Anticipated acquisition by Broadcom Inc. of VMware, Inc

Provisional findings

19 July 2023

The Competition and Markets Authority has excluded from this published version of the provisional findings report information which the inquiry group considers should be excluded having regard to the three considerations set out in section 244 of the Enterprise Act 2002 (specified information: considerations relevant to disclosure). The omissions are indicated by [✂]. Some numbers have been replaced by a range. These are shown in square brackets.

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Overview

1. The Competition and Markets Authority (**CMA**) has provisionally found that the anticipated acquisition (the **Merger**) of VMware, Inc. (**VMware**) by Broadcom Inc. (**Broadcom**) may not be expected to result in a substantial lessening of competition (**SLC**) in relation to the supply of various server hardware components in the United Kingdom (**UK**).

2. Broadcom and VMware are each a **Party** to the Merger; together they are referred to as the **Parties** and, for statements relating to the future, the **Merged Entity**.

3. This is not our final decision, and we invite any interested parties to make representations to us on these provisional findings by no later than 17.00 BST, on **Wednesday 9 August 2023**. Please make any response to these findings by email to Broadcom.VMware@cma.gov.uk. We will take all submissions received by this date into account in reaching our final decision.

About the server industry

4. Broadcom supplies hardware components for servers and VMware supplies virtualisation software that is primarily used either in data centres or in a private cloud. Both Parties have substantial sales in the UK, and their hardware and software are used by thousands of businesses that operate in the UK.

5. Data centres are owned by the company that uses the servers, while a private cloud is dedicated server capacity that can either be hosted by the company itself or by third parties. A public cloud is owned and operated by a company that supplies server capacity to other companies, enabling those other companies to scale their computing resources on-demand and pay only for the server capacity which they use. Servers have traditionally been located in data centres at premises owned by the company using the server but in recent years there has been significant growth of Cloud Service Providers (**CSPs**) offering public cloud services. These include companies such as Google (Google Cloud Platform), Amazon (Amazon Web Services) and Microsoft (Azure).

6. Broadcom is a technology company that designs, manufactures, and supplies a broad range of hardware and infrastructure software solutions. The hardware Broadcom supplies for servers includes components that allow

servers to connect and communicate with each other such as adapters and switches. Broadcom supplies these components globally, primarily to 'Original Equipment Manufacturers' (**OEMs**) such as Dell and Hewlett Packard, who in turn build and sell servers and related hardware components to companies and other institutions (**enterprise customers**). Servers are built using components from multiple suppliers. As such, it is necessary for different suppliers' components to interoperate with each other.

7. Server virtualisation software enables the processing power of a single server to be segmented into a number of 'virtual machines'. This means that separate computing environments can be created on a single server and the server's processing power can thereby be used more efficiently. VMware sells server virtualisation software globally to a range of enterprise customers (often large organisations such as government departments, financial institutions and telecoms companies) primarily for deployment on servers in data centres and private clouds (**enterprise deployments**).

8. The hardware components in a server must be compatible with the virtualisation software running on that server. In order to achieve interoperability, hardware suppliers will share information about new products such as product samples, product roadmaps, driver source code, and other technical information with suppliers of virtualisation software. VMware then 'certifies' hardware products as being compatible with its virtualisation software. This provides reassurance to customers that those hardware products have been tested to ensure that they interoperate correctly with VMware's server virtualisation software. In addition, VMware provides support (which includes troubleshooting and periodic updates) for certified hardware, which is important for enterprise customers.

9. Our investigation has focussed on those hardware components manufactured by Broadcom and its competitors that require interoperability with VMware's virtualisation software, and which are therefore relevant for our assessment of the Merger. These products are Ethernet network-interface cards (**NICs**), fibre channel host-bus-adapters (**FC HBAs**), storage adapters and fibre channel (**FC**) switches (together, **I/O hardware and switches**).

The Merger

10. Broadcom announced in May 2022 that it had agreed to acquire VMware for a purchase price of approximately USD61 billion (and Broadcom will assume VMware's net debt of USD8 billion). The Merger is subject to regulatory approval.

Our assessment

Why are we looking at this Merger?

11. The CMA's primary duty is to seek to promote competition for the benefit of UK consumers. In this context, it investigates mergers that could raise competition concerns in the UK, provided it has jurisdiction to do so.

12. While both Broadcom and VMware are US-based entities, the question for the CMA is whether the Merger may have an impact on competition in the UK. In this case, we have provisionally concluded that the CMA has jurisdiction to review this Merger because the UK turnover of VMware is in excess of our legal threshold of £70 million for its last business year.

How have we examined this Merger?

13. In deciding whether a merger may be expected to result in an SLC, the question we are required to answer is whether it is more likely than not - a more than 50% chance - that the merger will result in an SLC within any market or markets in the UK.

14. To determine whether this is the case, we have gathered information from a wide variety of sources, using our statutory powers to ensure that we have as complete a picture as possible, under the constraints of the statutory timetable, to understand the implications of this global Merger on competition in the UK.

15. Given VMware's importance in the supply of server virtualisation software, our investigation has focused on whether the Merged Entity might reduce the interoperability between VMware's virtualisation software and the I/O hardware and switches that are supplied by Broadcom's competitors, thereby encouraging customers to buy Broadcom's I/O hardware and switches rather than those of its competitors, and/or whether it could use any information provided to VMware by Broadcom's I/O hardware competitors to put those competitors at a significant competitive disadvantage.

16. We have focused on two ways, or 'theories of harm', in which the Merger could give rise to an SLC:

    (a) We first considered whether the Merged Entity would be able to harm the competitiveness of competing manufacturers of I/O hardware and switches by reducing the interoperability between VMware's virtualisation software and competitors' I/O hardware and switches. In assessing this theory of harm, we have considered whether the Merged Entity would be

able to reduce interoperability, whether the Merged Entity would have an incentive to do so, and what the impact would be on competition in each of these hardware markets.

(b) We also considered whether the Merged Entity (in particular the division of Broadcom which supplies Ethernet NICs, storage adapters and FC HBAs, **I/O hardware**) might have access to commercially sensitive information (**CSI**) from its I/O hardware competitors following the Merger, because these competitors may share such information with VMware when working to ensure their I/O hardware interoperates with VMware's virtualisation software. We considered whether, if Broadcom had access to such information, it could weaken either its incentives or those of its competitors to innovate in I/O hardware markets, thus harming competition now or in future, to the detriment of consumers. To assess this, we considered the CSI which is shared, how I/O hardware competitors are likely to respond post-Merger and the likely impact on innovation.

17. We have provisionally concluded that the Merger may not be expected to result in a substantial lessening of competition for either of these theories of harm. This is discussed in further detail below.

What evidence have we looked at?

18. In assessing this Merger, we looked at a wide range of evidence that we considered in the round to reach our provisional decision. We received a significant volume of evidence from the Parties, including internal business documents which were created in the ordinary course of business and set out each Party's views of the markets, as well as their future commercial strategies. We also held a site visit with each of the Parties, where the Parties' senior business staff provided an overview of the markets and products in question and explained the rationale for the Merger, and formal hearings with each of the Parties, in which we spoke to the Parties' senior management about topics that we were exploring in our investigation. In addition, the Parties made a number of other submissions setting out their views on our theories of harm and evidence base at different points in our investigation.

19. We gathered evidence from customers, other I/O hardware providers and virtualisation software providers. We sent out several requests for information, including to UK-based customers, holding calls with many respondents. These calls and information requests helped us to have a better understanding of the markets, the competitive landscape, likely future developments in these markets, and the likely responses of customers and

competitors to any change in the Merged Entity's commercial strategies post-Merger, globally and in the UK.

20. The evidence we have gathered has been tested rigorously, and the context in which the evidence was produced has been considered when deciding how much weight to give it.

21. We have looked at how competition works currently (and each Party's current market position), but at the same time we have recognised that markets, and in particular markets for technological products such as those offered by the Parties, are constantly changing over time. Our assessment therefore includes a forward-looking aspect and considered how these specific markets are evolving and each Party's plans for their businesses in future.

What did the evidence tell us about our first concern: harm to the competitiveness of Broadcom's competitors due to a reduction in interoperability with VMware?

VMware's position in server virtualisation software and is VMware able to reduce interoperability?

22. In light of the evidence we have received from our investigation, we have provisionally found that VMware has market power in the supply of server virtualisation software in enterprise deployments. This is relevant to our assessment as the Merged Entity will only be able to have a substantial impact in the markets for I/O hardware and switches through a reduction of the interoperability with VMware server virtualisation software if it occupies an important position in virtualisation software and customers cannot easily switch away from VMware to a range of effective alternative suppliers. VMware has a high market share in the supply of server virtualisation software for enterprise deployments and evidence provided by customers consistently shows that, as a pioneer of virtualisation software, VMware holds a strong and established position in the market, offering a wide range of complementary services to enterprise customers. We have also seen evidence that there are few other effective alternative virtualisation software providers for VMware customers and that switching away from VMware software is complex, time consuming and has a high cost for customers.

23. In the past few years enterprise customers have migrated some of their existing workloads from enterprise deployments to the public cloud, and they will continue to do so in future, and CSPs exert a constraint on VMware for at least some customers and workloads. However, we have provisionally found that the constraint from CSPs is insufficient to prevent VMware from holding a position of market power as customers have diverse needs and specific

requirements, several customers have strong preferences for some workloads to remain in enterprise deployments due to external factors and not all workloads may be suitable for the public cloud.

24. The evidence we have seen shows that interoperability with VMware is essential for providers wishing to offer I/O hardware components for use in servers running VMware server virtualisation software. Given VMware's market power, a lack of interoperability between VMware server virtualisation software and I/O hardware components manufactured by Broadcom's competitors has the potential to weaken the offering of Broadcom's I/O hardware competitors. We consider that there are ways through which the Merged Entity could potentially reduce or eliminate interoperability between VMware software and competitors' I/O hardware products, for example, by refusing VMware certification for their I/O hardware, thereby disadvantaging Broadcom's I/O hardware competitors. Refusing to certify I/O hardware would reduce interoperability as uncertified I/O hardware can give rise to security risks and compatibility issues, and isn't supported by VMware, so would not benefit from any troubleshooting or updates provided by VMware.

25. On this basis, we have provisionally found that the Merged Entity would have the ability to reduce interoperability between VMware's virtualisation software and Broadcom's competitors' I/O hardware. We have provisionally found that the Merged Entity would not have the ability to reduce interoperability between VMware's server virtualisation software and FC switches.

The commercial benefits of reducing interoperability between competitors' I/O hardware and VMware's server virtualisation software

26. We then considered whether reducing interoperability between competitor I/O hardware and VMware software could lead customers to switch (i) to Broadcom I/O hardware when purchasing new servers or (ii) away from VMware software. We assessed whether this would be a profitable business strategy and, therefore, whether the Merged Entity would have an incentive to engage in such a strategy.

27. We considered the profits which would be gained by the Merged Entity from customers switching to Broadcom I/O hardware relative to the profits which would be lost from any customers who choose to switch away from VMware. Profits earned from sales of VMware's server virtualisation software are significantly higher than the profits earned by Broadcom from sales of I/O hardware. As a result, it would only be commercially beneficial for the Merged Entity to reduce interoperability between competitors' I/O hardware and VMware software if the vast majority of customers would switch to Broadcom

I/O hardware when purchasing new servers, and only a very limited number of customers would choose to switch away from VMware.

28. Based on the evidence we have received from customers, including customers in the UK, we have provisionally found that the Merged Entity would not have a commercial incentive to engage in this strategy. The evidence shows that it is likely that a sufficient number of VMware customers would move workloads away from VMware to mean that this strategy would be unprofitable for the Merged Entity.

29. On this basis, we have provisionally found that following the Merger, the Merged Entity would not have an incentive to reduce interoperability between competitors' I/O hardware and VMware's virtualisation software.

What did the evidence tell us about our second concern: a reduction in the incentives to innovate by Broadcom and its I/O hardware competitors?

The level and type of innovation taking place in I/O hardware

30. Innovation to develop new generations of higher speed Ethernet NICs, FC HBAs and storage adapters is motivated by the need to support increases in the speed of data processing in the server as new generations of central processing units are launched. The protocols for higher speed next generation products are agreed at industry-wide standards bodies and the timelines for introducing new standards are determined by the relevant standards body and made publicly available.

31. Innovation in I/O hardware can also take place on product features such as encryption or power usage. In FC HBAs, these features are set by industry standards, with suppliers choosing which features to prioritise in their products.

The change in CSI available to Broadcom post-Merger

32. CSI is provided to VMware by I/O hardware suppliers as part of the process by which VMware certifies the interoperability of I/O hardware products with VMware's server virtualisation software. This includes product samples, product roadmaps, driver source code, and other technical information. In addition, Broadcom also receives CSI from suppliers of Ethernet NICs and FC HBAs (but not storage adapters) in its role as a supplier of (i) silicon used to manufacture Ethernet NICs; (ii) certain components used to manufacture FC HBAs; and (iii) FC switches (which need to interoperate with FC HBAs). We have therefore considered whether, as a result of the Merger, Broadcom

would have access to additional (or more timely) CSI through VMware's certification process. The evidence we have gathered shows that:

(a) For FC HBAs, the CSI Broadcom receives is similar to the CSI VMware receives, although the timing of when it is shared can differ.

(b) For Ethernet NICs, VMware receives additional CSI which is not available to Broadcom pre-Merger.

The likely impact on innovation

33. We have considered whether the sharing of information related to competitors' innovations with Broadcom (through VMware) could reduce the level of innovation and/or the incentive to innovate, undertaken either by Broadcom (eg as Broadcom could copy what its competitors are doing) and/or by competitors (as the commercial benefits from investing in innovation may be lower for competitors if Broadcom copies their innovation).

34. The evidence we have gathered for Ethernet NICs shows that there is limited innovation in lower speed products (which are predominantly used by OEMs). Innovation is focused on higher speed products, driven by demand from CSPs (who do not use VMware software). Evidence shows that OEMs adopt these higher speed products much later than CSPs. Accordingly, by the time information needs to be shared with VMware to achieve interoperability for hardware sales to OEMs, the higher speed product is already available on the market. We have therefore provisionally found that access by Broadcom after the Merger to CSI would be unlikely to impact significantly the incentives to innovate for Ethernet NICs.

35. For FC HBAs, the evidence shows that innovation takes place on product speeds and features which are set by industry standards bodies, and there is limited innovation which is driven by head-to-head competition. Further, Broadcom already receives CSI from hardware competitors which is similar to that which is shared with VMware. We have therefore provisionally found that access by Broadcom after the Merger to CSI would be unlikely to significantly impact the incentives to innovate for FC HBAs.

36. In storage adapters the evidence we have gathered shows that:

(a) Developing new products is a multi-year endeavour and can take three to four years or more. The chip design is typically finalised first, followed by the firmware. Engagement with VMware takes place towards the end of the process, in the last year or two.

(b) Different suppliers have adopted different strategies for sharing CSI with VMware. These differences relate to both the type of information shared and the timing of when it is shared. We consider that this may reflect different attitudes towards risk, with some suppliers sharing information earlier to allow more time for interoperability to be ensured.

(c) While innovations may be contained in parts of the product that are not shared with VMware, the driver source code shared with VMware may reveal the new features which have been added to the product. However, these new features can also be revealed by the driver source code which is shared with Linux and is open-source, and the evidence indicates that the driver source code may be shared with Linux first (ie prior to any information being available to VMware). Further, the new features which are being planned may be advertised well in advance of product launch, and before any engagement with VMware, such that the information is publicly available by the time driver source code is shared with VMware.

37. Even if suppliers choose not to change their strategies post-Merger, such that Broadcom after the Merger has earlier access to CSI from hardware competitors, given the length of the innovation cycle and the involvement of industry standards bodies, we have provisionally found that this would be unlikely to impact significantly the incentives to innovate for storage adapters.

Provisional conclusion

38. As a result of our investigation and our assessment, we have provisionally concluded that the anticipated acquisition by Broadcom of VMware would result in the creation of a relevant merger situation.

39. We have also provisionally concluded that the anticipated acquisition of VMware by Broadcom may not be expected to result in an SLC in relation to the supply of I/O hardware and switches in the UK.

Provisional findings

1. The reference

1.1 On 29 March 2023, the Competition and Markets Authority (**CMA**), in exercise of its duty under section 33(1) of the Enterprise Act 2002 (the **Act**), referred the anticipated acquisition by Broadcom Inc. (**Broadcom**) of VMware, Inc. (**VMware**) (the **Merger**) for further investigation and report by a group of CMA panel members (the **Inquiry Group**). Broadcom and VMware are together referred to as the **Parties** and, for statements relating to the future, the **Merged Entity**.

1.2 In exercise of its duty under section 36(1) of the Act, the Inquiry Group must decide:

(a) whether arrangements are in progress or in contemplation which, if carried into effect, will result in the creation of a relevant merger situation (**RMS**); and

(b) if so, whether the creation of that situation may be expected to result in a substantial lessening of competition (**SLC**) within any market or markets in the United Kingdom (**UK**) for goods or services.

1.3 The Inquiry Group is required to publish its final report by 12 September 2023.

1.4 Our terms of reference are set out in Appendix A.

1.5 This document, together with its appendices, constitutes the Inquiry Group's provisional findings published and notified to Broadcom and VMware in line with the CMA's rules of procedure.[1] Further information can be found on our webpage.[2]

[1] CMA rules of procedure for merger, market and special reference groups (CMA17), paragraphs 11.1–11.7.
[2] See webpage here: Broadcom / VMware merger inquiry - GOV.UK (www.gov.uk).

2. Parties, the Merger and the rationale

Introduction

2.1 This chapter sets out:

(a) an overview of the Parties and their principal activities;

(b) the background to the Merger; and

(c) Broadcom's rationale for the Merger and plans for the VMware business post-Merger.

The Parties

Broadcom

2.2 Broadcom is a global technology company that designs, manufactures and provides a range of semiconductors and infrastructure software solutions. It is listed on NASDAQ[3] and headquartered in San Jose, California.[4] For its financial year ended 30 October 2022 (**FY22**), Broadcom generated worldwide revenues of £26.9 billion, of which £[✂] was generated in the UK.[5]

Principal activities

2.3 Broadcom comprises two business divisions: the Semiconductor Solutions Group, its hardware division (FY22 net revenues of $25.8 billion, around 78% of Broadcom's consolidated worldwide net revenues); and the Broadcom Software Group, its global infrastructure software division (FY22 net revenues of $7.4 billion, around 22% of worldwide revenues). Supporting these are several central support divisions, which provide support for [✂], as well as central general and administrative functions, eg finance, human resources, legal and IT.[6,7,8,9]

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[3] Broadcom's five largest shareholders (by shareholding) are institutional investors. The Vanguard Group, Inc., Broadcom's largest shareholder, has a shareholding of 9.1%. Source: Final Merger Notice (**FMN**), paragraph 2.18, Table 1.
[4] FMN, paragraphs 2.1 and 2.17.
[5] FMN, paragraph 6.
[6] FMN, paragraph 3.2.
[7] See: Broadcom annual report on Form 10-K for the financial year ended 30 October 2022, accessed by the CMA on 10 July 2023.
[8] FMN, paragraph 3.8.
[9] Broadcom site visit presentation, 27 April 2023, slide 3.

2.4 Broadcom's activities in hardware are the most relevant to our assessment of the Merger.

Overview of the Broadcom hardware business

2.5 Within Broadcom's hardware business, four product families are the focus of our investigation: Ethernet NICs, FC HBAs, storage adapters and FC switches (see also Chapter 4 ('Industry Background') for further details).[10] The following business units within Broadcom's hardware business supply these hardware devices:[11,12,13,14]

(a) Emulex Connectivity Division (financial year 2022 (**FY22**) revenues: $[✂]), which supplies FC HBAs. In FY22, Broadcom generated revenues of around $[✂] from FC HBAs.[15]

(b) Data Center Solutions Group (FY22 revenues: $[✂]), which supplies Ethernet NICs and storage adapters, alongside several other products. In FY22, Broadcom generated revenues of around $[✂] from Ethernet NICs and $[✂] from storage adapters (both adapters and controllers).[16]

(c) Brocade Storage Networking Division (FY22 revenues: $[✂]), which supplies FC switch hardware, FC switch management software (SANnav) and support services. FC switch hardware sales account for the majority of the business unit's revenues. In FY22, Broadcom generated revenues of around $[✂] from FC switch hardware sales.[17]

VMware

2.6 VMware is active in IT software including virtualisation and related workload management technologies for data centres and cloud-computing environments, application development, and end-point management.[18] It is listed on the NYSE and headquartered in Palo Alto, California.[19] For its financial year ended 28 January 2022 (also referred to as FY22), VMware

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[10] Parties' response to the Issues Statement,10 May 2023, paragraphs 1.1, 1.2, 1.5, 1.6, 1.7 and 1.9.
[11] Parties' response to P2 RFI 1, 3 May 2023, paragraphs 4.1 to 4.3.
[12] Parties' response to P1 RFI 5, 9 January 2022, question 33, Annex RFI5Q33-001.
[13] FMN, Table 92.
[14] Parties' response to s109 Notice 5, 9 May 2023, question 2, Annex S109(5)Q2-001.
[15] Parties' response to P2 RFI 4, 6 July 2023, question 1.
[16] Parties' response to P2 RFI 4, 6 July 2023, question 1.
[17] Parties' response to P2 RFI 4, 6 July 2023, question 1.
[18] An 'end-point' is any device connected to a corporate network eg laptops, mobile devices, printers etc. End-point management is a security function which ensures only authenticated and approved devices are able to connect to the network.
[19] FMN, paragraph 2.2.

generated worldwide revenues of around £9.5 billion ($12.8 billion), of which £[✂] was generated in the UK.[20]

2.7 From 2004 to 2016, VMware was owned by EMC Corporation (**EMC**).[21] In 2016, EMC was acquired by Dell. On 1 November 2021, VMware was spun out of Dell.[22] Following the spin-off from Dell, Michael Dell and entities affiliated with Michael Dell have a combined shareholding of 40.2% in VMware. Michael Dell is currently Chairman of the VMware Board[23] and is VMware's largest single shareholder. The next largest shareholder is Silver Lake Partners, a technology investment firm, with a 10% shareholding.[24]

Principal activities

2.8 VMware's core business is in the supply of server virtualisation software (see also the subsections titled 'Virtualisation' and 'Workloads' in Chapter 4 below) to a range of enterprise customers (often large organisations such as government departments, financial institutions and telecoms companies), either directly or via a range of distributors and resellers. VMware provides server virtualisation for x86 systems only.[25] Licensing and provision of technical support or services in connection with VMware's virtualisation software business accounts for around [✂]% of VMware's revenue, with the remainder attributable to the sale or licensing of other software and the provision of professional services.[26]

2.9 The VMware product most relevant to our investigation is its server virtualisation software, vSphere, which sits within its [✂] and accounts for [✂] of VMware's revenue.[27,28,29] VMware also offers network virtualisation software (**NSX**) and storage virtualisation software (**vSAN**).[30] According to the Parties, most providers supply server virtualisation software as part of a suite of virtualisation solutions.[31]

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[20] FMN, paragraph 6. For its financial year ended 3 February 2023, VMware generated worldwide revenues of around USD13.4 billion (10-K, page 46).
[21] See VMware History and Interactive Timeline for further details.
[22] See VMware annual report on Form 10-K for the financial year ended 28 January 2022, page 37.
[23] See Broadcom public announcement of the transaction (26 May 2023).
[24] FMN, paragraph 2.19.
[25] An x86 server is a computer that uses an x86 central processing unit (**CPU**) architecture. The x86 architecture primarily handles programmatic functions and provides services, eg memory addressing, software and hardware interrupt handling, data type, registers and input/output (**I/O**) management. VMware has not entered the server virtualisation market for any non-x86 systems. Source: FMN, paragraph 15.269.
[26] FMN, paragraph 3.11.
[27] FMN, paragraph 20.112.
[28] Parties' Teach-in presentation, 21 September 2022, slide 28.
[29] FMN, paragraphs 15.268 and 15.271.
[30] FMN, paragraph 15.268.
[31] FMN, paragraph 15.340.

The Merger

2.10 On 26 May 2022, the Parties entered into an agreement for Broadcom to acquire all of the outstanding shares of VMware for a total consideration of around $61 billion[32] (around £48.5 billion) in exchange for cash and Broadcom shares (the **Merger Agreement**). If the Merger completes, Broadcom's current shareholders will own around 88% of the combined entity while VMware's current shareholders will own around 12% on a fully diluted basis. Broadcom will acquire all of the voting securities of VMware.[33] Broadcom will also assume VMware's net debt of $8 billion.[34]

2.11 Under the Merger Agreement, the transaction is anticipated to complete by November 2023 after all closing conditions have been satisfied or waived. These conditions include regulatory approvals.[35]

2.12 The Merger has been cleared by competition authorities in Australia, Brazil, Canada, South Africa, and the European Union. It is subject to ongoing review by competition authorities in the United States and China.[36]

Rationale for the Merger

2.13 The Parties told us that upon closing of the Merger, Broadcom intends to rebrand and operate its IT infrastructure software solutions business as 'VMware'. The Parties told us that combining the Parties' software offerings would create an improved software portfolio that would provide customers with greater choice and flexibility to build, run, manage, connect, and protect applications at scale across diversified, distributed environments, regardless of where these applications are deployed. The Parties told us that Broadcom's aim was to compete more vigorously with larger software and cloud computing providers such as Amazon, Alphabet, Microsoft, and IBM, by creating a more attractive software portfolio for data centre managers.[37] Broadcom's internal documents are broadly consistent with the rationale stated above.[38]

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[32] Based on the closing price of Broadcom's common stock on 25 May 2022.
[33] Based on the outstanding shares of each company as at the date of the Merger Agreement. Source: FMN, paragraph 2.4 and Broadcom public announcement of the transaction (26 May 2023).
[34] This is based on the closing price of Broadcom's common stock on 25 May 2022. FMN, paragraphs 2.4 and 2.6.
[35] FMN, paragraph 2.11.
[36] Parties response to P2 RFI 5, 7 July 2023, additional question.
[37] FMN, paragraph 2.12.
[38] For example: (a) a letter from Broadcom's CEO to VMware's board of directors in May 2022 proposing the Merger stated that [✂] (source: FMN, Annex RSLV_00008902, pages 1-2); and (b) a May 2022 report from external advisers to Broadcom management on the Merger rationale indicated that [✂], specifically that the Merged Entity would be able to create '[✂]' (source: FMN, Annex BCOM-CMA-00000057, pages 15, 17 and 18).

2.14 Broadcom told us that while VMware had the '[✂] in virtualisation of physical servers in data centres,[39] VMware Private Cloud (including vSphere, vSAN, NSX and Management) had been '[✂]',[40] and that VMware had instead been losing enterprise workloads to 'giant well-funded' CSPs (eg AWS, Azure and Google Cloud), which had much greater scale than VMware.[41] Broadcom told us that under its plans for VMware, VMware would expand into virtualising the entire data centre and helping enterprises to run private cloud applications by using virtualisation technology that would drive efficiencies in the data centre through a 'hardware-neutral' approach. Broadcom added that it would also pursue a 'multi cloud' offering, whereby enterprises running VMware workloads on premises could easily migrate existing workloads to any public cloud and back again – empowering customer choice and flexibility and mitigating cloud lock-in.[42]

2.15 The Parties also told us that Broadcom's anticipated synergies and efficiencies were focused on increasing sales and decreasing costs to increase VMware's EBITDA, namely:[43]

(a) *Increase investment in R&D:* Broadcom plans to increase VMware's R&D budget from around $[✂] on a pro forma basis to around $[✂], eg investing in its [✂] offering, to make VMware more competitive with CSPs and other competitors and increase the adoption of VMware products.

(b) *Increase sales:* Broadcom plans to make better use of professional services to drive VMware's software sales and the adoption of VMware software for more workloads.

(c) *Reduce costs:* Broadcom plans to identify cost synergies by eliminating duplicative functions across the Parties' central functions and improving the efficiency and structure of VMware's sales organisation.

[39] Broadcom P2 site visit presentation, 27 April 2023, slide 5.
[40] Broadcom P2 site visit presentation, 27 April 2023, slide 7.
[41] Broadcom P2 site visit presentation, 27 April 2023, slide 6.
[42] Broadcom P2 site visit presentation, 27 April 2023, slide 5.
[43] FMN, paragraphs 24.1 to 24.5.

3. Relevant merger situation

3.1 Section 36 of the Act and our terms of reference require that we investigate and report on two statutory questions:

(a) whether arrangements are in progress or in contemplation which, if carried into effect, will result in the creation of an RMS; and

(b) if so, whether the creation of that RMS may be expected to result in an SLC within any market or markets in the UK for goods or services.

3.2 We address the first of the statutory questions in this section.

Enterprises ceasing to be distinct

3.3 The first element of the RMS test in Section 23 of the Act provides that an RMS will be created if, as a result of the Merger, two or more enterprises cease to be distinct.[44]

3.4 The Act defines an 'enterprise' as 'the activities, or part of the activities, of a business'. A 'business' is defined as including any undertaking 'which is carried on for gain or reward or which is an undertaking in the course of which goods or services are supplied otherwise than free of charge.'[45]

3.5 The activities of Broadcom and VMware are described in paragraphs 2.3-2.4 and 2.6-2.7 above. In light of those activities, we are satisfied that each of Broadcom and VMware is a 'business' and an 'enterprise' within the meaning of the Act.

3.6 Section 26 of the Act provides that any two enterprises cease to be distinct if they are brought under common ownership or common control. Enterprises are in particular treated as being under common control where, among other things, one holds a majority of the voting rights in the other or one is a wholly-owned subsidiary of the other.[46]

3.7 The background to the Merger is described in paragraphs 2.10-2.12 above. Broadcom and VMware have no pre-merger ownership links.[47] On completion of the Merger, Broadcom will acquire all of VMware's outstanding shares and

[44] Section 23(1)(a) of the Act.
[45] Section 129(1) and (3) of the Act.
[46] Sections 26(2)(a) and 129(2) of the Act; section 1159 of the Companies Act 2006.
[47] FMN, paragraph 2.21; Response to P1 RFI 2, 18 October 2022, paragraph 4.1.

all of VMware's voting securities.[48] Therefore, Broadcom and VMware will be brought under common ownership and control.

3.8 We have therefore provisionally found that arrangements are in progress or contemplation which, if carried into effect, will result in Broadcom and VMware ceasing to be distinct enterprises under the Act.

Turnover test

3.9 The second element of the RMS test in Section 23 of the Act establishes whether the Merger has sufficient connection with the UK on a turnover or share of supply basis to give the CMA jurisdiction to investigate.

3.10 The turnover test is satisfied where the value of the turnover in the UK of the enterprise being taken over in its last business year[49] exceeds £70 million.[50] The Parties stated that VMware's UK turnover exceeds the £70 million threshold.[51] The Parties stated that VMware's turnover in the UK in its last business year was £[✂].[52]

3.11 Therefore, the turnover test is satisfied, and there is no need to consider whether the share of supply test is also satisfied.

Provisional conclusion on RMS

3.12 In light of the above, we have provisionally found that the Merger constitutes arrangements in progress or in contemplation which, if carried into effect, will result in the creation of an RMS. This means that the CMA has jurisdiction to review the Merger. As a result, we must consider whether the creation of that

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[48] Merger Agreement, section 3; FMN, paragraph 2.4, 2.6 and 2.21; Response to P1 RFI 2, 18 October 2022, paragraph 4.1.
[49] If a merger has not yet taken place, the turnover test applies to the turnover of the acquired enterprise that was generated in relation to customers within the UK in the business year preceding the date of the reference for a Phase 2 investigation or such earlier date as the CMA considers appropriate. See Enterprise Act 2002 (Merger Fees and Determination of Turnover) Order 2003, article 11(2).
[50] Section 23(1)(b) of the Act.
[51] FMN, paragraph 5.1.
[52] FMN, response to question 6. The figure in the enterprise's latest published accounts will normally be sufficient to measure whether the turnover test is met, unless there have been significant changes since the accounts were prepared. Where company accounts do not provide a relevant figure, for example because only part of a business is being acquired or the accounts do not provide a suitable geographic breakdown of turnover, the CMA will consider evidence presented by the merger parties and other interested parties to form its own view as to what it believes to be the value of UK turnover for jurisdictional purposes: Mergers: Guidance on the CMA's jurisdiction and procedure (**CMA2**), 4 January 2021, paragraph 4.56. The latest available accounts for VMware, Inc. are for the financial year ending 3 February 2023. See: VMware Annual Report FY February 2023. These accounts do not give separate turnover figures for operations in the UK. However, VMware UK Ltd's latest published accounts for the financial year ended 28 January 2022 state that it had turnover of £518.8m in the UK, see: VMware UK Ltd Full Accounts, FY 28 January 2022. In addition, as stated, the Parties stated that VMware's turnover in the UK in its last business year was £[✂], see: FMN, response to question 6.

situation may be expected to result in an SLC within any market or markets in the UK for goods or services.

4. Industry background

4.1 This chapter provides an overview of:

(a) an enterprise customer's IT network;

(b) the operating system;

(c) virtualisation and the server virtualisation software (also called the **hypervisor**);

(d) workloads;

(e) server hardware components;

(f) interaction between VMware server virtualisation software and Broadcom input/output hardware and switches;

(g) containerisation; and

(h) cloud computing.

Enterprise IT networks

4.2 Enterprise IT networks are built around a 'stack' of hardware and software layers, which include the server, operating system and applications, and can also include virtualisation software.

Server

4.3 A server is the hardware and the physical foundation of the enterprise stack. It is made up of several different components which are manufactured by several different suppliers. Server hardware components are designed to work together, and with no technical obstacles to mixing and matching from different suppliers because these products are based on open, industry-standard protocols that ensure interoperability.[53]

4.4 A network is typically comprised of multiple servers working together to perform different functions and multiple servers can work together to perform tasks that require more computing power than would be available from a single server. The server manages network resources and provides data to other computers in a network, eg web servers, print servers and mail servers. Servers in a network are connected to each other, enabling them to convey

[53] FMN, footnote 794.

commands and data between them in accordance with agreed industry standards. This is enabled by input/output devices (**I/O devices**).

4.5 Servers are typically housed within 'data centres'. Large data centres may contain tens or hundreds of thousands of servers, medium data centres may have hundreds or thousands of servers, and the data centres used by smaller enterprises may have only a handful of servers.[54] These can be on the premises of and owned by the enterprise or located 'in the cloud' and owned by a third-party provider of computing services.

Operating system

4.6 The operating system (**OS**) is the software that manages the computing resources in a server, such as memory, storage and processing. The OS represents the 'middle layer' of the enterprise stack, which intermediates between applications and servers. The OS runs directly on the server hardware (also referred to as **bare metal**).

4.7 The OS communicates directly with the I/O devices (in addition to the central processing unit (**CPU**) and graphics processing unit (**GPU**)), so these are all designed to be interoperable with the OS. Communication between the OS and I/O devices takes place through drivers. A driver is a program that tells software how to communicate with I/O devices, providing an interface between the two. Drivers must therefore be compatible with an OS to enable the I/O device to be used.[55] The purpose of the driver is to allow the OS to interoperate with devices supplied by I/O device vendors via an application programming interface (**API**).[56,57]

4.8 Drivers are developed by I/O device vendors. Since each OS communicates with drivers in different ways, I/O device vendors must create OS-specific drivers for their hardware.[58] Certification is used to verify that the I/O device will work properly with the OS.

Virtualisation

4.9 Applications (or **workloads**) running on an OS on a single physical server rarely consume all of the resources on the server, such as CPU and memory

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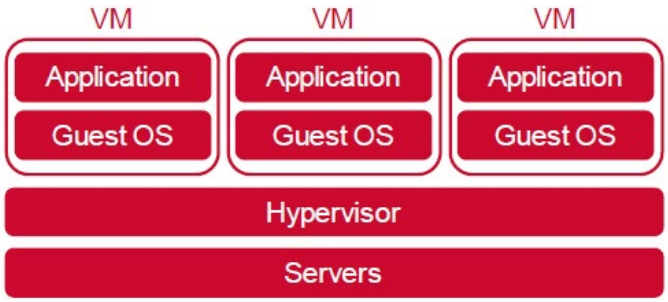
[54] Parties' Teach-in presentation, 21 September 2022, slide 5-6.
[55] FMN, paragraph 15.183.
[56] An API is an interface that enables one application to access another application without having to know complex details about how that other application works. Twitter's APIs, for example, are used by newspapers to embed tweets into articles. Instead of writing complex code to pull specific tweets from Twitter and embed them, website developers can simply invoke Twitter's API to do that job for them. Source: FMN, footnote 858.
[57] FMN, paragraph 20.19.
[58] FMN, paragraph 20.24.

capacity. Virtualisation overcomes this inefficient use of the server's hardware by enabling the hardware of a single server to be divided into multiple, isolated computers called 'virtual machines' (**VMs**).[59] Each VM acts as a 'computer within a computer'. As such, virtualisation creates multiple, isolated environments on a single server.[60]

4.10 Server virtualisation is achieved through the use of a hypervisor, which is the software that creates and manages VMs. A hypervisor is a 'specialised OS' that runs directly on server hardware (ie on bare metal), pooling the physical computing resources of the server (processors, memory, storage, etc) and allocating them to the VMs.

4.11 A single server can support VMs running different OSs, eg Windows or Linux ('guest' OS).[61] This is illustrated in Figure 4.1 below. Where virtualisation software is used, this software manages the I/O devices in the server. I/O devices are therefore designed to work with virtualisation software and undergo a certification process similar to that for the guest OS (see paragraphs 4.26 to 4.31 below for further details).

Figure 4.1: Hypervisor installed on the enterprise IT network



Source: Parties' Teach-in presentation, 21 September 2022, slide 25.

4.12 According to the Parties, the advantages of server virtualisation can include (i) efficiency (ie using server capacity more efficiently by enabling a single server to run multiple workloads simultaneously); (ii) keeping workloads isolated from each other so they can be configured in entirely different ways (iii) higher availability of the applications running in a VM, as the application can be quickly migrated or restarted in an identical VM running on a different server if the underlying hardware fails or needs maintenance; and (iv) enabling

[59] FMN, paragraph 15.177.
[60] Parties' Teach-in presentation, 21 September 2022, slide 26.
[61] FMN, paragraph 15.178.

enterprises uniformly to manage the diverse range of hardware and software in a data centre.[62] [63]

4.13 VMware's server virtualisation software (vSphere) consists of two core components:[64,65,66]

(a) ESXi (the hypervisor) which runs directly on server hardware and whose purpose is to deploy VMs. VMkernel, the OS within VMware's hypervisor, communicates with drivers when executing tasks on underlying physical hardware;[67] and

(b) vCenter Server, which allows the deployment and management of VMs across clusters of servers running ESXi. vCenter Server is a management and administration software that assists customers to manage their servers with ESXi. The vCenter Server software can only be used in a vSphere environment, but vSphere/ESXi can also be run without vCenter Server or with third-party software.[68,69]

Workloads

4.14 Workloads are software applications that perform specific functions for enterprise end users and which interwork with and run on an operating system. Workloads run on traditional data centres, the private cloud, the public cloud, as well as other deployment types.

4.15 We note that workloads are not homogeneous and include a wide variety of programs or applications that differ in (i) their importance to virtualisation customers (eg some could be critical to the operation of a business) and (ii) the ongoing resources needed to run a workload in storage systems, particularly in relation to the processing power they demand. Different deployment types use different charging structures, so there may be differences in the cost to run the same workload across different deployment types.

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[62] FMN, paragraph 15.180.
[63] *See* the Parties' response to the Issues Letter, dated 3 March 2023, paragraph 2.7, the Parties' teach-in presentation, dated 21 April 2023, slide 18, Broadcom's site visit presentation, dated 27 April 2023, slide 19, and the Parties' response to the Issues Statement, dated 10 May 2023, paragraph 1.9.
[64] FMN, paragraph 15.268.
[65] FMN, paragraphs 15.268 and 15.271.
[66] Parties' Teach-in presentation, 21 September 2022, slide 25.
[67] Parties' response to P1 RFI 2, 11 October 2022, paragraph 28.1.
[68] FMN, paragraph 20.200.
[69] Many vendors offer their own management and administration software alternative to vCenter Server, eg Lenovo, Dell, or Microsoft. VMware publishes APIs and the resources necessary for customers to develop their own management and administration software for their vSphere/ESXi servers. VMware estimates that most of its customers who purchase vSphere use vCenter Server. Source: FMN, footnote 485.

Server hardware components

Introduction

4.16 There are four types of server components supplied by Broadcom which are relevant to our assessment of the Merger.

I/O hardware devices

(a) *Ethernet network interface cards* (**Ethernet NICs**)*:* Ethernet NICs are server components that provide an interface between the server and other components (eg computers and equipment) of a network. Ethernet NICs communicate with other components of a network using the Ethernet standard protocol. Some network-interface cards are based on the InfiniBand standard protocol[70] but Broadcom only supplies Ethernet NICs.[71]

(b) *Fibre Channel host bus adapters* (**FC HBAs**)*:* FC HBAs are used to connect servers to networked storage located outside the server on a storage area network (**SAN**) using the standard Fibre Channel (**FC**) protocol.[72] Storage is media that records and preserves digital information for ongoing or future operations, examples include a hard-disk drive or solid-state drive.[73] A SAN is a network of storage disks that is accessed by a network of servers; SANs connect servers to storage devices enabling storage devices to be accessed and operated as if they were locally attached to the server.[74] FC HBAs are primarily used on deployment types outside the public cloud.[75]

(c) *Storage adapters:* Storage adapters connect the server's CPU to storage directly, ie to storage that is not located on a SAN. Direct-attached storage is storage that is connected directly to a server through a storage adapter. This storage may be internal (located within the server) or external (located in a storage enclosure).[76] Communication between the CPU and storage takes place over one of several industry-standard storage protocols. The principal storage protocols are SAS, SATA, and

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[70] FMN, paragraphs 15.446 and 15.447. InfiniBand is a network architecture with very low latency.
[71] So-called 'SmartNICs' add a sophisticated (ie CPU-level) processor to NICs. This enables the SmartNIC to handle network processing, relieving this burden from the server CPU. Like NICs, SmartNICs communicate with networked devices using open, industry standard protocols such as Ethernet and InfiniBand (source: FMN, paragraph 15.458). Broadcom does not supply SmartNICs, and we do not consider SmartNICs further.
[72] FMN, paragraphs 15.507-15.508.
[73] FMN, footnote 771.
[74] FMN, footnote 774.
[75] FMN, paragraph 15.537.
[76] FMN, paragraph 15.514.

NVMe. There are two main types of storage adapters, non-RAID and RAID:[77,78]

(i) A non-RAID adapter (also known as an I/O controller), is a basic chip for data transfer without any data protection capabilities.

(ii) A RAID adapter is a ready-made, more advanced storage adapter, with data protection capabilities built into it.

Other hardware components

(d) *Fibre Channel switches* (**FC switches**)*:* FC switches are used to connect the SAN to servers via FC HBAs. FC switches transfer data to/from FC devices. FC switches provide specific functionality, such as interconnecting different parts of a network to route and exchange data packets between the various sub-networks, which cannot be directly replicated by another hardware device.[79,80] FC switches are managed by an external software which is typically supplied by the FC switch provider, though FC switches can also be managed by third-party switch management software.[81] [82]

4.17 We refer to Ethernet NICs, FC HBAs, storage adapters and FC switches together as **I/O hardware and switches**, and Ethernet NICs, FC HBAs and storage adapters as **I/O hardware**.

I/O hardware and switches supply chain

4.18 Broadcom supplies a range of server hardware components to original equipment manufacturers (**OEMs**) such as Dell and Hewlett Packard, who in turn build and sell servers and related hardware components to companies (**enterprise customers**).[83]

4.19 In addition to I/O hardware and switches, Broadcom supplies a range of other components to OEMs (eg optical cables and transceivers, application specific integrated circuits (ASICs)[84], and physical layer products), and as such

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[77] Note of a call with [✂].
[78] RAID stands for redundant array of independent disks.
[79] Phase 1 Decision, 5 May 2023, paragraph 5.
[80] Broadcom P2 teach-in presentation, 21 April 2023, slide 45.
[81] Broadcom P2 teach-in presentation, 21 April 2023, slide 45.
[82] FMN, paragraph 20.10
[83] OEMs includes server OEMs, storage OEMs and those who are both.
[84] ASIC is a chip designed for a specific application or purpose, often for a specific customer, rather than intended for general-purpose use. Given their customisation, ASICs are often purchased under contract manufacturing arrangements where the customer owns the design and specifies the product to be manufactured. See FMN, footnote 22.

Broadcom has contractual relationships with these customers outside of the products relevant to this Merger.[85]

4.20 Broadcom also sells its hardware components, including Ethernet NICs and storage adapters, directly to Cloud service providers (**CSPs**) and hyperscalers who build their own servers.

4.21 Broadcom competes with other suppliers in I/O hardware and switches :

(a) *Ethernet NICs:* Broadcom is present in this market alongside Intel, NVIDIA, Cisco, AMD and others.[86]

(b) *Storage adapters:* Broadcom is present in this market alongside Marvell and Microchip.[87]

(c) *FC HBAs:* Broadcom is present in this market alongside Marvell.[88]

(d) *FC switches:* Broadcom is present in this market alongside Cisco.[89]

4.22 In addition to operating in the same I/O hardware and switches markets, customer and partner relationships exist between Broadcom and competing suppliers. For example: [✂] Broadcom; [✂]; Broadcom [✂] Broadcom [✂]; and [✂].[90]

Innovation in I/O hardware

4.23 Demand for new generation I/O hardware is driven by the need to keep up with the increasing processing power in compute products (ie CPUs). Suppliers of I/O hardware develop their own products to meet the new higher speed/performance standards, and next generation products are designed to match (or come close to) that same level of processing power. It is not possible for a supplier of I/O hardware to increase speed on its own – these products are by definition devices that connect a CPU to another device, and so their maximum speed is limited by the speed of the CPU and the other devices to which they connect.[91]

4.24 I/O hardware is built to comply with published industry standards. There are separate industry protocols for different speed/performance options, which are

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[85] Response to the CMA questionnaire from [✂], 14 April 2023, question 3; Parties' response to P1 RFI 5 , 23 December 2022, question 33.
[86] FMN, Table 77
[87] FMN, Table 83
[88] FMN, Table 82
[89] FMN, Paragraph 20.9
[90] Response to the CMA questionnaire from [✂], question 7,13, 20; Note of a call with [✂]; Note of a call with [✂].
[91] Parties response to the AIS and WPs, 15 June 2023, paragraph 6.11.

developed by the standards bodies through committees made up of suppliers, customers and other industry players. The expected performance of new generation devices are shared with industry standards bodies, who then develop the necessary protocols. The fact that suppliers are developing products to work with the new standard is not competitively sensitive; it is widely known as all suppliers are aware of and aiming to achieve the next stage of speed/performance set by the industry standard.[92] Roadmaps showing the expected timelines for launching new generation I/O hardware are published by the relevant industry standards bodies.[93]

4.25 Around one to two years before devices based on the new industry standard are due to be launched, the relevant standards body typically holds a public industry-wide 'plugfest' at which suppliers can test their prototype products. The purpose of the 'plugfest' is to publicise the new standard and encourage its adoption. Industry players are able to test their prototype product's interoperability with other industry players' prototype products, with test logs highlighting any issues which arise. The technical issues arising from these interoperability tests are visible to the industry players present. Suppliers of I/O hardware use this information to fine-tune their products prior to launch.[94]

Interaction between VMware server virtualisation software and Broadcom I/O hardware and switches

VMware's driver certification process for I/O hardware

4.26 Broadcom's I/O hardware interoperates with VMware's server virtualisation software.[95]

4.27 VMware has a range of certification programmes designed to provide vendors that produce I/O hardware with the necessary tools and development resources to design, build, and integrate products with core VMware features and capabilities and facilitate interoperability with VMware software.[96] VMware's testing suites run a series of tests to determine whether an I/O hardware product and driver works with VMware's products. The testing suites generate a log that the I/O hardware vendor submits to VMware for certification, which VMware then manually reviews. Hardware and software integration can also require some I/O hardware vendors to work with VMware

[92] Parties response to the AIS and WPs, 15 June 2023, paragraph 6.11.
[93] Parties response to the AIS and WPs, 15 June 2023, paragraph 6.11.
[94] Parties response to the AIS and WPs, 15 June 2023, paragraph 6.11.
[95] FMN, footnote 965.
[96] FMN, paragraph 20.38.

to troubleshoot issues that arise during testing.[97] VMware provides technical guidance to resolve these problems and has obligations to do so in its contracts with I/O hardware vendors.[98] Access to VMware's development kit is only available through VMware's I/O Vendor Partner (**IOVP**) programme, and the development kit is generally necessary to develop a driver that is compatible with VMware's hypervisor.[99]

4.28 When VMware confirms that a driver has passed all tests, VMware certifies the driver and lists the driver on its website (the **Compatibility Guide**).[100] If the vendor modifies the driver (eg to introduce new features or to maintain compatibility with new versions of VMware), the modified driver must be submitted for re-certification.[101]

4.29 Where I/O hardware vendors use already-certified device drivers in their new devices, VMware certifies these new devices via a process of 'equivalency', whereby VMware would certify that a new device was functionally equivalent to a pre-existing certified device, therefore obviating the need for a full certification process.[102]

4.30 VMware's server virtualisation software does have an option for customers to choose to allow uncertified drivers to load if an I/O hardware vendor were able to develop a compatible driver outside of the IOVP program. In practice, a customer would be unlikely to load uncertified drivers, as only loading certified drivers is a means to ensure the security of the environment and guard against malware.[103]

4.31 Since 2021, VMware has operated a subscription model, whereby I/O hardware vendors do not pay an additional fee for certification. Instead, they make a regular subscription payment to join the programme, which includes a number of certifications.[104] Membership also grants I/O hardware vendors access to updates and new releases of VMware products for development and testing.[105] The Parties told us that VMware introduced this new model to make it easier for I/O hardware vendors to budget.[106]

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[97] FMN, paragraph 20.56.
[98] FMN, paragraph 20.56.
[99] FMN, paragraph 20.44.
[100] See: VMware Compatibility Guide accessed by the CMA on 13 July 2023.
[101] FMN, paragraph 20.57.
[102] Parties' response to the Issues Statement, 10 May 2023, paragraph 4.9.
[103] FMN, paragraph 20.45.
[104] FMN, paragraph 20.53.
[105] FMN, paragraph 20.40.
[106] FMN, paragraph 20.53.

Interaction between FC switch management software and vCenter Server

4.32 FC switches do not communicate directly with vSphere, but instead communicate directly with servers and storage devices via FC HBAs only, using the industry-standard FC protocol. FC switches do not require a device driver for configuration or operational purposes.[107]

4.33 An FC switch's interaction with vSphere is limited to interaction between the FC switch provider's management software (**FC switch management software**) and vSphere's management component, vCenter Server, using public APIs provided by VMware (**vCenter APIs**).[108]

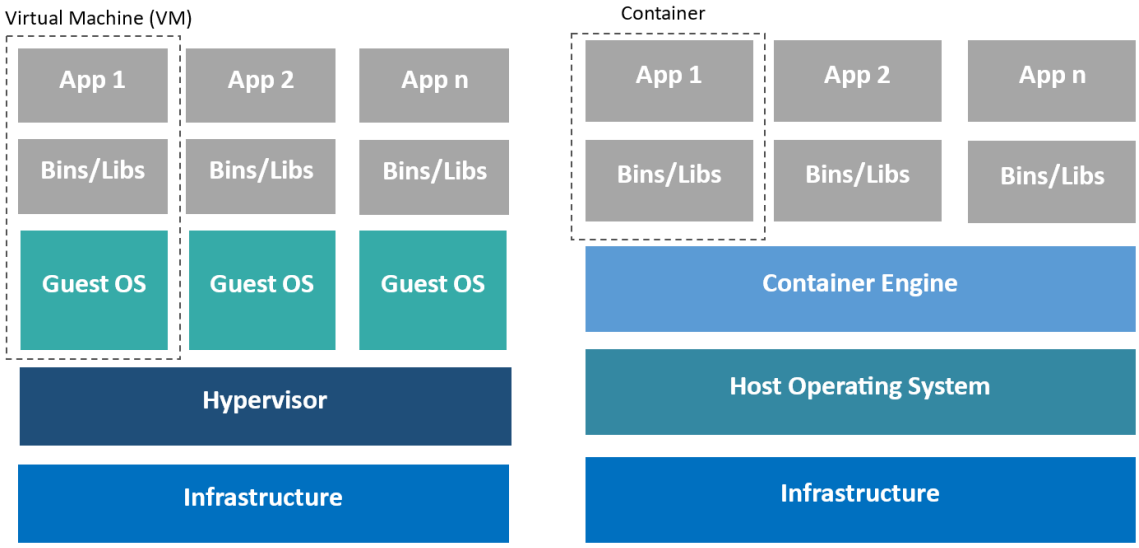
4.34 The same public vCenter APIs are used by enterprise customers to manage their IT environments, and by OEMs for their management and monitoring software.[109]

Containerisation

4.35 Containerisation is a way of partitioning an OS to produce isolated workspaces within it.[110] The level at which abstraction takes place in server virtualisation and containerisation is different. With a hypervisor, VMs are created through abstraction at the hardware (server) level, whereas containers are created through abstraction at the OS level (see also Figure 4.2 below).[111,112] Whereas server virtualisation divides a physical server (ie the 'Infrastructure' in the figure below) into isolated environments each with its own OS (diagram on left-hand side), containerisation divides a single OS into multiple isolated application runtimes (diagram on right-hand side).

[107] Parties' response to the Issues Statement, 10 May 2023, paragraphs 1.1, 1.2, 1.5, 1.6, 1.7 and 1.9.
[108] Parties' response to the Issues Statement, 10 May 2023, paragraphs 1.1, 1.2, 1.5, 1.6, 1.7 and 1.9.
[109] Parties' response to the Issues Statement, 10 May 2023, paragraphs 1.1, 1.2, 1.5, 1.6, 1.7 and 1.9.
[110] FMN, paragraph 15.236.
[111] FMN, paragraph 15.238.
[112] Containers can be used with or without hypervisors. Source: FMN, paragraphs 20.86 and 20.87.

Figure 4.2: Server virtualisation vs. Containerisation



Source: Parties' Teach-in presentation (21 September 2022), slide 31.
Notes: Bins = Binary Files. Libs = Libraries. Other than the combinations shown in this figure, it is also possible to use both a hypervisor and container engine technology at the same time (not shown in figure).

4.36 Containers enable workloads to share the same OS while remaining isolated from one another in a way that appears as though they are running in separate OSs. Workloads running in containers can only use the resources they are assigned and do not interact with workloads in other containers running on the same underlying OS.[113]

4.37 Containers can encapsulate all the requirements for an application independently of the underlying host OS, and consequently make it easier to port applications across on-premises, hybrid, and multi-cloud infrastructure. Other benefits identified by developers include enhanced functioning and productivity of applications, increased speed (as containers expedite workflows on applications), and flexibility (allowing developers to code applications in containers on their laptops).[114]

Cloud computing

4.38 VMs can also be deployed via cloud computing.[115]

[113] FMN, paragraph 15.237.
[114] FMN, paragraph 20.83.
[115] FMN, paragraph 15.187.

4.39 Cloud computing refers to the provision of computing resources as a service on-demand over a network. The two principal cloud deployment models are public cloud and private cloud:[116]

4.40 The **public cloud** is a service provided by a third-party CSP over a public network. Public cloud users only pay for the computing resources they use and can outsource their entire stack to CSPs (that pool these resources across multiple customers), eliminating the costs of purchasing and maintaining their own servers.[117] Other benefits to using the public cloud include increased agility, offering tools to allow customers to quickly develop and deploy their own modern applications and services, and scalability, as customers can easily expand or contract their public cloud usage as required by purchasing more resources from CSPs rather than having to invest in the capacity of their own data centre.[118] CSPs offer their own proprietary virtualisation software for this purpose.

4.41 The **private cloud** is more difficult to define and can overlap with other types of deployments. It generally refers to the provision of computing resources over a private network with hardware and software dedicated solely to the relevant enterprise. Private clouds can either be hosted by the enterprise for the benefit of its own users (**on premise**) or hosted by a third party who owns a data centre (**off premise**). Off premise private clouds are gated from other tenants using various isolation mechanisms, such as firewalls.

4.42 Ofcom's 'Cloud services market study' interim report (the **Ofcom market study**)[119] and industry research suggest that cloud computing (both public and private cloud) is expected to continue its growth in the coming years:

(a) The Ofcom market study states that it expects cloud computing to continue its growth as private and public cloud services become increasingly important to organisations.[120] In particular:

(i) Ofcom's customer research found that 82% of respondents had increased their spend on cloud in recent years, with 26% having greatly increased their budget in recent years.[121]

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[116] FMN, paragraph 15.184.
[117] FMN, paragraph 20.79.
[118] FMN, paragraph 15.194.
[119] Ofcom market study interim report, 5 April 2023.
[120] Ofcom market study interim report, 5 April 2023, paragraphs 3.13 and 3.14.
[121] Ofcom market study interim report, 5 April 2023, paragraphs 3.12. The Ofcom market study notes that '[i]t is possible that some respondents to our market research may have misunderstood the distinctions between private cloud, public cloud and on-premises infrastructure' (Ofcom market study interim report, 5 April 2023, paragraphs 3.41). However, this concern does not apply to this survey question as it asked about respondents' spend on 'cloud computing' generally rather than specifically about spend on private and public cloud environments.

(ii) Ofcom's customer research found that 79% of respondents expect to spend more on cloud in the next 18 months and that larger organisations are slightly more likely than smaller organisations to expect to increase spend.[122]

(b) IDC estimates provided by the Parties of the installed base of virtualised server units and CPUs on enterprise deployments and the public cloud globally show that, while the number of virtualised server units and CPUs on enterprise deployments has increased in the period 2019 – 2021, the number of virtualised server units and CPUs on the public cloud has increased at a faster rate in the same period.[123]

(c) Flexera research in 2022 with (mainly larger) European organisations found that 29% of respondents planned to increase their spend on the public cloud in the next twelve months, although Flexera notes that the rate of growth is slowing as some organizations may have already deployed high-priority applications to the public cloud.[124]

(d) Gartner 'cloud shift' research in 2022 forecast that enterprise IT spending on public cloud computing, within addressable market segments, will overtake spending on traditional IT in 2025.[125]

(e) A Goldman Sachs survey of IT executives from 100 Global 2000 companies in June 2022 suggested that 24% of respondents' workloads were already on the public cloud, with 42% of their workloads expected to be on the public cloud in the next three years.[126]

[122] Ofcom market study interim report, 5 April 2023, paragraphs 3.38.
[123] FMN, Tables 29 and 30.
[124] FMN, Annex Q15-008, '2022 State of the Cloud Report', page 46.
[125] See: Gartner Says More Than Half of Enterprise IT Spending in Key Market Segments Will Shift to the Cloud by 2025, accessed by the CMA on 13 July 2023.
[126] Survey cited in Ofcom market study interim report, 5 April 2023, page 18.

5. Counterfactual

5.1 The CMA assesses a merger's impact relative to the situation that would prevail absent the merger (ie the counterfactual). For anticipated mergers, the counterfactual may consist of the prevailing conditions of competition, or conditions of competition that involve stronger or weaker competition between the merger firms than under the prevailing conditions of competition.[127]

5.2 The CMA's conclusion on the counterfactual does not seek to ossify the market at a particular point in time, and an assessment based on the prevailing conditions of competition can reflect that, absent the merger, a merger firm would have continued making investments in improvements, innovations, or new products.[128]

5.3 The Parties stated that they do not submit any alternative counterfactual to the prevailing conditions of competition.[129,130] We have not received any evidence that indicates that our competitive assessment should be based on a counterfactual other than the prevailing conditions of competition.

5.4 It is therefore our provisional view that the prevailing conditions of competition represent the relevant counterfactual.

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[127] Merger Assessment Guidelines (CMA129), March 2021 (**MAGs**), paragraph 3.2.
[128] MAGs, paragraph 3.3.
[129] FMN, paragraph 11.1.
[130] In the context of submitting that VMware has no market power, the Parties later submitted that VMware's market position should not be assessed as it stands pre-Merger, but instead must be assessed in a counterfactual where VMware has reduced interoperability and weakened its product (see Parties' response to the AIS and WPs, 15 June 2023, paragraph 3.1(d)). We consider that submission when assessing VMware's market power as part of our competitive assessment in Chapter 7.

6. Market definition

6.1 The assessment of the relevant market is an analytical tool that forms part of the analysis of the competitive effects of the Merger.

6.2 VMware is active in server virtualisation software, and Broadcom is active in server hardware components, including Ethernet NICs, FC HBAs, storage adapters and FC switches. For the purposes of our inquiry, as a starting point for our analysis, we have considered the products offered by the Parties which were relevant to the theories of harm under investigation, namely:[131]

(a) the global supply of server virtualisation software (including the private cloud but excluding the public cloud and containerisation);

(b) the global supply of Ethernet NICs;

(c) the global supply of FC HBAs;

(d) the global supply of storage adapters; and

(e) the global supply of FC switches.

6.3 We have then considered whether some of these products could be part of a broader product market.

6.4 As set out in the MAGs, in assessing whether a merger may give rise to an SLC, the CMA may take into account constraints outside the relevant market, segmentation within the relevant market, or other ways in which some constraints are more important than others.[132] In many cases, rather than drawing 'bright lines' and reaching finely balanced judgements on what is 'inside' or 'outside' the market, it can be more helpful to describe the constraint posed by different categories of product or supplier as sitting on a continuum between 'strong' and 'weak'.[133]

6.5 The Parties did not make submissions on the frame of reference for FC switches. We consider that there is a separate product market for the supply of FC switches as they provide specific functionality (connecting servers and storage area networks outside the server through FC HBAs) which cannot be directly replicated by another hardware device.

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[131] These were the frames of reference adopted by the CMA in its Phase 1 Decision, 5 May 2023, paragraph 94.
[132] MAGs, paragraph 9.4.
[133] MAGs, paragraph 9.4.

6.6 The Parties submitted that the supply of FC HBAs and storage adapters each comprise a separate product market.[134] We agree that, for the purposes of our competitive assessment, it is appropriate to adopt these as relevant product markets and, where relevant, to take account of 'out-of-market' constraints as well as differentiation within the markets.

6.7 The Parties submitted in Phase 1 that the supply of Ethernet NICs should be part of a broader product market including the supply of non-Ethernet NICs.[135] We do not agree with the Parties that Ethernet NICs should be part of a broader market including other NICs. As noted in the Phase 1 Decision, the majority of customers that responded to the CMA's investigation considered that non-Ethernet NICs (such as InfiniBand NICs) do not constitute an alternative for Ethernet NICs.[136] Further, one hardware customer noted that InfiniBand is mostly used for high-performance computing, such as artificial intelligence and scientific computing.[137] The CMA therefore considers it appropriate to define a separate market for Ethernet NICs distinct from other, non-Ethernet NICs. We consider the differences between Ethernet NICs (ie those at or above 25 Gb/s and those below 25 Gb/s) as part of our competitive assessment.

6.8 The Parties also submitted that server virtualisation software used in data centres and the private cloud (ie **enterprise deployments**) should be part of a broader product market that also encompasses the public cloud, and separately that containers are an alternative to server virtualisation software.[138] In line with the approach set out in the CMA's MAGs, we consider that the analysis of the evidence gathered for the purposes of our competitive assessment in the present case, which assesses the constraints on VMware's market power, captures the competitive dynamics in server virtualisation software more fully than a separate formal analysis of market definition.

6.9 In the present case, we have assessed the competitive constraint on VMware's activities as a supplier of server virtualisation software in enterprise deployments globally. This includes the competitive constraint on VMware not only from other hypervisors (as discussed in paragraphs 7.33 to 7.53 below) but also from the virtualisation offering of CSPs (as discussed paragraphs 7.54 to 7.76 below) as well as from the use of containerisation software by virtualisation customers (as discussed in paragraphs 7.77 to 7.89 below). Provided the competitive constraints exerted by the offering of CSPs and/or

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[134] FMN, paragraphs 15.545-15.552.
[135] FMN, paragraphs 15.494-15.495.
[136] Phase 1 Decision, 5 May 2023, Paragraph 76(a).
[137] Response to the CMA questionnaire from [✂], question 5.
[138] FMN, paragraphs 15.327 and 15.343-15.345.

the use of containerisation software are taken into account we consider that it is not necessary to delineate exactly the contours of the server virtualisation software product market, and to determine whether, and to what extent, the product market definition should be widened to include these alternatives. This is the approach we have taken in Chapter 7 of the Provisional Findings.

6.10 We agree with the Parties' submissions that the geographic scope of the markets for server virtualisation software, Ethernet NICs, FC HBAs and storage adapters are global.[139] The Parties have not submitted any views on the appropriate geographic scope of the market for FC switches. Our analysis of the competitive effects in the UK supports a global frame of reference for each of these product markets.

6.11 Therefore, we have proceeded on the basis that we should assess the effects of the Merger in the markets listed at paragraph 6.2 above.

[139] FMN, paragraphs 15.350, 15.479, 15.553 and 15.554.

7. Foreclosure of I/O hardware and switches competitors through leveraging VMware's position in server virtualisation software

Introduction

7.1 In this chapter, we consider whether the Merged Entity would be likely to foreclose competitors by leveraging VMware's market power in server virtualisation software to reduce the competitiveness of Broadcom's hardware competitors by reducing interoperability between VMware's server virtualisation software and Broadcom's competitors' I/O hardware and switches. Such a reduction in interoperability may occur, for example, if the Merged Entity were to impair the certification of competitors' drivers for Ethernet NICs, FC HBAs, and storage adapters, or impair access to VMware's API for competitors' FC switches.

7.2 In assessing non-horizontal theories of harm, such as this, we follow the framework set out in the Merger Assessment Guidelines by considering whether three cumulative conditions are met: whether the Merged Entity would have the ability to foreclose its competitors, whether it would have the incentive to do so, and whether the effects of such foreclosure would substantially lessen overall competition.[140] We consider these in turn in the remainder of this chapter.[141]

Ability to foreclose

7.3 As part of our assessment of the Merged Entity's ability to foreclose, we have assessed and discuss in turn below:

(a) The degree of market power of VMware in the supply of server virtualisation software.

(b) The importance of interoperability with VMware for competition between suppliers of I/O hardware and switches.

[140] MAGs, paragraph 7.10.
[141] The theory of harm we consider in the present case could be assessed as either input foreclosure or as conglomerate effects. In line with the CMA's guidance, we have used an input foreclosure framework as part of our competitive assessment as the Merged Entity could use its presence in one market to directly harm the competitiveness of its competitors in another, even though there is not a conventional supplier/customer relationship between the Parties. See: MAGs, paragraph 7.11.

(c) The mechanisms the Merged Entity could use to foreclose Broadcom's competitors.

Assessment of VMware's market power in server virtualisation software

7.4 This section sets out one aspect of our assessment of whether the Merged Entity would have the ability to foreclose Broadcom's competitors – the extent to which VMware has market power in the supply of server virtualisation software in enterprise deployments. The Merged Entity will only be able to have a substantial impact in the markets for I/O hardware and switches if it occupies an important market position in server virtualisation software and customers cannot easily switch away to a range of effective alternative suppliers.[142]

The Parties' submissions

7.5 The Parties submitted that VMware does not have market power in the supply of server virtualisation software in enterprise deployments.[143] In the Parties' view, this is because:

(a) VMware's share of virtualised CPUs in on-premises data centres is around [✂]% and has been in decline for a number of years, with VMware losing [✂] of dollars of new business to CSPs and to other virtualisation software competitors each year.[144] For new virtualised licences shipped globally across all deployment types, the Parties provided IDC estimates that show that VMware's share of supply declined from [✂]% to [✂]% between 2019 and 2021.[145]

(b) VMware's virtualisation software competes with other virtualisation software, as well as with CSPs and containerisation software, including:[146]

(i) Other proprietary virtualisation software, such as Microsoft Hyper-V, which is bundled with Microsoft's Windows Server OS. The Parties note that Hyper-V is the main proprietary alternative to VMware.

[142] MAGs, paragraph 7.14 and 7.33.
[143] FMN, paragraph 20.75; Parties' response to the AIS and WPs, 15 June 2023, paragraph 1.3.
[144] Parties' response to the AIS and WPs, 15 June 2023, paragraph 1.3; Parties' VMware market position paper, 15 June 2023, paragraph 1.1.
[145] Parties' VMware market position paper, 15 June 2023, paragraph 1.1.
[146] FMN, paragraph 15.300.

(ii) Free open-source virtualisation software, such as KVM and Xen, which are both hypervisors as well as being the basis for other hypervisors (including Citrix, Red Hat, and Google Cloud).

(iii) Paid open-source virtualisation software, such as Red Hat's RHV, Nutanix's AHV, and Citrix's hypervisor, which are available for free but for which customers are charged for technical support by providers.

(iv) CSPs, such as AWS, Google, Microsoft, IBM, Oracle, and Alibaba, which have their own virtualisation offerings for workloads deployed on the public cloud as well as for use in enterprise deployments.

(v) Containerisation software, which can be an alternative to server virtualisation software, and can also facilitate the movement of workloads away from VMware to alternative virtualisation providers.

(c) Competing hypervisors and CSPs provide a strong competitive constraint on VMware, as shown by internal documents, lost opportunities, and industry reports.[147] VMware's customers are increasingly moving workloads to the virtualisation offerings of other hypervisors and CSPs, both in the private and public cloud, as well as using containerisation options for their workloads as alternatives to hypervisors.[148]

(d) Switching costs for moving workloads from VMware to alternative virtualisation products are low, and switching workloads is quick and straightforward in many circumstances.[149] The prevalence of multi-sourcing by VMware's customers (both across other hypervisors and CSPs) and the use of migration tools, third-party consultancies, and container software facilitate switching workloads away from VMware.

(e) VMware's customers would switch significant volumes of workloads away from VMware in response to a loss of interoperability, which would destroy VMware's fundamental value proposition of providing a virtualisation layer for the server that works with any hardware the customer has installed in their data centre.[150] Enterprises in all industries

[147] FMN, paragraph 20.79; Parties' response to the AIS and WPs, 15 June 2023, paragraph 1.3; Parties' VMware market position paper, 15 June 2023 paragraph 1.1.
[148] Parties' VMware market position paper, 15 June 2023, paragraph 1.1.
[149] Parties' response to the Phase 1 Issues Letter, 3 March 2023, paragraph 2.6.
[150] Parties' response to the AIS and WPs, 15 June 2023 paragraph 1.3; Parties' VMware market position paper, 15 June 2023, paragraph 1.1.

can and do move workloads of all types away from VMware to alternative virtualisation products offered by other hypervisors and CSPs.[151]

7.6 The Parties also submitted that VMware's market position should not be assessed against the conditions of competition that would prevail absent the Merger, but instead it must be assessed in a counterfactual where it has reduced interoperability and weakened its competitive offering to virtualisation customers given the fundamental change this would be to VMware's value proposition.[152] We disagree with the Parties' submission as any reduction in interoperability is conduct the Merged Entity may choose to pursue as a result of the Merger. Only events that would have happened in the absence of the merger under review – and are not a consequence of it – can be incorporated into the counterfactual.[153] We have therefore conducted our assessment of VMware's market power against the relevant counterfactual of the conditions of competition that would prevail absent the Merger.[154]

Our assessment

7.7 We have considered the range of alternatives available to VMware's customers. If VMware's customers can easily switch workloads away from VMware's server virtualisation software (vSphere) to a range of effective alternatives, then the Merged Entity is less likely to have the ability to foreclose Broadcom's competitors as a result of the Merger. On the other hand, if VMware's customers have few effective alternatives and/or cannot easily switch to these alternatives for both their existing and new workloads, the Merged Entity may be more likely to have the ability to foreclose Broadcom's competitors as a result of the Merger. The range of effective alternatives to vSphere could, in principle, include switching to another supplier of server virtualisation software, switching to the virtualisation offering of a CSP, and/or using containerisation software.

7.8 When assessing the extent to which VMware has market power, we have considered (and address in turn below) the following:

(a) Shares of supply in server virtualisation software.

(b) VMware's competitive position in the supply of server virtualisation software.

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[151] Parties' VMware market position paper, 15 June 2023, paragraph 1.1.
[152] Parties' response to the AIS and WPs, 15 June 2023, paragraph 3.1(d).
[153] MAGs, paragraph 3.4.
[154] As set out in the Counterfactual.

(c) The competitive constraint on VMware from other hypervisors.

(d) The competitive constraint on VMware from CSPs.

(e) The competitive constraint on VMware from containerisation providers.

7.9 As part of our assessment, we have considered the views of virtualisation customers, the behaviour of virtualisation customers, VMware's internal documents, and other evidence we have gathered as part of our inquiry.

Shares of supply in server virtualisation software

7.10 Measures of concentration, such as shares of supply, can be useful evidence when assessing the competitive constraints on the merger firms, particularly when there is persuasive evidence as to which potential substitutes should be included or excluded in the market, and when, although differentiated, the degree of differentiation between firms is more limited.[155] In other cases, such as where the boundaries of the market are not as clear-cut, where reliable estimates of shares of supply are not readily available, or where there is a high degree of differentiation, other sources of evidence on the competitive constraints on the merger firms may be relied on to a greater extent.[156]

7.11 In the present case, we consider that shares of supply may be of more limited evidentiary value, relative to other evidence, in assessing the competitive strength of suppliers of server virtualisation software as the available data is less reliable and there is a degree of differentiation in the offering of virtualisation providers (as set out below).

7.12 Given this, we use the shares of supply evidence to understand the relative size of virtualisation providers, how their relative market positions have changed over time and to provide an initial indication of the competitive constraints on VMware in the supply of server virtualisation software. Furthermore, as we have not concluded on a bright-line market definition, we have calculated shares of supply on multiple different bases as set out below.

7.13 We have estimated VMware's share of supply for server virtualisation software in enterprise deployments by supplementing the Parties' own analysis to include VMware's internal data and internal data obtained from third parties. Where the internal data of third parties was unavailable, we have relied on the shares of supply estimated by IDC as part of an analysis commissioned by the Parties. Our analysis is shown in Table 7.1 below.

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[155] MAGs, paragraphs 4.14.
[156] MAGs, paragraphs 4.15.

Table 7.1: Shares of supply in server virtualisation software based on number of CPUs installed in enterprise deployments globally, 2019-2021

%

Virtualisation provider	*2019*	*2020*	*2021*
VMware	[40-50]	[40-50]	[40-50]
Microsoft	[20-30]	[20-30]	[20-30]
IBM	[5-10]	[5-10]	[10-20]
Oracle	[0-5]	[0-5]	[0-5]
SUSE	[0-5]	[0-5]	[0-5]
Nutanix	[0-5]	[0-5]	[0-5]
Others	[20-30]	[10-20]	[10-20]

Source: CMA analysis of FMN, paragraph 15.364 and Table 43; Response to the CMA P1 virtualisation competitor questionnaire, question 3 from [✂]. Figures adjusted to reflect third party internal data.

7.14 Table 7.1 shows that, for enterprise deployments:

(a) VMware has consistently had the largest share of supply in each year of the period 2019 – 2021, with over [40-50]% in each year. Contrary to the Parties' submissions, it does not show a declining trend.[157]

(b) VMware's share of supply was almost twice the size of the second largest supplier, Microsoft (with a share of [20-30]%), followed by IBM (with a share of [10-20]%), in 2021.

(c) The supply of server virtualisation software in enterprise deployments is highly concentrated, with VMware and its two largest competitors representing around [70-80]% of supply and a tail of other suppliers (including Oracle, SUSE, and Nutanix) each having a share of supply of less than 5%.

7.15 We note that the enterprise deployment offerings of CSPs, such as AWS (with its Outposts product), Google (with its Anthos product), and Alibaba (with its Apsara Stack product), are included within the 'others' category set out in Table 7.1. We estimate that the combined share of these three suppliers was less than 5% in enterprise deployments in 2021.

7.16 Our analysis shown in Table 7.1 is broadly consistent with other evidence on VMware's share of supply in enterprise deployments.[158] Our review of VMware's internal documents found that, in the ordinary course of business, VMware views its share of supply in server virtualisation software as at least [40-50]% (although these documents do not calculate VMware's share of supply on the same basis as the analysis set out in Table 7.1).[159] Views from

[157] See Appendix C Shares of Supply, paragraph 10.
[158] More on our shares of supply analysis, as well as our assessment of the Parties' submissions, can be found in Appendix C.
[159] See Appendix C Shares of Supply, paragraph 25.

third parties we spoke to indicate that VMware is likely to have a share of at least 40% in some server virtualisation segments.[160]

7.17 We have also considered shares of supply based on the number of virtualised server CPUs installed in all deployment types (ie enterprise deployments and the public cloud) globally. While we give greater weight to the shares of supply set out in Table 7.1 as we consider vSphere to be more substitutable with other server virtualisation software than with the virtualisation offerings of CSPs for virtualisation customers' existing workloads (as set out below), we acknowledge that VMware competes with CSPs for at least some workloads. Other evidence that addresses the strength of the competitive constraint on VMware from CSPs is set out below.

7.18 Table 7.2 shows the shares of supply based on the number of virtualised server CPUs installed in all deployment types globally. As with the analysis for enterprise deployments, we have supplemented the Parties' own analysis of VMware's share of supply based on the number of virtualised server CPUs installed globally by including the internal data we obtained from third parties. Where the internal data of third parties was unavailable, we relied on the shares of supply estimated by IDC.

Table 7.2: Shares of supply in server virtualisation software based on number of CPUs installed in all deployment types globally, 2019-2021

%

Virtualisation provider	*2019*	*2020*	*2021*
Microsoft	[20-30]	[20-30]	[20-30]
VMware	[20-30]	[20-30]	[20-30]
AWS	[10-20]	[10-20]	[10-20]
IBM	[5-10]	[5-10]	[5-10]
Google	[0-5]	[0-5]	[0-5]
Alibaba	[0-5]	[0-5]	[0-5]
Others	[20-30]	[20-30]	[20-30]

Source: CMA analysis of FMN, Tables 43 and 51-55; Response to the CMA P1 virtualisation competitor questionnaire, question 3 from [✂].

7.19 Table 7.2 shows that, across all deployment types:

(a) Microsoft and VMware have had similar shares of supply in each year of the period 2019 – 2021, although VMware's share has fallen slightly faster than Microsoft's towards the end of this period. This is consistent with the Parties' submissions that VMware's share has followed a declining trend.

(b) Microsoft was the largest supplier with a share of [20-30]% in 2021, followed closely by VMware with a share of [20-30]%. AWS was the third largest supplier with a share of [10-20]% in 2021, whose share has

[160] See Appendix C Shares of Supply, paragraph 26.

increased from [10-20]% in 2019. IBM was the fourth largest supplier in 2021 with a share of [5-10]%.

(c) The supply of server virtualisation software across all deployment types is concentrated, with the four largest suppliers representing [60-70]% ([✂]) of supply and a tail of other suppliers (including Google and Alibaba) each having a share of supply of less than 5%.

7.20 Based on the evidence set out above, we consider that VMware's global share of supply in server virtualisation software in enterprise deployments has been at least 40% (almost twice the size of its nearest competitor) in each year of the period 2019 – 2021. When considering all deployment types (ie enterprise deployments and the public cloud), VMware is one of the two largest server virtualisation software providers with a global share of at least 20% in 2021 (a similar share to the other largest provider and significantly greater than the share held by any other), although its share has declined somewhat since 2019.

7.21 More details of our shares of supply analysis, as well as our assessment of the Parties' submissions, can be found in Appendix C.

VMware's competitive position

7.22 While our analysis of shares of supply shows that VMware was the largest supplier of server virtualisation software in enterprise deployments in each year of the period 2019 – 2021, measures of concentration are only one piece of evidence that we have considered as part our assessment of VMware's market power in the present case. We now set out other evidence and analysis relevant to assessing VMware's competitive position in server virtualisation software.

- *Use of VMware by virtualisation customers*

7.23 As part of our assessment of VMware's competitive position, we have considered how VMware is used by virtualisation customers in enterprise deployments.

7.24 The evidence on the behaviour of virtualisation customers shows that VMware is a key supplier of server virtualisation software to virtualisation customers:

(a) The majority of respondents to our questionnaire indicated that they either only use the hypervisor vSphere for their workloads, or where they use another supplier of server virtualisation software, they use vSphere for the

large majority of their workloads. More than half of respondents indicated that 95-100% of their workloads use vSphere.[161]

(b) The 2021 Workload Study (**WLS**) shows that[162] although VMware is typically used alongside other 'IT infrastructure platforms' (which include other hypervisors and CSPs), a material proportion of respondents that are VMware customers only deploy workloads on VMware and around one third of respondents who multi-source and use VMware deploy more than [60-70]% of their workloads on VMware.[163]

(c) The 2021 WLS also shows that respondents were [✂] to keep existing workloads on their current VMware software or to [✂] in the next [✂] than to [✂].[164]

7.25 The evidence on the behaviour of virtualisation customers also shows that VMware's importance to virtualisation customers is expected to continue at least in the short term.

(a) The WLS shows that VMware usage is expected to [✂] in the short term. While the share of workloads deployed on VMware is forecasted to be [✂] between 2021 and 2024, [✂] will remain deployed on VMware [✂] other provider (including CSPs and hypervisors).[165]

(b) An external market assessment conducted by [✂] on behalf of VMware shows that VMware will continue to be important for virtualisation customers in the short term. However, while [✂] between 2021 and 2024, [✂].[166]

(c) A VMware customer that offers managed cloud services told us that 'VMware as a hypervisor will still be the core of many enterprise and government customers in the next decades'.[167]

- *Views of virtualisation customers*

7.26 We asked VMware's customers for their views on VMware's competitive position in the supply of virtualisation software, to explain why they selected

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[161] [✂]. Responses to the CMA's Phase 2 Virtualisation customer questionnaire, question 5 from [✂].
[162] The WLS was conducted on behalf of VMware by Management Insight Technologies between October and December 2021 to assess the level of risk for cloud migration by VMware customers (See DMN dated 19 August 2022, Annex Q15-011, preface to the submission). More on the 2021 WLS can be found in Appendix F.
[163] CMA analysis of Parties' response to P1 RFI 4, 7 December 2022, question 12, RFI4Q12-001 'Workload_Study_Clean.dta', question B20.
[164] CMA Analysis of Parties' response to P1 RFI 4, 7 December 2022, question 12, Annex RFI4Q12-001, 'Workload_Study_Clean.dta', question E10; see also DMN, 19 August 2022, Annex Q15-011, p.19
[165] DMN 19 August 2022, Annex Q15-011, p.13
[166] VMware response to the s109 notice issued 2 May 2023, Annex Q2.1a, [✂].
[167] Note of call with [✂].

VMware, and whether alternative server virtualisation software suppliers would be able to meet their requirements.

7.27 Respondents to our questionnaire indicated that VMware has a strong, established position in the supply of virtualisation software. A large majority of them described VMware as having a leading position,[168] while several respondents explained that they selected VMware as a supplier due to its long-standing position in the supply of virtualisation software.[169,170] Most respondents also considered that there are few alternatives to VMware that meet their requirements.[171]

7.28 In addition to VMware's market leading and long-standing position, respondents identified VMware's broad range of products and the functionality of its software as important sources of its competitive strength:

(a) Several respondents considered VMware's ability to offer a broad range of products related to server virtualisation software, such as network and storage virtualisation software, as an important part of VMware's offering.[172]

(b) One respondent viewed the interoperability between VMware's broad range of products as a key factor in its selection of VMware, noting that '[i]t is the eco-system that makes VMware products attractive for our data centres and our customer-solutions [as] [m]ost of them use additional VMware products on top of virtualization'.[173]

(c) Another respondent told us that alternatives to VMware are not currently 'as feature rich, stable and considered business grade' and that, although 'there are other hypervisors, there are no alternatives that are as feature rich and mature' as VMware.[174]

7.29 As respondents identified VMware's broad range of products as an important source of its competitive strength, we asked customers to indicate which VMware products they use. We found that respondents typically use a number of other VMware products in varying proportions alongside its

[168] Responses to the CMA P1 customer questionnaire, question 6, [✂].
[169] Responses to the CMA P1 customer questionnaire, question 7, [✂].
[170] A number of respondents also told us that they have been long-time customers of VMware, choosing them either at the start of their virtualisation journeys, or having switched to them many years ago. (Note of calls with [✂]).
[171] Responses to the CMA P1 customer questionnaire, question 7, [✂].
[172] Responses to the CMA P1 customer questionnaire, question 7, [✂].
[173] Responses to the CMA P1 customer questionnaire, question 9, [✂].
[174] Responses to the CMA P1 customer questionnaire, question 7, [✂].

vSphere server virtualisation software, with the large majority of respondents also using VMware's vRealize, vSan, and NSX software.[175]

- *VMware's internal documents*

7.30 We have reviewed a wide range of VMware's internal documents as part of our assessment of its position in the supply of server virtualisation software. The vast majority of these have been produced in the normal course of business, although some have been prepared in the context of the Merger.

7.31 VMware's internal documents indicate that VMware holds [✂] position in the supply of server virtualisation software, in particular as a result [✂], and that its portfolio of [✂] across deployment types is a [✂].[176]

- *Our view on VMware's competitive position*

7.32 Based on the evidence set out above, we consider that VMware has a strong competitive position in the supply of server virtualisation software in enterprise deployments. In particular:

(a) Respondents to our questionnaire indicated that VMware has a strong, established position in the supply of virtualisation software, with its broad range of products and the functionality of its software being important sources of its competitive strength.

(b) VMware is a key supplier of server virtualisation software to virtualisation customers and VMware's importance to virtualisation customers is expected to continue in the coming years.

(c) VMware's internal documents indicate that VMware holds [✂] position in the supply of virtualisation software, in particular as a result of its [✂], and that its broad range of products [✂].

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[175] CMA analysis of responses to the CMA P2 virtualisation customer questionnaire, question 2, [✂]. This is in line with submissions made by the Parties. Specifically, the Parties have submitted that VMware's vSphere server virtualisation software is rarely used as a standalone product by its customers, who typically use a range of other software offered by VMware as a complement to vSphere (such as NSX, vSAN, SDDC Manager, and vRealize). See: Parties response to P1 RFI 4, 7 December 2022, question 2, M.10806 - Form CO - Conglomerate - Annex 55, paragraph 2.5. In addition, an MIT Study collecting core metrics for VMware's business planning found that vSphere customers commonly manage vSphere deployments with VMware's virtual machine management software (ie vRealize Operations or vCenter Server). See: VMware response to the s109 notice issued 2 May 2023, Annex Q2.13.a - MIT, VMware Core Metrics W12.pptx, slide 164.

[176] See, for example: VMware internal document, VMW-2R-003395415, pages 1 and 2; VMware internal document, RSLV_00029833, page 8; VMware internal document, RSLV_00028772, pages 4, 5, and 19; VMware internal document, Annex Q10(VM) - 011, page 113 – 114; Broadcom internal document, BVM000000046, page 43; and VMware internal document, RSLV_00020174, pages 31 and 32.

Competitive constraint on VMware from other hypervisors

7.33 We now turn to assessing the strength of the competitive constraint on VMware from other hypervisors that supply server virtualisation software in enterprise deployments.

7.34 There is a degree of differentiation between the competitive offerings of the other hypervisors available to VMware customers. As set out above, the server virtualisation software offered by hypervisors can be proprietary software (such as VMware's vSphere and Microsoft's Hyper-V products), free open-source software (such as KVM and Xen), or paid open-source software (such as Red Hat's RHV, Nutanix's AHV, and Citrix's hypervisor).[177] In addition to their differing business models, suppliers of server virtualisation software differ in the range of other associated software they offer virtualisation customers (such as containerisation software and OSs) and whether they offer a product that can be used across deployment types.[178] These offerings may be more or less substitutable with vSphere for virtualisation customers based on their diverse needs and specific requirements for server virtualisation in enterprise deployments, which we explore as part of our assessment below.

7.35 As noted above, we have found that the global supply of server virtualisation software in enterprise deployments is highly concentrated, with VMware and its two largest competitors (Microsoft and IBM) representing around [70-80]% of supply, Microsoft and IBM having significantly smaller shares of supply than VMware, and a tail of small suppliers. In this section, we set out other evidence and analysis relevant to assessing the constraint on VMware from other hypervisors.

- *Use of hypervisors by virtualisation customers*

7.36 As part of our assessment of the competitive constraint on VMware from other hypervisors, we have considered how customers choose to deploy workloads on server virtualisation software.

7.37 The evidence on the behaviour of virtualisation customers shows that the use of multiple hypervisors by VMware customers is uncommon.

(a) As set out above, the majority of respondents to our questionnaire indicated that they either only use the hypervisor vSphere for their

[177] FMN, paragraph 15.300.
[178] FMN, Tables 38 – 40.

workloads, or where they use another supplier of server virtualisation software, they use vSphere for the large majority of their workloads.[179]

(b) For those respondents to our questionnaire that use other suppliers' software alongside vSphere, the supplier most commonly used was Microsoft Hyper-V. However, no respondent indicated this to be its main supplier.[180] Other suppliers of server virtualisation software, including IBM (Red Hat), Nutanix (AHV), and Oracle (VM VirtualBox, VM Server), were rarely used alongside vSphere.[181]

(c) Respondents to our questionnaire commonly identified economies of scale to be a key driver for using only one hypervisor (ie vSphere), citing benefits such as: (i) better commercial terms for using one supplier given volume bundling or volume discounts,[182] (ii) training staff only in the use of one server virtualisation software,[183] (iii) simplifying IT operations and avoiding the duplication of maintenance,[184] and (iv) facilitating a high degree of standardisation.[185,186]

(d) The 2021 WLS shows that respondents more commonly multi-source by [✂].[187] This type of multi-sourcing where one hypervisor is combined with multiple CSPs is part of customers' hybrid cloud strategy.[188]

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[179] Responses to the CMA P2 Virtualisation customer questionnaire, question 5 [✂].
[180] Deployment on Hyper-V ranged from below 1% to at most 25% (Responses to the CMA P2 Virtualisation customer questionnaire, question 5 from [✂]).
[181] [✂] used Oracle for at most 5% of their workloads [✂]. [✂] used Nutanix for less than 5% of workloads [✂]. [✂] used IBM Red Hat for at most 10% of their workloads [✂]. [✂] [✂] used Red Hat for 30% of workloads in its [✂]. (Responses to the CMA P2 Virtualisation customer questionnaire, question 5).
[182] Responses to the CMA P2 Virtualisation customer questionnaire, question 7(a) from [✂].
[183] Responses to the CMA P2 Virtualisation customer questionnaire, question 7(a) from [✂].
[184] Responses to the CMA P2 Virtualisation customer questionnaire, question 7(a) from [✂].
[185] Response to the CMA P2 Virtualisation customer questionnaire, question 7(a) from [✂].
[186] While respondents tended to describe more extensively the benefits of using only one hypervisor, several respondents (including respondents with only one supplier) indicated that the use of multiple hypervisors allows a customer to have some competitive leverage in negotiations with their suppliers. (Responses to the CMA P2 Virtualisation customer questionnaire, question 7(b) from [✂]).
[187] We looked at which specific 'IT infrastructure platforms' were used most often alongside VMware. We found that around [40-50]% of respondents who use VMware said they are using [✂] and around [40-50]% of respondents said they are using the [✂]. Other CSPs and hypervisors were identified significantly less often ([✂] [20-30]%; [✂] [20-30]%; [✂] [10-20]%). We note for completeness that this could understate the magnitude of multi-homing with competing hypervisors as Microsoft Hyper-V and Citrix XenServer were not prompted as response options. Respondents could have used the 'Other (Specify)' option for competing hypervisors like Hyper-V. However, this option was selected by less than [0-5]% of respondents. The Parties also submitted that respondents could have reported Microsoft Hyper-V usage as 'Microsoft Azure'. (CMA Analysis of Parties' response to P1 RFI 4, 7 December 2022, question 12, Annex RFI4Q12-001 'Workload_Study_Clean.dta', question B10).
[188] Note of call with [✂].

- *Movement of existing workloads between hypervisors*

7.38 We also considered the extent to which virtualisation customers switch between suppliers of server virtualisation software.

7.39 We found that (i) there is limited switching between hypervisors due to the significant switching costs incurred by virtualisation customers for little benefit, and (ii) virtualisation customers do not have plans to move existing workloads between hypervisors in the coming years:

(a) Respondents to our questionnaire that had moved existing workloads between hypervisors since 2020 told us that this was only a minimal proportion of workloads.[189] When asked, no respondent indicated that they had plans to move existing workloads between hypervisors.

(b) The 2021 WLS shows that respondents were less likely to [✂].[190]

7.40 In addition, we found that barriers to switching are high due to the costs, time and effort involved in moving existing workloads between hypervisors.[191]

(a) Respondents to our questionnaire told us that they had no reason to switch given VMware's competitive position,[192] switching suppliers would be complex without offering enough benefit,[193] or switching costs would be substantial (beyond the sunk costs from having invested in the existing server virtualisation software licenses).[194,195]

(b) Respondents' estimates for the scale of investment required to switch from VMware to an alternative hypervisor ranged from $1m to more than

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[189] The proportion of existing workloads that respondents had moved was typically small and estimated to be no more than 5% (Responses to the CMA P2 Virtualisation customer questionnaire, question 8(a.i) and question 8(a.ii) from [✂]). There is [✂] [✂] [✂] which indicated having moved approximately 30% of existing workloads between suppliers of server virtualisation software since 2020 as these 'application and database servers' workloads could be moved based on its requirements and the location of these workloads.
[190] CMA Analysis of Parties' response to P1 RFI 4, 7 December 2022, question 12, Annex RFI4Q12-001 'Workload_Study_Clean.dta', question E10; see also DMN,19 August 2022, Annex Q15-011, page 19.
[191] Consistent with the barriers to switching and high switching costs identified by virtualisation customers, VMware's own IT team explained in a 2022 IDC case study that '[m]ost workloads that VMware runs are not designed to be portable, and once it is decided where a workload goes, that is where it stays'. See: VMware response to the s109 notice issued 2 May 2023, question 2, IDC White Paper (sponsored by VMware), Managing Multicloud Complexity, October 2022, page 16.
[192] These customers considered VMware as the market leader, offering the best value and functionality, and that moving existing workloads would not bring about significant cost improvements. (Responses to the CMA P2 Virtualisation customer questionnaire, question 8(b.i) from [✂]).
[193] Respondents explained that it would require, *inter alia*, extensive planning and preparation, testing and operational support, and could risk impacting services offered. (Responses to the CMA P2 Virtualisation customer questionnaire, question 8(b.i) from [✂]).
[194] Responses to the CMA P2 Virtualisation customer questionnaire, question 8(b.i) from [✂].
[195] One customer explained to us that switching hypervisors is significantly more complex than (i) upgrading a version of VMware Cloud Foundation (**VCF**) for which they are spending over £[✂] in professional services or (ii) moving from VMware's previous virtual suite to VCF which cost them in the order of £[✂] and took them [✂]. (Note of call with [✂]).

$300m.[196] Virtualisation customers' estimates regarding the time involved to move from vSphere to an alternative hypervisor ranged from 'over one year' to '[✂] of concentrated effort'.[197]

(c) Respondents to our questionnaire commonly also identified barriers to switching such as the need to rebuild or refactor existing workloads for the new hypervisor,[198] the potential loss of interoperability between existing workloads as some are moved away from VMware,[199] the need to upskill existing employees,[200] the significant time and labour required to implement changes,[201] as well as the disruption to the business.[202,203]

7.41 We found that barriers to switching supplier of server virtualisation software vary in some instances, depending on the existing workloads being switched, whether all or some existing workloads are being switched, and whether a customer switches to or away from vSphere:

(a) Respondents told us that simple VMs or existing workloads with few dependencies are easier to switch, whilst those with many dependencies as well as integrated solutions are more difficult to switch between suppliers of virtualisation software.[204]

(b) Respondents were divided as to whether barriers to switching depend on whether all existing workloads (ie total switching) or only some existing workloads (ie partial switching) are switched. Some respondents stated that partial switching is not feasible,[205] often due to higher efforts in maintaining multiple hypervisors or because total switching is simpler, inter alia, to avoid interoperability issues. Other respondents, in turn, suggested partial switching was preferable,[206] inter alia, because some existing workloads could not be switched, partial switching allows for priority movement of simpler existing workloads, and total switching is more expensive.

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[196] There was one exception [✂] which estimated costs of $250,000-500,000. (Responses to the CMA P1 Virtualisation customer questionnaire, question 18(b) from [✂]).
[197] Note of call with [✂]; Note of call with [✂].
[198] Responses to the CMA P1 Virtualisation customer questionnaire, question 18(a) from [✂].
[199] Responses to the CMA P1 Virtualisation customer questionnaire, question 18(a) from [✂].
[200] Responses to the CMA P1 Virtualisation customer questionnaire, question 18(a) from [✂].
[201] Responses to the CMA P1 Virtualisation customer questionnaire, question 18(a) from [✂].
[202] Responses to the CMA P1 Virtualisation customer questionnaire, question 18(a) from [✂].
[203] Some respondents also told us that switching hypervisors was more difficult than switching CSPs, inter alia, due to the additional planning required for hardware as well as the lack of seamless migration tools compared to the 'Lift and Shift functionality' in Infrastructure as a Service (**IaaS**). (Responses to the CMA P1 Virtualisation customer questionnaire, question 18(d) from [✂]).
[204] Responses to the CMA P1 Virtualisation customer questionnaire, question 18(c) from [✂].
[205] Responses to the CMA P1 Virtualisation customer questionnaire, question 18(e) from [✂].
[206] Responses to the CMA P1 Virtualisation customer questionnaire, question 18(e) from [✂].

(c) The majority of respondents said that it would be easier to move to VMware than to another supplier,[207] inter alia, because VMware offers migration tools or because their staff is already skilled in using VMware.

- *Views of virtualisation customers on other hypervisors*

7.42 We asked customers for their views on alternative providers of virtualisation and containerisation software and whether the offering of these providers was an effective alternative to VMware's virtualisation software.[208]

7.43 Microsoft was seen as a suitable alternative provider to VMware by respondents:

(a) Several respondents cited experience of using other Microsoft products to explain why Hyper-V is a suitable alternative to VMware, as this may reduce transition costs.[209]

(b) Some respondents identified Microsoft's breadth of product suites, particularly in virtualisation and containerisation, as a reason for it being a suitable alternative.[210]

(c) Some respondents also identified Microsoft as a suitable alternative especially for Microsoft-based systems as Hyper-V is integrated with the Microsoft Windows OS.[211]

7.44 IBM was seen as a somewhat suitable alternative provider to VMware by respondents.

(a) Many respondents identified RedHat OpenShift as a key player in containerisation,[212] with one referring to it as 'the leading Container Platform'.[213]

(b) However, some respondents explained that IBM was not a suitable alternative to VMware because its virtualisation product is comparable

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[207] Responses to the CMA P1 Virtualisation customer questionnaire, question 18(f) from [✂].
[208] We note that our question captured a wide variety of alternative providers and not just alternative server software virtualisation software as customers were asked: 'Please score the providers of virtualisation and containerisation for each deployment type. For each provider, please assign a score from 1 to 5, where 5 = a very suitable alternative to VMware and 1 = a provider that is not a suitable alternative VMware, and explain why you gave that ranking.' The alternatives given to respondents were: Alibaba, AWS, Citrix, Google, Huawei, IBM (including RedHat), Microsoft, Linux Foundation, Mirantis, Nutanix, Oracle, SUSE, Xen Project, Other. We have used the average scores from the responses to identify these alternatives as very suitable (with an average score of 5), suitable (4), somewhat suitable (3), not suitable (2), or not at all suitable (1).
[209] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[210] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[211] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[212] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[213] Responses to the CMA P1 customer questionnaire, question 8, from [✂].

only at a basic level. It lacks the 'advanced capabilities' of VMware and is, therefore, not a fully functional replacement.[214]

7.45 Nutanix was also seen as a somewhat suitable alternative provider to VMware by respondents:

(a) Some respondents noted a similarity in Nutanix's suite of tools to VMware, and raised its ability to span across cloud deployments as a key reason it could be an alternative.[215] One respondent referred to it as the 'best for hybrid cloud option'.[216]

(b) A few respondents raised a lack of product maturity to explain why Nutanix was not an effective alternative to VMware.[217]

7.46 Citrix was seen as a somewhat suitable alternative provider to VMware by respondents. Many respondents identified Citrix as an alternative in desktop virtualisation, but not for other workloads,[218] with one suggesting that it is 'not a fully functional replacement' for VMware.[219]

7.47 Oracle was not seen as a suitable alternative provider to VMware by respondents. Several respondents cited a lack of capabilities as a reason Oracle was not an alternative to VMware,[220] with two of these respondents highlighting Oracle's specific focus on databases.[221] A small number of respondents cited difficulty in working with Oracle as a reason not to see it as an alternative.[222]

7.48 Respondents did not see the virtualisation software of other providers, such as Linux KVM and Xen Project, which both offer free open-source hypervisors, as alternatives to VMware.[223]

- *VMware's internal documents*

7.49 Our review of VMware's competitive monitoring and benchmarking documents found that VMware typically monitors certain hypervisors, namely [✂], [✂],

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[214] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[215] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[216] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[217] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[218] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[219] Response to the CMA P1 customer questionnaire, question 8, from [✂].
[220] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[221] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[222] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[223] [✂] respondents identified limited capabilities as justification for not seeing SUSE OS as an alternative. See: Responses to the CMA P1 customer questionnaire, question 8, from [✂].

and [✂], more closely than other suppliers of server virtualisation software. For example:

(a) A VMware internal document dated November 2019 indicated that VMware considers [✂] product to be a strong competitor in virtualisation software, noting that [✂] competes with VMware in relation to a wide breadth of its portfolio and lists [✂] as a primary competitor to VMware's vSphere.[224]

(b) A VMware quarterly business review in September 2020 noted that, while [✂] is a strong competitor, it does not have the same functionality as vSphere and that '[✂]'.[225]

(c) VMware's internal documents noted that [✂] has a similar strategy to VMware.[226] However, these documents also noted [✂].[227]

(d) A VMware presentation to Broadcom dated July 2022 (which was prepared for the Merger) listed [✂].[228]

7.50 In addition, the Parties submitted analysis of [✂].[229]

7.51 Other hypervisors were identified less frequently, if at all, by VMware in its competitive monitoring and benchmarking documents and, where they were mentioned, were seen as weaker competitive threats than [✂], [✂], and [✂].

- *Our view on the competitive constraint from other hypervisors*

7.52 Based on the evidence set out above, we consider that there is a weak constraint on VMware's server virtualisation software from other hypervisors for existing workloads in enterprise deployments. In particular:

(a) Respondents to our questionnaire only identified Microsoft, with its Hyper-V product, to be a suitable alternative hypervisor to vSphere. IBM, Nutanix, and Citrix were only seen as somewhat suitable alternatives to vSphere by respondents.

(b) The use of other hypervisors alongside VMware by virtualisation customers is uncommon, there is limited switching between hypervisors,

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[224] VMware internal document, RSLV_00020174, page 31 and 94.
[225] VMware internal document, RSLV_00008337, page 32. It is not clear if this quote refers to [✂], rather than [✂]. However, given the reference to [✂].
[226] VMware internal document, RSLV_00029833, page 8, and VMware internal document, RSLV_00028772, page 24.
[227] VMware internal document, RSLV_00020174, page 95.
[228] VMware internal document, RSLV_00029833, page 8.
[229] Parties' VMware market position paper, 15 June 2023, Figure 3.

including to and from VMware, due to the significant switching costs incurred by virtualisation customers for little benefit, and virtualisation customers do not have plans to move existing workloads between hypervisors in the coming years.

(c) VMware typically monitors certain hypervisors, namely [✂], [✂], and [✂], more closely than other suppliers of server virtualisation software, who were identified less frequently, if at all, by VMware.

7.53 We note that the constraint from Microsoft's Hyper-V and (to a lesser extent) other hypervisors on VMware's server virtualisation software may be stronger for new workloads in enterprise deployments. For new workloads, customers would not face the same barriers to switching as they do for existing workloads given there is no migration process and new workloads would not need to be rebuilt or refactored for a different hypervisor.

Competitive constraint on VMware from CSPs

7.54 We now turn to assessing the strength of competitive constraint on VMware from CSPs which offer server virtualisation software in all deployment types. As set out above, CSPs such as AWS, Google, Microsoft, IBM, Oracle, and Alibaba have their own virtualisation offerings for workloads deployed on the public cloud as well as offerings that can be used in enterprise deployments.[230]

7.55 As noted above, we have found that VMware is one of the two largest virtualisation providers in the supply of server virtualisation software across all deployment types globally, following (closely) Microsoft and in turn followed by AWS and IBM, and a tail of small suppliers. In this section, we have set out other evidence and analysis relevant to assessing the constraint on VMware from CSPs.

- *Use of the public cloud by virtualisation customers*

7.56 As part of our assessment of the competitive constraint on VMware from CSPs, we have considered the workload deployment types that are currently used by virtualisation customers.

7.57 The evidence on the behaviour of virtualisation customers shows that, while the use of CSPs' virtualisation offering alongside VMware virtualisation

[230] FMN, paragraph 15.300.

software is common, many virtualisation customers run a material proportion of their workloads on enterprise deployments:

(a) As discussed in paragraph 7.24(b), the 2021 WLS showed that respondents more typically multi-source [✂].

(b) While almost all respondents to our questionnaire said that they have both enterprise deployments and deployments in the public cloud,[231] the large majority of respondents said that their enterprise deployment is larger than their deployment in the public cloud.[232,233]

(c) The 2021 WLS showed that most respondents do rely on public cloud to a certain extent.[234] However, the vast majority of respondents [✂] said they deploy the majority of their workloads on deployment types other than the public cloud.[235] Relying primarily or exclusively on the public cloud was [✂].[236]

- *Movement of existing workloads to the public cloud*

7.58 We have also considered the extent to which virtualisation customers move existing workloads from enterprise deployments to the public cloud, as well as what barriers they may face in moving these workloads.

7.59 Most respondents to our questionnaire indicated that they have moved some existing workloads from enterprise deployments to the public cloud since 2020.[237,238] In contrast to the movement of existing workloads between

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[231] [✂]. One respondent [✂] said that they have no information readily available on the proportion of workloads that run on enterprise deployments, the public cloud and other deployment types. (Responses to the CMA P2 Virtualisation customer questionnaire, question 10).
[232] In particular, [✂] respondents indicated that their current deployment mix favours public cloud over enterprise deployments (with 60% of workloads in the public cloud and 40% in enterprise deployments). (Responses to the CMA P2 Virtualisation customer questionnaire, question 10 [✂]).
[233] This is consistent with a 2022 IDC White Paper and case study of VMware's internal IT department. For most of the customers that IDC interviewed, on-premises was still the majority of their footprint (page 10). VMware's internal IT department similarly explained that '[w]hile VMware has footprints in many clouds, for cost reasons the preference is on-premises, and that is where the majority of its workloads are [deployed]'. (VMware response to the s109 notice issued 2 May 2023, question 2, IDC White Paper (sponsored by VMware), Managing Multicloud Complexity, October 2022, page 16).
[234] Less than [✂]% of respondents reported no deployment on public cloud.
[235] The median respondent had around [✂]% of their workloads on public cloud. These other deployment types included: a respondent's own data centre, Edge environment, Hoster/ Colocation/ Managed Services Provider, Other. Very few respondents (ie less than [✂]%) reported that they are deploying more than [✂]% of their workloads on the public cloud (CMA Analysis of Parties' response to P1 RFI 4, 7 December 2022, question 12, RFI4Q12-001 'Workload_Study_Clean.dta', Question A20).
[236] Less than [✂]% of respondents reported that they deploy more than 80% of their workloads on the public cloud.
[237] The exceptions were [✂]. [✂] respondents [✂] did not answer the question (Responses to the CMA P2 Virtualisation customer questionnaire, question 12(a.i) and 12(b)).
[238] While the proportion of existing workloads moved varied across respondents, the estimates provided by respondents showed that this movement did not normally exceed 30% for the three-year period. (Responses to the CMA P2 Virtualisation customer questionnaire, question 12(a.i) [✂].

hypervisors, respondents to our questionnaire considered that the benefits of moving certain existing workloads from enterprise deployments to the public cloud typically outweighed the costs. The most widely cited driver was the cost effectiveness of public cloud relative to traditional data centres due to the pay-as-you-go model offered by CSPs.[239] A related driver identified by several respondents was the public cloud's ability to offer scale on demand.[240] Some respondents also identified CSPs' differentiated capabilities as a reason for moving existing workloads.[241]

7.60 However, the majority of respondents to our questionnaire noted that there are high barriers to moving existing workloads to the public cloud.[242]

(a) The migration process can take weeks and, in some instances, months,[243] and generally depends on the complexity of the workload, the workload's architecture and age, whether it needs to be refactored, as well as the amount of data involved.[244,245]

(b) Besides migration cost and the time required to move an existing workload, respondents identified as barriers to migration: (i) the sunk costs from existing investments in on-premises data centres and technologies,[246] (ii) their existing or long-term contracts,[247] (ii) the technical complexity of the migration process,[248] (iii) the need to rearchitect applications,[249] and (iv) business risk.[250,251]

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[239] Responses to the CMA P2 Virtualisation customer questionnaire, question 12(a.iv) from [✂].
[240] Responses to the CMA Phase 2 Virtualisation customer questionnaire, question 12(a.iv) from [✂].
[241] This included PaaS, IaaS and SaaS, the 'use of dedicated cloud offerings', the 'available public cloud capabilities', the 'toolset available in public cloud', as well as 'automation'. (Responses to the CMA P2 Virtualisation customer questionnaire, question 12(a.iv) from [✂]).
[242] [✂] rated barriers to switching to public cloud as 'high' (including [✂] who said 'medium/high') [✂] as 'medium' and [✂] as 'low'. Responses to the CMA P1 Virtualisation customer questionnaire, question 5 from [High: [✂]; Medium: [✂]; Low: [✂].
[243] In particular, a VMware customer [✂] explained to us that 'lift and shift' migrations can take days or weeks to complete. If refactoring is required, however, the migration may take longer. Note of call with [✂].
[244] Responses to the CMA P2 Virtualisation customer questionnaire, question 12(a.iii) from [✂].
[245] Consistent with this, a customer explained to us that the migration of some internally written applications had taken them about 3 to 6 months in the past while the migration of a number of the customer's finance systems from their data centres into their [✂] cloud had taken over 18 months. (Note of call with [✂].
[246] Response to the CMA P1 Virtualisation customer questionnaire, question 5(a,b) from [✂].
[247] Responses to the CMA P1 Virtualisation customer questionnaire, question 5(a,b) from [✂].
[248] Responses to the CMA P1 Virtualisation customer questionnaire, question 5(a,b) from [✂].
[249] Responses to the CMA P1 Virtualisation customer questionnaire, question 5(a,b) from [✂].
[250] Response to the CMA P1 Virtualisation customer questionnaire, question 5(a,b) from [✂].
[251] The barriers identified by respondents to our questionnaire are consistent with a 2023 Accenture survey of business and IT leaders on the state of cloud adoption. The survey found that barriers to migrating existing workloads to the cloud persist despite an increase in cloud investment: (i) workload migration is 'time and resource intensive', and often particularly challenging for business-critical workloads, and (ii) 'acquiring and retaining the skills needed to migrate' is reported to be a persistent challenge. Another common barrier is the need to modernise legacy applications (Accenture, 'The race to the cloud', p.4, pp.18-19).

7.61 While virtualisation customers expect to increase their use of the public cloud in the coming years (see paragraph 4.42), they also expect to retain a material proportion of their workloads on enterprise deployments:

(a) Most respondents to our questionnaire who had moved existing workloads to the public cloud since 2020 indicated that they have plans to continue doing so over the next five years. While respondents' estimates regarding the proportion of existing workloads they expect to shift over the next five years varied significantly, only one respondent indicated plans to move all applications to public cloud over the next five years (ie completing the move to public cloud).[252]

(b) The 2021 WLS showed that the number of workloads deployed in data centres by respondents in aggregate was expected to remain stable between 2021 and 2024, declining by only [0-5]% per year in this period.[253]

(c) A VMware-commissioned IDC White Paper from October 2022 discussed that 'enterprises still have large footprints of on-premises servers that run bare metal and VMs, and they will have these for the foreseeable future',[254] that 'on-premises datacenters are not going away' and that '[o]n-premises infrastructure also continues to innovate'.[255]

(d) Other evidence from third parties and industry experts on the expected existing workload movements of virtualisation customers noted that the pace of migration to the public cloud has slowed recently in part due to (i) macroeconomic pressures,[256] and (ii) the ongoing costs and [✂],[257,258] and that this may continue over the coming years.

7.62 We also found that the reasons given by respondents for retaining workloads on enterprise deployments, and the proportion of their workloads that will remain on enterprise deployments in the coming years, varied based on their diverse needs and specific requirements:

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[252] Response to the CMA P2 Virtualisation customer questionnaire, question 12(a.vi) from [✂].
[253] DMN, 19 August 2022, Annex Q15-011, page 9.
[254] VMware response to the s109 notice issued 2 May 2023, question 2, IDC White Paper (sponsored by VMware), Managing Multicloud Complexity, October 2022, page 6.
[255] VMware response to the s109 notice issued 2 May 2023, question 2, IDC White Paper (sponsored by VMware), Managing Multicloud Complexity, October 2022, pages 9-10.
[256] Note of call with [✂].
[257] Note of call with [✂].
[258] 2023 Flexera State of the Cloud Report, page 38.

(a) Respondents to our questionnaire commonly noted that some workloads have specific requirements (such as latency and performance or security and privacy) which makes them unsuitable for the public cloud.[259]

(b) Several respondents also expressed a strong preference for running some workloads in enterprise deployments due to a range of external factors, such as regulation in their industry or contractual obligations limiting public cloud use,[260] as well as workloads not being optimised or at all compatible with the public cloud without refactoring.[261]

(c) For some respondents, the company's hosting strategy and workload placement governance also played a role in determining whether public cloud was a good alternative to their enterprise deployments.[262] Some respondents also identified the cost involved in moving existing workloads from enterprise deployments to the public cloud as a factor that limits substitutability.[263]

(d) Although respondents varied in their estimates of the proportion of workloads they have strong preference to retain in enterprise deployments, most respondents indicated that critical workloads, or workloads affected by regulation, make up less than 40% of their total workloads.[264] Only a relatively small subset of respondents suggested that those workloads make up the vast majority of their total workloads.[265]

(e) Respondents also varied significantly in their current demand for enterprise deployments (by number of virtualised servers) as well as how they expected their demand to evolve in the coming years,[266] based on

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[259] All the requirements mentioned by respondents are: latency and performance, security and privacy, data proximity and data residency, or compliance. (Responses to the CMA P2 Virtualisation customer questionnaire, question 11(a) from [✂]).
[260] Responses to the CMA P2 Virtualisation customer questionnaire, question 11(a) from [✂]. Our customer feedback regarding regulation as is consistent with an Industry Regulation Review, conducted by [✂] on behalf of VMware (dated August 2021). The review found that customers in highly regulated industries are: (i) significantly more likely to remain on-premises only, (ii) have a higher share of VMs on vSphere, and (iii) intend to migrate a significantly smaller share off vSphere than customers in less regulated industries. Highly regulated industries were considered to be: banking or financial services; education/training; federal, state and local agencies; healthcare; insurance. Less regulated were considered to be: consumer products; energy/utilities; industrials; media; non-profit; professional services; retail; real estate; technology; travel, tourism and hospitality (VMware response to the s109 notice issued 2 May 2023, question 2, [✂]).
[261] Responses to the CMA P2 Virtualisation customer questionnaire, question 11(a) from [✂]. Compatibility and optimisation may depend on the workload's age. Some respondents noted that older applications may have software licensing limitations, or require refactoring or rebuilding which means that they are not easily moved away from enterprise deployments. (Responses to the CMA P2 Virtualisation customer questionnaire, question 11(c) from [✂]).
[262] Responses to the CMA P2 Virtualisation customer questionnaire, question 11(c) from [✂].
[263] Responses to the CMA P2 Virtualisation customer questionnaire, question 11(c) from [✂].
[264] [✂]. Responses to the CMA P2 Virtualisation customer questionnaire, question 11(b) from [✂].
[265] Responses to the CMA P2 Virtualisation customer questionnaire, question 11(b) from [✂].
[266] In particular, out of all respondents who provided an estimate for the change in the number of virtualised servers they use between 2022 and 2027, around half of respondents estimated there to be an increase in the

their diverse business priorities and budgets for IT transformation (including for refactoring legacy applications).

7.63 In comparison to the workloads that virtualisation customers prefer to retain in enterprise deployments, workloads in the public cloud often make use of the differentiated offering of CSPs, including the ability to easily scale up and down the resources needed for workloads as well as the differentiated capabilities of CSPs' native cloud offerings compared to traditional hypervisors (see paragraph 7.59).[267]

7.64 Based on the evidence from virtualisation customers set out above, we consider that the observation that the number of workloads deployed on the public cloud is growing does not in itself suggest that the competitive constraint on VMware from the virtualisation offering of CSPs is becoming stronger, nor does it allow for strong inferences to be made about the substitutability of vSphere with the virtualisation offerings of CSPs for workloads in general. Respondents to our questionnaire differed in their views on whether the virtualisation offerings of CSPs are a substitute for server virtualisation software for their existing workloads.[268] While only a minority regarded the public cloud as an alternative to enterprise deployments for some of their existing workloads in the short term (ie within 24 months),[269] the majority of respondents did consider the public cloud to be an alternative in the longer term (ie more than 24 months).[270] However, respondents tended to qualify their views on the applicable timeframe, explaining that it depends on a workload's use case or architecture, or external factors such as compliance, security, regulatory and latency requirements.[271]

- *Views of virtualisation customers on the virtualisation offerings of CSPs*

7.65 As set out above, we asked customers for their views on alternative providers of virtualisation and containerisation software and whether the offering of

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number of virtualised servers they use while the others estimated there to be a decrease. One respondent [✂] estimated the number of enterprise deployments they use to be roughly constant over the next 5 years. (Responses to the CMA P2 Virtualisation customer questionnaire, question 9 [✂]).

[267] Related to the ability so scale up and down, some respondents considered the public cloud to be an alternative because of ongoing cost efficiencies stemming from a consumption-based subscription model. (Responses to the CMA P2 Virtualisation customer questionnaire, question 11(c) from [✂]).

[268] Responses to the CMA P1 customer questionnaire, question 5(a). We asked customers whether they would find the alternatives listed (virtualisation on public cloud, or containerisation on bare metal) to be a substitute for virtualisation software for enterprise in both the short and long run.

[269] [✂] said public cloud is an alternative to enterprise deployments in the 'short run'. Responses to the CMA P1 customer questionnaire, question 5(a), from [✂].

[270] [✂] said the public cloud is an alternative to enterprise in the 'short run' and/or 'long run'. We assume that respondents who said the public cloud is an alternative in the 'short run' would also regard the public cloud as an alternative in the 'long run' (ie [✂] only ticked 'short run' and are included in the count). Responses to the CMA P1 customer questionnaire, question 5(a), [✂].

[271] Responses to the CMA P1 customer questionnaire, question 5(c) [✂].

these providers was an effective alternative to VMware's virtualisation software.

7.66 Respondents indicated that CSPs are alternative providers to VMware for at least some of their workloads:

(a) As noted above, Microsoft was seen as a suitable alternative provider to VMware by respondents. A few respondents identified Microsoft's Azure hybrid-cloud offering and its key position as a public cloud provider when giving reasons for their views on its suitability as an alternative provider to VMware.[272]

(b) AWS was also seen as a suitable alternative provider to VMware by respondents. Many respondents identified AWS as a market leader for the public cloud and noted that AWS is an alternative for workloads that can be deployed on its public cloud.[273] Only one respondent identified AWS's enterprise deployment offering, AWS Outposts, when providing reasoning for the suitability of AWS as an alternative provider to VMware.[274]

(c) Google was seen as a somewhat suitable alternative to VMware by respondents. Many respondents also identified Google as an established public cloud provider, citing that it is an alternative provider of virtualisation and containerisation for workloads that can be deployed on its public cloud.[275] No respondent identified Google's enterprise deployment offering, Anthos, when providing their reasoning for the suitability of Google as an alternative provider to VMware.

7.67 Unlike other CSPs, Alibaba was not seen as a suitable alternative to VMware. Respondents explained that, for workloads deployed in the UK and the EU, Alibaba was not an effective alternative to VMware due to national security concerns.[276]

- *VMware's internal documents*

7.68 Our review of VMware's internal documents shows that VMware has recognised the growth of workloads on the public cloud and the virtualisation

[272] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[273] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[274] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[275] Responses to the CMA P1 customer questionnaire, question 8, from [✂].
[276] Responses to the CMA P1 customer questionnaire, question 8, from ✂]. [✂] respondents sighted data sovereignty/security concerns explicitly [✂] while other respondents stated Alibaba was only an alternative in China, and not in the UK/EU [✂].

offerings of CSPs as a long-term competitive threat to its strong competitive position for a number of years:

(a) One document from 2020 described VMware as a [✂] and that VMware's strategy to [✂].[277]

(b) Material presented to VMware's Board of Directors in April 2021 showed that, [✂].[278] [✂].

(c) A 2021 strategy document describes CSPs as [✂]' in the context of its multi-cloud strategy.[279] However, this document also notes [✂].

(d) A VMware presentation to Broadcom dated July 2022 (which was prepared in the context of the Merger) [✂].[280]

7.69 In addition, the Parties submitted analysis of [✂].[281] [✂].

7.70 VMware's internal documents also suggest that its portfolio of virtualisation and containerisation software means it is [✂].[282] However, more recent VMware internal documents show that [✂].[283] [✂].[284]

7.71 Customer studies commissioned by VMware with the objective to identify actions which accelerate the growth of VMC show that [✂]. For example, a [✂] (dated August 2021) found that VMware customers [✂].[285]

7.72 Although the number of workloads deployed in the public cloud is expected to continue to grow in the coming years, VMware's internal documents show that [✂] of workloads on enterprise deployments and that the number of workloads on enterprise deployments [✂] in the coming years.

(a) Material presented to VMware's Board of Directors in April 2021 showed that, [✂].[286]

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[277] VMware internal document, RSLV_00008105, pages 3-5.
[278] VMware internal document, Annex Q10(VM) - 011, page 114.
[279] VMware internal document, RSLV_00028772, pages 3 and 24.
[280] VMware internal document, RSLV_00029833, page 8.
[281] Parties' VMware market position paper, 15 June 2023, Figure 3.
[282] See, for example: VMware response to the s109 notice issued 2 May 2023, question 2 , IDC White Paper, Managing Multicloud Complexity – Summary Findings, pages 3 and 4; VMware internal document, RSLV_00029833, page 8; VMware internal document, RSLV_00008105, pages 3-5; and Broadcom internal document, BVM000000046, page 5.
[283] VMC combines vSphere, vSAN, NSX, and cloud infrastructure running on public cloud servers. VMware told us that by providing VMware software on public cloud servers, VMC enabled 'lift and shift' of on-premises workloads to the cloud, and that VMC was available on all major CSPs, eg 'VMC on AWS' [Amazon Web Services]. See: VMware site visit presentation, 26 April 2023, slide 34.
[284] See, for example, VMware internal document, RSLV_00100868, page 111.
[285] VMware response to the s109 notice issued 2 May 2023, question 2, [✂], page 23. [✂].
[286] VMware internal document, Annex Q10(VM) - 011, page 114.

(b) This material also noted that VMware estimated that [✂], which suggests that the vast majority of the growth of the public cloud comes from newly deployed workloads rather than workloads that are migrated away from enterprise deployments.[287]

(c) IDC estimates provided by the Parties show that the number of virtualised server units and CPUs on enterprise deployments has increased by [5-10]% and [5-10]%, respectively, over the period 2019 – 2021, although the number of virtualised server units and CPUs on the public cloud has increased at a faster rate over the same period.[288]

(d) The most recent update on the performance of VMware's server virtualisation software shows that [✂].[289] The document also notes that [✂].[290]

7.73 This evidence shows that VMware expects virtualisation customers to continue to deploy and rely on workloads in enterprise deployments, where VMware has a strong competitive position in the supply of server virtualisation software, for the foreseeable future despite the growth of the public cloud and the competitive threat of CSPs' virtualisation offerings.

7.74 In enterprise deployments, evidence from VMware's internal documents indicates that competition between VMware and the virtualisation offerings of CSPs for workloads is more limited. For example, the Parties submitted analysis of [✂].[291]

- *Our view on the constraint from CSPs*

7.75 Based on the evidence set out above, we consider that there is currently a moderate constraint on VMware from the virtualisation offerings of CSPs, with competition between VMware and CSPs limited to workloads that virtualisation customers are able and willing to deploy on the public cloud. In particular:

(a) While respondents to our questionnaire identified AWS and Microsoft Azure as suitable alternatives to vSphere for at least some of their workloads, the large majority of respondents either did not view CSPs' virtualisation offering as an alternative to server virtualisation software or

[287] VMware internal document, Annex Q10(VM) - 011, page 115.
[288] FMN, Tables 29 and 30.
[289] VMware internal document, [✂], page 40.
[290] VMware internal document, [✂], page 42.
[291] VMware's market position paper, 15 June 2023, Figure 3. [✂].

only considered this an alternative in the longer term (ie more than 24 months).

(b) While the use of CSPs' virtualisation offering alongside VMware virtualisation software is more common than using multiple hypervisors, virtualisation customers run a material proportion of their workloads on enterprise deployments and are expected to continue doing so despite increasing their use of the public cloud.

(c) Although there are benefits to moving certain existing workloads to the public cloud as the differentiated offerings of CSPs are seen to be better suited for some workloads than enterprise deployments, barriers to switching are high, and customers have a preference to retain some workloads on enterprise deployments based on their diverse needs and specific requirements.

(d) While VMware's internal documents recognise the [✂] of CSPs, they also show that the growth of public cloud is [✂], with workloads in enterprise deployments (where VMware has [✂] competitive position) expected to [✂].

7.76 We also consider that there is a weak constraint on VMware from the virtualisation offerings of CSPs for workloads in enterprise deployments. In particular:

(a) The combined share of the virtualisation offerings of CSPs in enterprise deployments (other than Microsoft Azure) was less than 5% [✂] in 2021, suggesting that these products have not been widely adopted by virtualisation customers.

(b) Only one respondent to our questionnaire identified AWS Outposts when providing its reasons for the suitability of AWS as an alternative provider to VMware. No respondent identified Google Anthos or Alibaba Apsara Stack in response to our questionnaire.

(c) Evidence from VMware's internal documents indicates that competition between VMware and the virtualisation offerings of CSPs for workloads in enterprise deployments is more limited than for workloads deployed in the public cloud.

Competitive constraint on VMware from containerisation software

7.77 We now turn to assessing the strength of the constraint on VMware from containerisation software. As set out above, containerisation software can be an alternative to server virtualisation software for VMware customers, and it

can also facilitate the movement of existing workloads away from VMware to other hypervisors and CSPs.[292]

- *Use of containerisation software by virtualisation customers*

7.78 As part of our assessment of the competitive constraint on VMware from containerisation software, we have considered the current use of containerisation software by virtualisation customers.

7.79 The evidence on the behaviour of virtualisation customers shows that there is currently limited adoption of containerisation software by VMware customers. The large majority of respondents did not deploy more than 15% of their workloads on containerisation software.[293,294] Moreover, one [✂].[295] Another VMware customer that offers [✂] also told us that while containerisation is of increasing popularity in the industry, these products are not yet compatible with existing 'big' enterprise applications.[296]

- *Movement of existing workloads using containerisation software*

7.80 We have also considered whether the use of containerisation software impacts the ease of moving existing workloads.

7.81 The evidence on the behaviour of virtualisation customers shows that the use of containerisation software to facilitate the movement of existing workloads between hypervisors or across deployment types is currently limited:

(a) A few respondents that are in the early stages of using containerisation said that the technology should make moving existing workloads between hypervisors easier in the future but did not necessarily expect the technology to significantly simplify workload movements in the short term.[297]

(b) In line with the limited adoption of containerisation software, few respondents were able to comment on whether its use impacts the ease of moving existing workloads from enterprise deployments to the public cloud. However, some of the respondents who did comment considered

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[292] FMN, paragraph 15.300.
[293] This included the deployment of containers on top of a hypervisor, as well as the deployment of containers on bare metal without a hypervisor. Responses to the CMA P2 virtualisation customer questionnaire, question 13, from [✂].
[294] Only a minority of respondents had more than 90% of their workloads on containerisation software, with a small number deploying all of their workloads on containerisation software. (Responses to the CMA P2 virtualisation customer questionnaire, question 13 from [✂]).
[295] Note of call with [✂].
[296] Note of call with [✂].
[297] Responses to CMA P2 Virtualisation customer questionnaire, question 14(a) from [✂].

that containers should, in principle, reduce the time and costs of moving existing workloads to the public cloud.[298]

(c) One customer explained to us that while they do expect to containerise more workloads in the future both on-premises and in the public cloud, they have not used containers to move existing workloads from their data centres to the public cloud and are not close to realising this potential use case.[299]

7.82 The views of respondents are consistent with the latest VMware-commissioned IDC White Paper from October 2022 discussing that hybrid, portable containers are a 'myth' because container migrations towards cloud take significant planning. Moreover, 'not all containers are easily portable in advanced scenarios'. Portability and migration remain difficult due to 'hard dependencies' on APIs as well as 'data gravity'.[300]

7.83 In addition, we also asked virtualisation customers for their views on whether containerisation software is a substitute for server virtualisation software for their existing workloads.[301] The majority of respondents to our questionnaire either did not view containers that run on bare metal as an alternative to the use of server virtualisation software on enterprise deployments or only considered this an alternative in the longer term (ie more than 24 months).[302, 303]

- *Views of virtualisation customers on containerisation providers*

7.84 As set out above, we asked customers for their views on alternative providers of virtualisation and containerisation software and whether the offering of these providers was an effective alternative to VMware's virtualisation software.

7.85 However, only one containerisation provider, IBM with its OpenShift product, was identified as a somewhat suitable alternative to VMware by respondents to our questionnaire.[304] Other providers of containerisation software, such as

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[298] Responses to CMA P2 Virtualisation customer questionnaire, question 15(a) from [✂].
[299] Note of call with [✂].
[300] VMware response to the s109 notice issued 2 May 2023, question 2, IDC White Paper (sponsored by VMware), Managing Multicloud Complexity, October 2022, p.11
[301] Responses to CMA P1 customer questionnaire, question 5. We asked customers whether they would find the alternatives listed (virtualisation on public cloud, or containerisation on bare metal) to be a substitute for virtualisation software for enterprise in both the short and long run.
[302] Responses to CMA P1 customer questionnaire, question 5, from [✂]. Only a small proportion considered containerisation on bare metal as an alternative in both the short run and long run, [✂].
[303] A few respondents to our questionnaire considered containerisation on bare metal as an alternative to the use of server virtualisation software on enterprise deployments in the short term (ie within 24 months). See: Responses to CMA P1 customer questionnaire, question 5, from [✂].
[304] Responses to CMA P1 customer questionnaire, question 8 from [✂].

Google and Microsoft, were seen as less suitable alternatives to VMware by respondents.

- *VMware's internal documents*

7.86 Our review of VMware's competitive monitoring and benchmarking documents found that providers of containerisation software were identified less frequently, if at all, by VMware and, where they were mentioned, were seen as weaker competitive threats than other hypervisors and CSPs.

7.87 For example, as set out above, a VMware presentation to [✂].[305] This document notes that [✂].

- *Our view on the constraint from containerisation software*

7.88 Based on the evidence set out above, we consider that containerisation software is currently a weak constraint on VMware's server virtualisation software. In particular, containerisation software is not adopted by the large majority of respondents to our questionnaire, and a large majority of respondents did not view containers that run on bare metal as an alternative to the use of server virtualisation software on enterprise deployments or only considered it to be an alternative in the longer term (ie more than 24 months).

7.89 We also consider that the use of containerisation software to facilitate the movement of existing workloads away from VMware to other hypervisors and CSPs is currently limited and, to the extent that containerisation software can lower the barriers in moving existing workloads away from VMware, this would be captured above as part of our assessment of the ease of moving existing workloads between hypervisors and across deployment types.

Our view on VMware's market power

7.90 Based on the evidence set out above, our provisional view is that VMware has market power in the supply of server virtualisation software in enterprise deployments globally as it has an important market position and customers cannot easily switch away to a range of effective alternative suppliers, including other hypervisors as well as the virtualisation offering of CSPs and the use of containerisation software.

7.91 As set out above, the Parties submitted that VMware's customers would switch significant volumes of workloads away from VMware in response to a

[305] VMware internal document, RSLV_00029833, page 8.

loss of interoperability as this would destroy VMware's fundamental value proposition of providing server virtualisation software that works with any hardware the customer has installed in their data centre.[306] We consider the evidence on the response of virtualisation customers to a loss of interoperability as part of our assessment of the Merged Entity's incentive to pursue a total foreclosure strategy below.

Importance of interoperability

7.92 The Merged Entity could only harm the competitiveness of Broadcom's competitors if interoperability with VMware plays an important role in competition between suppliers of I/O hardware and switches.[307]

7.93 The evidence shows that interoperability with VMware's virtualisation software is very important to Broadcom's competitors in order to sell I/O hardware and switches.[308] This is because interoperability with VMware's server virtualisation software is necessary for I/O hardware and switches to be used by VMware's customers.[309] This is also consistent with Broadcom's internal documents.[310] Several virtualisation customers also noted that it is essential to them that the I/O hardware and switches they use have been certified with VMware.[311]

7.94 On the basis of this evidence, we currently consider that interoperability with VMware plays an important role in the supply of I/O hardware and switches.[312] This means that if it were able to reduce the interoperability between VMware's server virtualisation software and Broadcom's competitors' I/O hardware and switches, the Merged Entity might cause VMware's customers to switch from competitor I/O hardware and switches to Broadcom I/O hardware and switches in order to continue to use VMware's software to virtualise their servers. In light of VMware's market power in server virtualisation software described above, this may enable the Merged Entity to improve its position and foreclose competition for the supply of I/O hardware and switches.

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[306] Parties' response to the AIS and WPs, paragraph 1.3; Parties' VMware market position paper, 15 June 2023, paragraph 1.1.
[307] MAGs, paragraph 7.14(b).
[308] Responses to the CMA questionnaire from [✂].
[309] We provide more detail on VMware's driver certification process for I/O hardware in Chapter 4.
[310] See for example Broadcom Internal Document, '[✂]', BCOM-CMA-00000900, pages 2-3.
[311] Responses to CMA P1 customer questionnaire, question 3 from [✂].
[312] We note, however, that the number of customers that overlap between the Parties may change over time as more existing workloads are moved from enterprise deployments (ie traditional data centres and the private cloud) to the public cloud. This migration could, in principle, lead to decrease in the overlap between VMware's server virtualisation customers and Broadcom's hardware customers. See: MAGs, paragraph 7.33(b).

Foreclosure mechanisms

7.95 Based on evidence from third parties and our understanding of the products involved, we have considered the following set of foreclosure mechanisms in relation to I/O hardware:

(a) Refusal to certify drivers for competitor I/O hardware that needs to interoperate with VMware's server virtualisation software;

(b) Reduction or delay in the information and support needed to achieve interoperability with VMware's server virtualisation software; and

(c) Preferencing the interworking between VMware's server virtualisation software and Broadcom I/O hardware over interworking with competitor I/O hardware.

7.96 In relation to FC switches, we have considered whether the Merged Entity could restrict the access of a vSphere API to rival FC switch management software.

7.97 In this section we consider each of these foreclosure mechanisms and whether the Merged Entity could use it as a way to potentially harm Broadcom's competitors.[313]

Refusal to certify competitor I/O hardware drivers

7.98 Following the Merger, VMware could refuse to certify drivers for competitor I/O hardware (for use with all versions of vSphere) and also no longer allow competitors to self-certify using VMware's VIVa platform. VMware could implement this mechanism directly by modifying the I/O hardware certification policies that apply to its current server virtualisation software. Alternatively, it could create a new version of vSphere and refuse to certify the drivers needed for new generations of competitor I/O hardware to interoperate with this new version of vSphere.

7.99 Certification is not strictly necessary for a customer to be able to use an I/O hardware device with VMware but running uncertified I/O hardware could introduce security risks and compatibility issues. In particular, customers who want to use the standard UEFI Secure Boot feature[314] must only use certified

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[313] MAGs, paragraph 7.13.

[314] UEFI (Unified Extensible Firmware Interface) is an interface between the hardware's firmware and the OS/hypervisor running on the hardware. UEFI is not a VMware-specific technology. UEFI Secure Boot provides security during the start-up process of a computer by checking for preauthorized signatures to confirm the authenticity of critical bootloaders (i.e., the initial set of applications being loaded by the firmware, such as the

drivers.[315] I/O hardware competitors have submitted that it is essential for their products to be certified with VMware's virtualisation software in order to sell their products to VMware customers.[316] This is in line with feedback from customers,[317] who told us that they would only purchase certified I/O hardware to ensure there is support from VMware in the event of any issues.

Parties' submissions

7.100 In relation to this mechanism, the Parties have submitted that the Merged Entity would be unable to reduce interoperability with the installed base and new sales of devices that are already supported as this would disrupt existing workloads. This could have potentially catastrophic consequences for customers and impose an enormous burden on customers to buy new servers or change their existing hardware installed in servers.[318]

7.101 The Parties have also submitted that total foreclosure of new devices is implausible as hardware neutrality is critical for virtualisation software, total foreclosure would be easy to detect and attribute to the Merged Entity and total foreclosure would cause reputational harm to the Merged Entity.[319]

Our assessment

7.102 Based on the evidence set out above, we consider that VMware customers are unlikely to be willing to buy I/O hardware that is uncertified and so may switch away from competitor I/O hardware to Broadcom if the competitor I/O hardware is no longer certified.

7.103 Furthermore, we consider that any mechanism which results in a breakdown of interoperability between VMware server virtualisation software and customers' existing I/O hardware would cause undesirable disruption to customers, as customers would need to immediately replace their I/O hardware (and most likely their entire servers), or switch away from VMware. Further, given VMware is unable to discriminate between the certification of new sales of existing I/O hardware and existing I/O hardware that is already installed in servers as both of these use the same drivers,[320] the same

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OS/hypervisor). Only software that is identified by its signature is loaded by the UEFI during the boot process. This is intended to prevent malware from being loaded into the OS or hypervisor, making these environments more secure for customers. Microsoft, Apple, and other OS vendors use a similar feature to UEFI Secure Boot to ensure the security of their systems.

[315] FMN, paragraph 20.58.

[316] Responses to the CMA questionnaire from [✂].

[317] CMA analysis of responses to the CMA's P2 virtualisation customer questionnaire, question 3 from [✂].

[318] Parties' response to the Phase 1 Issues Letter, 3 March 2023, paragraphs 2.15 and 2.16.

[319] Parties' response to the AIS and WPs, 15 June 2023, paragraph 3.5.

[320] Parties response to the Issues Statement, 10 May 2023, paragraph 1.9.

considerations would apply to this mechanism in relation to new sales of existing I/O hardware. Therefore, our provisional view is that the Merged Entity could refuse to certify new generations of competitor I/O hardware as a way to potentially harm Broadcom's competitors, but it appears unlikely that it could refuse to certify existing I/O hardware (whether these are new sales of existing products or I/O hardware which is already in use as part of the installed base).

7.104 We note that any effect arising from this mechanism would occur over several years. This is because the I/O hardware product lifecycle is 2-3 years for storage adapters, 3-4 years for NICs and 5-6 years for FC HBAs,[321] and the timing of any effect will depend on the rate at which customers then upgrade the servers containing the new I/O hardware, which the Parties estimate to be five years on average.[322] We do not consider that the length of this timescale undermines the ability of the Merged Entity to foreclose through this mechanism, but it implies that there is greater scope for customers and competitors to respond to the foreclosure strategy and any market trends occurring over the period also need to be taken into account. This is relevant for our assessment of incentive below.

7.105 Finally, we consider that the Parties' submissions set out in paragraph 7.101 above relate to the Merged Entity's incentive to pursue the foreclosure strategy using this mechanism rather than to its ability to do so. Consequently, we have considered these submissions as part of our assessment of incentive below.

Reduction in information and support needed to achieve interoperability

7.106 VMware might delay or hamper information exchange regarding driver updates or reduce the level of collaboration and technical support provided to I/O hardware competitors. This would not stop certification but may result in a delay in new generations of competitor I/O hardware becoming interoperable and certified with VMware.

7.107 In relation to this mechanism, one third party has submitted that information needs to be exchanged between it and VMware at least 1-3 years prior to the release of a new I/O hardware product to identify what features are being developed, what issues are arising and any other topics that would affect a clean deployment.[323] Delay or failure for VMware to engage in this process would affect the commercial viability of the competitor's I/O hardware and may

[321] Parties' response to the Phase 1 Issues Letter, 3 March 2023, footnote 42.
[322] Parties' response to P2 RFI 1, 3 May 2023, paragraph 20.11.
[323] Response to the CMA questionnaire from [✂], 10 February 2023.

cause customers to switch to more up-to-date or compatible I/O hardware. This third party also submitted that it is concerned that VMware will favour Broadcom in supplying information about any upcoming changes to VMware's software, [✂].[324]

Parties' submissions

7.108 In relation to this mechanism the Parties have submitted that:

(a) A delay of I/O hardware driver certification would be obvious to competitors and server OEMs as it would deviate from their past VMware driver certification experience as well as their experience with Linux and Windows. Consequently, delays cannot be achieved in a way that is not detectable and attributable to the Merged Entity.[325]

(b) Few opportunities for delay could arise during driver development and certification as nearly all driver certification is done via equivalency and for the small minority of I/O hardware devices that need a new certification, the process is largely automated. In addition, technical support from VMware is rarely required.[326]

(c) Delaying certification would not impact competitors' sales as driver certification occurs long before product release dates, server OEMs prefer to use existing devices with already-certified drivers for new servers, and sales of new servers are not concentrated around release dates.[327]

(d) Even if delaying certification was capable of affecting competitor sales it would have no material impact as new I/O hardware devices are adopted slowly and being late to market has no material impact.[328]

Our assessment

7.109 Based on the evidence set out above, we consider that this mechanism would not be capable of driving a material degree of customer switching from competitor I/O hardware to Broadcom I/O hardware. Even if the Merged Entity was able to delay the product launch for competitor I/O hardware, it would not be able to do so by more than a few months, given the current typical certification process, without the mechanism being clearly detectable and attributable to the Merged Entity. There would be little benefit to a longer

[324] Note of a call with [✂].
[325] Parties' response to the AIS and WPs, 15 June 2023, paragraph 3.6.
[326] Parties' response to the AIS and WPs, 15 June 2023, paragraph 3.7.
[327] Parties' response to the AIS and WPs, 15 June 2023, paragraph 3.8.
[328] Parties' response to the AIS and WPs, 15 June 2023, paragraph 3.9.

delay compared to an outright refusal to certify I/O hardware drivers in terms of maintaining VMware's attractiveness to customers, while it would be less effective in driving customer switching from Broadcom to competitors. Alternatively, a delay of up to a year would have little overall impact on the sales of I/O hardware given the slow rate at which new I/O hardware devices are adopted by end-customers. In particular, we note that sales of new I/O hardware device generations may represent fewer than 10% of overall sales in the first year after launch.[329] Therefore, our provisional view is that it appears unlikely that the Merged Entity could use this mechanism as a way to potentially harm Broadcom's competitors.

Preferencing interworking between vSphere and Broadcom over interworking with competitor I/O hardware

7.110 The Parties have submitted that communication between VMware's server virtualisation software and Broadcom's I/O hardware is confined to the hardware driver and that the hypervisor does not communicate with I/O hardware devices directly.[330]

7.111 However, one competing I/O hardware supplier has submitted that it is technically possible for VMware to take a wide variety of actions to reduce the interoperability between I/O hardware and VMware server virtualisation software without completely removing interoperability. This would most likely be realised through prioritising optimisation between VMware software and Broadcom products over optimisation with competitor I/O hardware products, improving the performance of Broadcom products compared to competitor products.[331]

Parties' submissions

7.112 In relation to this mechanism the Parties have submitted that:

(a) Preferencing interworking between vSphere and Broadcom over interworking with competitor I/O hardware is impossible for several reasons. APIs for I/O hardware devices are vendor neutral and device category neutral. The sub-system that handles management of I/O hardware devices within a hypervisor is one of the most timing dependent and critical elements. It would be impossible to introduce any functionally unnecessary code without introducing instability to the hypervisor and sacrificing its own performance. Changes to the hypervisor's I/O hardware

[329] Parties' response to the AIS and WPs, 15 June 2023, paragraph 3.9.
[330] FMN, paragraphs 20.19.
[331] Note of a call with [✂].

device interaction would also impact VMware's interaction with a server, including a potential performance impact on compute devices (CPUs and GPUs). Further, VMware does not currently test I/O hardware devices itself and the costs of doing so would be substantial and disproportionate.[332]

(b) There is a risk of disruption to existing I/O hardware devices in customers' installed base of servers, as for customers to detect the inferior performance of competitor I/O hardware devices they would need to have competitor I/O hardware devices installed. Sufficiently subtle changes in the relative optimisation of Broadcom I/O hardware compared to competitor I/O hardware to avoid this risk would not cause switching from competitors to Broadcom.[333]

(c) Any performance disadvantage would be obvious and attributable to the Merged Entity. This would lead to considerable costs to VMware from support calls (which cost VMware [✂]). In addition, server OEMs would blame VMware and may influence customers to migrate to alternative server virtualisation solutions.[334]

Our assessment

7.113 While the Parties' submissions on technical feasibility suggest that the scope for a mechanism of this type may be limited, given the technical complexity of this assessment we have not been able to exclude the possibility that it could be implemented.

7.114 However, based on the evidence set out above, our provisional view is that this mechanism would not be capable of driving a material degree of customer switching from competitor I/O hardware to Broadcom I/O hardware. This mechanism would need to result in a clearly observable performance disadvantage for competitor I/O hardware in order to drive a material degree of customer switching to Broadcom. Such a performance disadvantage would be likely to affect existing devices in customers' installed base of servers and may result in substantial costs for the Merged Entity from the need to handle support calls and risk undermining the performance of VMware's hypervisor itself.

7.115 In addition, we consider this mechanism is likely to be attributable to VMware given it would affect competitor I/O hardware when used with VMware's

[332] Parties' response to the AIS and WPs, 15 June 2023, paragraph 3.10.
[333] Parties' response to the AIS and WPs, 15 June 2023, paragraphs 3.11 and 3.12.
[334] Parties' response to the AIS and WPs, 15 June 2023, paragraphs 3.13 to 3.16.

server virtualisation software but not when used with other virtualisation software or in non-virtualised servers. This would be observable to server OEMs when testing I/O hardware. Compared to an outright refusal to certify I/O hardware drivers, therefore, there would be little benefit to this mechanism in terms of maintaining VMware's attractiveness to customers, while it would be less effective (than an outright refusal to certify drivers) in driving customer switching from Broadcom to competitors. Therefore, our provisional view is that it appears unlikely that the Merged Entity could use this mechanism as a way to potentially harm Broadcom's competitors.

FC switches

7.116 FC switches do not directly interoperate with vSphere. However, they interact with vSphere indirectly via management software. This management software can be provided either by server OEMs or by FC Switch suppliers, Cisco (Nexus Dashboard Fabric Controller '**NDFC'**) and Broadcom (SANnav).[335]

7.117 FC switch management software accesses a standard API made publicly available by VMware. We have considered whether VMware could reduce interoperability between the vSphere API and NDFC, reducing the functionality of NDFC and causing customers to switch from Cisco FC switches to Broadcom FC switches.

7.118 In relation to this mechanism, Cisco has submitted that:

(a) All Cisco FC switches are managed by its proprietary management software NDFC.[336] Third party management software lacks the functionality of NDFC. Customers using third-party software would typically be able to see basic status information but would be unable to configure and manage the Cisco FC switch. Third-party management software may be able to extract information from Cisco's FC switches using industry standards like SNMP (Simple Network Management Protocol), but that limited connectivity does not allow for extensive management, configuration, or troubleshooting of the switches or the servers and storage devices to which the switches are connected.[337] Server OEMs also submitted that it is necessary or industry standard to use the proprietary software from the switch provider[338] or that this is

[335] Parties' response to the Phase 1 Issues Letter, 3 March 2023, paragraph 2.53.
[336] Note of a call with [✂].
[337] Response to the CMA questionnaire from [✂], question 6.
[338] Response to the CMA questionnaire from [✂], question 6.

required for more comprehensive monitoring and management compared to the OEM software.[339]

(b) The information Cisco receives through the API is important to the functioning of NDFC. This API provides information on the server and storage resources in use to map connectivity across multiple virtual machines in a fabric. [340] This functionality is the result of recent innovation by Cisco.[341]

(c) Direct access for NDFC to the API is necessary to support NDFC functionality as an indirect link via another application would introduce an issue of reliability.[342]

(d) Following the Merger, access to API data could be restricted, either fully or partially, or the information could be made available only for a fee. This could affect numerous other companies that also use the API. However, certain aspects of the API are more useful for some purposes than others and other companies using the API would not be relying on the same data as Cisco. [✂].[343]

Parties' submissions

7.119 In relation to this mechanism the Parties submitted the following points:

(a) Information from vSphere is not important for FC switch management software.[344] Broadcom believes that [✂]% of FC switch customers do not collect information from vSphere at all, based on its experience and analysis of SANnav customer support calls which mention VMware or VM related information.[345]

(b) Users of Cisco's FC switches have the ability to access the same information through other means (eg vCenter Server).[346]

(c) VMware is unable to target a reduction in interoperability specifically at Cisco because Cisco's FC switches are managed by third-party OEM

[339] Response to the CMA questionnaire from [✂], question 6.
[340] Note that when multiple FC switches are combined to interconnect multiple servers and storage devices, this is referred to as a fabric. Response to CMA questions [✂], question 5.
[341] Note of a call with [✂].
[342] Note of a call with [✂].
[343] Note of a call with [✂].
[344] Parties' response to the Phase 1 Issues Letter, 3 March 2023, paragraph 2.55.
[345] Broadcom response to P2 RFI 1, 3 May 2023, question 6.
[346] Broadcom Site Visit presentation, 27 April 2023, slide 65 onwards.

software[347] and because the API is used by other applications and selectively interfering with FC switches is not possible.[348]

(d) Information from vSphere is not a relevant factor for competition in FC switches. Competition occurs only when customers set up a new FC SAN or replace all FC switches in an existing SAN as FC SANs use a single vendor's switches. FC switches compete on performance, quality and reliability and not on whether switch management software can collect information on virtual machines. The fact that Broadcom competes effectively without relying on information from vCenter Server confirms it is not competitively significant.[349]

Our assessment

7.120 Our provisional view is that the technical ability for the Merged Entity to implement this mechanism is limited. VMware currently has little to no interaction with customers and partners about the API and no ability to verify the function of third party software using the API.[350] While it may be possible in principle for the Merged Entity to restrict (or charge for) access to the information used by Cisco switches from the vSphere API, this would require the Merged Entity to identify the relevant information, over which VMware currently has no visibility. In addition, the Merged Entity would not be able to selectively target Cisco FC switches through this mechanism but would need to withhold access to this information to all of the applications using the API.

7.121 Further, we consider that this mechanism would not be capable of driving a significant degree of customer switching from competitors to Broadcom. As there is limited interoperability between FC switches made by Broadcom and Cisco, competition is limited to opportunities where an enterprise customer is deploying a new FC SAN or replacing all FC switches in an existing FC SAN simultaneously. These opportunities are infrequent.[351] In addition, the evidence we have reviewed shows that the ability of the FC switch management software to draw information from vSphere is not an important parameter of competition in FC switches. This was not identified as a relevant aspect of differentiation by server OEMs and Broadcom, the market leader in FC switches, has been able to compete successfully without relying on this information from the vSphere API.[352]

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[347] Parties response to the Phase 1 Issues Letter, 3 March 2023, paragraph 2.60.
[348] Broadcom Site Visit presentation, 27 April 2023, slide 75.
[349] Parties' response to the AIS and WPs, 15 June 2023, paragraph 3.18.
[350] VMware main party hearing transcript, 14 June 2023, page 11, lines 1-10.
[351] Response to CMA questionnaire from [✂].
[352] Parties' response to the AIS and WPs, 15 June 2023, paragraph 3.18.

7.122 Finally, we consider that this mechanism would be observable by customers and attributable to the Merged Entity, given it would require the Merged Entity to restrict access to information in an API that had previously been publicly available. This would affect both FC switches and other applications relying on access to the API. Consequently, this mechanism would carry the risk of undermining the attractiveness of VMware's software, potentially leading to customers switching away from VMware. Evidence on likely customer responses to a reduction in interoperability suggests this risk is significant.[353] In addition, the Merged Entity is likely to perceive at least some risk that the implementation of this mechanism could lead to retaliation by Cisco, given Cisco also operates as a server OEM that purchases [✂] of Broadcom products per year.[354]

7.123 In light of the evidence set out above, our provisional view is that it appears unlikely that the Merged Entity could use this mechanism as a way to potentially harm Broadcom's competitors.

Our view on the Merged Entity's ability to foreclose

7.124 Based on the evidence set out above, we have provisionally found that the Merged Entity has the ability to foreclose Broadcom's competitors in the supply of I/O hardware:

(a) VMware has market power in the supply of server virtualisation software in enterprise deployments globally to the extent that it has an important market position and customers cannot easily switch away to a range of effective alternative suppliers, including other hypervisors as well as the virtualisation offering of CSPs and the use of containerisation software.

(b) Interoperability with VMware plays an important role in the supply of I/O hardware.

(c) The Merged Entity could potentially harm Broadcom's competitors by refusing to certify I/O hardware drivers for new generations of competitor I/O hardware.

7.125 We have provisionally found that it appears unlikely that the Merged Entity could use the other foreclosure mechanisms considered as a way to harm Broadcom's competitors in I/O hardware, ie reducing or delaying the information and support needed to ensure interoperability, and preferencing

[353] See paragraph 7.179.
[354] Parties' response to the AIS and WPs, 15 June 2023, paragraph 1.4

the degree of interworking between vSphere and Broadcom over competitor I/O hardware.

7.126 In relation to FC switches, we have provisionally found that it appears unlikely that the Merged Entity could reduce interoperability between vSphere APIs and competitor switch management software as a way to harm Broadcom's competitors. As a result, FC switches are not discussed further in this chapter.

Incentive to foreclose

7.127 In this section, we assess the incentive of the Merged Entity to engage in foreclosure of Broadcom's competitors. Based on our analysis of ability, we focus solely on the incentive for the Merged Entity to pursue a total foreclosure mechanism – through a reduction in interoperability via refusal to certify drivers for new generations of competitor I/O hardware products – in relation to Ethernet NICs, storage adapters and FC HBAs.

7.128 A range of factors cumulatively are relevant to determining the Merged Entity's incentive to pursue a foreclosure strategy through reducing interoperability between VMware's server virtualisation software and competitor I/O hardware products. These include:[355]

(a) The gain in I/O hardware sales by Broadcom resulting from the strategy;

(b) The loss of software sales by VMware resulting from the strategy;

(c) The relative margins[356] of VMware's software and Broadcom's I/O hardware; and

(d) Other costs and benefits to the Merged Entity, including the possibility of retaliation and financial consequences arising from a negative impact on the Merged Entity's wider relationships.

7.129 In assessing these points, we have considered (and discuss in turn below) the following evidence and analysis:

(a) The Parties' quantitative analysis, which assesses how the profitability of foreclosure relates to the behaviour of VMware customers in response to a loss of interoperability with the I/O hardware products supplied by Broadcom's competitors.

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[355] MAGs, paragraph 7.34.
[356] Margins in this context refer to the absolute profit margins ie the monetary value of profit per sale, rather than percentage margins ie profit as a percentage of sales.

(b) Evidence from virtualisation customers on their likely response to a loss of interoperability between VMware and the I/O hardware products supplied by Broadcom's competitors as a result of any foreclosure strategy pursued by the Merged Entity.

(c) Evidence on the possibility of retaliation by server OEMs and on the possibility that the pursuit of a strategy that reduces interoperability would jeopardise the Merged Entity's wider relationships.

The Parties' quantitative analysis

7.130 This section sets out our assessment of the Parties' quantitative analysis of the Merged Entity's incentive to foreclose Broadcom's competitors in the supply of I/O hardware.

7.131 Based on this quantitative analysis of the Merged Entity's incentive to foreclose Broadcom's competitors, the Parties submitted *inter alia* that:[357]

(a) Nearly all affected customers would have to switch to Broadcom's I/O hardware products for a foreclosure strategy to be profitable given the substantial disparity between the considerably larger margin on VMware's virtualisation offering compared to the small margin on Broadcom's products.

(b) In contrast, it would only take a very small number of affected customers moving some existing workloads from VMware (so as to avoid having to change their preferred I/O hardware), or not placing with VMware new workloads that otherwise would have used vSphere with competitor I/O hardware, to render the strategy unprofitable. As customers across all industries are already migrating existing workloads away from vSphere, even a modest increase in the level of customer churn would make foreclosure unprofitable.

(c) The maximum profit that could be gained by foreclosure is 'miniscule' in the long run, particularly when compared to VMware's virtualisation profits that would be put at risk. The Parties estimate that, assuming 100% of foreclosed servers diverted to Broadcom I/O hardware, profit from foreclosure in the first year will be no greater than [✂]% of VMware's virtualisation software profits in the first year and would increase to no more than [✂]% over a [✂] period (all else being equal).[358]

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[357] Parties' response to the Phase 1 Issues Letter, 3 March 2023, paragraphs 2.20 and 2.21; Parties' Response to the Issues Statement, 10 May 2023, paragraphs 4.19 and 4.20.
[358] The Parties note that this is equal to the cumulative effect of a loss of profits of just [✂]% per year over [✂].

7.132 This section first gives an overview of the Parties' quantitative analysis and presents the Parties' results, before then setting out our assessment.

Overview of the Parties' analysis and results

7.133 The Parties submitted a quantitative analysis that considers the incentive of the Merged Entity to pursue a total foreclosure strategy post-Merger, ie where the Merged Entity no longer allows the I/O hardware supplied by Broadcom's competitors to interoperate with VMware's server virtualisation software.[359]

7.134 VMware's prospective customers could be segmented into two groups:[360]

(a) Some prospective customers would already prefer to purchase VMware server virtualisation software and the relevant Broadcom I/O hardware products in their new servers, and they are not affected by a total foreclosure strategy.

(b) Other prospective customers, who would prefer to purchase VMware's server virtualisation software and relevant I/O hardware products supplied by Broadcom's competitors in their new servers, would have to choose as a result of a total foreclosure strategy between purchasing both VMware's server virtualisation software and the relevant Broadcom I/O hardware products in their new servers; or purchasing software and I/O hardware products from the Parties' competitors.

7.135 The Parties' quantitative analysis considers the response of the second group of prospective VMware customers to a total foreclosure strategy.

7.136 The Parties rely on the pre-Merger margins of VMware's server virtualisation offering and Broadcom's I/O hardware.[361] These margins are used to estimate the minimum proportion of VMware customers that would need to switch to Broadcom I/O hardware (from its competitors' products) to make a total foreclosure strategy profitable. This minimum proportion is referred to as the 'critical switching rate'.[362]

7.137 The Parties noted that VMware's vSphere server virtualisation software is rarely used as a standalone product by its customers, who typically use a

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[359] This type of quantitative analysis of incentives is typically referred to as 'vertical arithmetic'. See, for example: Pittman, R. (2017) *Three Economist's Tools for Antitrust Analysis: A Non-Technical Introduction*.
[360] Parties response to P1 RFI 4, 7 December 2022, question 2, M.10806 - Form CO - Conglomerate - Annex 55, paragraph 2.3.
[361] The vSphere and other associated software margins used by the Parties in their analysis are based on the effective prices paid by customers for VMware's software, which includes volume-based and other discounts offered by VMware to its customers, rather than the listed prices of these products.
[362] Parties response to P1 RFI 4, 7 December 2022, question 2, M.10806 - Form CO - Conglomerate - Annex 55, paragraph 2.4.

range of other software offered by VMware as a complement to vSphere (such as NSX, vSAN, SDDC Manager, and vRealize).[363] The Parties have therefore considered two scenarios as part of their analysis, one that only includes the margins of VMware's vSphere software (ie 'vSphere only') and another that includes the margins of vSphere as well as VMware's associated software used by its customers (ie 'vSphere plus associated software').

Critical switching rates

7.138 The critical switching rates found by the Parties' quantitative analysis in each of these scenarios are shown below in Table 7.3.

Table 7.3 Results of the Parties' quantitative analysis of incentives

	VMware's server virtualisation offering	
		%
Broadcom products	*vSphere only*	*vSphere plus associated software*
Ethernet NICs	[90-100]	[90-100]
FC HBAs	[80-90]	[80-90]
Storage adapters	[90-100]	[90-100]
All Broadcom products	**[90-100]**	**[90-100]**

Source: Parties, Annex AISR-002.1 – ME7011.22 – Response to Incentive working paper – Technical Annex.xlsx.

7.139 The Parties' analysis in Table 7.3 shows that:

(a) For Ethernet NICs, at least [90-100]% of customers who currently buy VMware's vSphere software and Ethernet NICs supplied by Broadcom's competitors (eg Intel and NVIDIA) would need to switch away from the Ethernet NICs supplied by Broadcom's competitors, rather than switching away from VMware's software, to make a total foreclosure strategy profitable.[364] This would rise to at least [90-100]% of customers when considering vSphere as well as VMware's associated software as part of the analysis.

(b) For FC HBAs, at least [80-90]% of customers of VMware's vSphere software would need to switch away from the FC HBAs supplied by Broadcom's competitors (eg Marvell) to make a total foreclosure strategy profitable. This would rise to at least [80-90]% of customers that use vSphere as well as VMware's associated software as part of the analysis.

(c) For storage adapters, at least [90-100]% of customers of VMware's vSphere software would need to switch away from the storage adapters

[363] Parties response to P1 RFI 4, 7 December 2022, question 2, M.10806 - Form CO - Conglomerate - Annex 55, paragraph 2.5.
[364] This analysis assumes that customers who currently purchase VMware's VSphere software and non-Broadcom hardware would either switch away from one or the other in response to a reduction in interoperability between the two.

supplied by Broadcom's competitors (eg Microchip and Marvell) to make a total foreclosure strategy profitable. This would rise to at least [90-100]% of customers that use vSphere as well as VMware's associated software as part of the analysis.

(d) For all these Broadcom I/O hardware products, at least [90-100]% of customers of VMware's vSphere software would need to switch away from the I/O hardware products supplied by Broadcom's competitors to make a total foreclosure strategy profitable. This would rise to at least [90-100]% of customers that use vSphere as well as VMware's associated software as part of the analysis.

7.140 The critical switching rates above do not account for the possibility that customers switching away from VMware's vSphere software (as well as VMware's associated software) may move existing workloads to the public cloud. VMware could retain some of these sales if these customers maintain the use of VMware's software (such as its multi-cloud offering VMC), thus potentially reducing the profit loss for the Merged Entity. The Parties submitted that accounting for recapture by VMC has a negligible impact on the critical switching rates. This is because evidence from VMware's internal documents[365] shows that VMC recaptures only [✂] of vSphere churn to the public cloud ([✂]% of all lost vSphere workloads).[366]

7.141 In addition, the Parties submitted that VMC had a variable cost margin of -[✂]% in Q2 FY2023, [✂]. However, they also submitted analysis showing limited sensitivity of the estimated critical switching rates to the possibility of recapture by VMC even if margins for VMC are assumed to be much higher than vSphere.[367]

Total gains from foreclosure

7.142 In addition to estimating critical switching rates, the Parties also estimated the total potential gains from total foreclosure. The Parties based this estimate on:

(a) An estimate of the number of new VMware-virtualised servers that would use new non-Broadcom I/O hardware absent the foreclosure strategy. This is estimated using the number of servers shipped in a given year, the server penetration rates of each I/O hardware product, the estimated

[365] Parties' response to the AIS and WPs, 15 June 2023, annex AISR-015.
[366] Parties' response to the AIS and WPs, 15 June 2023, paragraph 4.23.
[367] Parties' response to the AIS and WPs, 15 June 2023, paragraph 4.24.

share of non-Broadcom I/O hardware, and the adoption rates for each I/O hardware product.

(b) The pre-Merger margins of Broadcom's I/O hardware products used in a server.

7.143 For the purpose of this analysis, the Parties assume that every single customer that chooses to purchase new VMware-virtualised server purchases Broadcom I/O hardware instead of competitor I/O hardware and that there is no switching away from VMware.[368]

7.144 Based on this analysis, the Parties find that in the first year of a foreclosure strategy the total potential gains would be $[✂] million, and in the long run (which allows for new I/O hardware products to be fully adopted and takes at least seven years to reach) they would be $[✂] million per year.[369]

Our assessment

7.145 Having reviewed the Parties' analysis and having considered the sensitivity of the estimated critical switching ratios to certain assumptions and factors that were not included in the analysis (as set out below), we consider the analysis is largely robust.

7.146 First, based on the evidence submitted by the Parties above, we consider the critical switching rates are not materially affected by the recapture of switching away from vSphere (as well as VMware's associated software) by the Parties' cloud-based product, VMC.

7.147 Second, we have considered the sensitivity of the critical switching rates to the way in which vSphere margins per server are calculated. In particular, we have considered the possibility that some vSphere customers who would switch away from vSphere may not have needed to purchase new vSphere licences over the period considered but may instead have only paid for maintenance and support.[370] However, even excluding revenues from licences entirely does not materially affect the estimated critical switching rates as shown in Table 7.4 below.

[368] Parties' response to the Issues Statement, 10 May 2023, annex ISR-028, ME.7011.22 - CL Incentives Paper, paragraph 3.11.
[369] Parties' response to the Issues Statement, 10 May 2023, paragraph 1.9.
[370] For the purpose of this analysis, VMware margins are estimated for the five year lifetime of a server.

Table 7.4: Sensitivity of critical switching rates to exclusion of licence revenues

	VMware's server virtualisation offering	
		%
Broadcom products	*vSphere only*	*vSphere plus associated software*
Ethernet NICs	[90-100]	[90-100]
FC HBAs	[70-80]	[80-90]
Storage adapters	[90-100]	[90-100]
All Broadcom products	**[90-100]**	**[90-100]**

Source: CMA calculations based on Parties, Annex AISR-002.1 – ME7011.22 – Response to Incentive working paper – Technical Annex.xlsx.

7.148 Third, we note that the vertical arithmetic model used by the Parties only assesses the direct costs and benefits to the Merged Entity's profits of customer switching in response to a total foreclosure strategy, based on the pre-Merger margins earned by VMware and Broadcom. However, when deciding whether to pursue a total foreclosure strategy and assessing its profitability, the Merged Entity may also take account of the more dynamic gains resulting from the successful execution of its foreclosure strategy. This includes the possibility that Broadcom's competitors' loss of sales from VMware customers switching their purchases of I/O hardware to Broadcom could deny Broadcom's competitors the scale necessary to compete effectively,[371] thereby reducing competition and allowing the Merged Entity to raise prices in the future.

7.149 The Parties submitted that there would be no such benefits and that the overall impact on the demand for competitors' I/O hardware products would be small and delayed as (i) VMware-virtualised servers account for a small proportion of the demand for the relevant I/O hardware products; (ii) a small fraction of these devices require full VMware driver certification (and related support) (around [✂]% for FC HBAs, [✂]% for NICs and [✂]% for storage adapters); (iii) new generation I/O hardware devices requiring driver certification are adopted slowly; and (iv) the options and opportunities for customers and server OEMs to switch away from VMware in response to a reduction in interoperability would also increase over time.[372]

7.150 Our provisional view is that any dynamic gains from the foreclosure strategy would be limited and would only occur after a long period for the reasons given by the Parties. In addition, even if such gains were likely outcomes of the foreclosure strategy, they are relatively immaterial in determining the Merged Entity's overall incentive to pursue the foreclosure strategy, given the substantial difference in absolute margin between VMware's server virtualisation software and Broadcom's I/O hardware. In particular, directly

[371] MAGs, paragraph 7.33.
[372] Parties' response to the AIS and WPs, 15 June 2023, paragraph 4.21.

accounting for these gains in the vertical arithmetic model used by the Parties does not reduce the critical switching rate to a material extent. For example, assuming that the Merged Entity is able to raise prices of I/O hardware by 10% only reduces the critical switching rates for each I/O hardware component by approximately one percentage point.

7.151 Based on the above, we consider that the inclusion of these factors would not materially change the critical switching rates estimated by the Parties.

7.152 In relation to the total gains from foreclosure, we have reviewed the Parties' analysis and consider that it shows that if all VMware customers were to switch from competitor I/O hardware to Broadcom I/O hardware, the total gains per year after at least a seven-year period would be $[✂] million.

Implications of the Parties' quantitative analysis

7.153 Our provisional view is that the critical switching rates show that a very large proportion of VMware customers would need to switch to the I/O hardware products supplied by Broadcom for a total foreclosure strategy to be profitable, whereas only a small proportion of VMware customers would need to move workloads away from vSphere for a total foreclosure strategy to be unprofitable.

7.154 We note that a high critical switching rates does not by itself imply that a foreclosure strategy is unlikely. This depends on how customers would behave in response to the foreclosure strategy and in particular whether the actual degree of switching would be expected to be greater than that implied by the critical switching rate, as well as any other more indirect costs and benefits to the Merged Entity resulting from the strategy. We consider evidence on how customers would respond to the foreclosure strategy below.

Response to total foreclosure by virtualisation customers

7.155 As part of our assessment of the Merged Entity's incentive to pursue a total foreclosure strategy, we have considered evidence on the response of virtualisation customers to a loss of interoperability between VMware's server virtualisation software and the I/O hardware supplied by Broadcom's competitors. We have used this evidence to compare the critical switching rates found in the Parties' quantitative analysis to evidence on the likely actual behaviour of virtualisation customers.

The Parties' submissions

7.156 As set out above, the Parties submitted that VMware's customers would switch significant volumes of workloads away from VMware in response to a loss of interoperability as this would destroy VMware's fundamental value proposition of providing server virtualisation software that works with any I/O hardware the customer has installed in their data centre.[373]

7.157 In support of their submissions, the Parties provided a survey of organisations using vSphere conducted by Management Insight Technologies in March 2023 (**the 2023 MIT survey**) which they used to show that only [✂]% of VMware customers would switch to servers with I/O hardware supplied by Broadcom in response to a loss of interoperability.[374] Given that this survey showed that a far larger number of workloads would switch away from VMware in response to a loss of interoperability, the Parties submitted that this evidence of switching by VMware customers indicated that a total foreclosure strategy would not be profitable for the Merged Entity and would instead cost it billions of dollars of lost VMware sales in the longer term.[375]

Our assessment

7.158 When assessing the likely response to a loss of interoperability between VMware's server virtualisation software and the I/O hardware supplied by Broadcom's competitors, we have considered (and address in turn below) the following evidence:

(a) The response of virtualisation customers to a material and long-lasting interoperability issue between the I/O hardware used in customers' servers and VMware's server virtualisation software.

(b) The response of virtualisation customers to a number of foreclosure scenarios, including possible total foreclosure strategies.

(c) The responses to the 2023 MIT survey commissioned by the Parties.

7.159 In our customer questionnaires, we asked virtualisation customers about whether they had previously experienced material and long-lasting interoperability issues between their server virtualisation software and their I/O hardware used in their enterprise deployment(s) that led them to move existing workloads between deployment types and/or between different

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[373] Parties' response to the AIS and WPs, 15 June 2023, paragraph 1.3; Parties' VMware market position paper, 15 June 2023, paragraph 1.1.
[374] Parties' VMware market position paper, 15 June 2023, paragraph 5.6.
[375] Parties' response to the AIS and WPs, 15 June 2023, paragraph 1.3.

suppliers of server virtualisation software. No respondent to our questionnaire stated that they had previously experienced material and long-lasting interoperability issues between server virtualisation software and I/O hardware.[376] Given the limited experience of respondents with material and long-lasting interoperability issues and the hypothetical nature of these foreclosure scenarios to virtualisation customers, we have interpreted the evidence on response to total foreclosure by virtualisation customers cautiously as part of our competitive assessment.

Response of virtualisation customers to a material and long-lasting interoperability issue

7.160 In our Phase 1 questionnaire, we asked virtualisation customers whether they would switch hypervisors, move to the public cloud, or purchase servers with I/O hardware that would allow them to retain interoperability with VMware in response to a material and long-lasting interoperability issue between the I/O hardware used in customers' servers and VMware's server virtualisation software.[377] We noted in the Phase 1 questionnaire that this could be either a 'total' or 'partial' foreclosure strategy pursued by the Merged Entity. This question was also included as part of our new Phase 2 questionnaire.[378]

7.161 We received 34 responses to this question across our Phase 1 (24) and Phase 2 (10) questionnaires, representing [5-10%] of VMware's bookings for its server virtualisation software in 2022. These respondents are active in a range of industries, including telecoms, financial services, IT services, manufacturing, utilities, technology, aerospace and defence, education and government.

7.162 As we found that there was no material difference in customers' responses to the hypothetical scenarios across I/O hardware products, we have set out our assessment of their responses in the round. [379]

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[376] Responses to CMA P2 virtualisation customer questionnaire, question 16/17 from [✂].
[377] Responses to CMA P1 Virtualisation customer questionnaire, question 16. We asked respondents to explain how a loss in interoperability between the hardware components used in their servers and VMware's virtualisation software would affect their future server purchasing decisions, and for each hardware type, to specify whether they would: a) switch to a different virtualisation software product; b) move to the public cloud; c) purchase servers that contain components from a different hardware manufacturer(s) which allow them to remain interoperability with VMware; or d) other.
[378] Responses to CMA P2 Virtualisation customer questionnaire, question 18 (for new contacts only). We asked a near identical question to that at Phase 1. The only differences were that we did not ask for differences by hardware type, and we asked to explain whether their actions would differ in the short run (within 24 months) and in the long run (more than 24 months).
[379] Customers at Phase 1 were asked how their actions would differ by Broadcom's I/O hardware, though there was no material difference in responses by product type, except where customers did not use certain I/O hardware components.

7.163 In response to our Phase 1 questionnaire, the majority of respondents indicated that in the event of a loss of interoperability they would switch or would consider switching their I/O hardware provider.[380] Only a minority of customers stated that they would consider switching virtualisation software or moving to the public cloud,[381] with many only doing so if changing I/O hardware was not possible first.[382]

7.164 The responses of virtualisation customers to our Phase 2 questionnaire were more mixed. In particular, we found that respondents at Phase 2 were as willing to consider moving all or some existing workloads to a different virtualisation provider (including other hypervisors and/or the virtualisation offering of CSPs) as they would be to change to I/O hardware and/or purchase servers that contain I/O hardware that would allow them to retain interoperability with VMware.[383]

7.165 As set out below, we held calls with several VMware customers to gain a more detailed understanding of their responses to our questionnaire, in part due to the differences in evidence received from our Phase 1 and Phase 2 questionnaires.

Response of virtualisation customers to foreclosure scenarios

7.166 As part of our Phase 2 investigation, we asked virtualisation customers about how they may respond to a range of foreclosure strategies that may be pursued by the Merged Entity. We received 24 responses to these questions, with these respondents representing [0-5]% of VMware's bookings for its server virtualisation software in 2022. These respondents varied significantly in their current demand for virtualised servers and are active in a range of industries, including telecoms, financial services, IT services, manufacturing, retail, utilities, technology, aerospace and defence, insurance, education, government and healthcare.

7.167 Two of our questions asked virtualisation customers what actions, if any, they would take in response to the following total foreclosure scenarios:[384]

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[380] Responses to CMA P1 virtualisation customer questionnaire, question 16 from [✂].
[381] Responses to CMA P1 virtualisation customer questionnaire, question 16 from [✂].
[382] Responses to CMA P1 virtualisation customer questionnaire, question 16 from [✂].
[383] Responses to CMA P2 Virtualisation customer questionnaire, question 18 (new contacts only) from [✂].
[384] Responses to CMA P2 Virtualisation customer questionnaire, questions 19/21 and 20/22 (for recontacts/new contacts). We asked respondents to explain what actions, if any, they would take if they believed that VMware was disadvantaging Broadcom's competitors by, for example: 19/21) refusing to supply driver updates to the I/O hardware components of Broadcom's competitors and/or technical support to the I/O hardware components of Broadcom's competitors; or 20/22) delaying and/or refusing to supply certification of new I/O hardware components from Broadcom's competitors. Respondents were asked to explain how these actions would differ in the short run (within 24 months) and in the long run (more than 24 months).

(a) VMware disadvantaging Broadcom's competitors by, for example, refusing to supply driver updates to the I/O hardware of Broadcom's competitors and/or technical support to the I/O hardware of Broadcom's competitors.

(b) VMware disadvantaging Broadcom's competitors by, for example, delaying and/or refusing to supply certification of new I/O hardware from Broadcom's competitors.

7.168 These questions also asked how the response of virtualisation customers to these foreclosure scenarios would differ, if at all, in the short term (ie within 24 months) and in the longer term (ie more than 24 months).

7.169 As we found that (i) a large majority of respondents did not differentiate their actions between the two total foreclosure scenarios put to them in our questionnaire and (ii) the responses to the two total foreclosure scenarios did not materially differ across the I/O hardware used by respondents, we have set out our assessment of their responses in the round.

7.170 When asked about what actions they would take in response to the total foreclosure scenarios in the short term, the majority of respondents said that they would raise any interoperability issue with their software and I/O hardware suppliers rather than switch away from vSphere or to Broadcom's products:

(a) About a third of respondents indicated they would use their influence as customers to press for timely updates for their I/O hardware products and/or raise concerns to VMware about their loss of interoperability.[385]

(b) A similar number of respondents stated that they would raise concerns with the I/O hardware suppliers and/or ask them to speed up delivery of I/O hardware drivers.[386]

(c) Several respondents stated they would explore alternatives to VMware, with most considering other virtualisation software providers,[387] with one considering speeding up their migration to the public cloud.[388]

[385] Responses to CMA P2 virtualisation customer questionnaire, questions 19-20/21-22 from [✂].
[386] Responses to CMA P2 virtualisation customer questionnaire, questions 19-20/21-22 from [✂].
[387] Responses to CMA P2 virtualisation customer questionnaire, questions 19-20/21-22 from [✂]. One of these respondents stated they would switch to Microsoft as they already use it for virtualisation alongside VMware [✂].
[388] Responses to CMA P2 virtualisation customer questionnaire, questions 19-20/21-22 from [✂].

(d) Some respondents said they would consider changing to Broadcom I/O hardware.[389] The majority of these respondents already used Broadcom for at least some of the I/O hardware in their servers.[390]

(e) A small number of respondents indicated they would not change either their server virtualisation software or I/O hardware in response to any loss of interoperability in the short term.[391]

7.171 When asked about what actions they would take in response to the total foreclosure scenarios in the longer term, more respondents were willing to consider switching away from vSphere or to Broadcom's products rather than raise any interoperability issue with their software and I/O hardware suppliers:

(a) Several respondents stated that they would move workloads away from vSphere to alternative hypervisors;[392] more respondents indicated that they would consider doing so.[393]

(b) A few respondents stated they would move to the public cloud rather than to a competitor hypervisor.[394]

(c) Two respondents noted lock-in to VMware as causing significant costs to switch between alternative virtualisation providers.[395]

(d) Another two respondents stated that they would replace their I/O hardware if problems with a lack of support by VMware persisted.[396]

(e) No respondents indicated that they would take no action in the longer term if faced with any of the four foreclosure scenarios.[397]

7.172 In addition to reviewing the responses to the total foreclosure scenarios in our questionnaires, we held calls with several VMware customers to gain a more detailed understanding of their responses to our questionnaire.[398]

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[389] Responses to CMA P2 virtualisation customer questionnaire, questions 19-20/21-22 from [✂]. One of these respondents stated they would only do so if leveraging action through contractual agreement was not possible first [✂].
[390] Responses to CMA P2 virtualisation customer questionnaire, questions 19-20/21-22 from [✂].The scenarios presented stated total foreclosure to all competitors of Broadcom, and therefore we assumed that those who stated they would switch I/O hardware components would be switching to Broadcom.
[391] Responses to CMA P2 virtualisation customer questionnaire, questions 19-20/21-22 from [✂].
[392] Responses to CMA P2 virtualisation customer questionnaire, questions 19-20/21-22 from [✂].
[393]Responses to CMA P2 virtualisation customer questionnaire, questions 19-20/21-22 from [✂].
[394] Responses to CMA P2 virtualisation customer questionnaire, questions 19-20/21-22 from [✂].
[395] Responses to CMA P2 virtualisation customer questionnaire, questions 19-20/21-22 from [✂].
[396] Responses to CMA P2 virtualisation customer questionnaire, questions 19-20/21-22 from [✂].
[397] Though one respondent stated they would take no action in the certification scenario, as certification is not important to them. Phase 2 virtualisation customer questionnaire, questions 19-20/21-22 [✂].
[398] These customers included two VMware customers that [✂] and three end users of VMware's server virtualisation software [✂].

7.173 We found that the response to a loss of interoperability between VMware's server virtualisation software and the I/O hardware supplied by Broadcom's competitors by these customers varied based on their diverse needs and specific requirements for server virtualisation software:

(a) VMware customers that offer [✂] told us that they would likely have to switch to servers with Broadcom I/O hardware if the I/O hardware supplied by Broadcom's competitors were no longer interoperable with VMware software products.[399] However, these VMware customers are not end users of VMware's server virtualisation software and instead facilitate the choice of their own customers to use VMware's server virtualisation software. These VMware customers are therefore less able to switch away from VMware in response to a loss of interoperability as they are 'locked in' to offering their end customers VMware's server virtualisation software as part of their [✂].

(b) In contrast, VMware customers that are end users of its server virtualisation software were more willing to consider moving existing workloads away from VMware's server virtualisation software in the longer term in response to a loss of interoperability with the I/O hardware supplied by Broadcom's competitors.

(i) One virtualisation customer told us that as it works with multiple server OEMs and I/O hardware suppliers, it would have alternative server options available in the short term to ensure their I/O hardware continued to interoperate with vSphere.[400] In the longer term, while the migration of existing workloads away from vSphere would be a lengthy process, this customer would make a strategic decision to move away from the Merged Entity in response to a deliberate reduction in interoperability by using other hypervisors and/or moving more existing workloads to the public cloud.

(ii) Another virtualisation customer said that its response in the short term may depend on the length of its licence agreement with VMware, where it may have no choice but to purchase I/O hardware that interoperates with vSphere, although it could consider a number of options to lessen their purchases of new I/O hardware.[401] In the longer term, this customer would have more alternatives to vSphere and could deploy workloads on containerisation software (as part of

[399] Notes of calls with [✂]. This is consistent with their responses to our Phase 1 questionnaire, question 16, where both stated that they would prefer to switch I/O hardware when faced with a loss of interoperability between the hardware used in their servers and VMware's virtualisation software.
[400] Note of a call with [✂].
[401] Note of a call with [✂].

its longer term strategy to deploy workloads on containers) but speeding up or scaling up this process would increase the costs of this process.

(iii) One other virtualisation customer told us that in the short term it would purchase I/O hardware that interoperates with vSphere unless it is significantly more expensive than alternatives as this would be easier than moving existing workloads away from vSphere.[402] If there were a driving reason to move away from VMware in the longer term, such as the lack of interoperability between VMware and non-Broadcom I/O hardware, this customer would consider both a full migration away from vSphere to another hypervisor (which would take a number of years at its scale) or a partial migration, eg running vSphere alongside another hypervisor if there was a commercial reason or technical advantage for doing so.

The 2023 MIT survey

7.174 The Parties provided detailed results and analysis from the 2023 MIT survey, which was commissioned for the purpose of providing evidence on possible VMware customer reactions to total foreclosure.

7.175 The Parties' analysis showed that more than half of the organisations represented in the survey indicated that, under total foreclosure, they would accelerate any planned migration from vSphere by switching away (on average) more than half of their existing workloads over and above any existing migration plans. Furthermore, the organisations represented indicated that, if they had (hypothetically) planned to run workloads using a combination of vSphere and non-Broadcom I/O hardware, in reaction to an introduction of complete non-interoperability they would have switched [✂]% of the affected workloads to run on servers with Broadcom I/O hardware. Both findings were broadly consistent across Ethernet NICs, storage adapters and FC HBAs.

7.176 The survey findings and our assessment of their evidential value are discussed in Appendix D. Having reviewed the survey methodology, taking into account the CMA's guidance on good practice in the design of surveys, we consider it to be reasonably robust. In summary, we therefore regard the survey as evidence that a meaningful proportion of existing and planned new

[402] Note of a call with [✂].

virtualised workloads would be switched away from vSphere in response to a total foreclosure strategy.[403]

Our view on the response to total foreclosure by virtualisation customers

7.177 As set out above, we considered evidence on the response of virtualisation customers to a loss of interoperability between VMware's server virtualisation software and the I/O hardware supplied by Broadcom's competitors to compare the likely actual behaviour of virtualisation customers with the critical switching rates found in the Parties' quantitative analysis. Our provisional view is that the critical switching rates found in the Parties' quantitative analysis show that a very large proportion of VMware customers would need to switch to the I/O hardware products supplied by Broadcom for a total foreclosure strategy to be profitable, whereas only a small proportion of VMware customers would need to move existing workloads away from vSphere for a total foreclosure strategy to be unprofitable.

7.178 When taking the evidence on the response to total foreclosure by virtualisation customers in the round, our provisional view is that it is likely that a sufficient number of VMware customers would move workloads away from VMware in response to a total foreclosure strategy to mean that such a strategy would be unprofitable for the Merged Entity. We note that, while our evidence from virtualisation customers focused on the existing workloads in enterprise deployments, customers could also choose not to deploy new workloads on VMware as a result of the Merged Entity pursuing a total foreclosure strategy, for which customers would not face the same barriers to switching as they do for existing workloads given there is no migration process. This could increase the financial losses to the Merged Entity from pursuing a total foreclosure strategy relative to the financial gains.

7.179 We consider that our provisional view that it is likely that a sufficient number of virtualisation customers would move workloads away from VMware in response to a total foreclosure strategy is not inconsistent with our provisional view that in light of VMware's market power the Merged Entity has the ability to harm the competitiveness of Broadcom's competitors in the supply of I/O hardware:[404]

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[403] We give less weight to the Parties' analysis of the proportion of affected existing workloads that would be switched to run on servers using Broadcom hardware. For further details, see Appendix D.
[404] The Parties submitted that VMware does not have market power in the supply of server virtualisation software in enterprise deployments, because amongst other things VMware's customers would switch significant volumes of workloads away from VMware in response to a loss of interoperability. Parties' VMware market position paper, 15 June 2023, paragraph 1.1.

(a) In general terms, a finding that a firm has market power is consistent with evidence of customer switching in response to a significant worsening of its offering. Firms with market power are subject to some competitive constraints, albeit these can be very limited. As explained below, the assessment of ability and incentive to foreclose addresses interrelated but different questions and it is clearly possible to find that the Merged Entity has the ability to foreclose but lacks the incentive to do so.

(b) Our provisional view that VMware has market power in the supply of server virtualisation software in enterprise deployments globally is based on evidence that the Merged Entity occupies an important position in server virtualisation software and VMware customers cannot easily switch existing workloads away to a range of effective alternative suppliers, including other hypervisors as well as the virtualisation offering of CSPs and the use of containerisation software.[405] As noted at (*a*), this market power does not imply a total absence of customer switching in response to a significant worsening of VMware's offering.

(c) In contrast, our assessment of the Merged Entity's incentive to pursue a total foreclosure strategy considers the profitability of such a strategy, which involves a trade-off between the profit loss from the lower sales of VMware's sever virtualisation software and the profit gain from the additional sales of Broadcom's I/O hardware as a result of foreclosure. This assessment is based on the relative margins and switching in sever virtualisation software and I/O hardware sales.

(d) In the present case, we note that, while the loss of profits in server virtualisation software depends partly on the degree of market power VMware has (ie the stronger the market power, the lower the loss of profits is likely to be, all else equal), given the substantial difference in the margins between VMware's server virtualisation software and Broadcom's I/O hardware, it only requires a small proportion of VMware customers to move workloads away from vSphere for a total foreclosure strategy to be unprofitable.

(e) Furthermore, the response to total foreclosure by virtualisation customers suggests that, while they currently have a preference to use vSphere for their existing workloads on enterprise deployments when vSphere is interoperable with all I/O hardware and switches, the value of continuing to use vSphere for these workloads may be diminished as a result of a reduction in interoperability with the I/O hardware supplied by Broadcom's

[405] See paragraph 7.2 and MAGs, paragraph 7.14(a).

competitors, such that the benefit of moving to other hypervisors and/or the virtualisation offerings of CSPs may be greater as a result of foreclosure. This means that, while customers will still face high switching costs to move existing workloads away from VMware, the benefit and incentive to do so may be greater in response to a reduction in interoperability than in response to other actions resulting in a worsening of VMware's offering.

(f) Finally, as set out above, while we note that our evidence from virtualisation customers focused on the existing workloads in enterprise deployments, in the case of new workloads customers would not face the same barriers to switching as they do for existing workloads. This means that, in response to a reduction in interoperability, customers may have an even greater incentive to use other hypervisors and/or the virtualisation offerings of CSPs, instead of VMware, for new workloads.

Other factors relating to incentive to foreclose

7.180 In addition to considering the direct gains from customers switching from competitors to Broadcom I/O hardware and the direct losses from customers switching away from VMware server virtualisation software, we have considered how the Merged Entity's incentive to pursue a total foreclosure strategy may be affected by other factors, such as the possibility of retaliation by server OEMs and the possibility that the pursuit of such a strategy would jeopardise the Merged Entity's wider relationships.

7.181 In relation to retaliation, we have considered whether server OEMs would have the ability and incentive to retaliate against the Merged Entity and how the Merged Entity may perceive this risk. In this case, we define customer retaliation as actions by customers that cause financial harm to the Merged Entity, undertaken in order to stop the Merged Entity from foreclosing.[406] The threat of retaliation and the related financial consequences represent a potential cost to the Merged Entity of engaging in a total foreclosure strategy and so affect its overall incentive to do so. The threat of retaliation, as opposed to actual retaliation, may be sufficient to deter the Merged Entity from foreclosing its rivals provided such a threat is credible.

7.182 The Parties have, and the Merged Entity will have, a complex set of wider relationships with (i) customers across a broad range of products and (ii) competitors who in several cases supply complementary products with which the Merged Entity needs to ensure interoperability, or supply inputs to the

[406] Compare anticipated acquisition by London Stock Exchange Group Plc of Quantile Group Limited, Final Report, 26 October 2022, paragraph 5.62.

Merged Entity (and vice versa). We have considered the extent to which the pursuit of a total foreclosure strategy may harm these relationships in a way that impacts the Merged Entity's profits, either in the short or long term, and how the Merged Entity may perceive this risk.

Retaliation by server OEMs

Parties' submissions

7.183 The Parties have submitted that 'Server OEMs like [✂], which are Broadcom's main customers for I/O hardware devices, could retaliate by (1) no longer including Broadcom's I/O hardware products in the c. [✂]% of the market that does not use VMware, (2) advising customers to no longer use VMware given the risk of lock-in, and (3) disciplining Broadcom in other hardware markets by switching purchases to other vendors or by switching purchases of Broadcom's [✂] to Microchip.'[407]

7.184 The Parties have submitted further details on the ways in which the server OEMs could cause the Merged Entity to lose sales at minimal to no cost to the OEMs:[408]

(a) Server OEMs can influence end customer demand for I/O hardware. They are able to present choices to customers in a way that promotes competitor I/O hardware over Broadcom, for example by changing the pricing and ranking of certain vendors' I/O hardware in a 'server configurator'. They are able to proactively promote non-Broadcom I/O hardware. Server OEMs have a particularly strong influence over the significant proportion of customers with no I/O hardware vendor preferences.

(b) Server OEMs can divert purchases away from Broadcom in other areas. In 2021, Broadcom generated more than $[✂]in revenue from [✂] alone. There are several areas where OEMs could switch away from Broadcom where end-customers do not have strong vendor preferences, such as [✂] (collectively these accounted for more than $[✂] of Broadcom sales to OEMs in 2021).

(c) Server OEMs can influence customer software choices. Server OEMs account for approximately $[✂] of VMware bookings annually and could

[407] Parties' response to the Phase 1 Issues Letter, 3 March 2023, paragraph 2.23.
[408] Parties' response to the AIS and WPs, 15 June 2023, paragraph 4.48.

influence customer choices by removing VMware from preloaded hypervisor options or select alternatives as defaults.

7.185 The Parties have also submitted that server OEMs are highly incentivised to neutralise foreclosure for the following reasons:[409]

(a) Server OEMs have significant long-term interests in protecting multi-sourcing strategies to ensure security of supply, competitive prices and to meet customer preferences.

(b) Retaliation would not involve material costs as the actions identified to influence customers to switch purchases away from Broadcom, either through subtle changes to server configurators or in relation to product areas where customers have no vendor preferences, involve little cost to OEMs.

Our assessment

7.186 Our provisional view is that server OEMs are able to retaliate through some of the mechanisms identified by the Parties:

(a) The majority of I/O hardware sales by server OEMs are for use in servers that do not use VMware's server virtualisation software.[410] For these sales, we have considered to what extent server OEMs are able to influence end-customers to choose competitor I/O hardware rather than Broadcom I/O hardware. Several server OEMs told us that their ability to switch away from Broadcom was limited by the preferences of their customers, as the final choice of I/O hardware configuration was left to their end customers.[411] However, evidence from customers and server OEMs suggests that there is potential for server OEMs to influence a significant proportion of customers that do not have strong preferences for I/O hardware vendors and treat I/O hardware devices as interchangeable.[412] Indeed, we note examples where server OEMs multisource across multiple vendors yet purchase the vast majority of a specific type of I/O hardware from a single vendor, indicating that few end-customers express strong preferences for alternative vendors.[413] We consider that server OEMs are able to influence these choices to some

[409] Parties' response to the AIS and WPs, 15 June 2023, paragraph 4.50.
[410] CMA calculations based on IDC data on virtualised and non-virtualised server units installed and CMA analysis of VMware market shares: FMN, paragraph 15.364 and Table 43.
[411] Response to the CMA questionnaire from [✂].
[412] Response to the CMA questionnaire from [✂], 14 April 2023, question 2a. Response to the CMA questionnaire from [✂], 14 April 2023, question 4. Response to the CMA questionnaire from [✂], 19 April 2023, question 16c.
[413] Response to the CMA questionnaire from [✂], 14 April 2023, question 2.

extent through the way in which options are presented to customers, the mark-ups applied to I/O hardware prices and the advice they give to customers.

(b) Similarly, server OEMs may be able to influence customer demand in relation to some of the other products supplied by Broadcom, which in aggregate account for a large amount of Broadcom revenues. The illustrative examples provided by the Parties show that Broadcom sales to server OEMs in areas where end-customers do not have strong vendor preferences collectively accounted for more than $[✂] in 2021. This compares to Broadcom's total sales of $[✂] in I/O hardware in year 2021.[414]

(c) In relation to server virtualisation software, the ability for server OEMs to influence customer choice appears more limited. Server OEMs responded that they have little influence over the customers' choice of virtualisation software or that this choice is driven by customers.[415] One server OEM expressed specific concern that if they were to retaliate by not distributing VMware software, they would lose business to competitors.[416]

7.187 The evidence on the incentive for server OEMs to retaliate is mixed:

(a) Responses from server OEMs indicate that there would be a benefit to them of retaliating in order to protect their ability to source from multiple providers. Server OEMs responding to our questionnaire generally indicate that for I/O hardware it is important to have multiple vendors to ensure a competitive price, security of supply and offer choice to end customers.[417]

(b) Influencing customer choice of I/O hardware in the ways described by the Parties is likely to involve some cost for server OEMs. Server OEMs are likely to price I/O hardware and present options to end customers in a way which maximises their profits, taking into account the margins made on different products, volume discount arrangements and competition between server OEMs. Consequently, if server OEMs wish to deviate from their current approach in order to retaliate against a foreclosure strategy pursued by the Merged Entity, this is likely to involve some cost. Given that many end-customers do not have strong preferences over I/O hardware, it appears possible that the costs of retaliation in relation to

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[414] Broadcom response to the s109 notice issued 28 April 2023, question 2, annex S109(5)Q2-3–001 ME.7011.22.
[415] Response to the CMA questionnaire from [✂], 14 April 2023, question 11.
[416] Response to the CMA questionnaire from [✂], 14 April 2023, question 11c.
[417] Response to the CMA questionnaire from [✂], 14 April 2023, question 2.

certain products would not be prohibitive. However, since the benefit of successfully deterring the foreclosure strategy would be shared across server OEMs, each has the incentive to free ride on retaliatory actions carried out by other server OEMs. This may undermine the incentive of each individual server OEM to retaliate.

(c) Responses from server OEMs suggest that they may be reluctant to retaliate against Broadcom given their dependency on it as a supplier. One server OEM responded that it would not have the ability to use the threat of switching away from Broadcom as a means to negotiate better terms.[418] The same server OEM explained that Broadcom has leverage from its position as a supplier in various products that are often solely supplied by Broadcom and require significant investment in terms of time and cost to switch. This has allowed Broadcom to encourage the purchase of further Broadcom products or increase prices on other products.[419] Another server OEM stated that it has little leverage with which to threaten Broadcom.[420]

7.188 While server OEMs are able to retaliate in various ways, it is not clear whether, individually, they would have the incentive to do so. However, given the broad scope of products over which retaliation could occur, accounting for a large amount of Broadcom's revenues in comparison to the limited potential gains from the foreclosure strategy, [421] our provisional view is that the Merged Entity would be likely to perceive at least some risk of retaliation by server OEMs.

The importance of interoperability for the Parties' wider relationships

Parties' submissions

7.189 The Parties submitted that a foreclosure strategy which reduces interoperability would cause reputational damage to the Merged Entity. In particular, the Parties submitted that:

(a) VMware has adopted a hardware-agnostic approach to promote broad adoption of its product, which is central to its product strategy.[422] Engaging in any foreclosure strategy which would lead to a loss of interoperability between VMware's software and the I/O hardware

[418] Response to the CMA questionnaire from [✂], 14 April 2023, question 11.
[419] Note of a call with [✂].
[420] Response to the CMA questionnaire from [✂], 14 April 2023, question 11.
[421] See paragraph 7.153.
[422] FMN, paragraphs 20.94-20.103; Parties' response to the Phase 1 Issues Letter, 3 March 2023, paragraphs 2.7-2.8 and 2.19a.

products supplied by Broadcom's competitors would undermine this strategy and VMware's reputation for openness.[423]

(b) In its Dell/EMC merger investigation, the Commission found that VMware has always adopted a 'hardware/software-neutral approach' and that to promote a large adoption of its product, VMware had to endorse an open and non-discriminatory architecture policy.[424]

(c) Any foreclosure strategy would run contrary to Broadcom's business model of separate franchises (eg [✂]) and the general principle of interoperability in the data centre environment.[425]

(d) Increasing prices or reducing interoperability would damage Broadcom's and VMware's reputations and risk undermining Broadcom's $61 billion investment in VMware.[426]

7.190 The Parties further submitted that the financial consequences of the reputational harm from reducing interoperability would be sufficient to remove any incentive to foreclose. The Parties submitted that there is no precedent involving the reduction in interoperability available as no one has attempted to reduce interoperability, being the foundational principle of the data centre.[427] However, the Parties submitted that the financial consequences would include:

(a) Lower VMware sales as customers value VMware for its ability to work with a wide range of hardware products and would be incentivised to seek other options for virtualisation or switch to CSPs if VMware were no longer adequate for this task.

(b) Lost sales across Broadcom's wider portfolio as customers would lose trust in Broadcom as a supplier that respects the need for interoperability in the data centre and may reduce their purchases not only of Broadcom's I/O hardware devices but also of Broadcom's thousands of other products. The Parties provided two recent examples of cases where Broadcom has lost sales in one business division due to actions taken in another.[428]

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[423] FMN, paragraphs 20.94-20.103;Parties' response to the Phase 1 Issues Letter, 3 March 2023, paragraphs 2.7-2.8 and 2.19a.
[424] Parties' response to the Issues Statement, 10 May 2023, paragraph 3.16.
[425]Parties' response to the Phase 1 Issues Letter, 3 March 2023, paragraph 2.12.
[426]Parties' response to the Issues Statement, 10 May 2023, paragraph 2.14.
[427] Parties' response to the AIS and WPs, 15 June 2023, paragraph 4.42.
[428] Parties' response to the AIS and WPs, 15 June 2023, paragraph 4.43.

7.191 In addition, the Parties submitted that Broadcom has wider relationships with many other companies in the x86 ecosystem,[429] where the Parties are competitors but also have to interoperate:[430]

(a) Intel and NVIDIA compete with Broadcom in NICs, while Broadcom depends on interoperability with their CPUs and GPUs to supply hardware for servers;

(b) Intel's NICs depend on Broadcom's ASICs but compete with Broadcom's NICs;

(c) Marvell competes with Broadcom in FC HBAs but interoperates with Broadcom's FC switches. Marvell [✂];

(d) Microchip competes with Broadcom in storage adapters [✂]; and

(e) Cisco competes with Broadcom in FC switches but [✂], generating [✂] sales across [✂] of Broadcom's hardware divisions.

7.192 The Parties have submitted that Broadcom's Ethernet NIC competitors could respond to the foreclosure strategy by degrading compatibility of CPUs and GPUs with Broadcom's Ethernet NICs and Ethernet top of rack switching chips or with VMware's software.[431] [✂].[432]

Our assessment

7.193 Both Parties operate in several markets where interoperability between software and hardware supplied by a range of providers is an important and recognised parameter of competition. As noted in paragraph 7.94 above, this is supported by evidence from both Broadcom's competitors and end-customers in relation to I/O hardware. Consistent with this, we note that we have not received evidence of previous relevant examples where the Parties or any of their competitors have reduced interoperability in the past in a similar way to the foreclosure strategy under consideration.

7.194 In this context, a total foreclosure strategy has the potential to damage the Merged Entity's wider relationships through undermining its reputation for interoperability. Customers may become more reluctant to do business with the Merged Entity as a result. The main financial consequence to the Merged

[429] As set out in Chapter 2, an x86 server is a computer that uses an x86 CPU architecture. The x86 architecture primarily handles programmatic functions and provides services, eg memory addressing, software and hardware interrupt handling, data type, registers and I/O management.
[430] Parties' response to the AIS and WPs, 15 June 2023, paragraph 4.51.
[431] Parties' response to the Phase 1 Issues Letter, 3 March 2023, paragraph 2.23(b).
[432] Parties' response to the AIS and WPs, 15 June 2023, paragraph 4.53.

Entity from this is likely to be from lower VMware sales, due to its high margins and because some customers value VMware's server virtualisation software's ability to work with a wide range of hardware products.

7.195 In our view, this effect is likely to be already largely captured by our assessment of virtualisation customers' response to the foreclosure strategy in paragraphs 7.155 to 7.179 above, which suggests that the cost to the Merged Entity of customers switching away from VMware is likely to be significantly higher than the gains from the foreclosure strategy. In addition, there may also be costs to the Merged Entity from:

(a) Lost sales across Broadcom's wider product portfolio as server OEMs and end-customers lose trust in Broadcom as a supplier that respects the need for interoperability in the data centre; and

(b) The reaction of Broadcom's competitors on which Broadcom relies for interoperability or the supply of key inputs.

7.196 Given the considerable uncertainty around how third parties might respond to the foreclosure strategy in practice and the fact that a similar reduction in interoperability has not been attempted in the past, it is difficult to quantify the financial consequences to the Merged Entity from these responses. However, we note that the scope for the potential losses may be much larger than the potential gains from the foreclosure strategy. Broadcom sells 16,000 products and services,[433] and in 2021 generated [✂] in revenue from sales to [✂] alone.[434] This compares to a potential gain of $[✂] million per year after at least a seven year period if the foreclosure strategy is successful in driving I/O hardware switching.[435]

7.197 Based on the above, our provisional view is that the Merged Entity may perceive at least some risk of substantial costs arising from damage to its wider relationships in comparison to the possible gains from the foreclosure strategy.

Our view on the Merged Entity's incentive to foreclose

7.198 Based on the evidence above, we have provisionally found that the Merged Entity would not have the incentive to foreclose hardware rivals. The critical switching rates found in the Parties' quantitative analysis show that a very large proportion of VMware customers would need to switch to the I/O

[433] See Parties' response to the Issues Statement, 10 May 2023, paragraph 1.1.
[434] Parties' response to the AIS and WPs, 15 June 2023, paragraph 4.48.
[435] See paragraph 7.153.

hardware products supplied by Broadcom for a total foreclosure strategy to be profitable, whereas only a small proportion of VMware customers would need to move workloads away from vSphere for a total foreclosure strategy to be unprofitable. Evidence from customers shows that it is likely that a sufficient number of VMware customers would move workloads away from VMware to mean that such strategy would be unprofitable for the Merged Entity

7.199 In addition, we note that the Merged Entity would be likely to perceive at least some risk from the possibility of retaliation by server OEMs and may also perceive at least some risk that the pursuit of a strategy that reduces interoperability would jeopardise the Merged Entity's wider relationships with customers and competitors and result in substantial costs.

Effect of foreclosure on competition

7.200 In light of our conclusion that the Merged Entity does not have the incentive to pursue a foreclosure strategy, we have not considered its effects on competition.

Conclusion on foreclosure of I/O hardware and switches competitors through leveraging VMware's position in server virtualisation software

7.201 For the reasons set out above, our provisional conclusion is that:

(a) the Merged Entity would have the ability but not the incentive to foreclose Broadcom's I/O hardware competitors by refusing to certify drivers for new generations of Broadcom's competitors' I/O hardware products, and

(b) therefore, the anticipated acquisition of VMware by Broadcom may not be expected to result in an SLC as a result of foreclosing Broadcom's I/O hardware competitors by reducing interoperability.

7.202 In relation to FC switches, we have provisionally found that it appears unlikely that the Merged Entity could reduce interoperability between vSphere APIs and competitor switch management software as a way to harm Broadcom's competitors.

7.203 We note that, in addition to the Parties' submissions considered above, the Parties submitted that Broadcom has [✂]. The Parties submitted that, [✂].[436] They also submitted that [✂].[437]

7.204 We note that [✂].[438]

7.205 We also note that the [✂], and that [✂] does not provide us with reliable evidence regarding the Merged Entity's incentives in the same way as other past behaviour [✂].

7.206 For the reasons set out above, however, we have provisionally concluded that the Merged Entity does not have the incentive to foreclose Broadcom's I/O hardware competitors. In doing so, we have not needed to consider the impact of [✂] on that incentive and, in light of our provisional conclusions, we do not consider it necessary in this case to determine whether or not [✂] materially impact the Merged Entity's ability or incentive to foreclose Broadcom's I/O hardware competitors.

[436] Parties' response to the AIS and WPs, 15 June 2023, paragraph 3.17; Parties' response to Issues Statement, 10 May 2023, paragraphs 4.14 - 4.16
[437] Parties' response to the AIS and WPs, 15 June 2023, paragraphs 4.57-4.58; Parties' response to Issues Statement, 10 May 2023, paragraph 4.26(e).
[438] [✂].

8. Non-horizontal effects in the supply of I/O hardware from sharing of commercially sensitive information

Introduction

8.1 In addition to our assessment of foreclosure effects, we have considered potential non-horizontal effects related to the sharing of commercially sensitive information (**CSI**) with VMware in the supply of I/O hardware.[439]

8.2 Under this theory of harm, we consider whether competition could be harmed as a result of the Merged Entity[440] being able to gain access to CSI that it would not have absent the Merger about the activities of its hardware competitors (in this case technical product specifications or innovation plans) in the supply of I/O hardware.

8.3 In particular, we consider that harm to competition could occur in two ways:

(a) A competitor's incentive to innovate may be reduced as a result of a loss or deterioration of its first mover advantage. In other words, if the competitor knows that the Merged Entity could use CSI related to the competitor's product innovation plans in developing the Merged Entity's own products, this may weaken the competitor's incentive to innovate in the first place, thus resulting in a lessening of competition in innovation; and/or

(b) The Merged Entity may reduce its efforts to innovate and ultimately offer less competitive and innovative products[441] as it is better informed about competitors' product developments (or lack thereof) and faces less uncertainty about the risk of losing sales from failing to keep up with competitor innovations. This may be expected to lead to lower innovation and lower quality products being produced than would otherwise have been the case absent the Merger.

8.4 As discussed in paragraphs 4.26 to 4.31, I/O hardware manufacturers certify their products to work with VMware's server virtualisation software via a driver certification process. As part of this process I/O hardware manufacturers share information with VMware before new products and features are launched to ensure they will be interoperable with VMware's software.

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[439] MAGs, paragraph 7.3.
[440] Specifically, the division of the Merged Entity that supplies I/O hardware.
[441] MAGs, paragraph 7.3.

8.5 In our assessment we consider:

(a) the CSI that I/O hardware competitors share with VMware, but not Broadcom, pre-Merger and when this information is shared;

(b) the importance of this information to I/O hardware competitors' innovations, such that the Merged Entity's access to the CSI would enable it to respond more rapidly with its own product improvements;

(c) the likely response of I/O hardware competitors to the Merged Entity having access to this information (ie, would they continue to share the same information with VMware or change the type or timing of information they share); and

(d) the likely impact on I/O hardware competitors' and the Merged Entity's incentives to innovate and the overall effect on competition.

Parties' submissions

8.6 The Parties submitted that VMware receives no CSI from I/O hardware competitors through the driver development and certification process.[442] Specifically the Parties submitted:

(a) All I/O hardware must be built to comply with published industry standards and improvements in speed and performance are public and led by the industry standards bodies. To the extent that a product roadmap is shared, it consists of high-level information on the timing of an upcoming product and contains no CSI, as equivalent roadmaps are made available by industry standards bodies for each I/O hardware product.[443]

(b) Improvements in speed and performance for I/O hardware are publicised in industry-wide testing at events where market participants are able to test their prototype product's interoperability with other industry players' prototype products. The tests highlight any issues arising around 1-2 years before a new industry standard is due to be launched.[444]

(c) I/O hardware competitors only need to share the driver source code and testing results with VMware as part of the driver certification process, which do not contain sensitive information.[445] Sharing information on the

[442] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.11.
[443] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.11(c), and 6.12(f)(i).
[444] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.11(d).
[445] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.11(f)-(g).

chip and firmware is unnecessary for driver development and certification.[446]

(d) Driver source code is provided to Linux (an open-source operating system) first and is therefore public before it is provided to VMware,[447] and the differences between the VMware and Linux drivers supplied by Broadcom are not competitively significant.[448]

8.7 The Parties submitted that Broadcom receives information from I/O hardware competitors to ensure interoperability with Broadcom's ASICs,[449] optical modules,[450] and FC switches.[451] Broadcom also receives basic information about the new features and updates server OEMs are looking to introduce to their Ethernet NICs and storage adapters 6-18 months ahead of their release, through its supply of Ethernet controllers and storage controllers.[452]

8.8 The Parties also submitted that to the extent that I/O hardware competitors do share CSI with VMware, this information is not important to innovation:[453]

(a) Speed and performance are the core parameters of competition for I/O hardware, driven by changes to the controller chip, and VMware does not receive information on this from I/O hardware competitors.[454] While manufacturers may attempt to differentiate their products through new or additional features or functionalities, these are not important characteristics.[455]

(b) Any information received by VMware is shared with it long after the point at which Broadcom could use it to make product changes.[456] The development of a controller chip takes around 3-4 years. Therefore, Broadcom's investment decisions are made years before any information is shared by I/O hardware vendors with VMware. Even until 2 years in advance of driver certification, the only information shared by I/O

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[446] Parties' response to the Phase 1 Issues Letter, 3 March 2023, paragraph 3.6.
[447] Parties' response to the Issues Statement, 10 May 2023, paragraph 5.9.
[448] Parties' response to the Phase 1 Issues Letter, 13 March 2023, paragraphs 3.7 and 3.8.
[449] Silicon used by some competitors to produce Ethernet NICs (Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.15).
[450] An input used to produce FC HBAs (Parties' response to the CMA's RFI 7, 3 May 2023, question 5).
[451] Parties' response to the AIS and WPs, 15 June 2023, paragraph 1.5.
[452] The Parties did not make any submissions about information they receive directly from Ethernet NICs and storage adapters manufacturers, other than via server OEMs.
[453] The Parties also submitted that the CMA's description of third party collaboration with VMware appears to relate to compute and/or processor devices rather than Ethernet NIC, FC HBA, and/or storage adapters (Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.12(a)). We note that the collaboration described relates to compute and/or processor devices as well as Ethernet NIC, FC HBA, and/or storage adapters.
[454] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.13(a) and (b).
[455] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.11(e).
[456] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.13.

hardware vendors with VMware is the high-level timing of an upcoming product release (without any details on that product).[457]

8.9 The Parties submitted that to the extent that I/O hardware competitors have provided CSI to VMware, this is not necessary to ensure interoperability and they could stop providing this information with no adverse effects for interoperability with VMware.[458] Over the past 10 years Broadcom has only provided VMware with one roadmap relating to its FC HBAs (which did not contain any competitively sensitive information) and has not provided any roadmaps for Ethernet NICs or storage adapters.[459]

8.10 Further, [✂]% of servers do not use VMware, innovations are not specific to VMware, and the majority of new NIC and storage adapter sales in the first few years after a new generation's release are to CSPs.[460] In relation to Ethernet NICs, Broadcom also submitted that it has deprioritised testing of its new [✂] with VMware and focused on testing with Linux and Windows because higher speed NICs are primarily sold to CSPs before being supported by VMware.[461]

8.11 Further, the Parties submitted that the information shared by Broadcom's I/O hardware competitors would not impact the Merged Entity's or competitors' incentives to innovate because products or features are not developed specifically for VMware;[462] suppliers would still need to innovate to compete for the majority of servers that do not run VMware;[463] and even if competitors did share information on their chip and firmware it would be shared with VMware long after it may be useful to the Merged Entity, as chip and firmware development begins years before competitors need to engage with VMware.[464]

8.12 The Parties also submitted that there is no first-mover advantage that could be lost or deteriorated. Being the first to release new product improvements, features or functionalities has no significant impact on sales. This is partly due to the slow customer adoption curve of new device generations, where some customers may prefer to wait until the new generation of devices has been used in the market for a while and other customers may not consider that they need the upgraded speed or performance. In addition, server OEMs will

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[457] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.13(c).
[458] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.11(h) and 6.12(g).
[459] Parties' response to Issues Statement, 10 May 2023, paragraph 5.8; and Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.12(g).
[460] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.18(a).
[461] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.18(b)(i).
[462] Parties' response to the AIS and WPs, 15 June 2023, paragraphs 6.16(a) and 6.18(a).
[463] Parties' response to the AIS and WPs, 15 June 2023, paragraph 1.5.
[464] Parties' response to the AIS and WPs, 15 June 2023, paragraphs 1.5 and 6.12(f).

sometimes not list a new generation device until at least two vendors have a device on the market.[465]

8.13 Finally, the Parties submitted that to the extent the Merged Entity receives CSI, post-Merger VMware will have no incentive to share this with Broadcom because its business model and reputation relies on working constructively with a wide range of hardware vendors, keeping the CSI shared through these relationships confidential and not using it internally for anything other than the purpose for which it was shared.[466] The Parties submitted that any leak or misuse of I/O hardware vendors' information would be quickly detected, because vendors' IP is distinctive and easily recognisable (and in some cases watermarked), would invite litigation for breach of confidentiality terms, and would severely damage the Merged Entity's relationships and reputation.[467] Hardware competitors that manufacture compute products (such as CPUs, GPUs and/or SmartNICs/DPUs) could withhold (i) information necessary for VMware to ensure its virtualisation software functions correctly on these devices and (ii) information necessary for Broadcom to ensure interoperability of its I/O hardware with these devices.[468]

Our assessment

8.14 Due to the differences between I/O hardware products, we have assessed the effect of the Merger on Ethernet NICs, FC HBAs and storage adapters separately, applying to each product the framework set out in paragraph 8.5.

8.15 As set out in paragraphs 7.92 to 7.94 above, we note however that Ethernet NICs, FC HBAs, and storage adapters all have in common the fact that, in order for suppliers to sell these products to customers that wish to use them with VMware, it is essential that each be VMware certified.[469]

Ethernet NICs

8.16 The evidence we have gathered from the Parties and third parties shows that speed and bandwidth are important parameters of competition for Ethernet NICs.[470] For Ethernet NICs below 25 Gb/s the evidence also shows that innovation is limited, and new or additional features or functionalities are not an important parameter of competition as these products are considered to be

[465] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.19(a).
[466] Parties' response to the Phase 1 Issues Letter, 13 March 2023, paragraph 2.6 and paragraphs 3.13-3.14.
[467] Parties' response to the Annotated Issues Statement, paragraph 6.15(d).
[468] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.15(f).
[469] Responses to the CMA's questionnaire from [✂], question 16; and responses to the CMA's questionnaire from [✂], question 3.
[470] Note of a call with [✂]; and Response to the CMA's questionnaire from [✂].

'standardized' or 'commoditized'.[471] Ethernet NICs below 25 Gb/s are therefore not considered further in this chapter due to the limited innovation in relation to these products.

8.17 However, for Ethernet NICs at or above 25 Gb/s the evidence from third parties indicates that new or additional features or functionalities are an important parameter of competition. In addition to increased speed and bandwidth, manufacturers compete on improved security, additional features that reduce latency, and increased application predictability and throughput, which customers value.[472] This is supported by Broadcom's internal documents which show that features are an important parameter of competition for Ethernet NICs.[473]

Pre-Merger, additional CSI VMware receives compared to Broadcom

8.18 Third parties submitted that VMware receives CSI from Ethernet NIC competitors through:

(a) its formal driver certification process (VMware's VIVa and DCPN processes), such as programming guides, API information regarding firmware interfaces and architectural information approximately 7 weeks prior to a product or feature launch;[474] and

(b) information outside the formal VMware certification process through discussions on product roadmaps, which include the products and/or features competitors are developing up to 3 years before the products and/or features are launched.[475] This information is exchanged in order to ensure new products will work with VMware when launched, without the need for hardware manufacturers to redesign their products if issues arise during the certification process.[476]

8.19 In relation to the Parties' submission that information shared through product roadmap discussion contains no CSI, as equivalent roadmaps are made available by industry standard bodies for Ethernet NICs, we note that the industry standards body publishes information about the next generation of

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[471] Response to the CMA's questionnaire from [✂]; Response to the CMA's questionnaire from [✂]; and Response to the CMA questionnaire from [✂].
[472] Response to the CMA questionnaire from [✂]; response to the CMA's questionnaire from [✂]; and response to the CMA's questionnaire from [✂].
[473] For example, a Broadcom internal document [✂]. The same document also noted that [✂] (Broadcom response to s109 Notice issued 7 October 2022, question 4, BCOM-CMA-00000302, page 32 and 52. The document is [✂]).
[474] Response to the CMA questionnaire from [✂]; Response to the CMA questionnaire [✂] and Response to the CMA questionnaire from [✂].
[475] Note of a call with [✂]; and note of a call with [✂].
[476] Note of a call with [✂]. Note of a call with [✂].

higher speed Ethernet NICs but not the specific features competitors are looking to introduce.[477] Further, NVIDIA, a key Ethernet NIC competitor, is not a member of the industry standards body referred to by the Parties.[478] However, the evidence we have seen, in line with the Parties' submissions, indicates that Ethernet NIC competitors do not provide VMware with information on their chip and firmware design.[479]

8.20 The information Broadcom receives from Ethernet NIC competitors is limited. All Ethernet NIC competitors that responded to our investigation stated that the information provided to Broadcom is not the same type of information they share with VMware, as it does not disclose the new products or features competitors are looking to introduce.[480]

8.21 Therefore, the evidence we have received from the Parties and third parties is not consistent. The Parties submitted that no CSI is shared for the driver development and certification process (see paragraph 8.6 above), while third parties submitted that pre-Merger VMware has access to additional CSI, relative to Broadcom, from Ethernet NICs competitors through:

(a) the formal driver certification process on programming guides, API information regarding firmware interfaces, architectural information approximately 7 weeks prior to a product or feature launch; and

(b) product roadmap discussions which disclose high level information on the new features Broadcom's competitors are looking to introduce to their Ethernet NICs up to 3 years before Broadcom would receive it pre-Merger.

8.22 However, for the reasons set out below we have not had to conclude on whether VMware has access to additional CSI or not, as we do not find access to the additional CSI described by competitors would materially impact the competitors' or the Merged Entity's incentives to innovate.

Importance of the additional CSI to innovations

8.23 To the extent the Merged Entity has access to competitor CSI via VMware as described in paragraph 8.21 we have assessed whether this would enable it to respond more rapidly with its own product improvements.

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[477] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.11(c)(ii).
[478] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.11(c)(ii).
[479] Response to the CMA questionnaire from [✂], question 15; Response to the CMA questionnaire from [✂] and Response to the CMA questionnaire from [✂].
[480] Response to the CMA questionnaire from [✂]; Note of a call with [✂]; Third party submission to the CMA [✂]; Response to the CMA questionnaire from [✂]; and Response to the CMA questionnaire from [✂].

8.24 Through the formal driver certification process, VMware receives information on the features Broadcom's competitors are planning to introduce approximately 7 weeks prior to the launch of those products.[481] However, it takes 3 to 4 years to develop a new Ethernet NIC with different features.[482] Therefore, this information is unlikely to give the Merged Entity the ability to respond in a timely fashion with its own Ethernet NIC product improvements.

8.25 In relation to the information shared via roadmap discussions, the Merged Entity may have a greater opportunity to use it to respond with its own Ethernet NIC product improvements in a timely way. The information shared by some competitors via roadmap discussions is shared 2-3 years prior to a product being launched,[483] and although the information shared does not disclose changes made to the underlying chip, it does disclose the product features a competitor is looking to introduce. Therefore, the Merged Entity gaining access to this information significantly in advance of a product launch could enable it to develop a similar product more quickly, reducing the first mover advantage of its competitors as well as the Merged Entity's incentives to innovate independently.

Post-Merger, response from hardware competitors

8.26 The evidence from competitors on their response to sharing information with the Merged Entity is mixed. While Ethernet NIC competitors stated that they would be unlikely to change the scope of the information they share with the Merged Entity,[484] as this information is needed to ensure compatibility with VMware, several competitors also noted that they have the ability to release new products to the market before engaging with VMware. For example:

(a) One competitor noted that CSPs are the first to adopt new high speed NICs and server OEMs will generally adopt these one to two years later, [✂]. The competitor also noted that post-Merger, it may share information about new features later with VMware to prevent Broadcom getting timely access to it.[485]

(b) Another competitor noted that although it would generally not release new products publicly without receiving full test results from VMware, it may do so if delaying launch altogether would mean that it lost significant sales to

[481] Response to the CMA questionnaire from [✂], question 15.
[482] Note of a call with [✂]; and Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.13(c).
[483] Note of a call with [✂]; and note a of call with [✂].
[484] Note of a call with [✂]; Response to the CMA questionnaire from [✂]; Note of a call with [✂]; Response to the CMA questionnaire from [✂]; Response to the CMA questionnaire from [✂] and Response to the CMA questionnaire from [✂].
[485] Note of a call with [✂].

competitors for customers that did not plan to use the product with VMware (eg, with Linux or Windows). In this case, it would still aim to get certified by VMware as soon as possible following the release of its product.[486] It also noted that new Ethernet NIC products are not always put into new servers.[487]

8.27 Typically all innovations in Ethernet NICs will be applicable to all use cases regardless of whether, and/or the type of, virtualisation software is used on the servers.[488] For Ethernet NICs at or above 25 GB/s only a small proportion of competitor sales are to VMware customers, given the majority of sales are to CSPs and not to OEMs.[489] This is supported by a Broadcom internal document which shows that [✂].[490] In addition, the evidence shows that Ethernet NICs at or above 25 GB/s are adopted by CSPs around 2 years before OEMs (and hence enterprise customers for use with VMware).[491]

8.28 Given this, we consider that post-Merger Ethernet NIC competitors would have the ability to reduce the CSI they share with the Merged Entity by delaying product roadmap discussions and the formal driver certification process with VMware. Delaying engagement with VMware would not affect Ethernet NIC competitors' ability to develop new products and features and sell these new products to CSPs, which typically takes place around 2 years in advance of sales to OEMs. A delay in the sharing of any CSI would reduce any impact on competitors' and the Merged Entity's incentives to innovate.

Overall effect on competition

8.29 Overall, the evidence we have gathered on Ethernet NICs shows that there is limited innovation in lower speed products (which are predominantly used by OEMs). Innovation is focused on higher speed products, driven by demand from CSPs (who do not use VMware), with OEMs adopting these higher speed products around 2 years later than CSPs. Our provisional view is that competitors would have the ability to delay when they share information with VMware relating to these higher speed products. Therefore, we consider that hardware competitors' and the Merged Entity's incentives to innovate are unlikely to be significantly affected by the Merger.

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[486] Note of a call with [✂].
[487] Note of a call with [✂].
[488] Response to the CMA questionnaire from [✂].
[489] CMA estimates based on: Broadcom response to the s109 notice issued 28 April 2023, question 3/ Annex S109(5)Q2-3–001; Response to the CMA questionnaire from [✂], question 3; and IDC data on virtualised and non-virtualised server units installed and VMware market shares (FMN, paragraph 15.364 and Table 43).
[490] Parties response to the AIS and WPs, paragraph 6.11(e)(i); Broadcom response to s109 Notice issued 7 October 2022, question 4, BCOM-CMA-00000302, page 6.
[491] Note of a call with [✂].

8.30 Therefore, our provisional conclusion is that sharing of CSI with the Merged Entity is unlikely to result in a substantial lessening of competition in the supply of Ethernet NICs.

FC HBAs

8.31 Evidence from third parties, in line with the Parties' submissions, indicates that the key parameters of competition for FC HBAs are speed and bandwidth improvements.[492] As FC standards are harmonised across the industry, additional features manufacturers may look to introduce are also standardised across providers.[493] Consistent with this, evidence from some third parties shows that features are not an important parameter of competition for FC HBAs. One server OEM considered that FC HBAs have '[n]o real feature differentiation' and they are 'commoditized',[494] while another did not include product features as key aspects of differentiation between FC HBA providers.[495] Further, any developments in FC HBAs (including new features) are not proprietary and are set by the industry standards body.[496]

8.32 The evidence shows that Broadcom receives similar information[497] to VMware although the timing of when the information is shared can differ.[498] The Merged Entity could gain access to information competitors share with VMware via roadmap discussions on the timing of product launches and features being prioritised 6-12 months earlier than Broadcom currently does.[499] This would allow the Merged Entity to identify which features its competitors were prioritising. However, the relevance of this information would be limited by the fact that FC HBAs features are standardised across the industry,[500] and therefore the Merged Entity would in any event be aware of the range of features competitors could introduce. Further, competitors would also be able to delay or reduce the product roadmap discussions they have with VMware, in line with Broadcom's past behaviour of rarely sharing product roadmaps (as described in paragraph 8.9). As such, we consider that competitors' and the Merged Entity's incentives to innovate are unlikely to be significantly affected by the Merger.

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[492] Response to the CMA questionnaire from [✂].
[493] Note of a call with [✂].
[494] Response to the CMA questionnaire from [✂].
[495] Response to the CMA questionnaire from [✂].
[496] Note of a call with [✂].
[497] Note of a call with [✂].
[498] Response to follow-up questions from [✂].
[499] Note of a call with [✂]; Note of a call with [✂]; response to the CMA questionnaire from [✂]; and response to follow-up questions from [✂].
[500] Note of a call with [✂].

8.33 Overall, we therefore provisionally conclude that sharing of CSI with the Merged Entity is unlikely to result in a substantial lessening of competition in the supply of FC HBAs.

Storage adapters

8.34 The evidence we have gathered shows that in addition to speed and bandwidth, a key parameter of competition for storage adapters is new features driven by changes to the controller/chip.[501] One competitor noted that innovations were typically focussed on improvements to speed, bandwidth, manageability, malware protection and encryption capabilities.[502] A server OEM noted that for virtualised environments, 'performance and features are very important',[503] while another submitted that there is substantial feature differentiation in storage adapters and customers will often base choice on supplier preference and features and less on price.[504] One competitor did note that recently hyperscalers (such as Google and Meta) have been the early adopters of these new features, with server OEMs adopting them later.[505]

8.35 One of the Parties' internal documents also shows that new or additional features or functions may be important parameters of competition for storage adapters. The Broadcom document highlights several features for storage adapters which are identified as 'customer requested growth opportunities'.[506]

Pre-Merger, additional CSI VMware receives compared to Broadcom

8.36 Broadcom does not receive any CSI from non-Broadcom based[507] storage adapter competitors.[508]

8.37 Third parties submitted that VMware receives CSI from storage adapter competitors, namely:

[501] Parties' response to the AIS and WPs, paragraph 6.20(b); and response to follow-up questions from [✂].
[502] Note of a call with [✂].
[503] Response to the CMA's questionnaire from [✂].
[504] Response to the CMA's questionnaire form [✂].
[505] Note of a call with [✂].
[506] Broadcom's response to s109 Notice 2, BCOM-CMA-00000061, page 14. The document is [✂]. However, the Parties explained that Broadcom considered but ultimately rejected these requests.
[507] Broadcom does supply storage controllers to server OEMs that use these to create their own storage adapters and through this relationship server OEMs shares some information with Broadcom about their storage adapters (Parties' response to the CMA's RFI 7, 3 May 2023, question 5).
[508] Note of call with [✂].

(a) through the formal driver certification process information such as the driver source code and information on product performance and limitations; and

(b) outside the formal VMware certification process, through roadmap discussions, information on the products and features competitors are developing 1-2 years in advance of product launch.[509]

CSI shared through driver certification process

8.38 One competitor submitted that the driver source code discloses the product features.[510] Another competitor submitted that in addition to disclosing the product features the driver source code also reveals changes to the software and firmware.[511] It told us it shares the driver source code with VMware 6-12 months ahead of product launch when a driver is released with a new VMware OS update in a bundle, and 4-6 months ahead when a driver is released outside of a VMware OS update. For all major product updates it releases the driver in a bundle with VMware OS updates.[512,513]

8.39 However, we note that new features revealed through the formal driver certification process can also be largely revealed by the driver source code shared with Linux. One competitor noted that the driver source code may be shared with Linux first (ie, prior to any information being available to VMware).[514] This is consistent with evidence provided by the Parties, which shows that, for its latest storage adapter innovation (Excalibur), Microchip had submitted the Linux driver source code to the Linux kernel several months before engaging with VMware for certification of the Excalibur-based devices, and the Linux driver source code had been published prior to this engagement with VMware.[515] In contrast, another competitor noted that, although it provides driver source code to Linux which does disclose 'most' of the same

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[509] Response to the CMA questionnaire from [✂].
[510] Response to follow-up questions from [✂].
[511] The [✂] of a product configures and managed a device while also helping to determine the [✂] of a device (Parties' response to Issues Statement, 10 May 2023, paragraphs 1.11, 5.3 and 5.4(b)).
[512] Response to the CMA questionnaire from [✂]; and response to follow-up questions from [✂].
[513] In relation to the driver source code shared by storage adapter suppliers as part of the formal driver certification process, in contrast to the Parties' submission, Broadcom's internal documents show it expressing concerns when finding that changes it had made to its driver, [✂] following [✂] from VMware (Broadcom response to s109 notice dated 17 May 2023, Annex S109(6)Q1-011 - Exhibit PX2063 – BCOMV-FTC-14848298 to BCOMV-FTC-14848299, page 1). Broadcom escalated this incident with VMware directly (Annex S109(6)Q1-006 - Exhibit PX2056 – BCOMV-FTC-13236984 to BCOMV-FTC-13236986, page 1) and the Parties' documents show that this was in relation to [✂], rather than concerns its competitors would gain access to information, as [✂] during the [✂] (Parties' supplementary response dated 12 July 2023, paragraphs 3.1-3.3.).
[514] Response to follow-up questions from [✂].
[515] Parties' supplementary submission on Microchip's latest storage adapter innovation, 7 July 2023, paragraphs 1.3(c) and 2.6.

information about the underlying hardware, these drivers are usually made publicly available after it has launched the new product or feature.[516]

CSI shared outside driver certification process

8.40 In relation to the Parties' submission that information shared through product roadmap discussion contains no CSI, as equivalent roadmaps are made available by industry standard bodies for storage adapters, we note that the industry standards body publishes information about the next generation of higher speed storage adapters and not the specific features competitors are looking to introduce.[517] Further, one third party noted that the information it shares to facilitate the industry standards is not the same type of information it shares with VMware.[518]

8.41 The Parties provided evidence that although information on new product features is not published by the industry standards body, it may already be publicly available before any engagement with VMware, for example where competitors choose to advertise new products to customers. For example, Microchip published details about its new Excalibur storage adapter, which outlined some of its features, in press releases[519] and a demonstrational video,[520] up to 1.5 years before informing VMware that the new product would be submitted for certification and around 2.5 years before it submitted driver source code to VMware for certification.[521]

Summary of additional CSI shared

8.42 As set out above, the evidence we have received from the Parties and third parties is not consistent. The Parties submitted that no CSI is shared for the driver development and certification process (see paragraph 8.6 above) and that information about competitors' products is public before they engage with VMware, while third parties submitted that pre-Merger VMware has access to additional CSI through:

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[516] Response to follow-up questions from [✂].
[517] Parties' response to the AIS and WPs, paragraph 6.11(c)(iii).
[518] Note of call with [✂].
[519] Parties' supplementary submission on Microchip's latest storage adapter innovation, 7 July 2023, paragraph 2.2; Microchip, What's New in 24G SAS, July 2018; Microchip announcement, 6 August 2018; and Microchip announcement 7 August 2018.
[520] Microchip 24G SAS Expanders and Controllers plus DCM Technology Break the Storage Bottleneck - YouTube, 24 June 2019.
[521] Parties' supplementary submission on Microchip's latest storage adapter innovation, 7 July 2023, paragraphs 2.2 and 2.6.

(a) the formal driver certification process on product features, testing logs and changes to the firmware via the driver source code, typically 6-12 months ahead of product launch; and

(b) product roadmap discussions in relation to high level information on the new features Broadcom's competitors are looking to introduce to their storage adapters 1-2 years ahead of product launch.

8.43 However, for the reasons set out below we have not had to conclude on whether VMware has access to additional CSI or not, as we do not find access to the additional CSI described by competitors would materially impact the competitors' or the Merged Entity's incentives to innovate.

Importance of the additional CSI to innovations

8.44 To the extent the Merged Entity has access to the CSI via VMware described in paragraph 8.43 we have assessed whether this would enable it to respond more rapidly with its own product improvements to storage adapter competitors' innovations.

8.45 Based on the evidence set out above, we consider that Broadcom could gain access to competitors' driver source code information, revealing changes to firmware, up to 6-12 months ahead of product launch (unless the Linux source code or information on the new product is already publicly available), and this would provide the Merged Entity with information relevant to the development of similar product features. However, we note that the development of a new generation of storage adapter is a [✂] year process,[522] with the development of firmware taking [✂] years,[523] which would limit the ability of the Merged Entity to quickly develop similar product features to its competitors and significantly reduce their first mover advantage.

8.46 In relation to the product roadmap information shared 1-2 years before a product is released, this information does not disclose changes made to the chip or firmware, where the majority of innovations occur. It does however disclose the product features a competitor is looking to introduce (when such information has not already been made publicly available by the competitor), which may enable the Merged Entity to prioritise similar product features more quickly than it otherwise would have.

8.47 In view of this evidence, we consider that to the extent that competitors would share CSI with the Merged Entity, this may give the Merged Entity the ability

[522] Note of a call with [✂].
[523] Parties' response to Issues Statement, 10 May 2023, paragraph 5.4(b).

to react more quickly to competitors' innovation in new features, which in turn could reduce the first mover advantage of its competitors, albeit not significantly.

8.48 Based on the above, we consider below what competitors' response would be in this scenario.

Post-Merger, response from hardware competitors

8.49 Microchip, Broadcom's main storage adapter competitor, told us that it would be unlikely to change the scope of the information it shares with the Merged Entity. It noted that it would wish to avoid sharing the same information with VMware post-Merger but considered this could affect its interoperability with VMware products, reducing its ability to sell hardware for use in VMware environments.[524]

8.50 Microchip told us that without sharing the roadmaps it would be unable to coordinate as well with VMware on development of new features and products.[525] It also noted that it could provide drivers unbundled with VMware's OS updates, which would reduce the lead time for sharing driver source code information to [✂], but this would reduce the testing done on the drivers and would also require customers to download the new drivers themselves.[526]

8.51 However, we note that Broadcom and Microchip have adopted different strategies in relation to the information they share with VMware to obtain certification. Broadcom has not shared any product roadmaps with VMware in the last 10 years and does not share any information on changes it makes to its chip and firmware with VMware.[527] By comparison, Microchip has been more risk averse in that it has shared additional information with VMware such as product roadmaps, and has chosen to share driver source codes earlier (and well in advance of any deadline set by VMware for receiving them) to increase the amount of testing it can do for a new product.[528]

8.52 Based on this evidence, we consider that Microchip would have the ability to reduce or delay the information it shares with the Merged Entity.

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[524] Response to the CMA questionnaire from Microchip, [✂]; and note of a call with Microchip, [✂].
[525] Submission from Microchip, [✂] and response to the CMA questionnaire from Microchip, [✂].
[526] Response to follow-up questions from Microchip, [✂].
[527] Parties' response to the AIS and WPs, 15 June 2023, paragraph 6.12(g); and Parties' response to the Issues Statement, 10 May 2023, paragraph 1.11.
[528] Response to follow-up questions from Microchip, [✂].

Overall effect on competition

8.53 Overall, the evidence gathered shows that:

(a) Developing new products is a multi-year endeavour and can take 3-4 years or more. The chip design is typically finalised first, followed by the firmware. Engagement with VMware for the purpose of certification takes place towards the end of the process, in the last year or two.

(b) The CSI relates to new features rather than new generation higher speed storage adapters (due to industry standards bodies publishing roadmaps). The driver source code shared with VMware may reveal the new features which competitors are adding to the product. Even if this were the case these new features can also be revealed publicly by the driver source code which is shared with Linux and the driver source code may be shared with Linux first (ie prior to any information being available to VMware). Further, the new features which are being planned may be advertised well in advance of product launch, and before any engagement with VMware, such that the information is publicly available by the time driver source code is shared with VMware.

(c) Different suppliers have adopted different strategies for sharing CSI with VMware. These differences relate to both the type of information shared and the timing of when it is shared. Therefore, should competitors have significant concerns about the risk of the Merged Entity using this information to quickly replicate their innovations, competitors would have the ability to reduce the information they share without materially compromising the development of new features/products and their interoperability with VMware's software.

(d) Further, in line with the Parties' submission (paragraph 8.12), one third party submitted that server OEM customers are slower to adopt new devices or features when they come to market, compared to CSPs (who do not use VMware).[529] Therefore, delaying certification with VMware would be unlikely to significantly impact the early sales of new devices or products with new features, limiting the effect of the Merged Entity using competitors' CSI on their first mover advantage.

8.54 Based on the above, we consider that competitors' and the Merged Entity's incentives to innovate are unlikely to be significantly affected and so we have

[529] Note of a call with [✂].

provisionally found that the sharing of CSI with the Merged Entity is unlikely to substantially lessen competition in storage adapters.

Conclusions on non-horizontal effects in the supply of I/O hardware from sharing of commercially sensitive information

8.55 We provisionally conclude that the anticipated acquisition of VMware by Broadcom may not be expected to result in an SLC as a result of non-horizontal effects from sharing of commercially sensitive information in relation to the supply of Ethernet NICs, FC HBAs, and storage adapters in the UK.

8.56 We note that, in addition to the Parties' submissions considered above, the Parties submitted that [✂].[530] The Parties submitted that [✂]:[531]

(a) [✂].

(b) [✂].

8.57 We discussed [✂] and our general position on [✂] at paragraphs 7.205-7.208 above.

8.58 In any event, for the reasons set out above, we have provisionally concluded that the Merger may not be expected to result in an SLC as a result of non-horizontal effects from sharing CSI in relation to the supply of I/O hardware in the UK. In doing so, we have not needed to consider the impact of [✂] on that concern.

8.59 Finally, we note the Parties' submission that trust over the handling and use of CSI is important for their wider relationships with CPU/GPU suppliers, such as Intel. While the Merged Entity may perceive some risk that using CSI would undermine broader relationships the Merged Entity has with other suppliers, it is not clear that this is sufficient to eliminate any incentive for the Merged Entity to use the information:

(a) For such a reputational risk to materialise it would require external parties to detect the Merged Entity's use of CSI. Our provisional view is that third parties would not have the necessary visibility of how the Merged Entity is using CSI for such a reputational risk to be effective. This is due to both the nature of how the information is shared and the timing difference

[530] Parties' response to Issues Statement, 10 May 2023, paragraph 5.14; Parties response to the AIS and WPs, paragraph 6.15(b).
[531] Parties' response to Issues Statement, 10 May 2023, paragraph 5.14.

between the Merged Entity receiving the information and any potential product release it introduces based on this information.

(b) It is not clear how CPU/GPU suppliers would respond even if they did become aware that the Merged Entity was using competitor CSI as (1) they may not perceive the same risks of the Merged Entity using their CSI given that Broadcom does not compete in the supply of these CPU/GPU products and (2) there would be costs to CPU/GPU suppliers from reducing the information shared with Broadcom and VMware.

(c) Hardware competitors have expressed reservations about sharing information with VMware post-Merger, indicating that they consider the Merged Entity could have the incentive to use the information.[532]

8.60 In any event, irrespective of the impact of the [✂] and reputational issues referred to by the Parties, for the reasons set out above, we have provisionally concluded that the Merger may not be expected to result in an SLC as a result of non-horizontal effects from sharing CSI in relation to the supply of I/O hardware in the UK. As such, we have not needed to conclude on the likely impact of damage to the reputation of the Merged Entity.

[532] Responses to the CMA's questionnaire from [✂].

9. Provisional conclusions

9.1 As a result of our assessment which is set out in the preceding chapters, we have provisionally concluded that:

(a) the anticipated acquisition by Broadcom of VMware, if carried into effect, will result in the creation of an RMS; and

(b) the creation of that RMS may not be expected to result in an SLC in relation to the supply of Ethernet NICs, FC HBAs, storage adapters and FC switches in the UK.

9.2 We invite any parties to make representations to us on these provisional findings by no later than 17.00 BST, on Wednesday 9 August 2023. Please make any response to these findings by email to Broadcom.vmware@cma.gov.uk. We will take all submissions received by this date into account in reaching our final decision.