiple virtual servers, commonly called virtual machines. Each virtual machine runs its own operating system and behaves like an independent server, even though it is running on just a portion of the actual underlying server hardware. The software that creates, runs and manages virtual machines is called a hypervisor.
Virtualised network functions (VNFs)	Network functions (e.g. policy control) that are decoupled from the underlying hardware and converted to software using virtualization.
Virtual machines	A software-defined computer that is created by running a guest operating system on top of the host operating system of the physical server.
Workload	A specific application, service, capability or a specific amount of work that can be run on a cloud resource.