Anticipated acquisition by Illumina, Inc. of Pacific Biosciences of California, Inc.

Decision on relevant merger situation and substantial lessening of competition

ME/6795/18

The CMA's decision on reference under section 33(1) of the Enterprise Act 2002 given on 18 June 2019. Full text of the decision published on 19 July 2019.

Please note that [✂] indicates figures or text which have been deleted or replaced in ranges at the request of the parties or third parties for reasons of commercial confidentiality.

SUMMARY

1. Illumina, Inc. (**Illumina**) has agreed to acquire Pacific Biosciences of California, Inc. (**PacBio**) for approximately £930.2 million (the **Transaction**). Illumina and PacBio are together referred to as the **Parties** or the **Merged Entity**.

2. The Competition and Markets Authority (**CMA**) believes that it is or may be the case that each of Illumina and PacBio is an enterprise; that these enterprises will cease to be distinct as a result of the Transaction; and that the share of supply test 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.

3. The Parties overlap in the supply of DNA sequencing systems on a worldwide basis. The CMA has found that the product frame of reference should include both short read and native long read technologies on the basis that the available evidence, including the majority of third party submissions, industry reports and many of the Parties' internal documents, all indicated a material (and increasing) overlap between these technologies for at least some use cases. The evidence indicated in particular that read length is just one consideration taken into account by customers (along with

factors such as price, accuracy and throughput) when choosing between suppliers' DNA sequencing systems, and that there is no clear-cut demand-side distinction between the two types of technology. The CMA has found that the geographic frame of reference is worldwide in scope. The CMA has therefore assessed the impact of the Transaction in the supply of DNA sequencing systems on a worldwide basis.

4. The CMA considered a horizontal unilateral effects theory of harm and examined the concern that the Transaction could adversely affect the prices of sequencing systems (including prices of both sequencing instruments and their related consumables), product quality and innovation. In assessing this theory of harm, the CMA considered the following evidence:

   (a) **Shares of supply**. The CMA has found that the Parties have a very high combined share of supply in relation to DNA sequencing systems ([90-100%] in the UK and [80-90%] worldwide). Such high shares of supply *prima facie* raise competition concerns. While the vast majority of the Parties' combined share is accounted for by Illumina's existing very strong market position, the CMA also took into account, within the context of the dynamic nature of the market, the evidence that PacBio's current share of supply does not accurately reflect its competitive significance following the launch of its Sequel II instrument in April 2019.[1]

   (b) **Closeness of competition between the Parties**. The CMA has found that a significant number of the Parties' internal documents indicate that the Parties monitor each other and view each other as close competitors. Along with the Parties' internal documents, some third parties also told the CMA that they considered PacBio capable of becoming the strongest competitive constraint on Illumina as a result of the release of its Sequel II system. While the Parties submitted that [✂], the CMA found that the available evidence, while mixed, does not in the round support this position.

   (c) **Competitive constraint of alternative suppliers**. The CMA has found that the alternative suppliers currently available to customers (namely Thermo Fisher Scientific (**Thermo Fisher**), Beijing Genomics Institute (**BGI**),[2] Qiagen N.V. (**Qiagen**), and Oxford Nanopore Technology (**ONT**))

[1] For the purposes of this Decision, references to PacBio's Sequel II system will be taken to encompass its 8M chip as a component of that system.

[2] Consistent with the approach taken by the Parties in their submissions, the CMA uses the name BGI to encompass both BGI and MGI (a subsidiary of BGI Group which specialises in the supply of sequencing instruments and sequencing reagents).

have low market penetration in comparison to Illumina and less well-developed [✂] offerings than PacBio.

5. The Parties identified a number of alternative suppliers that they suggested are poised to enter (or materially expand within) the DNA sequencing market within the next few years. The CMA found, however, that the barriers to successful entry and expansion were high and could be increased as a result of the Transaction, in particular because of the technical risks associated with the development of new sequencing technologies, barriers raised by IP rights, and the possibility that the Merged Entity could deploy a mixed bundling strategy to expand and entrench its market position post-Transaction. The CMA therefore concluded that it was not clear that the potential entry and/or expansion of the suppliers cited by the Parties would be timely, likely or sufficient to prevent a realistic prospect of a substantial lessening of competition (**SLC**) as a result of the Transaction.[3]

6. The CMA therefore believes that the Transaction gives rise to a realistic prospect of an SLC within a market or markets in the United Kingdom as a result of horizontal unilateral effects in relation to the supply of DNA sequencing systems worldwide.

7. The CMA is therefore considering whether to accept undertakings under section 73 of the Enterprise Act 2002 (**the Act**). The Parties have until 25 June 2019 to offer an undertaking to the CMA that might be accepted by the CMA. If no such undertaking is offered, then the CMA will refer the Transaction pursuant to sections 33(1) and 34ZA(2) of the Act.

ASSESSMENT

Parties

Illumina

8. Illumina is a global genomics company that is publicly listed on the NASDAQ stock exchange. Illumina develops, manufactures and commercialises systems, consumables, bioinformatics and services used for genetic analysis worldwide. Illumina's systems include second generation, short read DNA sequencing instruments based on its Sequencing by Synthesis (**SBS**)[4] technology as well as DNA microarray scanners.

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[3] *Merger Assessment Guidelines*, from paragraph 5.8.1.
[4] SBS technology is responsible for 90% of the world's NGS sequencing. It is a multi-molecular approach to sequencing.

9. Illumina also provides product support services for its systems as well as genetic analysis services powered by its sequencing and microarray technologies. Illumina's sequencing systems use consumables that include library preparation kits, sequencing kits and flow cells. The sequencing data that they produce is interpreted with specific bioinformatics software and applications.[5]

10. Illumina's customers include a variety of government and not-for-profit genomic research institutes, academic institutions, hospitals, genomics centres as well as pharmaceutical, biotechnology, agrigenomics, clinical and diagnostic laboratories, and consumer genomics companies.[6]

11. Illumina' turnover in 2017 was £2.1 billion, of which £[✂] was attributable to the UK.[7]

PacBio

12. PacBio is also a global genetics company that is publicly listed on the NASDAQ stock exchange. PacBio develops, manufactures and commercialises third generation, native long read[8] DNA sequencing systems based on its Single Molecule, Real Time (**SMRT**) technology.[9] PacBio's long read systems run on proprietary consumables that include library preparation kits, sequencing kits and SMRT Cells commercialised by PacBio. The sequencing data produced is interpreted with bioinformatics tools provided by PacBio and by third parties. PacBio's customers include government and not-for-profit genomic research institutes, genomics centres, pharmaceutical companies and agricultural companies. PacBio also provides product support services for its native long read sequencing systems.[10]

13. PacBio introduced its new Sequel system (**Sequel II**) on 24 April 2019 following a (reportedly-successful) early access program. Sequel II is based on the same underlying SMRT technology as previous PacBio sequencing

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[5] The term application is used in this Decision to refer to the broad category of uses that sequencing technology can be used for, for example, clinical, diagnostic, or agrigenomics applications.
[6] Paragraphs 3 and 15 of the Parties' merger notice submitted on 17 April 2019 (**Merger Notice**).
[7] Paragraph 25 and Table 1 of the Parties' Merger Notice.
[8] The term native long read sequencing is used to differentiate PacBio's technology (which generates single, contiguous long reads) from 'linked long read' or 'associated short read' solutions, such as that offered by 10x Genomics, which use barcoding techniques applied as part of the library preparation workflow to order and assemble short reads together to create an artificial long read. For the purposes of this Decision, the term 'long read' shall be used to mean native long read, unless indicated otherwise.
[9] The Parties are both active in the supply of Next-Generation Sequencing (**NGS**) technologies. For this reason, this Decision focuses only on NGS (ie there is no discussion of first generation Sanger sequencing technologies) and therefore any references to DNA sequencing contained in this Decision should be understood as references to NGS only.
[10] Paragraphs 4 and 16 of the Parties' Merger Notice.

systems but now includes the SMRT Cell 8M chip which increases the number of potential observations (the number of DNA molecules analysed) from 1 million to 8 million, increasing output and reducing cost of sequencing considerably as a result.[11]

14. PacBio's turnover in 2017 was £72.4 million, of which £[✂] was attributable to the UK.[12]

Transaction

15. On 1 November 2018, the Parties signed an Agreement whereby a wholly-owned direct subsidiary of Illumina will acquire 100% of the voting securities of PacBio. As consideration, Illumina will pay $8.00 (equivalent to £6.20) per share, with a total acquisition price of approximately £930.2 million.

16. The Parties informed the CMA that the Transaction is also the subject of review by the US Federal Trade Commission.

Rationale for the Transaction

17. The Parties submitted that the Transaction will:[13]

    (a) facilitate wider distribution of/access to PacBio's products and technology by enabling PacBio to benefit from Illumina's global production, and support and service infrastructure;

    (b) increase adoption of PacBio's systems by clinical and diagnostic customers by enhancing PacBio system quality with Illumina's quality systems and system management processes;

    (c) improve PacBio's systems using Illumina's proprietary technologies;

    (d) enable Illumina to develop coordinated solutions (including bioinformatics) to enable customers to harness the complementary nature of the technologies; and

    (e) accelerate innovation.

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[11] Paragraphs 52-55 of the Parties' Merger Notice. The Parties confirmed in the Issues Meeting dated 23 May that the Sequel II instrument had now been launched.
[12] Paragraph 25 and Table 1 of the Parties' Merger Notice. See also the Parties' press releases: https://www.illumina.com/company/news-center/press-releases/press-release-details.html?newsid=2374913; http://investor.pacificbiosciences.com/news-releases/news-release-details/illumina-acquire-pacific-biosciences-approximately-12-billion
[13] Paragraph 10 of the Parties' Merger Notice.

18. However, some of Illumina's internal documents further suggest an alternative rationale behind the Transaction: namely, that the Transaction could be an opportunity for Illumina to eliminate a competitive threat (either the threat of PacBio alone, or of the risk that PacBio could be acquired by another major player). For example, Illumina's internal documents refer to:

    (a) [✂];[14]

    (b) [✂];[15,16]

    (c) [✂];[17] and

    (d) [✂].[18]

19. Consistent with this alternative rationale, two third parties suggested to the CMA that the recent development of PacBio's new Sequel II instrument could have triggered Illumina's decision to enter into the Transaction.

20. The Parties have argued that this alternative rationale was incorrect on the basis that native long read and short read technologies do not compete and therefore Illumina could not be using the Transaction to eliminate a [✂].[19] The Parties have asserted that Illumina's intention is to invest and develop PacBio's technology, rather than eliminate it. Instead, the Parties have submitted that the rationale behind the Transaction lies in the fact that growth is foreseen in both short read and long read technologies concomitantly and that PacBio's Sequel II instrument could be used alongside Illumina's short read solutions in a complementary manner. The Parties also submitted that Illumina believes that it can accelerate the rate of development of PacBio's technology due to its significant research and development resources, providing examples of Illumina's investment in sequencing technologies in the past.

21. Some third parties have also suggested a further alternative rationale for the Transaction: the acquisition of PacBio's patent portfolio. Third parties have informed the CMA that the combination of the Parties' patent portfolios would not only allow the Merged Entity to challenge current competitors such as ONT through increased litigation and/or the threat of increased litigation, but would also allow Illumina access to patent-protected technology for an

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[14] Illumina document: [✂].
[15] Whole Genome Sequencing.
[16] Illumina document: [✂].
[17] Illumina document: [✂].
[18] Illumina document: [✂].
[19] See paragraphs 14-29 of the Parties' response to the CMA's issues paper, as submitted on 27 May 2019 (**Response to Issues Paper**).

extended duration, as the CMA understands that some of Illumina's patents are coming to the expiration of their legal term.

22. In response to these submissions, the Parties stated that there would be no change to the patent landscape as a result of the Transaction, as the duration of any patent is fixed and there are no PacBio patents that would cover Illumina sequencing systems. The Parties also submitted that PacBio already enforces its patent infringements so there would be no Transaction-specific effect.[20]

Procedure

23. The Transaction was considered at a Case Review Meeting.[21]

Jurisdiction

24. Each of Illumina and PacBio is an enterprise. As a result of the Transaction, these enterprises will cease to be distinct.

25. The Parties overlap in the supply of DNA sequencing systems, with a combined share of supply by value of [90-100%] (increment of [0-5%]) in 2018 in the UK.[22] The CMA therefore believes that the share of supply test in section 23 of the Act is met.

26. The CMA therefore believes that it is or may be the case that arrangements are in progress or in contemplation which, if carried into effect, will result in the creation of a relevant merger situation.

Counterfactual

27. The CMA assesses a merger's impact relative to the situation that would prevail absent the merger (ie the counterfactual). For anticipated mergers, the CMA generally adopts the prevailing conditions of competition as the counterfactual against which to assess the impact of the merger. However, the CMA will assess the merger against an alternative counterfactual where, based on the evidence available to it, it believes that, in the absence of the merger, the prospect of these conditions continuing is not realistic, or there is

[20] Paragraphs 141-145 of the Parties' Response to the Issues Paper.
[21] See *Mergers: Guidance on the CMA's jurisdiction and procedure* (CMA2), January 2014, from paragraph 7.34.
[22] See the Table 2 below for estimated shares of supply by value of sales of sequencing systems on a UK and worldwide basis for 2016-2018.

a realistic prospect of a counterfactual that is more competitive than these conditions.[23]

28. In the present case, the Parties have not submitted that, [✂] and has submitted that the CMA should have regard to this evidence, as well as evidence of [✂], when assessing the competitive effects of the Transaction.

29. In particular, PacBio has submitted that [✂].[24]

30. PacBio has also submitted that [✂]. The Parties have suggested that this information on [✂] be borne in mind by the CMA when assessing the competitive effects of the Transaction.

31. In line with the Parties' submission, the CMA has considered the evidence submitted in relation to PacBio's financial circumstances, to the extent relevant, within its competitive assessment.

32. The CMA has also considered the broader market context of DNA sequencing systems; in particular, the available evidence indicates that this is a dynamic sector in which all players invest significantly in R&D to improve existing, or develop new, sequencing technologies. Innovation has been recognised by the Parties and third parties as one of the key competitive parameters.[25] Therefore, the CMA also considered in detail the implications for PacBio's competitive position of the release and commercialisation of PacBio's Sequel II instrument (along with the available evidence relating to future product development by other suppliers).

33. In conclusion, the CMA believes the prevailing conditions of competition to be the relevant counterfactual in this case. As noted above, the CMA has considered the financial position of PacBio, [✂] and the release of its Sequel II instrument within its competitive assessment.

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[23] *Merger Assessment Guidelines* (OFT1254/CC2), September 2010, from paragraph 4.3.5. The *Merger Assessment Guidelines* have been adopted by the CMA (see *Mergers: Guidance on the CMA's jurisdiction and procedure* (CMA2), January 2014, Annex D).
[24] Paragraph 40-55 of the Parties' Merger Notice.
[25] Paragraphs 208 – 210 of the Parties' Merger Notice. This has also been supported by the Parties' internal documents, see, for example, Illumina documents: [✂].

Background

Market overview

34. The Parties are both active in the supply of DNA sequencing systems. DNA sequencing is used for detecting the identity and order of nucleotides in the DNA and is increasingly used in various research and clinical applications.

35. Sequencing customers comprise a variety of government and not-for-profit genomic research institutes, academic institutions, hospitals, genomics centres as well as pharmaceutical, biotechnology, agrigenomics, clinical and diagnostic laboratories, and consumer genomics companies. The applications for which DNA sequencing is used also vary significantly.[26]

36. One of the key differentiating factors of NGS technologies is their read length:[27]

    (a) Short read technologies produce read lengths ranging from tens to hundreds of base pairs per read; and

    (b) Native long read technologies are able to produce read lengths of up to hundreds of thousands of base pairs per read.[28]

37. At present, there are four suppliers of short read sequencing systems: Illumina, BGI, Thermo Fisher and Qiagen, and two suppliers of native long read sequencing systems: PacBio and ONT.

38. The read length that a sequencing system can measure can have significant implications for sequencing costs (ie at present, achieving highly accurate native long reads tends to be more expensive) and for determining which applications and use cases a particular technology is used for.

39. The market for sequencing technologies has grown significantly over the last ten years, primarily as a result of decreased sequencing costs, and is projected to grow even further.[29]

40. Customers requiring DNA sequencing can choose between:

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[26] Paragraphs 58 and 66 – 69 of the Parties' Merger Notice.
[27] Read length as a differentiator is discussed in further detail in the Product frame of reference section below.
[28] Paragraphs 70 – 72 of the Parties' Merger Notice.
[29] The Parties submitted that '*as of today, less than 0.01% of species and less than 0.02% of human genomes have been sequenced, less than 1% of variants in the human genome have been fully characterised*' and that the NGS revenues are expected to grow from £4.42 billion in 2018 to £12.67 billion in 2024, see paragraph 364 of the Parties' Merger Notice and paragraphs 160-162 of the Parties' Response to the Issues Paper. The Parties' internal documents also project fast growth, see eg Illumina document: [✂], PacBio document: [✂].

(a) Purchasing a sequencing technology, which comprises a sequencing instrument, consumables[30] (eg sample extraction and library preparation and reagent kits),[31] data analysis and data storage solutions as well as product support services;[32] and

(b) Outsourcing sequencing to providers of sequencing services. Sequencing services are provided by a number of third-party providers (eg Novogene and Wellcome Sanger institute), and some manufacturers of sequencing systems also provide sequencing services, eg the CMA understands that Illumina, BGI and Qiagen all provide sequencing services in the UK.

41. Different suppliers of sequencing technologies employ different pricing models, for example:

(a) Illumina and PacBio charge separately for sequencing instruments and consumables;[33]

(b) Thermo Fisher supplies its instruments and consumables [✂];

(c) ONT sells 'starter packs' which include both sequencing instruments and consumables [✂]; and

(d) Qiagen applies [✂] pricing models. The Parties have also submitted that Qiagen's 'price per insight' model allows customers to pay for each clinical report generated.[34]

42. Sequencing instruments, consumables and sequencing services are usually purchased following individual negotiations, unless the purchaser is a UK public authority, such as a university, government research institute or the NHS, which are required to adhere to public procurement procedures (ie formal tenders).[35] Illumina estimates that [30-50]% of its 2018 sales by value

[30] Sales of consumables usually account for more than a half of sequencer suppliers' revenues.
[31] While some consumables, such as sample extraction and library preparation kits can be used across all sequencing technologies and are also provided by third parties, some consumables, such as reagent kits are exclusively provided by the instrument manufacturer. For instance, during the period from 2016 to 2018, reagent kits accounted for [70-90]% of Illumina's and [60-80]% of PacBio's sales of consumables in the UK.
[32] While data analysis and data storage solutions can be provided by sequencing instrument manufacturers as well as third parties, the CMA understands that product support services are provided exclusively by instrument manufacturers.
[33] Paragraphs 213, 232 and 246 of the Parties' Merger Notice.
[34] Paragraphs 213, 232 and 245 of the Parties' Merger Notice.
[35] Paragraphs 264 to 280 of the Parties' Merger Notice.

in the UK were made through formal tenders.[36] Between 2014 and 2019, PacBio participated in [✂] tenders in the UK, [✂].[37]

Competitive dynamics

43. The Parties submitted that suppliers of sequencing technologies compete through product innovation, system performance, workflow simplicity, product differentiation, accuracy, product size/portability and scalability.[38]

44. The Parties consider innovation to be the key parameter of competition – the rapid rate of innovation over the past ten years has resulted in lower sequencing costs and significantly higher throughput and scalability. Suppliers of sequencing systems invest significant amounts into R&D in order to develop new technologies or improve the performance, utility and value of the existing systems.[39] The importance of innovation as a key competitive parameter is also evident in the Parties' internal documents, which suggest that investment in R&D is often made in response to the threat from competing suppliers:[40]

    (a) [✂];[41]

    (b) [✂];[42]

    (c) [✂];[43] and

    (d) [✂].[44]

45. When choosing which sequencing instrument to purchase, customers consider various different parameters, such as read length, accuracy, speed, output, throughput and sequencing cost. These parameters vary significantly across different sequencing instruments; Illumina itself provides a range of different sequencers, ranging from low throughput benchtop sequencers to medium and high throughput production scale sequencers, which are designed to meet different customer's needs.[45] It is the combination of these

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[36] Paragraph 274 of the Parties' Merger Notice. [✂]. The [30-50]% figure has been calculated on the basis of the assumption that all contracts with public entities valued at more than the public procurement thresholds should have been tendered.
[37] Paragraphs 278 – 280 of the Parties' Merger Notice.
[38] Paragraph 207 of the Parties' Merger Notice.
[39] Paragraphs 208 – 210 of the Parties' Merger Notice.
[40] Illumina documents: [✂].
[41] Illumina documents: [✂].
[42] Illumina document: [✂].
[43] Illumina document: [✂].
[44] Illumina document: [✂].
[48] See, for example, Annex 001 to the Parties' Merger Notice.

parameters, rather than a single specific feature, that influences the overall performance of the sequencing instrument and determines the fit of the technology to a particular sequencing application or use case.[46] Third-party responses to the CMA's merger investigation confirm that technical parameters, such as read length, accuracy, speed and quantity of data produced, and sequencing costs are typically the most important parameters influencing customers' decisions and the suppliers of sequencing technologies. The available evidence also indicates that suppliers make considerable investments in order to constantly continue to improve their performance across these parameters.[47]

Frame of reference

46. Market definition provides a framework for assessing the competitive effects of a merger and involves an element of judgement. The boundaries of the market do not determine the outcome of the analysis of the competitive effects of the merger, as it is recognised that there can be constraints on merging parties from outside the relevant market, segmentation within the relevant market, or other ways in which some constraints are more important than others. The CMA will take these factors into account in its competitive assessment.[48]

47. The Parties overlap in the supply of DNA sequencing systems on a worldwide basis. However, the Parties have submitted that short read sequencing (as supplied by Illumina) and native long read sequencing (as supplied by PacBio) are complementary technologies and, as such, fall into distinct product markets.[49]

Product frame of reference

Sequencing systems

48. The Parties have submitted that sequencing instruments and their related consumables fall into systems markets on the basis that customers purchase sequencing instruments taking into account the 'total cost of ownership' of the system,[50] including the price of both the primary product (ie the sequencing instrument) and secondary products (ie library preparation and

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[46] Paragraph 207 of the Parties' Merger Notice and Project Pluto – CMA briefing note, paragraph 71.
[47] [✂]
[48] *Merger Assessment Guidelines*, paragraph 5.2.2.
[49] Paragraph 97 onwards of the Parties' Merger Notice.
[50] Paragraphs 129 and 231 of the Parties' Merger Notice.

reagent kits,[51] bioinformatics tools and product support services), meaning that the price of the sequencing instrument itself and the price of the consumables are linked. The Parties also submitted that suppliers of sequencing instruments adopt different pricing policies, some of which include the price of the consumables together with the sequencing instrument (see section on Market overview above). For example, ONT sells 'starter packs' which include both sequencers and consumables, and Qiagen applies a 'price per insight' model whereby customers pay for each clinical report generated.[52]

49. The CMA has not received any evidence that contradicts the position that the Parties' activities should be analysed on the basis of a 'systems' market, with the Parties' submissions in this respect being supported by the feedback received from third parties. Third parties confirmed that the costs of consumables, in particular, account for the majority of sequencing costs and therefore play an important role in a customer's decision regarding which sequencing system to buy.

50. The CMA therefore believes that sales of sequencing instruments and the various types of consumables (eg library preparation kits, reagent kits and data analysis tools) should be assessed within the scope of a single product frame of reference, ie as a systems market.[53]

Sequencing services

51. The Parties have submitted that customers requiring DNA sequencing have the option to either purchase a sequencing system (for example, from one of the Parties) or outsource their sequencing activities to providers of sequencings services, such as Novogene and the Wellcome Sanger Institute.[54]

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[51] While some consumables, such as sample extraction and library preparation kits can be used across all sequencing technologies and are also provided by third-party providers, some consumables, such as reagent kits are exclusively provided by the instrument manufacturer, for use with a particular instrument, see Paragraphs 137 and 173 of the Parties' Merger Notice and Annex 001 and Annex 002 to the Parties' Merger Notice. This has also been confirmed by third parties.
[52] Paragraphs 135 – 137, 198, 213, 232 and 246 of the Parties' Merger Notice. Further information is also provided in the Sequencing costs section, paragraphs 83-84.
[53] While the product frame of reference in this case has been defined as a systems market, the term 'sequencing technologies' is also used in this Decision where appropriate in the context of the sentence. Unless indicated otherwise, the term 'sequencing technologies' is not intended to differentiate from a systems market, and is instead used where necessary to highlight the precise chemistry and machinery of the instruments in question.
[54] The CMA understands that some suppliers of sequencing instruments, such as Illumina, BGI and Qiagen also provide sequencing services, see paragraph 214 of the Parties' Merger Notice. PacBio does not provide sequencing services.

52. While the Parties have provided a few examples of customers switching between purchasing sequencing services and purchasing a sequencing system,[55] the evidence provided to the CMA by the Parties and third parties indicates that customers do not usually consider the purchasing of a sequencing instrument and the outsourcing of sequencing services as substitutes for one another. The Parties have submitted that sequencing services are usually purchased by customers who need to do sequencing sporadically and are, therefore, unwilling to make a significant investment into a sequencing instrument and the related costs of training staff. On the other hand, the Parties have submitted that outsourcing sequencing services tends to be more expensive on a per-sample basis, it may take longer to receive sequencing results, and it does not allow customers to oversee the sequencing process (which makes sequencing services less attractive to certain customers).[56]

53. The Parties' submissions on sequencing services have been largely supported by third-party evidence. Some third parties have indicated that customers with their own sequencing facilities would only consider outsourcing sequencing services in limited circumstances, such as when their instrument was not working or they had exceeded their sequencing capacity. One customer, who currently primarily outsources sequencing services, indicated that switching from purchasing sequencing services to purchasing sequencing systems would be costly and lengthy; it would need to acquire a facility large enough to house sequencing instruments, train staff, re-engineer pipelines and get necessary accreditations, which could take years to complete.

54. Third-party responses received from other suppliers of sequencing systems also indicate that they do not consider providers of sequencing services as competitors. Similarly, the Parties' internal documents and industry reports do not suggest that they view providers of sequencing services as competitors.[57]

55. Accordingly, the CMA believes that the supply of sequencing instruments and the provision of sequencing services form two separate product frames of reference. As the Parties only overlap in relation to the supply of sequencing systems, the CMA has not considered the provision of sequencing services further in this Decision.

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[55] [✂]. Illumina document: [✂]. See also paragraph 382 of the Parties' Merger Notice.
[56] Paragraphs 216 – 219 of the Parties' Merger Notice.
[57] See, for example, Illumina document: [✂]

*Sequencing and alternative methods of ascertaining genetic information (**non-NGS technologies**)*

56. The Parties have also submitted that alternative methods of ascertaining genetic information such as microarrays, polymerase chain reaction, fluorescence in situ hybridisation and DNA mapping are not substitutable with DNA sequencing systems as methods of DNA sequencing.[58]

57. The CMA believes that while non-NGS technologies may exert some constraint on sequencing technologies with respect to specific clinical applications (eg emerging sequencing technologies may offer increased clinical utility when attracting new clinical customers),[59] this constraint on the suppliers of sequencing systems is limited.

58. The Parties' internal documents also broadly support this position. While a few of Illumina's internal documents suggested that sequencing technologies may compete with other non-NGS technologies for new customers,[60] they did not suggest that non-NGS technologies had any meaningful effect on Illumina's incentives to innovate, nor did they significantly affect its pricing policies.[61] PacBio does not appear to monitor non-NGS technologies in its internal documents.

59. The CMA tested this view with third parties and found that the majority of third parties agreed that alternative technologies (microarrays in particular) are not substitutes for sequencing technologies.

60. The CMA therefore believes that the evidence does not support the inclusion of non-NGS technologies in the same product frame of reference as sequencing systems.

Short read and long read sequencing systems

Parties' views

61. The Parties have submitted that they are not active in the same product market, though they are both suppliers of sequencing systems.[62] Instead, the Parties have submitted that short read sequencing (as supplied by Illumina) and native long read sequencing (as supplied by PacBio) are

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[58] Paragraph 142 of the Parties' Merger Notice.
[59] See, Annex 003 to the Parties Merger Notice.
[60] See, eg Illumina document: [✂].
[61] [✂].
[62] Paragraph 24 of the Parties' Merger Notice.

complementary technologies and, as such, fall into distinct product markets.[63]

62. The Parties have submitted that short read and long read sequencing fall into distinct product markets for the following reasons:

    (a) Sequencing systems that perform short read and long read sequencing are not considered to be substitutable by customers and are instead used for different applications and use cases,[64] or in a complementary fashion.[65]

    (b) The Parties argued that customers cannot use both sequencing systems to 'answer the same questions', primarily due to the inherent strengths and limitations of the two technologies.[66] They said that short read and long read systems are technologically distinct, with unique characteristics which mean that they are not substitutes in any given use case. While short read systems sequence up to hundreds of base pairs per read, have high throughput (or run output), and are scalable and economical, long read systems sequence up to thousands of base pairs per read, have lower throughput, are not scalable and are materially more expensive.[67]

    (c) The Parties further argued that while short read and long read sequencing systems could sometimes be used in a complementary fashion within the same application, there are no use cases within different sequencing applications for which short read and long read technologies can be used interchangeably.[68] The Parties provided examples of applications in which customers may wish to use both short read and native long read systems together, such as reflex testing, initial discovery and coordinated sequencing.[69] The Parties also provided examples of public statements of customers indicating that they saw short read and long read sequencing systems as complementary.[70] The Parties further submitted that evidence of the systems' complementarity is found in the fact that [✂].[71]

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[63] Paragraph 97 onwards of the Parties' Merger Notice.
[64] The term 'use case' refers to a particular research question that the customer wants to address within a specific application.
[65] Paragraphs 97 – 122 of the Parties' Merger Notice.
[66] Paragraph 30 of the Parties' Response to the Issues Paper.
[67] Paragraphs 35-36 of the Parties' Response to the Issues Paper.
[68] Paragraphs 69-74 of the Parties' Response to the Issues Paper.
[69] Paragraphs 113-116 of the Parties' Merger Notice.
[70] Paragraph 52 of the Parties' Response to the Issues Paper.
[71] Paragraph 119 of the Parties' Merger Notice.

(d) Further, the Parties' submissions (and some third-party responses) indicated that there are certain applications for which either short read or native long read technologies might have clear advantages, for example:[72]

(i) native long read sequencing is more suitable for *de novo* sequencing of longer genomes, as well for discovery and detection of large structural variants, haplotype phasing and applications requiring near real-time sequencing;[73] and

(ii) short read sequencing is more suitable for certain applications where very high accuracy is needed (eg for clinical and diagnostic sequencing) or where short read technologies have significant cost or throughput advantages (eg counting of short DNA fragments).[74,75]

63. As the costs of short read sequencing are lower than those of native long read sequencing, the Parties submitted that customers will only use native long read systems where short read systems are unable to provide an answer to the question at hand.[76] (The importance of sequencing costs is further discussed in the separate section on Sequencing costs below.)

64. The Parties have submitted that there are fundamental limitations in PacBio's and ONT's native long read technologies which will prevent it from scaling in a manner that would enable it to deliver run outputs at costs similar to those of Illumina's systems.[77] As a result, the Parties argued that there will continue to be a difference in run output and cost between short read and native long read systems for the foreseeable future.

65. The Parties have also submitted that the growth of PacBio to date has not been at the expense of short read sequencing systems, including Illumina. In support of these statements, the Parties provided a regression analysis which, in their view, shows that the purchase of a PacBio sequencing instrument does not reduce [✂].[78]

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[72] [✂].
[73] Paragraph 76 of the Parties' Merger Notice.
[74] Counting is often used in relation to non-invasive pre-natal testing (**NIPT**) and liquid biopsy.
[75] Paragraph 74 of the Parties' Merger Notice. This is also supported by the Parties' internal documents, see eg Illumina document: [✂].
[76] Paragraph 41 of the Parties' Response to the Issues Paper.
[77] Paragraphs 53-66 of the Parties' Response to the Issues Paper.
[78] Paragraphs 75-83 of the Parties' Response to the Issues Paper. Please see the below section on Econometric analysis for the CMA's response to this analysis.

CMA's assessment

66. In order for the CMA to consider products to be included in the same relevant product frame of reference, it is not a requirement that the products, or their prices, should be identical. Rather, the aim when identifying the relevant product frame of reference is to include the most significant constraints on behaviour of the merging firms.[79]

67. As set out in the Merger Assessment Guidelines, the relevant product market is a set of products that customers consider to be close substitutes, for example in terms of utility, brand or quality.[80] The fact that some customers might only use short read and native long read systems in a complementary fashion (as is submitted by the Parties)[81] does not preclude the two sequencing systems from being used interchangeably by other customers.

68. For the reasons set out below, the CMA believes that there is not, for the purposes of market definition, a clear-cut distinction between sequencing technologies on the basis of read length. The Parties' internal documents and the CMA's merger investigation support the Parties' arguments that, due to their inherent strengths and limitations, short read and native long read technologies may be particularly suitable for certain applications and use cases, in particular those discussed at paragraph 62 above. However, the same evidence also indicates that for most other generic sequencing applications, which account for a large proportion of all sequencing applications,[82] both short read and native long read technologies are technically interchangeable (ie can technically be used for the same applications and use cases). Accordingly, the CMA believes that the position is more nuanced than that presented by the Parties: although there are certain specific applications and use cases where the Parties' technologies cannot be used interchangeably, the 'grey area' of applications where the technologies may be substitutable is liable to inform the nature of competition between the two technologies.

69. Native long read sequencing technologies have traditionally been viewed as a poor substitute for short read sequencing technologies (in particular because of their lower accuracy and throughput and higher sequencing costs) and were (and still are) primarily used for applications and use cases which cannot be addressed by short read technologies. The available

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[79] *Merger Assessment Guidelines*, from paragraph 5.2.1.
[80] *Merger Assessment Guidelines*, from paragraph 5.2.5(a).
[81] Paragraphs 97 – 122 of the Parties' Merger Notice.
[82] One third party estimated this proportion to be around 60%, [✂].

evidence indicates, however, that native long read technologies are increasingly viewed by customers as an alternative to short read sequencing technologies as they continue to improve in terms of both technical capabilities and sequencing cost. Some third parties suggested that in five to ten years' time, native long read technologies may completely replace short read technologies. In particular, as explained in further detail below in relation to Closeness of competition, the available evidence suggests that PacBio's Sequel II instrument has strong potential to increase the overlap between short read and native long read systems.

70. The CMA has assessed the following evidence on the degree of actual and potential substitutability between short read and native long read sequencing systems, having particular regard (within the context of a dynamic market) to the potential for future convergence between short read and native long read systems:

(a) Internal documents;

(b) Industry reports;

(c) Third party evidence; and

(d) Bidding data.

- *Internal documents*

71. While a significant number of the Parties' internal documents do suggest complementarity between systems for some applications,[83] both Illumina's and PacBio's internal documents also indicate that the two technologies can be used interchangeably for a variety of applications and use cases.[84] For instance, Illumina's internal documents indicate that around [90-100]% of Single Nucleotide Polymorphism Variants (**SNPs**)[85] identified[86] by Illumina's sequencing systems are also identified by PacBio's sequencing systems[87] and that Illumina's sequencing systems, at least to some extent, already compete with native long read systems: [✂].[88]

72. In attributing probative value to specific internal documents, the CMA has taken into account the timing, purpose and context in which they were

[83] See, eg Illumina document: [✂].
[84] Illumina document: [✂].
[85] SNP, also known as SNV, refers to a Single Nucleotide Polymorphism Variant – a change in a single nucleotide that occurs within a DNA sequence.
[86] The process of identifying variants from a DNA sequence is also known as 'variant calling'.
[87] Illumina document: [✂].
[88] Illumina document: [✂].

prepared. When undertaking the assessment of product frame of reference and in relation to the competitive assessment below, the CMA has therefore considered to what extent the contents of the internal documents are consistent with and corroborated by other sources of evidence.

73. Illumina also regularly tracks the advancements of native long read technologies, while its internal documents recognise the possibility of future convergence between short read and native long read technologies, especially as the accuracy, scale and economics of long read technologies continue to improve. Long read technologies are often viewed in Illumina's internal documents as [✂] and presenting substantial risks, requiring Illumina to take actions to improve its product offering and some documents recognise that long read technologies with [✂] accuracy may be preferred to Illumina's sequencing systems. For example:[89]

    (a) [✂];[90]

    (b) [✂];[91]

    (c) [✂];[92]

    (d) [✂];[93]

    (e) [✂];[94]

    (f) [✂'];[95] and

    (g) [✂]'.[96]

74. Similarly, PacBio's internal documents also recognise the overlap between PacBio's long read technology and short read technologies, and that this overlap is expected to increase following the introduction of PacBio's Sequel II instrument in April 2019. In particular, some of these documents suggest that the throughput and cost of Sequel II are now competitive with Illumina's sequencers. For example:

[89] Illumina document: [✂].
[90] Illumina document: [✂].
[91] Illumina document: [✂].
[92] Illumina document: [✂].
[93] Illumina document: [✂].
[94] Illumina document: [✂].
[95] Illumina document: [✂].
[96] Illumina document: [✂].

(a) A PacBio customer survey indicates that [✂][97] of the lab directors surveyed (ie [✂]% of respondents) considered PacBio's Sequel II instrument to be competitive with Illumina's sequencers. The same survey also indicates that PacBio's customers would switch a significant proportion of their sequencing workload to the Sequel II instrument (ie, from [✂]% on current PacBio sequencers to [✂]% on Sequel II, on average) at the expense of Illumina (ie, sequencing workload done on Illumina sequencers would drop from [✂]% to [✂]%, on average);[98]

(b) [✂];[99]

(c) [✂];[100]

(d) [✂];[101] and

(e) [✂].[102]

75. The Parties submit that the fact that short read and native long read sequencing systems are used to address the same application does not automatically mean that they are used interchangeably to address the same use cases within that specific application. For instance, within whole genome sequencing (**WGS**), long read systems may be used to produce a *de novo* genome, which will then be re-sequenced in order to polish the results and achieve the desired accuracy using cheaper and more accurate short read systems.[i103]

76. The CMA notes, however, that the Parties' internal documents and third-party responses indicate that while it may be true at present that some applications, particularly those requiring *de novo* sequencing, require the use of both native long read and short read technologies, native long read systems are increasingly likely to reduce the need to use short read sequencing systems to complement and polish their results. For example:

(a) [✂];[104] and

(b) [✂].[105]

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[97] PacBio's own calculations shows this as [✂], although this appears to be an error.
[98] PacBio document: [✂].
[99] PacBio document: [✂].
[100] PacBio document: [✂].
[101] PacBio document: [✂].
[102] PacBio document: [✂].
[103] Issues Meeting, 23 May 2019.
[104] PacBio document: [✂].
[105] Illumina document: [✂].

- *Industry reports*

77. The industry reports provided by the Parties to the CMA also broadly support the position that short read and native long read systems should form part of the same product frame of reference. The reports consistently list suppliers of long read systems such as PacBio and ONT alongside suppliers of short read systems such as Illumina, Qiagen, Thermo Fisher and BGI and mention them gaining market share at the expense of the suppliers of short read sequencing systems.[106] For example:

(a) [✂];[107]

(b) [✂];[108] and

(c) [✂].[109]

- *Third party views*

78. The CMA's merger investigation also indicated that short read and native long read technologies can be and are used interchangeably by customers. While third parties recognised that short read and native long read systems may be particularly suited for certain applications, given the difference in read lengths and sequencing cost, third parties generally agreed that, from a technical perspective, both sequencing technologies could be used interchangeably. For example, as noted above, one third party estimated this to be true for approximately 60% of sequencing applications. Several responses suggested that the distinction between short read sequencing systems and native long read sequencing systems suggested by the Parties was over-stated, particularly in the context of WGS, and a number of third parties stated that native long read sequencing systems were generally more advantageous than short read sequencing systems on the basis that they can be used to sequence reads of any length. Only a single third-party respondent did not think that short read and long read systems could be used interchangeably.

79. Furthermore, while some respondents suggested that, at present, some customers require both short read and native long read sequencing systems,[110] the majority of third parties submitted that reliance on short read

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[106] [✂].
[107] Illumina document: [✂].
[108] PacBio document: [✂].
[109] Illumina document: [✂]
[110] One third party estimated that around 70-80% of customers could require both short read and native long read systems at present while another party estimated this to be over 50%.

sequencing systems was expected to decrease as the cost of native long read sequencing systems and their ease of use continues to improve. Some third parties thought that long read sequencing systems may even be capable of completely replacing short read sequencing systems in the longer term.

- *Bidding data*

80. The UK bidding data provided by the Parties also suggests that customers do not typically specify the read length of the technology that they require, nor the particular sequencing instrument. For instance, the CMA's analysis of this data shows that customers do not typically specify whether short read or long read technology is sought, nor do they specify a particular sequencing supplier, in the clear majority of cases (eg for 63% of customers that purchased sequencing instruments during the period between 2015 and 2019).[111]

- *Linked long reads*

81. Third parties have also told the CMA that there are ways to improve the technical capabilities of short read sequencing technologies, for example through linked long reads.[112] In contrast to PacBio's technology (which generates single, contiguous long reads) 'linked long read' solutions, such as that offered by 10x Genomics, use barcoding techniques applied as part of the library preparation workflow to order and assemble short reads together to create an artificial long read. The Parties submitted that linked long read solutions are just 'associated short reads' and cannot fully replicate the advantages of native long read technologies.[113] However, third parties have indicated to the CMA that linked long reads and native long reads can be used interchangeably in some circumstances.

82. While the CMA notes that linked long read technologies may not represent a perfect alternative to native long read technologies in all cases, the available evidence indicates that linked long read solutions offer significant enhancements to short read sequencing technologies, thus further increasing the ability of short read sequencing technologies to compete with native long read sequencing technologies. This position is supported in Illumina's internal documents, which suggest that linked long reads can

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[111] CMA analysis based on Illumina document: [✂].
[112] Linked long read solutions are barcoding techniques applied as part of the library preparation workflow to order and assemble short reads together to create an artificial long read
[113] Paragraph 90 of the Parties' Merger Notice.

increase the competitiveness of short read sequencing systems *vis-à-vis* native long read sequencing systems. For example:[114]

(a) [✂];[115] and

(b) [✂].[116]

- *Sequencing costs*

83. The Parties have submitted that short read and native long read sequencing systems differ with regard to cost, to the extent that these technologies would not be considered as interchangeable by customers. The Parties provided comparisons of Illumina's high throughput instrument (the NovaSeq) and PacBio's Sequel II instrument to compare metrics such as Total Cost of Ownership (**TCO**), cost per gigabase (**Gb**) and cost per run, estimating that operating costs of short read sequencers (however measured) will be materially lower than those of native long read sequencers such that customers will always chose a short read sequencing system unless a short read sequencing system is not capable of addressing their needs.

84. The CMA notes that direct cost comparisons between Illumina's and PacBio's technologies are (particularly where taken in isolation) likely to be of limited relevance to competitive assessment. In particular:

(a) **Sequencing cost is only one of a multitude of parameters of competition (amongst read length, accuracy, speed, output and throughput), that customers consider when choosing a sequencing instrument**. The parameters that drive customer decision-making can vary significantly across different applications (eg some applications require higher accuracy while others would benefit from longer read lengths or throughput), which means that a particular technology may be more or less suitable for a particular application.

The Parties also submitted that customers often use the same sequencing instrument for multiple applications and their decision on which sequencing instrument to purchase is influenced by a multitude of different technical parameters in addition to cost, such as read length, accuracy and throughput. This significantly complicates the comparison of costs for different customers.

[114] Illumina document: [✂].
[115] Illumina document: [✂].
[116] Illumina document: [✂].

The Parties had previously submitted that different customers may give more weight to different cost metrics (for example, the Parties submitted that higher throughput customers are typically most sensitive to cost per Gb or cost per million reads) and the importance of those cost metrics may vary over time due to changes in sample volumes, sequencing applications and sources of funding.[117]

(b) **Further, any cost comparison should also take into account the amount of information provided by the technology, and when differences in read length are taken into account, the costs of the Parties' technologies are more comparable.** For example, Illumina sequencing instruments can read segments of up to 300 base pairs (bp), while PacBio instruments can measure 30,000 base pairs. Table 1 below shows that, while the cost per million reads is significantly lower for Illumina's sequencers, sequencing costs using PacBio's instruments decrease dramatically when the read length is taken into account (cost per million reads per 300bp fragment), making the costs of the two systems much more comparable, particularly following the launch of PacBio's Sequel II instrument.

Table 1: Comparison of sequencing costs at Q30 accuracy

Instrument	Read Length (bp)	Q30† reads per run (millions)	Cost per run ($)	Cost per million reads ($)	Cost per run per 300bp fragment ($)	Cost per million reads per 300bp fragment ($)
PacBio Sequel	10,000*	0.125	[✂]	[✂]	[✂]	[✂]
PacBio Sequel II	10,000*	1	[✂]	[✂]	[✂]	[✂]
Illumina iSeq i1‡	300	4	[✂]	[✂]	[✂]	[✂]
Illumina [✂]‡	300	8	[✂]	[✂]	[✂]	[✂]
Illumina NovaSeq S4§	300	20,000	[✂]	[✂]	[✂]	[✂]

Source: CMA analysis based on the Parties' data provided in response to question 3 of the CMA's questionnaire dated 15 April 2019.

Notes:
† Q score is the most commonly used metric to assess read accuracy. A Q score of 10 translates to a 1 in 10 chance of the base pair being misidentified due to a sequencing error (90% accuracy), Q20 is 1 in 100 chance (99% accuracy), Q30 is 1 in 1000 chance (99.9% accuracy) and so on.
* PacBio has explained that [✂].
‡Illumina's low throughput instruments.
§Illumina's high throughput instrument.

(c) **Finally, the CMA has found other methodological difficulties with the Parties' costs analysis.** For example, it is unclear whether the Parties' analysis reflects the time and costs needed to assemble short reads into longer fragments. Moreover, the Parties' analysis focuses only on Illumina's NovaSeq sequencer (its high throughput sequencer), while Illumina's internal documents indicate that the competitive

[117] Footnote 54 to the Parties' Merger Notice.

constraint from PacBio is strongest with respect to the low and medium throughput segments, where the cost gap is likely to be smaller (for example, in relation to Illumina's MiSeq, iSeq and NextSeq instruments).[118]

- *Econometric analysis*

85. In response to the Issues Paper, the Parties also submitted econometric analysis which aims to evaluate the substitutability between the sequencing instruments of Illumina and PacBio. The Parties submit that this analysis shows that Illumina's global customers[119] that purchased a PacBio sequencer subsequently purchased [✂], which supports the Parties' arguments that short read and native long read systems are not used interchangeably by customers.

86. The CMA believes that limited weight should be put on this analysis, primarily because any such analysis is based on historical sales and therefore does not reflect the increasing constraint of PacBio's Sequel II instrument. In addition, the CMA has identified a number of other methodological drawbacks to the econometric analysis submitted by the Parties, which further limit the weight that can be placed on this analysis. These are set out in Annex 1 to this decision.

Conclusion on short read and long read sequencing systems

87. In conclusion, on the basis of the evidence set out above, the CMA believes that it is appropriate to assess the Transaction by reference to the supply of all DNA sequencing systems, rather than to differentiate between short and long read sequencing technologies.

Conclusion on product frame of reference

88. For the reasons set out above, the CMA has considered the impact of the Transaction in the following product frame of reference: DNA sequencing systems.

89. Any differences between different sequencing systems have been taken into account as part of the Competitive assessment section, where relevant.

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[118] Illumina document: [✂].
[119] The results were not statistically significant with respect to the customers in the UK.

Geographic frame of reference

90. The Parties have submitted that the markets for short read and long read systems are worldwide in scope[120] and that for customers of short read and long read systems, the location of suppliers is not particularly important. The Parties submitted that suppliers are active on a worldwide basis and typically offer identical products from centralised production facilities regardless of customer location. The Parties have also submitted that transport costs are not significant and that there are no significant price differences between jurisdictions worldwide.[121]

91. [✂] and its internal documents often track competitive developments in the three key areas: the Americas, APAC and EMEA,[122] it has confirmed that [✂].[123] With the exception of BGI, all suppliers of sequencing technologies are active on a worldwide basis, although it is possible that some competitors may have certain local advantages. Importantly, key competitive parameters such as innovation, product quality and pricing strategies are decided on a worldwide basis and are, thus, primarily influenced by global competitive conditions.

92. The CMA has considered whether China should be excluded from the geographic frame of reference, on the basis that the strengths of suppliers may differ in China in comparison to the rest of the world. For example, third parties have told the CMA that both BGI and ONT are particularly strong in China in comparison to the Parties. For the reasons set out above, for the purposes of this Decision, the CMA considered a worldwide frame of reference. In addition, there is no need for the CMA to conclude on this point as concerns would arise whether or not China was included in the geographic frame of reference. However, the CMA has considered regional factors, such as any difference in the impact of the Transaction inside and outside China, within its competitive assessment, below.

Conclusion on geographic scope

93. For the reasons set out above, the CMA has considered the impact of the Transaction on the basis of a worldwide frame of reference.

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[120] Paragraph 145 of the Parties' Merger Notice.
[121] Paragraph 146 of the Parties' Merger Notice.
[122] Annex 001 to the Parties' Merger Notice, paragraph 41. Illumina document: [✂].
[123] Annex 001 to the Parties' Merger Notice, paragraph 41.

94. Any regional differences in competitors' product offering (such as differences in the competitive offering inside and outside China) have been taken into account as part of the Competitive assessment.

Conclusion on frame of reference

95. For the reasons set out above, the CMA has considered the impact of the Transaction in the following frame of reference: The worldwide market for DNA sequencing systems.

Competitive assessment

Horizontal unilateral effects

96. Horizontal unilateral effects may arise when one firm merges with a competitor that previously provided a competitive constraint, allowing the merged firm profitably to raise prices or to degrade quality on its own and without needing to coordinate with its rivals.[124] Horizontal unilateral effects are more likely when the merging parties are close competitors. The CMA assessed whether it is or may be the case that the Transaction has resulted, or may be expected to result, in an SLC in relation to horizontal unilateral effects in the worldwide market for DNA sequencing systems.

97. This theory of harm addresses a concern that the removal of one party as a competitor could allow the merged company to profitably raise prices, lower quality, reduce the range of their services and/or, particularly in this case, reduce innovation. After the merger, it may be less costly for the merged company to raise prices or degrade other competitive parameters because it will be able to recoup the profit on recaptured sales from those customers who would have switched to the offering of the other merging company.

98. Innovation, product quality and pricing are some of the key competitive parameters on which the suppliers of sequencing technologies compete. The CMA is therefore particularly concerned that Transaction could adversely affect the prices of sequencing technologies (including prices of both sequencing instruments and their related consumables), product quality and innovation (including a possible slowdown of innovation).

99. In order to assess the likelihood of the Transaction resulting in horizontal unilateral effects, the CMA has considered:

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[124] *Merger Assessment Guidelines*, from paragraph 5.4.1.

(a) Shares of supply;

(b) Closeness of competition between the Parties; and

(c) Competitive constraints.

100. Because of the importance of innovation, the length of innovation cycles, and the recent launch of Sequel II in April 2019, the CMA has placed more weight on forward-looking evidence than on the historical performance of the Parties and their competitors.

Shares of supply

101. The Parties submitted their own sales and estimates of shares of supply for sales of sequencing systems, and the CMA supplemented these with data from the Parties' competitors. The CMA is not aware of any independent estimates of the total market size with respect to the sales of NGS sequencing systems, and has therefore based its estimate of the total market size on the cumulative sales of the suppliers listed below.

Table 2: Estimated shares of supply by value of sales of sequencing systems in the UK and worldwide (2016 – 2018)

Supplier	UK			Worldwide		
	2016	2017	2018	2016	2017	2018
Illumina	[90-100]%	[90-100]%	[90-100]%	[80-90]%	[80-90]%	[80-90]%
PacBio	[0-5]%	[0-5]%	[0-5]%	[0-5]%	[0-5]%	[0-5]%
Parties combined	*[90-100]%*	*[90-100]%*	*[90-100]%*	*[80-90]%*	*[80-90]%*	*[80-90]%*
ONT	[0-5]%	[0-5]%	[0-5]%	[0-5]%	[0-5]%	[0-5]%
Thermo Fisher	[5-10]%	[0-5]%	[0-5]%	[5-10]%	[5-10]%	[5-10]%
Qiagen	[0-5]%	[0-5]%	[0-5]%	[0-5]%	[0-5]%	[0-5]%
BGI	[0-5]%	[0-5]%	[0-5]%	[0-5]%	[0-5]%	[0-5]%

Source: CMA analysis using data received from the Parties and third parties.

Notes: (1) Includes sales of sequencing instruments, consumables used with those instruments and data analytics tools. (2) All figures provided in USD have been converted to GBP using the approach applied by the Parties in the Parties' Merger Notice, ie 2016 figures have been converted from USD to GBP using the Bank of England's 2016 average exchange rate of GBP 1 = USD 1.35, 2017 figures have been converted using the Bank of England's 2017 average exchange rate of GBP 1 = USD 1.29, and 2018 figures have been converted using the Bank of England's 2018 average exchange rate of GBP 1 = USD 1.34.

102. As is evident from Table 2 above, Illumina is the largest supplier of sequencing technologies by a significant margin (with all remaining players having < [5-10]% share), both on a worldwide basis and in the UK. The CMA estimates that Illumina had around [80-90]% of the worldwide DNA sequencing market in 2018, and [90-100]% of the UK market.

103. The Transaction will bring about a relatively limited increment in share, of [0-5]% worldwide and [0-5]% in the UK, and other competitors will remain post-Transaction with similar shares of supply to that of PacBio (Thermo Fisher, Qiagen, BGI and ONT). However, the CMA believes that even a limited

degree of increment raises *prima facie* competition concerns given Illumina's very high share of supply at present (even leaving aside, as explained below, that existing shares may not capture PacBio's competitive significance). The CMA estimates that post-Transaction the Parties will have a combined share of supply of [80-90]% on a worldwide basis and [90-100]% in the UK.[125] These shares of supply are in line with third party estimates and the Parties' own internal documents.[126]

104. The shares of supply presented in Table 2 above provide a largely historical (and relatively static) picture of competition in the market for DNA sequencing. While historical trends provide some insight, the CMA believes that, as the sequencing market is evolving rapidly (for example, the Parties noted that less than 0.01% of species having been sequenced so far and submitted that the global NGS revenues are expected to grow from £4.42 billion in 2018 to £12.67 billion in 2024), only relatively limited weight should be placed on static shares of supply.[127] Further, given the recent developments in PacBio's sequencing technology associated with the release of its Sequel II instrument, the CMA believes that historical shares of supply may understate the competitive significance of PacBio in particular.

105. Accordingly, the CMA believes that the Parties' combined shares of supply are high enough to raise *prima facie* competition concerns. The CMA believes that the relatively low increment is not reflective of the potential competitive significance of PacBio going forward.

106. In addition to shares of supply, the CMA has also considered a range of other evidence to assess closeness of competition between the Parties and the constraint imposed on the Parties by their rivals.

Closeness of competition

Parties' views

107. The Parties have argued that Illumina and PacBio systems are not close competitors for a number of reasons:

    (a) As set out above in relation to Product frame of reference, the Parties have argued that short read systems (such as Illumina's) and long read

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[125] As the product frame of reference is a systems market (see section on Sequencing systems above for further detail), these market shares include only those competitors able to provide the full system (sequencer and related consumables) and does not take into account providers of consumables only.
[126] Illumina document: [✂].
[127] See paragraph 155 of the Parties' Merger Notice and paragraphs 160-162 of the Parties' Response to the Issues Paper. Parties' internal documents also project fast growth, see eg Illumina document: [✂] PacBio document: [✂].

systems (such as PacBio's) are technologically distinct, with unique characteristics which mean that they are not substitutes in any given use case. For example, while short read systems sequence up to hundreds of base pairs per read, have high throughput (or run output), and are scalable and economical, long read systems sequence up to thousands of base pairs per read, have lower throughput, are not scalable and are materially more expensive.[128] The Parties submitted that there will continue to be a significant gap in output performance of the Parties' systems going forward (even following the launch of the Sequel II instrument in April 2019) due to fundamental limitations with the long read technology.[129]

(b) The Parties further argued that the number of use cases for long read and short read will grow in parallel and that native long read will not 'cannibalise' short read sequencing.[130] The CMA notes, however, that the Parties [✂].

(c) The Parties also argued that there are a number of other competitors available who compete more closely with each of the Parties. For example, the Parties cited certain internal documents stating that Illumina considers [✂] to be its 'biggest competitor.'[131] The Parties also submitted that ONT is PacBio's primary competitive constraint.[132] The Parties have further submitted that Illumina does not consider [✂]. Further, the Parties argued that Illumina's internal sales training materials do not mention PacBio and [✂].[133]

(d) Finally, the Parties have argued that [✂].[134] Further discussion of [✂] can be found below.

CMA's assessment

108. In addition to the information provided by the Parties, in examining the closeness of competition between the Parties, the CMA has considered:

(a) Evidence from internal documents;

(b) Industry reports;

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[128] Paragraphs 35-36 of the Parties' Response to the Issues Paper.
[129] Paragraph 54-55 of the Parties' Response to Issues Paper.
[130] Paragraphs 84-87 of the Parties' Response to the Issues Paper.
[131] Paragraph 96 of the Parties' Response to the Issues Paper.
[132] Paragraph 128 of the Parties' Response to the Issues Paper and PacBio submission: [✂] submitted on 16 May 2019.
[133] Paragraph 49-50 of the Parties' Response to Issues Paper.
[134] Paragraph 180 of the Parties' Response to the Issues Paper.

(c) Third party evidence on closeness of competition; and

(d) PacBio's financial strength.

109. The CMA has also taken into account the pricing model used in the sequencing industry. Sequencing instruments, consumables and sequencing services are usually purchased following individual negotiations by customers, meaning that it is possible that closeness of competition could vary on an individual application basis.

- *Internal documents*

110. The CMA has considered the extent to which the Parties view each other as close competitors based on their internal documents. A significant number of the Parties' internal documents mention the complementarity of short read and native long read technologies.[135] For example:[136]

(a) [✂];[137] and

(b) [✂].[138]

111. However, while a significant number of the Parties' internal documents mention the complementarity between the Parties' technologies, a number of these documents have been prepared in 2017 and 2018[139] and, hence, are examining the interchangeability between Illumina's and older versions of PacBio's sequencing instruments, which the CMA has recognised to have been more limited than in relation to Sequel II.

112. Moreover, it is possible that some of the more recent of the Parties' internal documents may have been prepared with the Transaction already in contemplation. By way of example, the CMA notes that the [✂]. As a general principle, the CMA believes that internal documents prepared in the ordinary course of business are liable to have higher probative value than internal documents prepared with the Transaction already in contemplation. The CMA therefore believes that certain of these documents may understate the competitive dynamics between the Parties.

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[135] The Parties also provided further evidence on the complementarity between the two technologies in response to the Issues Paper.
[136] See, eg Illumina document: [✂].
[137] Illumina document: [✂].
[138] Illumina document: [✂].
[139] The majority of documents provided in response to Issues Paper are from the period between 2015 and 2017.

113. A large number of the Parties' internal documents also suggest that, notwithstanding the inherent differences between certain aspects of their sequencing technologies, both Illumina and PacBio view each other as competitors with respect to the supply of sequencing systems and have been regularly tracking each other's activity in the sector.[140]

114. The internal documents submitted by Illumina regularly list PacBio as a competitor alongside other suppliers of short read sequencing systems such as Thermo Fisher, Qiagen and BGI, and other long read suppliers such as ONT.[141] In particular, PacBio's developments relating to its Sequel II instrument appear to have been contributing to Illumina increasingly viewing PacBio as an important competitive force, both currently and in future, with PacBio being increasingly mentioned, alongside BGI, as Illumina's [✂] competitor, in particular with respect to WGS sequencing.[142] The Parties submitted that the 8M chip within the Sequel II system will allow for higher throughout and lower projected cost of sequencing a human genome, which is in turn expected to improve PacBio's market penetration.[143] Examples of Illumina's internal documents demonstrating the constraint provided by PacBio (both currently and in future) include:

(a) [✂];[144]

(b) [✂];[145]

(c) [✂];[146]

(d) [✂];[147]

(e) [✂];[148]

(f) [✂];[149]

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[140] Contrary to the Parties' Merger Notice, some of Illumina's internal documents suggest that complementarity and competition are not necessarily mutually exclusive, eg PacBio and ONT are both recognised as [✂] in the NGS market, while at the same time also being viewed as more suitable for [✂], see Illumina document: [✂].
[141] See, eg Illumina document: [✂].
[142] Illumina document: [✂].
[143] Paragraphs 52 – 55 of the Parties' Merger Notice. The Parties also provided a comparison of sequencing costs using PacBio's new Sequel II instrument and Illumina's sequencing instruments in response to question 3 of the CMA's questionnaire dated 15 April 2019.
[144] Illumina document: [✂].
[145] Illumina document: [✂].
[146] Illumina document: [✂].
[147] Illumina document: [✂].
[148] Illumina document: [✂].
[149] Illumina document: [✂]

(g) [✂];[150]

(h) [✂];[151] and

(i) [✂].[152]

115. Some of Illumina's internal documents record sales lost as a result of customers switching to PacBio[153] and several of Illumina's internal documents are dedicated exclusively to tracking PacBio.[154]

116. Further, despite the Parties' arguments that they do not compete with each other, specific Illumina internal documents demonstrate the impact that certain competitive scenarios concerning PacBio will have on Illumina's revenue.

117. For instance, a slide taken from Illumina's document titled [✂].[155]

Figure 1: Slide from Illumina's document titled [✂] examining the impact from PacBio on Illumina

[✂]

Source: [✂].

118. Similar slides to that shown in Figure 1 monitoring the impact that both BGI and ONT could have on Illumina revenues are also included in the same slide deck. However, the CMA notes that [✂].[156]

119. A number of Illumina's internal documents also indicate that developments in PacBio's technology may lead to pricing pressure on Illumina and that Illumina is, in fact, responding to PacBio's developments by improving its offering, in particular with respect to the WGS segment. For example:[157]

(a) [✂];[158] and

(b) [✂];[159]

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[150] Illumina document: [✂].
[151] Illumina document: [✂].
[152] Illumina document: [✂].
[153] Illumina document: [✂]. The Parties have also provided examples of sales lost to other competitors, as is discussed further in the Competitive constraints: Alternative suppliers section below.
[154] Illumina document: [✂] Although some of these documents also discuss rationale for acquisition, eg see [✂]; Illumina document: [✂].
[155] Illumina document: [✂].
[156] Illumina document: [✂].
[157] [✂].
[158] Illumina document: [✂].
[159] Illumina document: [✂].

120. Similarly, PacBio's internal documents recognise that its throughput and cost are now competitive with Illumina in larger market segments and its sales have the potential to grow in the short term, possibly winning customers from suppliers of short read sequencing technologies, including Illumina. For example:[160]

(a) [✂];[161] and

(b) [✂].[162]

121. PacBio also appears to view Illumina as a key competitor in its internal documents, tracking Illumina's progress, often comparing the two technologies, and also exploring ways to compete and win customers from Illumina. For example:[163]

(a) PacBio's customer survey indicates that [✂] of its surveyed customers said that PacBio's new Sequel II instrument would be competitive with all offerings from Illumina and was thought to achieve [✂]% of the sequencing market;[164]

(b) [✂];[165]

(c) [✂];[166]

(d) [✂];[167]

(e) [✂];[168]

(f) [✂];[169]

(g) [✂];[170] and

(h) [✂].[171]

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[160] PacBio document: [✂].
[161] PacBio document: [✂].
[162] PacBio document: [✂].
[163] PacBio documents: [✂].
[164] PacBio documents: [✂].
[165] PacBio document: [✂].
[166] PacBio document: [✂].
[167] PacBio document: [✂].
[168] PacBio document: [✂].
[169] PacBio document: [✂].
[170] PacBio document: [✂].
[171] PacBio document: [✂].

122. Both Parties also often compare the technical capabilities and performance of each other's sequencers (sometimes also benchmarking against other suppliers of sequencing systems).[172]

123. The CMA has seen some internal documents from the Parties which indicate that the competitive constraint from long read sequencing technology suppliers (including PacBio) is strongest with respect to low and medium throughput segments,[173] which account for [✂][174] of Illumina's revenue. For example:

(a) [✂];[175]

(b) [✂];[176] and

(c) [✂].[177]

Industry reports

124. Industry reports provided by the Parties also indicate that the Parties are close competitors, and that this will only be increased by PacBio's technical developments relating to its Sequel II instrument.[178] For example, the Cowen Life Sciences report (2019)[179] recognises Illumina as the market leader in the supply of sequencing technologies, while also noting that PacBio's new Sequel II instrument has the potential to compete more effectively with short read technologies in the near future. For example:

(a) [✂];[180] and

(b) [✂].[181]

125. Some of PacBio's internal documents also quote industry reports which see the launch of the Sequel II instrument as a positive factor in PacBio's revenue growth and market expansion: [✂].[182]

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[172] For Illumina see, eg: [✂] For PacBio see, [✂].
[173] Illumina document: [✂].
[174] Eg, [60-80]% of new-to-Illumina labs first purchase a low-throughput instrument, low throughput segment accounts for [40-60]% of Illumina's revenue, see Illumina document: [✂]. Benchtop sequencers (ie low to medium throughput sequencers) account for [70-90]% of all Illumina's installed sequencers worldwide, see [✂].
[175] Illumina document: [✂].
[176] Illumina document: [✂].
[177] Illumina document: [✂].
[178] [✂].
[179] [✂].
[180] [✂].
[181] [✂].
[182] [✂].

126. The [✂] provided by PacBio also shows that various sequencing parameters, such as sequencing costs, throughput and yield, vary significantly across different sequencing instruments. The same note also estimates that with the release of PacBio's Sequel II instrument, PacBio's cost per Gb will drop from $[✂] to $[✂], achieving cost per Gb levels similar to those of Illumina's high throughput NovaSeq instrument and much lower cost per Gb levels than those of Illumina's lower throughput instruments.[183]

Third party views

127. A number of third-party responses to the CMA's merger investigation indicated a growing competitive constraint from PacBio on Illumina's sequencing systems, particularly in light of the release of its Sequel II instrument, and a number of customers indicated that the proportion of workflow run on PacBio instruments would increase if they had access to a Sequel II instrument at the expense of the workflow currently run on Illumina instruments. Some third parties considered that, as a result of the recent developments in PacBio's technology, PacBio was the only supplier who could compete effectively with Illumina going forward. As is explained in further detail below (see section on Competitive constraints: Alternative suppliers below), while other suppliers are present in the market for DNA sequencing systems, their technologies were generally considered by third parties to be inferior to those of the Parties, particularly Illumina.

128. On the other hand, several respondents did not consider Illumina and PacBio to be close competitors and some thought that the Parties' sequencing systems were essentially complementary at present. However, of those respondents who did not consider the Parties to be close competitors, the majority, nevertheless, (i) thought that short read and native long read systems could, in principle, be close alternatives (ie if the costs of native long read sequencing were to decrease); (ii) had specific concerns which related only to PacBio's financial constraints; or (iii) did not seem well informed about the capabilities of the Sequel II instrument or had no or limited experience with PacBio's technology. Additionally, the majority of customers which thought that the Parties' technologies were complementary at present due to differences in sequencing costs and accuracy, nevertheless indicated that they anticipated that they would switch a

[183] While PacBio's instrument yield was lower than Illumina's (ie [✂]% on PacBio Sequel II compared to [✂]% on Illumina NovaSeq), the average read length achieved with PacBio Sequel II (ie [✂] base pairs) was also significantly higher than the [✂] base pair read lengths achieved with Illumina NovaSeq instrument. See PacBio document: [✂] See also the section on Sequencing costs above.

proportion of their workflow to the Sequel II instrument at the expense of Illumina instruments.

129. On the basis of the evidence described above, the CMA believes that the responses to the its merger investigation are consistent with Illumina and PacBio being regarded as close competitors, notwithstanding that some third parties observe a degree of complementarity between the short read and native long read sequencing systems.

PacBio's financial strength

130. As noted in the Counterfactual section above, the extent to which the Parties compete in future may be impacted by:

    (a) [✂]; and

    (b) The commercialisation of PacBio's new Sequel II system.

131. PacBio has submitted that it has been [✂]. The Parties have provided information relating to [✂].

132. In addition, the Parties have submitted the following evidence to indicate that it is unclear if and when [✂] absent the Transaction:[184]

    (a) [✂];

    (b) [✂];

    (c) [✂]; and

    (d) [✂].

133. The results of the CMA's merger investigation and review of the Parties' internal documents on the subject of PacBio' financial strength have been mixed. While some third parties acknowledged reports of PacBio's financial difficulties, the vast majority still considered PacBio to be an important competitive constraint on Illumina and thought that it would be able to continue its growth (albeit that the Parties submitted that third parties may not be in a position to comment meaningfully on PacBio's finances and its continuing participation in the market absent the Transaction).[185]

[184] Paragraph 187 of the Parties' Response to the Issues Paper.
[185] Paragraph 182 of the Parties' Response to the Issues Paper.

134. Further, while some of PacBio's internal documents (including PacBio's public Quarterly Results)[186] [✂], some of PacBio's internal documents indicate that [✂].[187] The Parties stated that early customer feedback on the Sequel II instrument has been positive (a position that was supported by the results of the CMA's merger investigation). As is set out in further detail in paragraph 127 above, third parties indicated that the competitive constraint provided by PacBio was expected to grow with the launch of the Sequel II instrument, and that the proportion of the workflow conducted on PacBio's sequencing technology was expected to increase.

135. While the Parties have submitted that [✂].[188] This has also been supported by the responses received from actual and potential competitors. The fact that PacBio has a key product at a well-advanced stage of development should make it a more attractive target for investment compared to companies that have product offerings at a more formative stage.

136. Further, the CMA considers that the value that Illumina has attached to PacBio, with the approximately £930.2 million purchase price, is not consistent with [✂].[189]

137. In conclusion, while the evidence provided to the CMA on PacBio's financial strength is mixed, the CMA believes that the available evidence does not, in the round, [✂].[190]

Conclusion on closeness of competition

138. The CMA therefore believes that the Parties are currently close competitors. In particular, Illumina's internal documents indicate that PacBio is imposing a competitive constraint on Illumina and is forcing it to improve its product offering. This constraint appears to be most significant with respect to the WGS segment, as indicated by both the Parties' internal documents and third-party responses. The Parties' internal documents and evidence from the CMA's merger investigation also indicate that the launch of PacBio's Sequel II instrument may further increase the closeness of competition between the Parties, potentially leading to PacBio becoming the most significant competitive constraint on Illumina in the near future.

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[186] PacBio's Quarterly Financial Results for first quarter of 2019, page 10
[187] PacBio document: [✂].
[188] Paragraph 163 of the Parties' Response to the Issues Paper.
[189] Illumina document: [✂].
[190] The CMA notes that views submitted by third parties on the extent of PacBio's constraint on Illumina are likely to have been based on PacBio's current situation to the extent that it is apparent to a third party (eg PacBio's already allegedly limited salesforce and support).

Competitive constraints: Alternative suppliers

139. Unilateral effects are more likely where customers have little choice of alternative suppliers. The CMA has therefore considered whether there are alternative suppliers which would provide a competitive constraint on the combined entity.

140. The Parties named [other short read system suppliers] as the most significant competitors to Illumina in relation to short read sequencing; they suggested that ONT, as the only other supplier of native long read sequencing systems, is the closest competitor to PacBio:[191]

    (a) **Thermo Fisher**. Thermo Fisher entered the NGS DNA sequencing market in 2014 with its acquisition of Life Technologies,[192] which marketed and sold the SOLiD and Ion Torrent short read sequencing systems (Thermo Fisher no longer actively markets the SOLiD system). The Ion Torrent system is based on SBS technology and comprises of low-to-medium throughput benchtop sequencers that are widely used for clinical and translational purposes.

    (b) **BGI**. BGI first commercialised a short read system in 2015, after acquiring Complete Genomics in 2013.[193] BGI provides a variety of short read sequencing systems and services, native long read sequencing services and genetic testing for medical institutions, research institutions and other public and private partners. BGI states that it is the world's largest genomics centre, producing at least a quarter of the world's genomics data.[194]

    (c) **Qiagen**. Qiagen acquired Intelligent BioSystems in 2012, which had released its first system, a short read sequencer called the MAX-Seq, in 2011 and was working on a benchtop sequencer. In November 2015, Qiagen commercialised its first system (the GeneReader). In addition to the sequencing system, Qiagen also supplies universal library preparation kits, assays and bioinformatics software which can be used with any NGS sequencer, including Illumina's.

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[191] Paragraph 170 onwards of the Parties' Merger Notice.
[192] The Parties have estimated that the first customer shipment of Life Technologies' sequencer was in 2010 (table at paragraph 361 of the Parties' Merger Notice).
[193] The Parties have estimated that Complete Genomics' first customer shipment was in 2009/2010 (table at paragraph 361 of the Parties' Merger Notice).
[194] https://www.bgi.com/us/company/careers/bgi-opens-seattle-office-for-north-america-expansion/

(d) **ONT**. ONT entered the market for sequencing technologies in 2014/15 with a nanopore sequencing system. ONT currently commercialises three native long read systems: the MinION, GridION and PromethION.

141. The Parties have argued that every system sale made by [other short read system suppliers] could have been made by Illumina. The Parties have provided examples of instances in which Illumina has competed head-to-head with each of [other short read system suppliers] in recent years.[195] Similarly, the Parties have provided examples of instances in which ONT has won opportunities for which PacBio has also competed in recent years.[196] In addition, Illumina has provided the CMA with [✂].[197]

142. The Parties also submitted that there were a number of potential competitors poised to enter the DNA sequencing market. Some of them (eg [✂]) were expected by the Parties to enter within the next 12 to 18 months,[198] and were viewed by the Parties as developing products which could pose a competitive constraint on Illumina. For example:

(a) Roswell's public statements state that it '*is on track to make a chip that* [...] *can sequence a full genome for less than $100 in the next three years'*;

(b) Quantapore's public statements characterise its technology as having *'unprecedented speed and cost'*;

(c) GenapSys has stated that it is developing a [✂]; and

(d) The Parties argued that [✂].

143. Further information on potential entrants is also provided below in the Barriers to entry and expansion section.

144. The CMA has assessed the constraint from these alternative suppliers by taking into consideration:

(a) Evidence from the Parties' internal documents; and

(b) Third party views on existing alternatives.

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[195] Paragraphs 90, 102, 112 and 121 pf the Parties' Response to the Issues Paper.
[196] Paragraph 127-128 of the Parties' Response to the Issues Paper.
[197] Paragraph 91 of the Parties' Response to the Issues Paper.
[198] Paragraph 394-395 of the Parties' Merger Notice and paragraph 169 and 172 of the Parties' Response to the Issues Paper.

Internal documents

145. Illumina's internal documents indicate that, in addition to PacBio, Illumina also tracks the activities of other competitors (Thermo Fisher, Qiagen, ONT and BGI), of which ONT and BGI are followed most closely. In addition, while not always referring to a particular competitor, a significant number of Illumina's internal documents suggest it is closely tracking competition in the sequencing market, viewing increased competition as a risk and actively responding to competitors' actions.[199]

146. The Parties' internal documents with respect to the above-mentioned competitors are examined in further detail below.

- *ONT*

147. ONT, a provider of native long read sequencing systems is regularly tracked by Illumina and is at times considered [✂] competitor and one of the [✂] competitors to Illumina. Illumina's internal documents suggest that ONT's constraint may be strongest with respect to clinical and benchtop segments and some provide a comparison of ONT's and Illumina's technical capabilities showing ONT's potential to achieve same results as Illumina as soon as [✂].[200] For example:[201]

(a) [✂];[202]

(b) [✂];[203]

(c) [✂];[204]

(d) [✂];[205]

(e) [✂];[206] and

(f) [✂].[207]

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[199] Illumina documents: See in particular, [✂].
[200] Illumina document: [✂].
[201] Illumina documents: [✂].
[202] Illumina document: [✂].
[203] Illumina document: [✂].
[204] Illumina document: [✂].
[205] Illumina document: [✂].
[206] Illumina document: [✂].
[207] Illumina document: [✂].

148. PacBio's internal documents also suggest it competes closely with ONT, which is often regarded as a competitive threat and is sometimes considered as PacBio's [✂]. For example:[208]

(a) [✂];[209]

(b) [✂];[210] and

(c) [✂].[211]

149. However, there are also examples of PacBio's internal documents where Illumina is considered to be the closest competitor both to PacBio and ONT: [✂].[212]

150. A number of PacBio's internal documents also emphasise that ONT's systems are technically inferior to PacBio's, in particular due to systematic errors and issues leading to coverage bias.[213] These documents also suggest that in order to overcome these technical limitations and achieve usable accuracy, re-sequencing in order to polish the results[214] using Illumina's instrument is necessary, which increases the overall costs of the project.[215]

- *BGI*

151. Illumina's internal documents suggest that BGI is regularly viewed as an important competitor to Illumina. Although its competitive constraint is largely limited to China, some documents suggest that it could also become a threat in Europe as its presence in this area increases. In particular, BGI is considered to be competing strongly on price with Illumina. For example:[216]

(a) [✂];[217]

(b) [✂];[218]

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[208] PacBio document: [✂].
[209] PacBio document: [✂].
[210] PacBio document: [✂].
[211] PacBio document: [✂].
[212] PacBio document: [✂].
[213] PacBio documents: [✂].
[214] Although these documents do not state whether re-sequencing to polish the results would be necessary if PacBio's instruments were used, this seems to be inferred.
[215] PacBio documents: [✂].
[216] Illumina documents: [✂].
[217] Illumina document: [✂].
[218] Illumina document: [✂].

(c) [✂];[219]

(d) [✂];[220]

(e) [✂];[221]

(f) [✂];[222] and

(g) [✂].[223]

152. Furthermore, Illumina has a number of slide packs prepared exclusively on BGI, which track in more detail its technical and marketing developments and instrument sales in different regions.[224]

153. However, notwithstanding multiple references to the threat from BGI, some of Illumina's internal documents also suggest that this threat may not have materialised yet in practice. For example:

(a) [✂];[225] and

(b) [✂].[226]

- *Thermo Fisher and Qiagen*

154. Thermo Fisher and Qiagen are often considered by Illumina as [✂] sequencing technologies produced by trusted brands with strong customer loyalty.[227] However, a number of Illumina's internal documents also indicate that both Thermo Fisher's and Qiagen's instruments are viewed as technically inferior to Illumina's instruments.[228] In addition, Illumina's internal documents suggest that the competitive constraint posed by Thermo Fisher and Qiagen is limited to certain clinical applications, such as NIPT and oncology.[229]

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[219] Illumina document: [✂].
[220] Illumina document: [✂].
[221] Illumina document: [✂].
[222] Illumina document: [✂].
[223] Illumina document: [✂].
[224] Illumina documents: [✂].
[225] Illumina document: [✂].
[226] Illumina document: [✂].
[227] Illumina document: [✂].
[228] Illumina document: [✂].
[229] Illumina documents: [✂].

- *Potential entrants*

155. While Illumina's internal documents also mention a number of potential entrants into the market for the supply of sequencing systems, such as [✂], these documents primarily focus on tracking the [✂] and the [✂] of such technologies.[230] With the exception of [✂], who has been mentioned as a competitor in the clinical segment,[231] internal documents do not suggest that other potential entrants exert any meaningful competitive constraint on Illumina at present. A small number of Illumina's internal documents assessing the threat posed by actual and potential competitors indicate that Illumina considers the level of competitive threat from potential entrants to be significantly more limited than that of existing competitors.[232] With the exception of [✂], PacBio's internal documents do not suggest that it tracks potential entrants at all.

Third party views

156. The CMA's merger investigation has indicated that there are few alternative suppliers available in the DNA sequencing market, with a large number of third parties commenting that the market is highly concentrated and with few players.

157. The majority of respondents submitted that the Transaction would strengthen Illumina's very strong pre-existing market position, leading to a reduction in competition (including competition on price) in an already very concentrated market with very few alternative suppliers, and that this would likely limit the development of new technologies.

158. Third parties also had mixed views on the competitive strength of other suppliers of sequencing systems. Respondents frequently mentioned BGI and ONT as competitors to Illumina. In addition, ONT was, as the only other supplier of native long read technologies, also often mentioned as the closest alternative to PacBio. A few respondents mentioned that they considered ONT, rather than PacBio, as having the highest potential of becoming the closest competitor to Illumina if it were able to improve the accuracy of its technology.

159. However, a number of these respondents recognised various limitations to both BGI's and ONT's systems. For example:

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[230] Illumina documents: [✂].
[231] Illumina documents: [✂].
[232] Illumina documents: [✂].

(a) In relation to BGI, third parties raised concerns that its technology was unproven, and some expressed concerns that IP issues may limit BGI's expansion into Europe. While Illumina has often considered BGI's pricing policy as aggressive and leading to stronger price competition, BGI's presence and, hence, its competitive constraint, remains largely limited to the Chinese market, where it has acquired a strong position. BGI has said that [the majority] of its sales currently originate in China and that it is [✂].[233]

(b) With respect to ONT, the evidence suggests that its technology still suffers from significant technical shortcomings, limiting its ability to constrain the Merged Entity. Several customers told the CMA that they thought that ONT's technology was not performing well and that its low accuracy, in particular, was preventing it from becoming a closer alternative to both Illumina and PacBio. [✂]. The CMA has also heard from the Parties that ONT's sales are growing in China, where its placement of a number of new instruments with GrandOmics has led to [✂],[234] which also suggests that ONT's competitive constraint may be stronger in some regions than others.

160. Some third parties considered that, at present, there were no practical alternatives to the Parties' sequencing products at all.

161. Thermo Fisher and, to a lesser extent, Qiagen, were also mentioned as competitors to Illumina, but concerns were also raised about the limitations of such technologies for certain applications and, more broadly whether they could represent a credible alternative to Illumina.

162. The CMA has not received any evidence to indicate that [✂] which is likely to increase the extent of the competitive constraint imposed by them on the Merged Entity post-Transaction. In particular, while third party responses consistently indicated that PacBio's competitive strength was likely to increase following the launch of its Sequel II instrument, no similar views regarding a growing competitive constraint from the remaining suppliers of sequencing systems were expressed. [✂].

163. While third parties mentioned a number of companies, including Roche, Omniome, Genapsys and NanoString, which they considered were likely to enter the market for the supply of sequencing systems in the near feature, responses to the CMA's merger investigation also suggested that significant investments and time were necessary in order to develop and commercialise

[233] Currently BGI [✂] provides sequencing services in the UK. [✂], see Illumina document: [✂].
[234] Presentation delivered to the CMA at the Issues Meeting on 23 May 2019.

a DNA sequencing technology and that there was significant uncertainty, including from the developers of the sequencing technologies themselves, about the future commercial success of these products (in contrast to the much greater confidence in PacBio's future prospects). This is considered further in the Barriers to entry and expansion section below.

Conclusion on alternative suppliers

164. For the reasons set out above, the CMA believes that there are limited alternatives to the Parties in the market for DNA sequencing. While a number of alternative suppliers of sequencing systems exist, the CMA believes that the evidence indicates, in the round, that the remaining suppliers of sequencing systems would not, at present, act as a sufficient competitive constraint on the Merged Entity post-Transaction. This is, for example, due to concerns regarding the technology (BGI), technical limitations (ONT) or because the technology is limited to use in relation to certain, primarily clinical, applications (Thermo Fisher and Qiagen). This is also reflected in the very low shares of supply of alternative suppliers (see section on Shares of supply above); none of the alternative suppliers of sequencing systems have managed to gain more than [0-5]% share of the worldwide market since their entry.[235] Nor, unlike PacBio, has the CMA received evidence that these alternative suppliers expected to undergo any significant improvements in the near future, that could increase their competitive constraint on the Merged Entity. Importantly, responses received from competitors indicate that none of these alternative suppliers have, at present, any [✂].

165. While a number of companies are planning to enter the market for the supply of sequencing systems, the Parties' internal documents do not suggest that any of these companies are anticipated to exert any meaningful competitive constraint on either Illumina or PacBio in future. Moreover, the evidence received from the Parties and third parties (see the section on Barriers to entry and expansion below for more detail) indicates that there are significant uncertainties about the potential entrants' ability to become viable competitors to the Merged Entity.

166. In conclusion, for the reasons set out above, the CMA believes that there will be limited competitive constraints operating on the Merged Entity post-Transaction.

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[235] See paragraph 140 above for more detail on the market entry dates for each of the alternative suppliers.

Conclusion on horizontal unilateral effects theory of harm

167. As set out above at paragraphs 101-106, Illumina is the clear market leader in a concentrated market, with very high shares of supply. Based, in particular, on the evidence gathered from third parties and a review of the Parties' internal documents, the CMA believes that Illumina and PacBio both compete for the same customers and that the degree of competitive interaction between the Parties is likely to increase following the commercialisation of PacBio's Sequel II instrument. While a number of alternative suppliers of sequencing systems, including ONT, BGI, Thermo Fisher and Qiagen, will remain post-Transaction, the available evidence shows that the competitive constraint from each of these competitors is limited.

168. On the basis of the evidence described above, the CMA believes that PacBio, ONT and BGI are the closest competitors to Illumina, and that ONT and Illumina are the closest competitors to PacBio. In particular, it has been suggested by a large number of third party respondents and in the Parties' internal documents, that PacBio, notwithstanding concerns about its financial status, has the potential to become the closest alternative to Illumina, particularly in light of the release of its Sequel II instrument, which will only increase the competitive constraint from PacBio on Illumina.

169. While the Parties have argued that [✂], should be viewed as the closest competitors to Illumina and PacBio respectively, the CMA believes that the evidence does not support a finding that the competitive constraints from these two suppliers are stronger than that exerted by the Parties on each other.

170. In the round, the CMA believes that the Transaction will lead to the removal of one of Illumina's closest competitors. Importantly, some evidence suggests that the Transaction will remove potentially the most significant competitive threat to Illumina in the short to medium term, which was expected to further increase competition in the market for the supply of sequencing systems. The CMA does not believe that there are sufficient alternative options to act, alone or in combination, as a sufficient competitive constraint on the Merged Entity post-Transaction.

171. While a number of companies are developing services for possible entry into the market for the supply of sequencing technologies, significant uncertainty remains about their ability to develop and commercialise their technologies.

172. Accordingly, the CMA found that the Transaction raises significant competition concerns within a market or markets in the United Kingdom as a

result of horizontal unilateral effects in relation to the worldwide market for DNA sequencing systems.

Barriers to entry and expansion

173. Entry, or expansion of existing firms, can mitigate the initial effect of a merger on competition, and in some cases may mean that there is no SLC. In assessing whether entry or expansion might prevent an SLC, the CMA considers whether such entry or expansion would be timely, likely and sufficient.[236] In terms of timeliness, the CMA's guidelines indicate that the CMA will generally look for entry to occur within two years.[237]

Parties' views

174. The Parties submitted that no significant barriers to entry and expansion exist and that a number of suppliers have started supplying sequencing technologies in recent years, with several others expected to start supplying such technologies in the short term.[238] The Parties estimate that it takes eight years on average to invent, research, develop and commercialise a new sequencing technology, and that this could cost hundreds of millions of US dollars. The Parties also submitted that while developing new sequencing technologies requires significant investment, many current and potential suppliers of sequencing technologies have been able to secure substantial funds from a wide range of investors, including venture capitalists and large life science companies, and the market is expected to grow significantly in the near future.[239]

175. The Parties further argued that, on launch, innovative sequencing technologies can rapidly gain wide adoption and expand significantly, as demonstrated most recently by ONT.[240] The Parties submitted that switching costs are not significant, being limited primarily to (i) the price of the new sequencing technology and the time invested to train the employees on the new workflow and (ii) the costs of revalidating the tests and workflows for clinical customers.[241] The Parties also stated that a large number of sequencing customers do not face any switching costs at all as they are new

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[236] *Merger Assessment Guidelines*, from paragraph 5.8.1.
[237] *Merger Assessment Guidelines*, paragraph 5.8.11.
[238] Paragraph 360 of the Parties' Merger Notice.
[239] Paragraphs 361 – 364 of the Parties' Merger Notice.
[240] Paragraph 361 of the Parties' Merger Notice. However, the CMA notes that while ONT's sales have grown in recent years, the Parties' claims about ONT's technologies gaining wide adoption are not supported by its low share of supply (see Table 2).
[241] See paragraph 371 of the Parties' Merger Notice.

to sequencing.[242] The Parties submitted that brand image is not an important competitive differentiator and reputation is primarily driven by offering a reliable technology that meets customers' needs.[243]

176. The Parties have submitted that the growth and expansion of the demand for sequencing has attracted new entrants (and funding) and cite a material increase in the number of sequencing entrants over the past decade:[244] this includes both recent examples of entrants (eg Thermo Fisher, Qiagen, BGI and ONT) and potential future entrants (eg Roche, GenapSys, Omniome).[245] As noted above, the DNA sequencing market is expected to grow significantly in future as the number of possible use cases for which DNA sequencing technologies can be applied grows.[246] Moreover, as is described in further detail above in the Competitive constraints: Alternative suppliers section, the Parties have submitted that a number of these potential future entrants are poised to enter within the next 12-18 months and appear to have credible and competitive offerings in development according to their public statements.[247] The Parties have also provided examples of investment interest from angel investors, investment firms, venture capitalists, governments and large life sciences companies.[248] Illumina believes that the number of commercial sequencing systems provided by third parties will continue to increase in line with the expected growth rate of sequencing use cases, the increasing levels of investment and the increasing number of technical approaches to sequencing.[249]

CMA's assessment

177. The CMA notes that the available evidence broadly supports the position that the sequencing market is expected to grow in the foreseeable future and that some third parties are currently investing in technologies with the intention of entering into the sequencing market. For the reasons set out below, however, the CMA believes that the available evidence does not indicate that entry or expansion will be timely, likely or sufficient to mitigate any SLC arising. [250] On the contrary, the available evidence suggests that the Transaction may further strengthen the Merged Entity's position, significantly reducing the scope for other suppliers to make sufficient sales to

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[242] Paragraphs 368 and 370 – 371 of the Parties' Merger Notice.
[243] Paragraphs 361 and 366 of the Parties' Merger Notice.
[244] Paragraphs 164-167 of the Parties' Response to the Issues Paper.
[245] Paragraph 373 onwards of the Parties' Merger Notice.
[246] Paragraphs 160-162 of the Parties' Response to the Issues Paper.
[247] Paragraphs 169-170 and 172 of the Parties' Response to the Issues Paper.
[248] Paragraph 163 of the Parties' Response to the Issues Paper.
[249] Paragraph 173 of the Parties' Response to the Issues Paper.
[250] *Merger Assessment Guidelines*, from paragraph 5.8.1.

reach the scale that would be needed to compete with the Parties post-Transaction.

178. The factors limiting competing suppliers' ability to enter and expand in the market for the supply of sequencing technologies are discussed in more detail below.

Technical and development risks

179. Third parties have told the CMA that there are significant costs and risks associated with entry into the supply of DNA sequencing technology, partly due to the significant time and resources required to be dedicated to R&D efforts, but also due to the litigious IP landscape (see section on Intellectual property for more detail).

180. Limited information is currently available regarding potential entrants' sequencing technologies. Evidence provided by third parties has indicated that developing a sequencing technology to bring to market has typically cost between $30 million and upwards of $250 million and taken between two and eight years. Importantly, the responses received from third parties indicated that there are substantial technical risks in developing highly accurate low-cost sequencing technologies and the probability of success is often uncertain. The vast majority of third party potential entrant respondents to the CMA's merger investigation cited technical risks as the main risk of bringing a product to successfully to market.

181. The majority of potential entrants had little certainty regarding when they were going to be able to commercialise their technologies, nor had they a clear idea of the probability of their success. Even respondents with projected launch dates within the next couple of years acknowledged that ongoing developments could impact and delay their planned entry. For example, one potential entrant confirmed to the CMA plans for upcoming entry but was unable to confirm the projected timing for the commercialisation of the technology because of a number of challenges which would impact the timescales for the launch; the potential entrant also expressed some uncertainty regarding the projected success of the technology.

182. While a number of competitors have entered the market within the last ten years,[251] none of these suppliers have been able to acquire significant

[251] For example, PacBio in 2011, Qiagen in 2012 (via acquisition), BGI in 2013 (via acquisition), Thermo Fisher in 2014 (via acquisition) and ONT in 2015.

market share (see section on Shares of supply above) in order to challenge Illumina's market leading position,[252] despite making significant investment,[253] and some have had to abandon technologies and exit the market, such as Roche's 454 instrument (a short read system), which was discontinued in 2013.[254] Responses received from existing competitors also indicate that they are [✂].

Intellectual property

183. The CMA has also examined whether the Transaction was likely to raise barriers to entry and expansion, making it more difficult for other actual and potential suppliers of sequencing systems to compete with the Merged Entity.

184. The Parties have argued that intellectual property is not a significant barrier to entry for the following reasons:

    (a) The basic methodologies of many currently commercialised sequencing platforms (SBS and nanopore sequencing) are already in the public domain;[255] (However, the CMA notes that PacBio's sequencing technology (SMRT) is still under patent protection.)

    (b) While patents relating to sequencing technologies can prevent direct copying, companies have demonstrated that they can develop alternative approaches;[256]

    (c) Patent lawsuits are the exercising of legitimate legal rights, rather than an attempt to raise barriers to entry;[257] and

    (d) There will be no change to the IP landscape post-Transaction, as PacBio already enforces against infringements of its patents.[258]

185. However, several third parties expressed concerns that the Transaction was likely to increase Illumina's ability to strategically block the entry and expansion of competing suppliers of sequencing systems by means of increasing the scope and extending the lifetime of Illumina's patent portfolio. In particular, one third party suggested that the larger combination of patents would make it difficult for competitors to modify their technology, where

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[252] Paragraphs 361 and 376 – 393 of the Parties' Merger Notice.
[253] Paragraph 363 of the Parties' Merger Notice.
[254] Footnote 141 of the Parties' Merger Notice.
[255] Paragraph 130-132 of the Parties' Response to the Issues Paper.
[256] Paragraph 133 and 136 of the Parties' Response to the Issues Paper.
[257] Paragraphs 134, 138 and 140 of the Parties' Response to the Issues Paper.
[258] Paragraph 139-140 and 142 of the Parties' Response to the Issues Paper.

required, to avoid infringing a narrower set of patents. Many third parties said that Illumina would aggressively protect its IP, perhaps more so than PacBio would have done.

186. Third parties have expressed concerns that the barriers to entry and expansion in the supply of sequencing systems associated with IP rights may be exacerbated by what they characterise as a highly litigious IP landscape. In particular, some third parties suggested that Illumina is particularly 'aggressive' in pursuing IP litigation against actual competitors and potential entrants.[259]

187. The CMA notes that the available evidence indicates that there has been considerable IP litigation within the sector, in particular, the Parties provided a comprehensive summary of the ongoing and recent IP litigation between the Parties and any other sequencing providers, which shows that Illumina has challenged a number of its competitors, including ONT, Qiagen, Thermo Fisher (Life Technologies) and, most recently, BGI.[260]

188. Some third parties also expressed concerns that the combination of Illumina's and PacBio's extensive 'Trading Technologies' patents might be more difficult for actual and potential competitors to overcome and that Illumina, given its considerable financial strength, would be significantly more likely than PacBio to assert these IP rights. Some third-party responses suggested examples of Illumina acquiring IP rights from various entities in the past and then seeking to deploy these IP rights in litigation intended to impede its competitors. Third parties have suggested that litigation (or the threat of litigation) in relation to IP rights can have a chilling effect on innovation in relation to DNA sequencing, with suppliers being concerned that any litigation could be lengthy and costly (and particularly difficult for smaller suppliers in particular to withstand).

189. Within the context of this Transaction, several third parties suggested to the CMA that part of the rationale for the Transaction could be the acquisition of patent rights, allowing Illumina an extension on the time period before which the key patents in its (newly expanded post-Transaction) portfolio might expire. (See above in paragraphs 21-22 on the rationale of the Transaction.)

[259] A number of third parties referred to Illumina's prior behaviour in relation to IP litigation as 'aggressive'.
[260] Updated Annex 007 to the Parties' Merger Notice.

190. Illumina's approach to the strategic importance of IP litigation (and, in some cases, the significance of acquiring PacBio within this context) is also reflected in its internal documents:

(a) [✂];[261,262]

(b) When talking about potential actions to mitigate the negative effect of competition on Illumina's prices (ie price erosion) and market shares, Illumina considers [✂];[263]

(c) [✂];[264] and

(d) When discussing benefits from PacBio acquisition, Illumina has considered its broad patent portfolio.[265]

191. Accordingly, on the basis of the evidence set out above, the CMA believes that access to IP rights (in conjunction with a litigious IP landscape) gives rise to significant costs and risks associated with entry and expansion.

The Merged Entity's ability to bundle post-Transaction

192. While, as is explained in further detail in relation to the competitive assessment above, the evidence indicates that the Parties are close competitors and that there is substitutability between their DNA sequencing systems, the CMA has also noted that there are applications for which customers may need to use both types of instrument together, in a complementary fashion, for example in relation to *de novo* sequencing, where long read systems may be used to produce a *de novo* genome, which will then be re-sequenced in order to polish the results and achieve the desired accuracy using cheaper and more accurate short read systems.

193. Several third parties have also expressed concerns that the Transaction, allowing for a combination of the leading short read and native long read technologies within the hands of a single entity, will further strengthen the Merged Entity's position *vis-à-vis* its actual and potential competitors. The CMA has, therefore, examined whether the Merged Entity would have the ability and incentive to be able to offer targeted discounts to customers who purchase both types of sequencing instruments and whether this could act as a barrier to entry and expansion by increasing the strategic advantage

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[261] Illumina documents: [✂].
[262] Illumina's internal documents also recognise that PacBio has a broad patent portfolio, see [✂].
[263] Illumina document: [✂].
[264] Illumina document: [✂].
[265] Illumina documents: [✂].

that Illumina would have over rivals seeking to enter or expand within the market.[266]

194. The Parties submitted that the Merged Entity will not have the ability or incentive to engage in a bundling strategy post-Transaction for the following reasons:

(a) [✂].[267]

(b) Illumina's ability and incentive to engage in pure or mixed bundling of systems will not change as a result of the Transaction as native long read systems are only used in a limited number of use cases, so a pure bundling strategy would lead to fewer short read systems being sold, which would therefore be unprofitable;[268]

(c) Cross-system mixed bundling would also be an unprofitable strategy, as ONT and PacBio have different pricing models and sequencing providers compete on a number of other parameters in addition to price;[269]

(d) [✂] PacBio customers ([✂]) already own an Illumina sequencer. Given the upfront cost of a sequencer, they are unlikely to purchase another short read system in the near future, reducing the likelihood that existing Illumina customers would purchase their next short read system from Illumina in future. This would be further impacted by ONT's 'reagent rental' model under which customers do not pay upfront for a sequencer, meaning that the Merged Entity would need to discount any bundle significantly in order to make it attractive;[270]

(e) Only 'some' third parties indicated that one-stop-shopping may be desirable and in fact, customers often source laboratory equipment from different suppliers;[271]

(f) Due to the differences in PacBio and ONT's pricing models, the Parties have estimated that unless customers are acquiring at least 1,152 ONT flow cells in each purchase, PacBio's consumables are already cheaper than ONT's consumables. Therefore, there are few customers

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[266] *Merger Assessment Guidelines*, paragraph 5.8.5.
[267] Paragraph 150 of the Parties' Response to the Issues Paper.
[268] Paragraph 151-152 of the Parties' Response to the Issues Paper.
[269] Paragraph 153 of the Parties' Response to the Issues Paper.
[270] Paragraph 154-155 of the Parties' Response to the Issues Paper.
[271] Paragraph 156 of the Parties' Response to the Issues Paper.

for whom discounts on PacBio consumables would be the factor that would make PacBio's systems cheaper than ONT's;[272] and

(g) Finally, Illumina's customers adopt a range of different sequencing strategies driven by a range of factors, including the number of samples they sequence, the use cases they are interested in etc. Any discount structure which limits the ability of customers to choose the type of sequencer best suited to their needs would cost Illumina sales.[273]

195. However, the CMA believes that there are several factors which indicate that the Merged Entity may have the ability to engage in mixed bundling[274] and/or targeted discounting strategies post-Transaction, and that this could increase the strategic advantage that Illumina would have over rivals seeking to enter or expand within the market, thereby acting as a barrier to entry or expansion. In particular:

(a) Illumina has significant market power making it a 'must have' brand for customers requiring short read sequencing technologies;[275]

(b) [✂] PacBio's and ONT's customers were also customers of Illumina (eg, Illumina estimated that [✂]).[276] Some third-party responses also indicate that customers may value one-stop shopping. This suggests that there may be demand for the bundled product, meaning that a successful bundling strategy could potentially negatively affect the sales of other suppliers of sequencing technologies, in particular ONT, as the only other current supplier of native long read systems;

(c) While PacBio's and ONT's sequencing technologies are differentiated, third-party responses nevertheless suggest that customers do consider options from both providers when making their purchasing decisions. As PacBio's costs continue to decrease following the launch of Sequel II, the CMA believes that even more customers may start viewing PacBio as an alternative to ONT;

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[272] Paragraph 157 of the Parties' Response to the Issues Paper.
[273] Paragraph 158 of the Parties' Response to the Issues Paper.
[274] Mixed bundling refers to a situation where each bundled product is also available on a standalone basis, but at a higher price than the bundle. Mixed bundling strategies could also include discounts offered to the current customers purchasing another sequencing technology.
[275] Several third parties suggested that they do not consider that there are any alternatives to Illumina. The Parties have argued that Illumina is not a 'must have' brand as it faces direct competition from each of BGI, Thermo Fisher and Qiagen.
[276] Paragraphs 118 – 119 of the Parties' Merger Notice. This accounted for around [0-10]% of Illumina's customers in the UK, as set out in Annex 21 to the Parties' Merger Notice.

(d) Illumina's internal documents suggest that it has previously considered applying [✂] bundling and discounting strategies in order to gain a competitive advantage, including applying various targeted discounts. For example:

(i) When talking about competition and the positioning of their offering, Illumina has considered [✂];[277]

(ii) [✂].[278] The document further proposes [✂].[279,280]

(iii) [✂];[281]

(iv) [✂];[282] and

(v) [✂].[283]

196. The CMA believes that similar tactics may be adopted with respect to PacBio's long read sequencing technologies. The Merged Entity may also tie its discounts on consumables to the number of Illumina and PacBio sequencing instruments owned by a customer, thus incentivising its customers to increasingly use PacBio's instruments, rather than those of a third party sequencing supplier. As the sale of consumables accounts for the majority of sequencing revenues, this may have a significant effect on competing native long read suppliers' revenues, thus making it harder for them to compete with the Merged Entity and making entry and expansion into the market more difficult and less desirable.

197. On balance, given the substantial R&D investment required to produce and improve sequencing technologies, and therefore the high level of expected sales to justify such investment, the CMA believes that a substantial loss of sequencing revenues could significantly reduce the ability of potential suppliers to invest in R&D, thus further limiting their constraint on the Merged Entity in the longer term. The CMA also believes that the long-term benefits to the Merged Entity of reduced competition are likely to outweigh any short-term costs of such a strategy. The effects of such a strategy, in the context of significant difficulties in developing and commercialising competing sequencing technologies, could be further exacerbated by the litigious IP landscape (as described above). The CMA has therefore found the Merged

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[277] Illumina document: [✂].
[278] Illumina document: [✂].
[279] Illumina document: [✂].
[280] See also Illumina document: [✂], which lists various customer specific discounts, targeting customers wishing to keep the old sequencing instrument.
[281] Illumina document: [✂].
[282] Illumina document: [✂].
[283] Illumina document: [✂].

Entity's ability to adopt bundling and discounting strategies post-Transaction could act as a barrier to entry and expansion in the market for DNA sequencing systems.

Conclusion on barriers to entry and expansion

198. For the reasons set out above, in particular the technical and development risks, the IP risks, and the possibility of the Merged Entity entering into a mixed bundling or targeted discounting strategies post-Transaction, the CMA believes that entry or expansion would not be sufficient, timely or likely to prevent a realistic prospect of an SLC as a result of the Transaction.[284]

Countervailing buyer power

199. In some circumstances, an individual customer may be able to use its negotiating strength to limit the ability of a merged firm to raise prices. The CMA refers to this as countervailing buyer power.[285]

200. The Parties submitted that the Transaction will not impair customers' ability to negotiate favourable terms with the Merged Entity, and that some customers, such as the [✂], are particularly well placed to negotiate with the Parties due to their size and the scale of the analysis they conduct.[286]

201. The existence of countervailing buyer power is important to the extent that it may limit the Parties' ability to raise prices or negatively affect other competitive parameters, thus, making a finding of an SLC less likely. However, even in circumstances where the market is characterised by large customers, this is not in itself sufficient to conclude that such customers have buyer power. In order to effectively constrain the Merged Entity from exercising its market power, these customers also need to have a choice as to whether to continue buying from the Merged Entity. Hence, customers' negotiating strength and their ability to exercise countervailing buyer power is determined by the number of alternatives available to them. Further, even if some customers have a degree of buyer power, that will not generally protect other customers in a market where terms are individually negotiated.

202. As explained in the Competitive constraints section above, the CMA does not consider that there are sufficient alternative options to act, alone or in combination, as a sufficient competitive constraint on the Merged Entity post-Transaction. Third-party responses also concur that the market is

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[284] *Merger Assessment Guidelines*, from paragraph 5.8.1.
[285] *Merger Assessment Guidelines*, paragraph 5.9.1.
[286] Paragraphs 418 – 423 of the Parties' Merger Notice.

'monopolised by Illumina' and there are not enough credible alternative technologies for customers to choose from. In addition, the very high market shares of Illumina also indicate that customers do not appear to have enough credible alternatives in relation to the supply of sequencing systems.

203. Accordingly, the CMA believes that customers will not have a sufficient degree of countervailing buyer power post-Transaction to constrain the Merged Entity from exercising its market power.

Conclusion on substantial lessening of competition

204. Based on the evidence set out above, the CMA believes that it is or may be the case that the Transaction may be expected to result in an SLC within a market or markets in the United Kingdom as a result of horizontal unilateral effects in relation to the worldwide market for DNA sequencing systems.

Decision

205. Consequently, the CMA believes that it is or may be the case that (i) arrangements are in progress or in contemplation which, if carried into effect, will result in the creation of a relevant merger situation; and (ii) the creation of that situation may be expected to result in an SLC within a market or markets in the United Kingdom.

206. The CMA therefore believes that it is under a duty to refer under section 33(1) of the Act. However, the duty to refer is not exercised whilst the CMA is considering whether to accept undertakings under section 73 of the Act instead of making such a reference.[287] The Parties have until 25 June 2019[288] to offer an undertaking to the CMA.[289] The CMA will refer the Transaction for a phase 2 investigation[290] if the Parties do not offer an undertaking by this date; if the Parties indicate before this date that they do not wish to offer an undertaking; or if the CMA decides[291] by 2 July 2019 that there are no reasonable grounds for believing that it might accept the undertaking offered by the Parties, or a modified version of it.

[287] Section 33(3)(b) of the Act.
[288] Section 73A(1) of the Act.
[289] Section 73(2) of the Act.
[290] Sections 33(1) and 34ZA(2) of the Act.
[291] Section 73A(2) of the Act.

Colin Raftery
Senior Director
Competition and Markets Authority
18 June 2019

ANNEX 1

The Parties' Econometric analysis

Methodological drawbacks

207. As is set out above in the Product frame of reference section, the Parties submitted econometric analysis which aims to evaluate the substitutability between the sequencing instruments of Illumina and PacBio.[292] The CMA believes that limited weight should be put on this regression analysis, primarily because any such analysis is based on historical sales and therefore does not reflect the increasing constraint of PacBio's Sequel II instrument.

208. In addition, the CMA has identified a number of other methodological drawbacks to the econometric analysis submitted by the Parties which further limit the weight that can be placed on this analysis. For example:

    (a) The Parties attempt to measure substitution between PacBio's and Illumina's systems by measuring the effect that a purchase of a PacBio instrument has on the usage of Illumina's consumables; however, as substitution could have already occurred at the time at which the PacBio sequencer was purchased, this evidence cannot be considered to be conclusive on this point;

    (b) The analysis estimates the average effect across all applications and use cases and does not take into account that PacBio and Illumina systems could be substitutes with respect to some applications but not others;

    (c) The Parties' internal documents suggest that the degree of competitive constraint may differ with respect to different models (eg low, medium and high throughput) of sequencing instruments. However, the Parties' analysis does not take into account the degree of heterogeneity between different of sequencing instruments; and

    (d) Since the Parties operate in markets where continuous innovation takes place and sequencing systems are being upgraded regularly, only analysis controlling for time-fixed effects or time trends should be

[292] Paragraphs 75-83 of the Parties' Response to the Issues Paper.

considered as this allows for control for any correlation resulting from a common growth through time. [✂]. However, the CMA recognises that the UK estimate may be less important given that the CMA believes the geographic frame of reference to be worldwide (see section on Geographic frame of reference below).

END NOTES

[i] In relation to paragraph 75 and the production of a de novo genome, the Parties submitted the following proposed correction (in bold) of the description of the process undertaken: 'within whole genome sequencing (WGS), long read systems may be used to produce a de novo genome, which will then be **polished using a cheaper and more accurate short read system in order to create a high-quality reference genome. That reference genome can then be widely used for re-sequencing other samples**' (emphasis added).