

NVIDIA – Arm

Summary of the CMA's report to the Secretary of State for Digital, Culture, Media & Sport on the anticipated acquisition by NVIDIA Corporation of Arm Limited

20 July 2021

© Crown copyright 2021

You may reuse this information (not including logos) free of charge in any format or medium, under the terms of the Open Government Licence.

To view this licence, visit www.nationalarchives.gov.uk/doc/open-government-licence/ or write to the Information Policy Team, The National Archives, Kew, London TW9 4DU, or email: psi@nationalarchives.gsi.gov.uk

1. Executive summary

- 1.1 This CMA report relates to the proposed acquisition by NVIDIA Corporation (**NVIDIA**) of the Intellectual Property Group business of Arm Limited (**Arm**) (the **Merger**).
- 1.2 This report is provided to the Secretary of State for Digital, Culture, Media and Sport (the **Secretary of State**) pursuant to a [public interest intervention notice](#) (**Notice**). This summary focuses on the CMA's competition assessment of the Merger.
- 1.3 NVIDIA and Arm are active at different levels of the global semiconductor technology industry. NVIDIA is a US-based company that supplies semiconductors (often referred to as 'chips', including graphics processing units (**GPUs**)), and network interconnect products to customers globally for a variety of applications. Arm is a UK-headquartered company which supplies semiconductor intellectual property (**IP**) based on a specific instruction set architecture (**ISA**). It primarily supplies IP relating to central processing units (**CPU IP**) to semiconductor suppliers and systems-on-chip (**SoC**) developers globally. Such suppliers (including NVIDIA) use Arm's IP to produce semiconductor chips and related products for a variety of applications. Arm estimates 70% of the world's population engages with Arm-based technology.
- 1.4 The semiconductor technology industry is worth billions of pounds and is critical to many of the products used every day by businesses and consumers across the UK. The Merger takes place against the background of important changes in the industry. These include the emergence of artificial intelligence, which has driven significant growth in sectors such as datacentres, internet-of-things and autonomous driving.
- 1.5 NVIDIA and Arm are important drivers of technological change in their fields, and the Merger would afford the merged business a significant degree of control over key technologies for a range of sectors.
- 1.6 The CMA received a substantial number of detailed and reasoned submissions from customers and competitors raising concerns in numerous markets. After careful examination, the CMA found significant competition concerns associated with the merged business' ability and incentive to harm the competitiveness of NVIDIA's rivals (that is, to 'foreclose') by restricting access to Arm's CPU IP and impairing interoperability between related products, so as to benefit NVIDIA's downstream activities and increase its profits.

- 1.7 The CMA found significant competition concerns as a result of the effect of such foreclosure in the supply of CPUs, interconnect products, GPUs, and SoCs across several global markets, spanning the datacentre, internet-of-things, automotive and gaming console applications.
- 1.8 The CMA found that the foreclosure strategies identified would reinforce each other and would, individually and cumulatively, lead to a realistic prospect of a substantial lessening of competition (**SLC**), and consequently to a stifling of innovation, and more expensive or lower quality products.
- 1.9 NVIDIA offered a set of behavioural remedies seeking to address the CMA's concerns. The CMA found the offer to present considerable specification, circumvention, and monitoring and enforcement risks. Having regard to: (i) the complex and evolving nature of the contracts and markets involved; (ii) the magnitude of the competition concerns; and (iii) the breadth and technical nature of the offer, the CMA does not believe any form of behavioural remedy would address the competition concerns identified to the phase 1 clear-cut standard.
- 1.10 In conducting its investigation, the CMA has worked closely with other competition authorities around the world to carefully consider the impact of the Merger.

The CMA's report and decisions

- 1.11 The Notice requires the CMA to investigate and report on its assessment of the Merger's effects on competition by midnight on 30 July 2021, following which the Secretary of State shall make its decision on the relevant public interest considerations. The CMA's decisions in this report are summarised below.
- 1.12 Jurisdiction: The CMA believes that NVIDIA and Arm are enterprises that would cease to be distinct as a result of the Merger, and that the turnover test under section 23(1)(b)(i) of the Act is met. Accordingly, arrangements are in progress or in contemplation which, if carried into effect, will result in the creation of a relevant merger situation.
- 1.13 Competitive assessment: The CMA has concluded that the Merger gives rise to a realistic prospect of an SLC within a market or markets in the United Kingdom (**UK**) and that the test for reference is met on competition grounds. The CMA found an SLC in:
- (a) the supply of CPUs for datacentre servers globally;

- (b) the supply of network-interface controllers enabling the transfer of data in datacentres globally;
 - (c) the supply of GPUs for datacentre servers globally;
 - (d) the supply of SoCs for high performance internet-of-things applications globally;
 - (e) the supply of SoCs for automotive applications globally, in respect of:
 - (i) advanced driver assistance systems applications; and
 - (ii) information and entertainment applications; and
 - (f) the supply of SoCs for gaming consoles globally.
- 1.14 Remedies: The CMA concluded that it would not be appropriate to deal with the competition concerns identified by way of undertakings in lieu of a reference to a phase 2 investigation.

The CMA's competitive assessment

- 1.15 NVIDIA and Arm together are referred to as the **Parties** in this report and, for statements referring to the future, as the **Merged Entity**.
- 1.16 Several relationships arise between the Parties at different levels of the supply chain and across neighbouring sectors. The CMA therefore assessed the Merger by reference to **vertical** and **conglomerate** effects. Concerns relating to vertical effects can arise when a merged entity may use its control of an important input to harm downstream rivals. Concerns relating to conglomerate effects can arise when a merged entity may harm its rivals in one market by restricting their access to customers through its strong position in a related market.

Vertical and conglomerate effects in datacentres

- 1.17 Arm supplies CPU IP for use in (i) CPUs for datacentre servers (**Datacentre CPUs**); and (ii) enhanced network-interface controllers enabling the transfer of data in datacentres (**SmartNICs**). NVIDIA supplies SmartNICs and GPUs for use in datacentres (**Datacentre GPUs**), and is developing Datacentre CPUs. The majority of third parties (ie customers and competitors) that responded to the CMA's investigation in relation to datacentres raised concerns relating to vertical and/or conglomerate effects.

Vertical effects

- 1.18 The CMA considered whether the Merged Entity could harm NVIDIA's rivals and lessen competition in the supply of (i) Datacentre CPUs and, separately (ii) SmartNICs. The CMA assessed whether the Merged Entity could do so by: (i) refusing to supply Arm's CPU IP for use in rival Datacentre CPUs and SmartNICs (total foreclosure) or (ii) by increasing the price or worsening the quality of this CPU IP supplied to them (partial foreclosure). For the reasons set out below, the CMA found that the Merged Entity would have the ability and incentive to foreclose rivals' access to Arm's IP, thereby harming downstream competition.
- 1.19 With regard to the Merged Entity's ability to foreclose rivals, the CMA found Arm controls an important input and has market power in the supply of CPU IP for Datacentre CPUs and for SmartNICs.
- (a) Third parties indicated Arm is a very important supplier of CPU IP due to technical proficiencies, the strength of Arm's software ecosystem and the 'open' nature of Arm's IP-only business model. Arm's CPU IP is key for Datacentre CPU suppliers without access to the x86 ISA (as used by Intel or AMD) or to in-house solutions. This includes cloud service providers which are driving growth in the Datacentre CPU market. Sales of Arm-based Datacentre CPUs have grown rapidly in recent years and are projected to continue this growth, thus exerting pressure on Intel and AMD's Datacentre CPUs. The CMA found the constraint posed by current or future alternative suppliers of CPU IP to third parties (such as RISC-V and MIPS) is weak, and that there are significant barriers to switching CPU IP licensor.
- (b) Arm is the leading supplier of CPU IP for SmartNICs with a longstanding, near-100% share of supply. The constraint posed by other CPU IP licensors such as MIPS and Power is weak, and there are significant barriers to switching CPU IP licensor.
- (c) Given the limited alternatives to Arm's CPU IP, the CMA does not consider licensees to have the buyer power to defend themselves against foreclosure.
- 1.20 The CMA found that the Merged Entity would be able to implement a total and/or partial foreclosure strategy. This could include targeting NVIDIA's rivals to restrict or downgrade future access, and/or develop or roll-out IP in a way that favours NVIDIA.
- 1.21 With regard to the Merged Entity's incentives, the evidence indicates that the benefits of foreclosure are likely to outweigh the costs of such strategy. The

CMA believes that the Merger may create incentives to change Arm's business model to favour NVIDIA and notes the rapid growth of the addressable Datacentre CPU and SmartNIC markets specifically.

Conglomerate effects

- 1.22 Datacentre CPUs, Datacentre GPUs and SmartNICs perform key and complementary functions in datacentres. The CMA therefore considered whether the Merger could give rise to conglomerate effects through the Merged Entity restricting or degrading the interoperability between Datacentre GPUs and Arm-based Datacentre CPUs and/or SmartNICs. The CMA considered whether the Merged Entity could leverage its positions in the supply of: (i) CPU IP to foreclose rival suppliers of Datacentre GPUs; and/or (ii) Datacentre GPUs, to foreclose rival suppliers of Arm-based Datacentre CPUs and/or SmartNICs. The CMA found the Merged Entity would have the ability and incentive to foreclose rivals, thereby harming downstream competition.
- 1.23 With regard to the ability to engage in foreclosure, the CMA found (as outlined above) that Arm controls an important input and has market power in the supply of CPU IP for Datacentre CPUs and SmartNICs. As the longstanding leading supplier with over 90% share of supply, NVIDIA also has market power in the supply of Datacentre GPUs. The evidence indicates the Merged Entity could modify the interoperability between Datacentre GPUs and Arm-based Datacentre CPUs and/or SmartNICs, to enhance NVIDIA's products and undermine the operability of rivals' products, so as to *de facto* 'bundle' the supply of these products. The CMA believes that, given the importance of these products, customers would be incentivised to buy such product combinations.
- 1.24 With regard to the incentives, the CMA found that: (i) the above foreclosure strategies are consistent with NVIDIA's existing business practice to bundle certain products; and (ii) gains in Datacentre GPU, and Datacentre CPU and SmartNIC sales are likely to outweigh the costs.
- 1.25 The CMA believes that there is a realistic prospect that the foreclosure strategies (or combination thereof) outlined above would have the effect of substantially reducing competition in the supply of (i) Datacentre CPUs; (ii) SmartNICs; and (iii) Datacentre GPUs.

Vertical effects in internet-of-things, automotive, and gaming consoles

- 1.26 The CMA also considered total and/or partial foreclosure (referred to collectively as foreclosure below) by the Merged Entity restricting access to Arm's CPU IP to:
- (a) rival suppliers of SoCs for high performance internet-of-things applications;
 - (b) rival suppliers of SoCs for advanced driver assistance systems (**ADAS**) and infotainment automotive applications; and
 - (c) rival suppliers of SoCs for gaming console applications.
- 1.27 The CMA received a significant number of detailed and reasoned concerns from customers and competitors relating to these theories of harm.
- 1.28 With regard to the ability to foreclose, the CMA believes that Arm controls an important input and has market power in the supply of CPU IP for each of: (i) SoCs for high performance internet-of-things; (ii) SoCs for both ADAS and infotainment in automotive; and (iii) SoCs for gaming console applications.
- 1.29 Similarly to datacentre, common factors attesting to the importance of Arm's CPU IP across all of these products included evidence on the critical role of CPU IP for these SoCs, the technical advantages of Arm's CPU IP, the strength of Arm's software ecosystem, the lack of credible alternatives, the barriers to switching, and the absence of countervailing buyer power. For the reasons outlined in relation to datacentre, the CMA believes that the Merged Entity would be able to target rival SoC suppliers.
- 1.30 With regards to the incentives, the evidence indicates that, across each of these theories of harm, the benefits are likely to outweigh the costs of such a strategy. The markets for the supply of SoCs for each of high performance internet-of-things, ADAS and high-end infotainment applications are nascent and growing, which the CMA believes gives NVIDIA a strong incentive to gain a first-mover advantage through a foreclosure strategy.
- 1.31 The CMA believes that there is a realistic prospect that the effects of a foreclosure strategy in relation to the supply of CPU IP for use in internet-of-things, automotive and gaming console applications would substantially reduce competition in each of the downstream markets, namely the supply of SoCs for: (i) high performance internet-of-things; (ii) ADAS in automotive; (iii) infotainment in automotive; and (iv) gaming consoles.

Conclusion on competitive assessment

- 1.32 The CMA therefore believes that it is or may be the case that the Merger may be expected to result in an SLC in the following markets:
- (a) the supply of Datacentre CPUs globally;
 - (b) the supply of SmartNICs globally;
 - (c) the supply of Datacentre GPUs globally;
 - (d) the supply of SoCs for high performance internet-of-things applications globally;
 - (e) the supply of SoCs for automotive applications globally, in respect of:
 - (i) ADAS applications; and
 - (ii) infotainment applications; and
 - (f) the supply of SoCs for gaming consoles globally.
- 1.33 In addition, having regard to the important links between these markets, the CMA found that the effects of the individual foreclosure strategies would variously reinforce each other.
- 1.34 In addition to the theories of harm outlined above, the majority of customers and competitors that responded to the CMA's investigation in relation to general-purpose personal computers (**PCs**) also raised vertical foreclosure concerns along the lines outlined above. Within the constraints of the phase 1 process and limits on the information made available by the Parties to the CMA at this stage, the CMA has not been able to investigate this area sufficiently to come to a conclusion as to whether there is a realistic prospect of an SLC. The CMA believes that this is an area which may warrant further examination in any phase 2 investigation.

Undertakings in lieu

- 1.35 The Parties offered a behavioural undertaking which purported to ensure an open licensing regime, based on equal access and interoperability, with protections against disclosure of competitively sensitive information.
- 1.36 The CMA does not consider that the conduct required to address the competition concerns identified can be specified with sufficient clarity, to provide a lasting remedy that is capable of effective monitoring and enforcement. This risk is significant in this case, having regard to: (i) the

complex and evolving nature of the contracts and markets involved; (ii) the magnitude of the concerns identified, spanning a number of markets and applications; and (iii) the breadth and technically specialist nature of the offer. The CMA found such a behavioural remedy would carry material specification, circumvention, and monitoring and enforcement risks. Therefore, the CMA does not believe any form of behavioural remedy would address the competition concerns identified to the phase 1 standard.

- 1.37 It also does not believe any partial divestment of Arm's IP business(es) would be sufficiently clear-cut and comprehensive for phase 1.

Public interest

- 1.38 As required by section 44(3)(b) of the Act, the CMA has summarised representations received from third parties which relate to the national security public interest consideration mentioned in the Notice.