

CLOUD INFRASTRUCTURE-AS-A-SERVICE AS AN ESSENTIAL FACILITY: MARKET STRUCTURE, COMPETITION, AND THE NEED FOR INDUSTRY AND REGULATORY SOLUTIONS

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ABSTRACT

This Note examines whether public cloud infrastructure-as-a-service (IaaS) has a market structure that incentivizes a small number of cloud providers to engage in anticompetitive conduct to the detriment of competitors, competition, and ultimately consumers. As cloud IaaS becomes the dominant model for configuring and delivering computing resources in our increasingly cloud-based economy, the U.S. IaaS market is consolidating around a small number of players. These dominant players—Amazon, Microsoft and Google—also have a significant presence in downstream markets, which creates strong incentives for these providers to leverage their IaaS market power to distort competition in the diverse markets that depend on access to IaaS. While there is the potential for IaaS providers to *act* anticompetitively, the larger challenge is a structural one—*ineffective competition*, which results in a market structure that incentivizes anticompetitive conduct. Given the increasingly vital role cloud IaaS plays in our economy, as well as in our connected lives, important questions emerge as to whether national regulators should take steps to ensure consumers and competition are protected in the emerging cloud-based economy. This Note gives an overview of the IaaS market and examines whether the cost structure of the market has facilitated, and will continue to facilitate, the dominance of a small number of IaaS providers. It goes on to explore how consolidated control over IaaS incentivizes conduct that is potentially harmful to consumers and competitors in varied other markets that depend on access to IaaS. This Note finally explores possible industry and regulatory solutions for ensuring consumers and competition are protected in the emerging cloud-based economy.

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I. INTRODUCTION

“Friends don’t let friends build data centers,” proclaimed Infor CEO Charles Phillips, when he announced global software company Infor would shift to a “cloud-first” development approach and move all of its IT operations onto Amazon’s cloud computing platform.¹ The motto aptly captures the profound paradigm shift taking place in the way foundational computing resources are configured and delivered in our Internet-dependent economy—a shift to what may be understood as “utility computing.”²

The National Institute of Standards and Technology (NIST) defines cloud computing as “a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources . . . that can be rapidly provisioned and released with minimal management effort or service provider interaction.”³ In simpler terms, “cloud computing is on-demand access to virtualized IT resources that are housed outside of your own data center, shared by others, simple to use, paid for via subscription, and accessed over the Web.”⁴

Cloud computing is an umbrella concept, encompassing a multilayered ecosystem of IT services that connect users to a variety of resources through

1. Kate Miller, *Friends Don’t Let Friends Build Data Centers*, AWS PARTNER NETWORK BLOG (Mar. 15 2016), <https://aws.amazon.com/blogs/apn/friends-dont-let-friends-build-data-centers/> [https://perma.cc/92X2-A3C8].

2. See Bob O’Donnell, *Cloud Computing As a Utility Is Going Mainstream*, RECODE (Aug. 17, 2016), <https://www.recode.net/2016/8/17/12519046/cloud-computing-as-utility-private-public-data-center> [https://perma.cc/USV2-GDE3].

3. PETER MELL & TIMOTHY GRANCE, THE NIST DEFINITION OF CLOUD COMPUTING: RECOMMENDATIONS OF THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY 2 (2011), <http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf> [https://perma.cc/2UJH-RMJV].

4. Erik Brynjolfsson et al., *Cloud Computing and Electricity: Beyond the Utility Model*, 53 COMM. ACM 32, 34 (2010).

web-based tools and applications. This paper will focus on the foundational layer in that ecosystem, cloud infrastructure-as-a-service. Infrastructure-as-a-service is an automated offering where hardware resources, such as servers, networking, hard drive space, and operating systems, are owned and hosted by a service provider and offered to customers on a pay-per-use consumption model.⁵ Instead of building expensive IT infrastructure on-premises, businesses large and small can purchase access to scalable, expert-managed and hosted IT services. The cloud computing model is paving the way for tomorrow's cutting-edge services and products that rely on large amounts of data—driverless cars, artificial intelligence, and everything encompassed in the Internet of Things, to name a few.⁶

In the rapidly expanding cloud services market, the infrastructure-as-a-service market is expected to show the fastest growth among the various cloud offerings over the next three years.⁷ As prices for infrastructure-as-a-service go down and the U.S. market for cloud infrastructure service consolidates around a handful of big players, small and medium size infrastructure-as-a-service providers are finding it hard to compete with the largest providers. While there is the potential for infrastructure-as-a-service providers to *act* anticompetitively, the larger challenge is a structural one—*ineffective competition*, which results in a market structure that incentivizes anticompetitive conduct. Given the increasingly vital role cloud infrastructure-as-a-service plays in our economy, as well as in our connected lives, important questions emerge as to whether national regulators should take steps to ensure consumers and competition are protected in the emerging cloud-based economy.

The purpose of this Note is to examine whether public cloud infrastructure-as-a-service has a market structure that incentivizes a small number of cloud providers to engage in anticompetitive conduct, to the detriment of competitors, competition, and ultimately consumers. Part II gives an overview of the infrastructure-as-a-service market. Part III discusses the cost structure of the market and how this cost structure has facilitated, and will continue to facilitate, the dominance of a small number of providers. Part IV goes on to discuss why consolidated control over this essential facility incentivizes conduct that is potentially harmful to consumers and competitors. Lastly, Part V explores possible industry and regulatory solutions for a future where connectivity and cloud computing are ubiquitous.

5. See MELL & GRANCE, *supra* note 3, at 2–3.

6. See Mike Chan, *Why Cloud Computing Is the Foundation of the Internet of Things*, THORN TECHS. (Feb. 15, 2017), <https://www.thorntech.com/2017/02/cloud-computing-foundation-internet-things/> [<https://perma.cc/5XSX-MYV4>].

7. See Press Release, Gartner, Inc., Gartner Forecasts Worldwide Public Cloud Revenue to Grow 21.4 Percent in 2018 (Apr. 12, 2018) [hereinafter Gartner Press Release on Forecast].

II. OVERVIEW OF INFRASTRUCTURE-AS-A-SERVICE MARKET

Infrastructure-as-a-service provides consumers with “provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications.”⁸ The infrastructure-as-a-service provider hosts and manages the underlying infrastructure, while the cloud user purchases computing resources and data storage as needed, avoiding the expense of building and maintaining on-premises data-center infrastructure.⁹ This Section gives an overview of the infrastructure-as-a-service market, identifying “who” is selling “what” to “whom” in the public cloud infrastructure-as-a-service market.

A. WHAT ARE INFRASTRUCTURE-AS-A-SERVICE (IAAS), PLATFORM-AS-A-SERVICE (PAAS), AND SOFTWARE-AS-A-SERVICE (SAAS)?

In *public* cloud infrastructure-as-a-service (IaaS), providers create a shareable multi-tenant IT infrastructure by “virtualizing” hardware resources, using specialized software to break hardware into discrete and separate units, for purchase on a pay per use basis.¹⁰ Key to the public cloud IaaS model is that the provider’s resources are pooled to serve a multitude of consumers, dynamically provisioned and deprovisioned according to the demands of individual consumers.¹¹ In a *private* cloud model, computing resources are provisioned for exclusive use by a single organization, eliminating most of the cost benefits gained from resource pooling in the public model.¹²

The development and deployment of other cloud services are broadly categorized as platform-as-a-service (PaaS) and software-as-a-service (SaaS). The three layers of the cloud computing stack—IaaS, PaaS, and SaaS—encompass three different but interdependent services, with most SaaS and PaaS running atop IaaS.

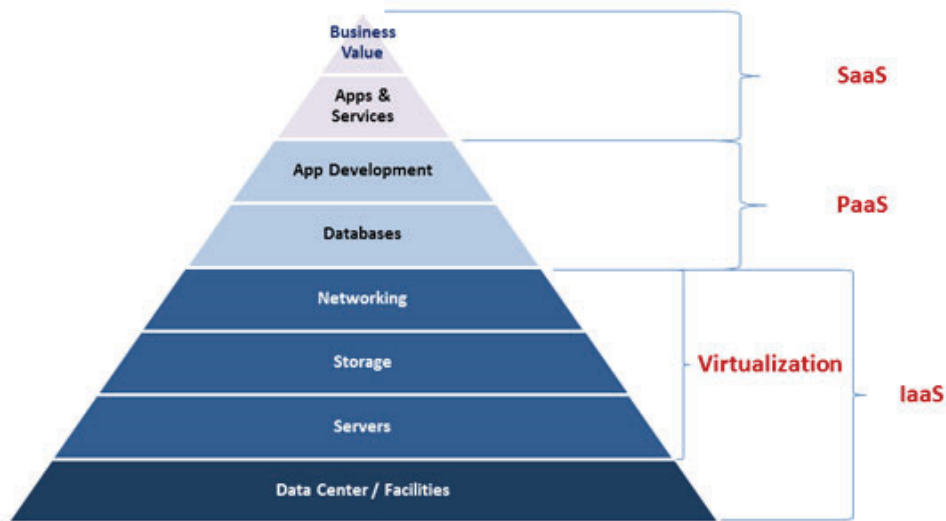
8. MELL & GRANCE, *supra* note 3, at 3.

9. *See id.*

10. See Sreedhar Kajeepeta, *Multi-tenancy in the cloud: Why It Matters*, COMPUTERWORLD (Apr. 12, 2017), <https://www.computerworld.com/article/2517005/multi-tenancy-in-the-cloud--why-it-matters.html> [<https://perma.cc/38AY-V925>]; MELL & GRANCE, *supra* note 3, at 2 n.1.

11. *See* MELL & GRANCE, *supra* note 3, at 2–3.

12. *See id.* at 3.

Figure 1: Hierarchy of Cloud Offerings¹³

Platform-as-a-service (PaaS) allows consumers “to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider.”¹⁴ PaaS provides additional functionality on top of IaaS, allowing developers to host, build, test, and deploy applications without having to manage the underlying computing resources.¹⁵ An example of cloud PaaS is Amazon Elastic Beanstalk, a platform that makes it easier for users to deploy and manage applications in the AWS Cloud by providing functions such as load balancing and application health monitoring.¹⁶

Software-as-a-service (SaaS) is the capability provided to the consumer “to use the provider’s applications running on a cloud infrastructure.”¹⁷ SaaS is the “[delivery of] applications that are managed by a third-party vendor and whose interface is accessed on the clients’ side.”¹⁸ Most SaaS applications can be run

13. See Ephraim Baron, *Aren't Virtualization and Cloud the Same Thing?*, EQUINIX (Nov. 2, 2011), <https://blog.equinix.com/blog/2011/11/02/aren%E2%80%99t-virtualization-and-cloud-the-same-thing> [<https://perma.cc/U4BK-Y323>].

14. MELL & GRANCE, *supra* note 3, at 2–3.

15. See *IaaS, PaaS, SaaS (Explained and Compared)*, APPENDA, <https://appenda.com/library/paas/iaas-paas-saas-explained-compared/> [<https://perma.cc/XR67-ANE7>] (last visited Apr. 2, 2019) [hereinafter *IaaS, PaaS, SaaS (Explained and Compared)*].

16. See AWS ELASTIC BEANSTALK, <https://aws.amazon.com/elasticbeanstalk/> [<https://perma.cc/2YH9-3TR5>] (last visited Apr. 2, 2019).

17. MELL & GRANCE, *supra* note 3, at 2.

18. *IaaS, PaaS, SaaS (Explained and Compared)*, *supra* note 15.

directly from a web browser and do not have to be downloaded. The average Internet user likely encounters SaaS multiple times a day by using cloud-based applications such as Google Apps, Microsoft 365, or Netflix. SaaS has also emerged as a major component of the IT systems of large companies and organizations, allowing these entities to purchase and rent software licenses as needed with the flexibility to scale up and down as their needs evolve.¹⁹ Of the three service layers, the SaaS market is the largest, with an array of providers offering varying platforms and applications.²⁰

B. WHO IS BUYING PUBLIC CLOUD IaaS?

To illuminate who is buying public cloud IaaS, it is helpful to identify the most common use cases of IaaS and then discuss the various types of customers of the service.

1. *What Are the Use Cases of Public Cloud IaaS?*

To illuminate *who* is buying public cloud IaaS, it is helpful to first identify the four most common use cases of IaaS: (1) development and testing, (2) website hosting, (3) enterprise applications, and (4) cloud native applications.²¹ Many developers turn to IaaS as a cost-effective way to build, test, and deploy applications.²² Unlike traditional, on-premises infrastructure, IaaS allows developers to rapidly self-provision testing environments and scale up and down as needed. Developers realize cost savings and time efficiencies when using cloud-based development environments, rather than building infrastructure or tapping into existing on-premises infrastructure.²³

Individuals and organizations also use public cloud IaaS for hosting Internet-facing websites and web-based applications, such as SaaS. These are the websites and applications that the everyday user interacts with online. Unlike traditional hosting agreements, where a user pays a flat fee for a set amount of storage and processing power, IaaS provides resources on an on-

19. See Sebastian Lambert, *2018 SaaS Industry Market Report: Key Global Trends & Growth Forecasts*, FINANCESONLINE, <https://financesonline.com/2018-saas-industry-market-report-key-global-trends-growth-forecasts/> [<https://perma.cc/6RKM-ARHR>] (last visited Apr. 2, 2019).

20. See Gartner Press Release on Forecast, *supra* note 7.

21. See LYDIA LEONG ET AL., MAGIC QUADRANT FOR CLOUD INFRASTRUCTURE AS A SERVICE, WORLDWIDE (June 15, 2017).

22. See David Linthicum, *Why Application Development Is Better in the Cloud*, INFOWORLD (Jan. 25, 2013), <https://www.infoworld.com/article/2613509/paas/why-application-development-is-better-in-the-cloud.html> [<https://perma.cc/U94P-HBRL>].

23. See *id.*

demand, as-needed basis.²⁴ When necessary, the provider can balance the information load across a number of servers in a cluster configuration to accommodate wide variation in usage, scaling up and down automatically with website traffic.²⁵ IaaS providers, such as Amazon Web Services, offer cloud web hosting solutions to customers looking to host a variety of websites on their infrastructure, from small-scale “simple website hosting” to large scale “enterprise web hosting,” for either fixed monthly fees or pay-as-you-go pricing plans.²⁶

Enterprise applications are general-purpose workloads used by businesses internally to perform various business functions.²⁷ These kinds of workloads could traditionally be found in the “on-premises” (company owned and operated) data centers of enterprise IT environments, including storage and operating systems. Enterprise applications range from automated billing systems to enterprise content management, and they demand reliable and high-performance infrastructure.²⁸

Lastly, there are cloud native applications, which are specifically architected to run in a cloud infrastructure environment.²⁹ Cloud native applications are designed from the ground-up on the cloud (rather than being migrated to the cloud from an on-premise data center), allowing the application developers to exploit innovative ways of designing, partitioning, scaling, testing and deploying. These include applications in the rapidly emerging Internet of Things, which require high availability, flexibility, and scalable capacity.³⁰

24. See *Cloud Hosting vs. Traditional Hosting*, OPUS:INTERACTIVE, <http://www.opusinteractive.com/cloud-hosting-vs-traditional-hosting/> [https://perma.cc/ZK2X-6SVQ] (last visited Apr. 2, 2019).

25. See *id.*

26. *Web Hosting*, AMAZON WEB SERVICES, <https://aws.amazon.com/websites/> [https://perma.cc/J8J9-EAPZ] (last visited Apr. 2, 2019).

27. See Patrick Hogan, *Why Infrastructure as a Service (IaaS) Works for Enterprise-Level Companies*, TENFOLD, <https://www.tenfold.com/iaas/iaas-enterprise-companies> [https://perma.cc/2AXN-53FR] (last visited Apr. 2, 2019).

28. See *id.*

29. See Rishi Yadav, *What Real Cloud-Native Apps Will Look Like*, TECHCRUNCH (Aug. 3, 2016), <https://techcrunch.com/2016/08/03/what-real-cloud-native-apps-will-look-like/> [https://perma.cc/B7M3-Q3RQ].

30. See Andrew Meola, *The Roles of Cloud Computing and Fog Computing in the Internet of Things Revolution*, BUSINESS INSIDER (Dec. 20, 2016), <https://www.businessinsider.com/internet-of-things-cloud-computing-2016-10> [https://perma.cc/CP7-L38Z].

2. *Who Are the Main Customers of Public Cloud IaaS?*

Whereas SaaS and PaaS are commonly employed by a range of consumers, IaaS is directed primarily toward enterprise-level companies, organizations, and government entities that operate on a large scale.³¹ IaaS gives companies control over IT, but requires extensive expertise on the part of the customer to manage the computing infrastructure.³² Most small to medium-size businesses opt for PaaS and SaaS solutions that allow them to use cloud-based applications without needing to manage the underlying infrastructure.³³ Providers of these PaaS and SaaS solutions are increasingly turning to the large IaaS providers, such as Amazon Web Services, rather than attempting to continue competing in the infrastructure-as-a-service market.³⁴

One 2016 study predicted over half of all large enterprises will adopt infrastructure-as-a-service as the primary environment for workloads by 2018.³⁵ This is not surprising, given that today the average enterprise deploys 464 custom applications, all of which depend on the underlying infrastructure that the large IaaS providers are selling at increasingly lower prices.³⁶ Many major companies are already running operations fully through cloud-based services, while others are integrating cloud IaaS into their IT systems incrementally. In 2017, 75% of hospitals' Chief Information Officers planned to use IaaS within a year—up from just 15.3% in 2014.³⁷ Higher education institutions are also adopting cloud-first policies for running on-campus IT infrastructure and are heavy consumers of public cloud IaaS.³⁸

The other major customers of IaaS are federal, state, and local government entities. In 2016, the federal government spent nearly \$8.5 billion on cloud

31. See Hogan, *supra* note 27.

32. See Gleb B., *Choosing the Right Cloud Service: IaaS, PaaS, or SaaS*, RUBYGARAGE <https://rubygarage.org/blog/iaas-vs-paas-vs-saas> [<https://perma.cc/M7U9-J4LW>] (last visited Apr. 2, 2019).

33. See Leong et al., *supra* note 21.

34. See *id.*

35. See Arul Elumalai et al., *IT as a Service: From Build to Consume*, MCKINSEY & COMPANY (Sept. 2016), <https://www.mckinsey.com/industries/high-tech/our-insights/it-as-a-service-from-build-to-consume> [<https://perma.cc/PU3F-9B4L>].

36. See SKYHIGH NETWORKS, *CUSTOM APPLICATIONS AND IAAS TRENDS* 4–5 (2017).

37. Laleh Hassibi, *SaaS, Paas, IaaS; What's the Difference?*, DATICA BLOG (July 4, 2017), <https://datica.com/blog/saas-paas-iaas-whats-the-difference/> [<https://perma.cc/BE64-WADM>].

38. See, e.g., Brandon Butler, *How Notre Dame Is Going All in with Amazon's Cloud*, NETWORK WORLD (Dec. 14, 2015), <https://www.networkworld.com/article/3014599/cloud-computing/how-notre-dame-is-going-all-in-with-amazon-s-cloud.html> [<https://perma.cc/4SDC-CJUK>] (reporting on University of Notre Dame's 2015 adoption of a cloud-first policy).

IaaS, leveraging both public and private clouds.³⁹ In response to the federal government's "Cloud First" policy (now the "Cloud Smart" policy),⁴⁰ Amazon Web Services launched GovCloud, an isolated data center region which exclusively serves federal government entities and partners.⁴¹ The GovCloud adheres to strict security standards under the Federal Risk and Authorization Management Program that Amazon's public cloud does not necessarily meet.⁴² GovCloud still leverages the resource pooling and multi-tenant benefits of a public cloud, but limits access to a specific community of customers. Amazon's GovCloud clients include NASA, the United States Airforce, and the Department of Justice, as well as US government contractors like Lockheed Martin.⁴³ Microsoft, Google, and IBM have been authorized to provide similar cloud offerings to the federal government and are eager to compete for dominance in the federal cloud market.⁴⁴

C. WHO IS SELLING PUBLIC CLOUD IAAS?

Amazon was the first to arrive at the IaaS market in 2006,⁴⁵ and today commands more than half of the \$23.5 billion global cloud IaaS market.⁴⁶ The top five IaaS providers—Amazon, Microsoft, Alibaba, Google, and IBM—control 75% of the global IaaS market, with Amazon and Microsoft dominant in the United States. In 2017, Amazon Web Services had a 51.8% share of the

39. *The Bumps, Cuts and Zeros in Trump's Tech Budget*, NEXTGOV (May 23, 2017), <http://www.nextgov.com/cio-briefing/2017/05/bumps-cuts-and-zeros-trumps-tech-budget/138096/> [https://perma.cc/49T5-JYAJ].

40. *See Cloud Smart Strategy*, U.S. DEP'T OF THE INTERIOR, <https://www.doi.gov/cloud/strategy> [https://perma.cc/5TCE-PHNY] (last visited Apr. 2, 2019).

41. *See Introduction to the AWS GovCloud (US) Region*, AMAZON WEB SERVICES, <https://aws.amazon.com/govcloud-us/> [https://perma.cc/9UEF-CXK2] (last visited Apr. 2, 2019).

42. *Cf. id.*

43. *See* Cassandra Stephenson, *AWS GovCloud Announces Eastern Expansion*, FEDSCOOP (June 13, 2017), <https://www.fedscoop.com/aws-govcloud-announces-eastern-expansion/> [https://perma.cc/M8NG-HHJQ]; *Lockheed Martin Case Study*, AMAZON WEB SERVICES, <https://aws.amazon.com/solutions/case-studies/Lockheed-martin/> [https://perma.cc/3TQ5-DSHD] (last visited Apr. 2, 2019).

44. Frank Konkel, *Google Cloud Targets Federal Government*, NEXTGOV (Mar. 23, 2018), <http://www.nextgov.com/it-modernization/2018/03/google-cloud-targets-federal-government/146917/> [https://perma.cc/L789-4BNQ].

45. *See* Ron Miller, *How AWS Came to Be*, TECHCRUNCH (July 2, 2016), <https://techcrunch.com/2016/07/02/andy-jassys-brief-history-of-the-genesis-of-aws/> [https://perma.cc/9YTN-LR3K].

46. *See* Press Release, Gartner, Inc., *Gartner Says Worldwide IaaS Public Cloud Services Market Grew 29.5 Percent in 2017* (Aug. 1, 2018) [hereinafter Gartner Press Release on Growth].

global cloud IaaS market.⁴⁷ Its next biggest competitor was Microsoft Azure, which had 13.3% market share.⁴⁸ Together, Amazon and Microsoft represented 75% of IaaS industry growth in 2017—Amazon with 45% and Microsoft 28.9%.⁴⁹

The next biggest competitor is Chinese e-commerce giant Alibaba, which commands 4.6 % of the global market share,⁵⁰ garnering most of its business in Asia.⁵¹ U.S. companies Google and IBM trail with 3.3% and 1.9% of the IaaS market share, respectively.⁵² The remainder of the IaaS market is highly fragmented, with small and mid-sized cloud providers facing decreasing market shares.⁵³ As competing providers are increasingly unable to meet the prices offered by major providers such as Amazon and Microsoft, they are moving away from hosting their own infrastructure, opting instead to help companies manage and implement their use of the major players' IaaS.⁵⁴

As Gartner's analysis highlights, "[c]loud IaaS providers have increasingly openly acknowledged that they cannot compete directly against the market leaders for public cloud IaaS. Many such providers that historically have managed hosting businesses have pivoted to offer their managed services on top of market-leading cloud IaaS platforms instead."⁵⁵ While Google, IBM, and Alibaba's IaaS revenues grew substantially in 2017,⁵⁶ these three companies, along with all other IaaS providers combined, only represented 25% of overall IaaS industry growth,⁵⁷ which suggests the two largest IaaS providers—Amazon and Microsoft—are not ceding ground in the near future.

47. *See id.*

48. *Id.*

49. Jamal Carnette, *Microsoft Is Taking On Amazon's Profit Center*, MOTLEY FOOL (Aug. 13, 2018), <https://www.fool.com/investing/2018/08/13/microsoft-is-taking-on-amazons-profit-center.aspx> [<https://perma.cc/SE5R-Q46V>].

50. *See* Gartner Press Release on Growth, *supra* note 46.

51. *See* Ron Miller, *Alibaba Continues to Gain Cloud Momentum*, TECHCRUNCH (Aug. 24, 2018), <https://techcrunch.com/2018/08/24/alibaba-continues-to-gain-cloud-momentum/> [<https://perma.cc/D5SU-Z7CP>].

52. *See* Gartner Press Release on Growth, *supra* note 46.

53. *See* Leong et al., *supra* note 21.

54. *See id.*

55. *Id.*

56. *See* Gartner Press Release on Growth, *supra* note 46.

57. *See* Miller, *supra* note 51.

III. IS EFFECTIVE COMPETITION POSSIBLE IN THE IAAS MARKET?

The barriers to entry that exist in the U.S. IaaS market make it difficult for new entrants and smaller IaaS providers to compete with Amazon, Microsoft, and Google. A “barrier to entry” is “[a]ny market condition that makes entry more costly or time-consuming and thus reduces the effectiveness of potential competition as a constraint on the pricing behavior of the dominant firm”⁵⁸ The major barriers to entry for new competitors in the IaaS market include: the incumbents’ large sunk costs; technological leadership and reputation; and customer switching cost and inconvenience. The following Sections present these barriers to entry in more detail and discuss how they are already facilitating concentration in the IaaS market.

A. THE LARGEST INCUMBENT IAAS PROVIDERS BENEFIT FROM ECONOMIES OF SCALE, WHILE NEW ENTRANTS ARE UNABLE TO COMPETE DUE TO LARGE SUNK COSTS

“Economies of scale” is “the phenomenon where the average costs per unit of output decrease with the increase in the scale or magnitude of the output being produced by a firm.”⁵⁹ As public cloud IaaS providers increase output, input costs per unit decrease because of bulk buying, organizational efficiencies, and virtualization technology that allows for high utilization of data infrastructure.

To enter the IaaS market, a firm must make enormous investments in facilities and the equipment, as well as in the technology that will allow for essential cloud characteristics such as high elasticity and scalability. IaaS providers must build and maintain data centers that operate twenty-four hours a day, seven days a week. Large data centers contain tens of thousands of servers that require reliable and continuous power, cooling, and connectivity.⁶⁰ Smaller providers are not able to achieve this scale without massive investment in physical infrastructure and hiring expert teams to configure and manage the infrastructure. An IaaS provider must buy the expensive hardware that goes in the datacenters, the physical space needed to house the servers, and the utility services that will keep the datacenter running. One study showed “that very

58. *S. Pac. Commc’ns Co. v. AT&T*, 740 F.2d 980, 1001 (D.C. Cir. 1984).

59. *Glossary of Statistical Terms*, THE ORG. FOR ECON. CO-OPERATION & DEV., <https://stats.oecd.org/glossary/detail.asp?ID=3203> [<https://perma.cc/F5PN-69QC>] (last visited Apr. 2, 2019).

60. Michele Lerner, *Data Centers and the Cloud Are Going Green*, NAREIT (July 20, 2016) <https://www.reit.com/news/reit-magazine/july-august-2016/data-centers-and-cloud-are-going-green> [<https://perma.cc/3SWE-9PD4>].

large datacenters (tens of thousands of computers) can purchase hardware, network bandwidth, and power for 1/5 to 1/7 the prices offered to a medium-sized (hundreds or thousands of computers) datacenter.”⁶¹ Entry to the IaaS market requires a large amount of capital and those entrants who can invest very large amounts have an automatic advantage in terms of input cost.

B. THE IMPORTANCE OF TECHNOLOGICAL LEADERSHIP IN ACHIEVING ECONOMIES OF SCALE MAKES IT DIFFICULT FOR NEW ENTRANTS OR SMALLER PROVIDERS TO COMPETE

Leading in the cloud IaaS space is not just about the size of a company’s data centers. Leveraging the economies of scale offered by public cloud IaaS requires innovative virtualization, automation, dynamic scaling, and metering technology that allow for both higher utilization of data infrastructure and the spreading of fixed hardware and software costs over many more machines, and therefore over many more consumers.⁶² These technologies enable IaaS providers to pool resources to dynamically serve multiple consumers with varying demands for physical and virtual resources.⁶³

This is the way IaaS companies will continue to differentiate their products and prices, making it difficult for smaller providers to compete with those companies that are leaders in developing and patenting new cloud technology. The secret to Amazon Web Service’s success has been the evolution of its datacenter technology, which has advanced over time to allow for higher utilization of its networks.⁶⁴ While Amazon Web Services entered the IaaS market in 2006 by purchasing basic servers, the company realized the benefits of developing customized technology that allowed for more sophisticated uses of IaaS.⁶⁵ The datacenters have become more advanced, and the systems have evolved as well, allowing for higher utilization of networks.

IT giants like Amazon, Google, and Microsoft have the money to put into research and patent licensing over these technologies that other providers do not.⁶⁶ For example, Amazon has patents claiming technology that removes the

61. MICHAEL ARMBRUST ET AL., ABOVE THE CLOUDS: A BERKELEY VIEW OF CLOUD COMPUTING 5 (2009).

62. *See id.*

63. *See* Timothy Prickett Morgan, *A Rare Peek into The Massive Scale of AWS*, ENTERPRISE AI (Nov. 14, 2014), <https://www.enterpriseai.news/2014/11/14/rare-peek-massive-scale-aws/> [<https://perma.cc/CYJ4-U8ZF>].

64. *See id.*

65. *See id.*

66. *See Winners And Losers In The Patent Wars Between Amazon, Google, Facebook, Apple, and Microsoft*, CB INSIGHTS (Nov. 16, 2017), <https://www.cbinsights.com/research/innovation-patents-apple-google-amazon-facebook-expert-intelligence/> [<https://perma.cc/59VW->

complexity associated with provisioning, administering, and managing resources of data centers, as well as technology that monitors the execution of a computing service to reduce errors and delays.⁶⁷ This patented technology enables Amazon Web Services to improve management and monitoring, which are key to optimizing utilization of infrastructure resources.

C. NEW ENTRANTS AND SMALL IAAS PROVIDERS FACE REPUTATIONAL BARRIERS TO ENTRY TO THE IAAS MARKET AND LACK THE MARKET KNOWLEDGE THAT BREEDS CUSTOMER LOYALTY

Amazon, Microsoft, and Google are global technology conglomerates that span industries from cloud computing (IaaS, PaaS, SaaS) to search engines to online retail. With high name recognition and a broad array of customer connections, these IaaS providers do not require as much capital to attract IaaS customers. Their reputation allows for lower per-customer attraction costs and facilitates customer loyalty.

In the case of Amazon—a company that was traditionally a leader in online retail—many of Amazon Web Service’s loyal customers in the IaaS space come from its earliest days as one of the only IaaS providers. Most of these early customers were small developers who used Amazon Web Service’s infrastructure offerings as a cheap way to test or run simple websites.⁶⁸ These small startups include the likes of what are now Netflix and Airbnb, who still rely on Amazon Web Services for their cloud infrastructure needs.⁶⁹

The leading IaaS providers also have long-term working relationships in other markets which give them cheaper access to customers. For example, Microsoft’s dominance in software—driven by its most popular SaaS offering, Office 365—has given it an established customer base and deep knowledge of enterprise IT.⁷⁰ Time and money spent in the IaaS market plus well-established data analytics teams mean the major providers also have more information about customers, such as their various needs and uses for IaaS, as well as their consumption patterns. Market knowledge, customer knowledge, and internal

FAUM]; *Patent Transaction Trends in Cloud Computing: Are Paes Buying Into The Market?*, IAM-MEDIA (Oct. 25, 2017), <https://www.iam-media.com/patent-transaction-trends-cloud-computing-are-paes-buying-market> [https://perma.cc/7P53-A9TY].

67. Steve Brachmann, *A Modest Patent Portfolio Doesn’t Stop Amazon Web Services from Earning \$5.16 Billion*, IPWATCHDOG (May 1, 2015), <http://www.ipwatchdog.com/2015/05/01/modest-patent-portfolio-amazon-web-services/id=57252/> [https://perma.cc/8W52-GZMM].

68. See Matt Weinberger, *The Cloud Wars Explained: Amazon Is Dominating, but Microsoft and Google Are Striking Back*, BUSINESS INSIDER (July 22, 2017), <https://www.businessinsider.com/why-amazon-is-so-hard-to-topple-in-the-cloud-and-where-everybody-else-falls-2017-7> [https://perma.cc/7P5Y-94H6].

69. See *id.*

70. See *id.*

expertise also breed customer loyalty, meaning existing customer relationships are more readily (less costly) maintained.

D. THE COSTS AND SECURITY RISKS OF SWITCHING IAAS PROVIDERS MAKES IT DIFFICULT FOR NEW ENTRANTS OR PROVIDERS WITH SMALL MARKET SHARES TO COMPETE FOR CUSTOMERS ALREADY “LOCKED-IN” TO ANOTHER IAAS PROVIDER

Once entities move to public cloud IaaS, it is not easy to switch providers. One survey showed the majority of businesses interviewed would not change IaaS providers even for a 20% discount, as switching would bring new risks and added costs in the re-development of tools on the new provider’s interface.⁷¹ High switching costs and risk disadvantages new entrants who are seeking to lure IaaS customers away from the major providers. Because it is difficult and costly to port personal and business data from one infrastructure provider to another, users may end up locked in to a suboptimal contractual relationship, with no feasible way to switch to competing offers.

The continued rapid growth of Amazon, Microsoft, and Google, as well as the departure of other smaller IaaS providers, suggests the market is moving toward an oligopoly, if not a duopoly. These barriers to entry make it more likely that a handful of major providers will make it difficult for smaller existing IaaS providers or new entrants to compete, thereby maintaining and continuing to expand their market power in an already concentrated IaaS market.

IV. WHY IS INEFFECTIVE COMPETITION IN THE IAAS MARKET BAD FOR COMPETITION AND CONSUMERS?

Increased concentration in the U.S. IaaS market poses several potential threats to consumers. As a leading researcher at Gartner aptly warned, “[t]he increasing dominance of the hyperscale IaaS providers creates both enormous opportunities and challenges for end users and other market participants;” and “[w]hile it enables efficiencies and cost benefits, organizations need to be cautious about IaaS providers potentially gaining unchecked influence over customers and the market.”⁷²

This Part takes a closer look at the potential threat an IaaS duopoly, or oligopoly, poses to competition in the diverse markets that depend on access to IaaS. IaaS is an essential service, providing the opportunity for a monopoly

71. See John DeWolf, *The Future of the Cloud: Will AWS Continue to Dominate?*, BACKUPIFY (May 9, 2013), <https://www.backupify.com/blog/the-future-of-the-cloud-will-aws-continue-to-dominate> [<https://perma.cc/Q9PS-YAVB>].

72. Gartner Press Release on Forecast, *supra* note 7.

firm, or oligopoly firms, to leverage their market power in IaaS to distort competition in markets that depend on access to IaaS. While it is difficult to prove to what extent this kind of behavior is already taking place, this Part underscores that the incentives to engage in this anticompetitive behavior do exist and will likely become more potent as the cloud market grows and matures.

A. INFRASTRUCTURE-AS-A-SERVICE IS AN ESSENTIAL SERVICE

An essential facility is a facility that (1) is essential for competition and (2) competitors cannot duplicate economically.⁷³ As described above, the infrastructure layer is the layer on which every other cloud service depends—an application or platform cannot exist without the underlying servers, networks, hard drive space, and operating systems that IaaS provides. Access to IaaS is therefore essential to compete in the PaaS and SaaS markets. According to Gartner, “[b]y 2020, a corporate ‘no-cloud’ policy will be as rare as a ‘no-internet’ policy is today.” For many of the reasons discussed in Part III, it is becoming increasingly infeasible for most companies, organizations, or individuals to duplicate IaaS in ways that allow them to compete with companies using IaaS provided by AWS, Microsoft, or Google.⁷⁴ IaaS is becoming an essential facility for more than just other cloud services. As large companies increasingly depend on cloud computing for their IT operations, access to IaaS also becomes essential to remain competitive in their respective markets.

Some might argue that cloud IaaS is only one way to access the infrastructure layer—many large companies still have on-premises IT or access to a private cloud. However, “[t]o be ‘essential’ a facility need not be indispensable; it is sufficient if duplication of the facility would be economically infeasible and if denial of its use inflicts a severe handicap on potential market entrants.”⁷⁵ For small and medium size businesses, including emerging cloud-native applications, public cloud services are the only economically feasible way to tap into even the most basic business IT operations; this includes hosting a website, storing large amounts of data, or accessing an e-mail platform.

73. See SCOTT HEMPLING, REGULATING PUBLIC UTILITY PERFORMANCE: THE LAW OF MARKET STRUCTURE, PRICING AND JURISDICTION 135 (2013).

74. See Press Release, Gartner, Inc., Gartner Says By 2020, a Corporate “No-Cloud” Policy Will Be as Rare as a “No-Internet” Policy Is Today (June 22, 2016).

75. Hecht v. Pro-Football, Inc., 570 F.2d 982, 985, 992 (D.C. Cir. 1977).

B. THE COMPANIES THAT CONTROL IAAS COULD LEVERAGE THAT MARKET POWER TO DISTORT COMPETITION THROUGH TYING AND PRICE SQUEEZING

As the dominant IaaS providers continue to widen their menu of PaaS and SaaS offerings, they have incentives to leverage their market power in IaaS to distort competition in these IaaS-dependent markets. Other markets vulnerable to such distortion include those that depend on access to IaaS for IT operations and other enterprise applications.

1. *Providers with IaaS Market Power Could Distort the SaaS and PaaS Markets by “Tying” Services to IaaS Purchases*

IaaS providers could distort markets of services that depend on access to IaaS through “tying”: conditioning the sale of their IaaS on the purchase of a different service they offer. For example, Amazon Web Services could require its IaaS platform customers to also purchase Amazon Aurora, a cloud database service that is the company’s fastest growing PaaS offering.⁷⁶ If a large enterprise customer is already locked into Amazon’s IaaS platform, it may be economically infeasible to change providers. In that case, Amazon is effectively forcing their IaaS customers to also purchase their PaaS offerings instead of a competitor’s.

Another version of “tying” is “technology tying”: where a seller designs a product that only functions when used with that seller’s complementary product.⁷⁷ In cloud computing, there are a diverse array of interfaces and applications that work together at the IaaS, PaaS, and SaaS levels.⁷⁸ In order to exchange information, the different applications and interfaces must be interoperable, where resources on one cloud provider system can communicate with resources on another’s cloud provider system.

When it comes to IaaS, interoperability refers to the application programming interfaces “needed so that the virtualization platform’s management interfaces to operate between different providers.”⁷⁹ Amazon Web Services, for example, could configure its infrastructure to enable communication only with its own PaaS and SaaS applications and not others.

76. See *How Amazon Is Disrupting a \$34bn Database Market*, CLOUDTECH (Aug. 11, 2016), <https://www.cloudcomputing-news.net/news/2016/aug/11/how-amazon-disrupting-34bn-database-market/> [https://perma.cc/9J67-NFXQ].

77. See HEMPLING, *supra* note 73, at 202.

78. See CLOUD STANDARDS CUSTOMER COUNCIL, INTEROPERABILITY AND PORTABILITY FOR CLOUD COMPUTING: A GUIDE 4 (2017).

79. Niamh Christina Gleeson & Ian Walden, ‘It’s a Jungle Out There’: *Cloud Computing, Standards and the Law*, 5 EUR. J.L. & TECH. 461, 462 (2014).

This interoperability is also important to ensure consumers have the ability to migrate workloads between different providers, to prevent customers from being “locked-in” to any one provider because of inaccessibly high costs and risks in migrating data to a new provider’s system.

Notably, the major IaaS providers are already selling PaaS offerings that are tightly woven into IaaS offerings. For example, Microsoft Azure currently offers two services: a fully-automated PaaS environment and a do-it-yourself IaaS capability.⁸⁰ Microsoft is blurring the lines by releasing certain application extensions that will bring some of the managed functionality of PaaS to the IaaS.⁸¹ Amazon Web Services now also offers more curated services in response to a demand for IaaS that is more user-friendly.⁸² Some experts predict that PaaS will be absorbed into IaaS, meaning the myriad features and functions of platform-as-a-service could become systemic to the IaaS platform.⁸³ This is leading many companies to go “all-in,” obtaining all their cloud services from a single provider.⁸⁴

2. *Providers with IaaS Market Power Could “Price Squeeze” to Disadvantage Competitors in Other Markets*

Companies with infrastructure-as-a-service market power could also price squeeze their competitors in other industries that utilize their IaaS for most, or all, of their operations. A “price squeeze” occurs when a vertically-integrated carrier has competitors who depend on an input provided by that carrier.⁸⁵ The carrier can harm those “in the downstream market by reducing the margin between the retail price it charges in the downstream market and the wholesale access price it charges [its competitors] for an essential input.”⁸⁶ For example, Amazon’s video streaming service through Amazon Prime competes with

80. See Mary Jo Foley, *Microsoft’s Azure Cloud Team Moves Toward Blurring the IaaS/PaaS Lines*, ZDNET (Feb. 24, 2014), <http://www.zdnet.com/article/microsofts-azure-cloud-team-moves-toward-blurring-the-iaaspaas-lines/> [https://perma.cc/TRK8-YGPC].

81. See *id.*

82. See Valerie Silverthorne, *AWS Blurs the Lines with PaaS and IaaS*, TECHTARGET (Apr. 2015), <http://searchcloudapplications.techtarget.com/tip/AWS-blurs-the-lines-with-PaaS-and-IaaS> [https://perma.cc/QJ72-YSUD].

83. See David Linthicum, *Will 2017 Mark the Death of PaaS?*, CLOUD TECH. PARTNERS (Jan. 11, 2017), <https://www.cloudtp.com/doppler/paas-death-watch/> [https://perma.cc/RS6Y-6BWX].

84. See Larry Dignan, *Enterprises Learning to Love Cloud Lock-In Too: Is It Different This Time?*, ZDNET (Apr. 8, 2018), <https://www.zdnet.com/article/enterprises-learning-to-love-cloud-lock-in-too-is-it-different-this-time/> [https://perma.cc/67VG-29V3].

85. *Price Regulations – FAQ*, INT’L TELECOMM. UNION, <http://www.itu-coe.ofca.gov.hk/vtm/price/faq/q10.htm> [https://perma.cc/ZWA9-FDC3] (last visited Apr. 2, 2019).

86. *Id.*

Netflix, one of Amazon Web Service's most prominent IaaS customers. Because Amazon controls the IaaS that underlies all of Netflix's operations—a service on which Netflix depends—Amazon could disadvantage Netflix by charging a price for the input exceeding the cost to Amazon of self-providing that input, leaving Netflix disadvantaged in competing with Amazon's video streaming prices.

However, competitors are noticing Amazon's control of this powerful resource. After Amazon's recent acquisition of Whole Foods, competitors in the brick-and-mortar supermarket industry, including Target and Wal-Mart, are reportedly scaling back their use of Amazon Web Services, moving e-commerce activities, mobile development, and operations away from Amazon.⁸⁷ Walmart is building its own cloud-based data-centers, while Target is looking at using other cloud providers.⁸⁸ In fact, one possible explanation for Microsoft's growth in 2017 is that Walmart, Target, Costco, and Walgreens have all opted for Microsoft's off-site servers, storage, and networking services.⁸⁹ As described in Part III, however, many companies do not have the resources to build their own infrastructure or go through the expensive process of switching providers, especially as the IaaS market becomes more concentrated and customers have fewer viable options.

3. *Tying and Price Squeezing Could Lead to Reduced Competition in a Wide Range of Industries, Leading to Fewer Choices for Consumers*

Tying can bring both benefits and harm to consumers. On the one hand, bundled offerings of IaaS, PaaS, and SaaS could create efficiencies that lead to lower prices, and benefit consumers that seek the convenience of going to one provider for various services. On the other hand, if the major IaaS providers engage in unlawful tying and price squeezing, they would disadvantage competitors in markets that depend on IaaS. These practices would make it

87. See Christina Farr & Ari Levy, *Target Is Plotting A Big Move Away From AWS as Amazon Takes Over Retail*, CNBC (Aug. 29, 2017), <https://www.cnbc.com/2017/08/29/target-is-moving-away-from-aws-after-amazon-bought-whole-foods.html> [<https://perma.cc/P4TP-QJ24>].

88. See Nandita Bose, *Walmart Goes to the Cloud to Close Gap with Amazon*, REUTERS (Feb. 14, 2018), <https://www.reuters.com/article/us-walmart-cloud/walmart-goes-to-the-cloud-to-close-gap-with-amazon-idUSKCN1FY0K7> [<https://perma.cc/K3AL-B3YU>]; Farr & Levy, *supra* note 87.

89. See Alex Hickey, *AWS Maintains Stranglehold on Cloud Market After Q2; Microsoft, Google Top Cloud Growth Rate*, CIO DIVE (July 30, 2018), <https://www.ciodive.com/news/aws-maintains-stranglehold-on-cloud-market-after-q2-microsoft-google-top/528805/> [<https://perma.cc/RH6N-VW6P>]; Jamal Carnette, *Microsoft Is Taking on Amazon's Profit Center*, MÖTLEY FOOL (Aug. 13, 2018), <https://www.fool.com/investing/2018/08/13/microsoft-is-taking-on-amazons-profit-center.aspx> [<https://perma.cc/3MP9-9SK6>].

too difficult to compete in such markets. This means customers could face fewer choices of SaaS and PaaS offerings.

Without any standards for interoperability, customers can find themselves locked into one of the dominant IaaS providers, making it difficult to switch if needed. Given the vibrant and dynamic state of the burgeoning SaaS market, this kind of market distortion could prevent new companies and technologies in downstream industries from reaching consumers. This is especially risky when the companies with market power in the IaaS market are global conglomerates that compete in a wide range of downstream industries.

V. INDUSTRY AND REGULATORY SOLUTIONS

A. U.S. ANTITRUST LAW FALLS SHORT IN ADDRESSING THE VERTICAL ANTICOMPETITIVE CONDUCT

United States antitrust laws fall short in addressing the vertical anticompetitive conduct discussed in this Note. When it comes to addressing the type of technology tying discussed in Section IV.B., U.S. courts have adopted a fact-specific approach, balancing the efficiencies and other benefits of tying with its anticompetitive effects.⁹⁰ Given the high bar *Twombly* pleading standards set for plaintiffs, and the difficulties plaintiffs face in accessing evidence of anticompetitive behavior, it is costly and timely for plaintiffs to bring antitrust cases.⁹¹ In an article on the role of antitrust in broadband net neutrality, Hal Singer explained that “antitrust litigation imposes significant costs on private litigants, and it does not provide timely relief; if the net neutrality concern is a loss to edge innovation, a slow-placed [sic] antitrust court is not the right venue.”⁹²

The same goes for the possibility of lost innovation in cloud computing. Small to medium-sized competitors that are hurt by anticompetitive behavior in the IaaS market are not likely to pursue antitrust claims given the costly and time-consuming nature of antitrust litigation. If a new business is trying to enter the PaaS market with a novel service to compete against Amazon’s Aurora database services, discriminatory treatment by Amazon in selling that start-up could mean that company never gets off the ground. Singer also emphasized, again in the context of broadband, that “competition is not the

90. See *United States v. Microsoft Corp.*, 253 F.3d 34, 59 (D.C. Cir. 2001) (“[C]ourts routinely apply a . . . balancing approach” requiring plaintiff to “demonstrate that the anticompetitive harm . . . outweighs the procompetitive benefit.”).

91. See Herbert J. Hovenkamp, *The Rule of Reason*, 70 FLA. L. REV. 81, 87–90 (2018).

92. Hal J. Singer, *Paid Prioritization and Zero Rating: Why Antitrust Cannot Reach the Part of Net Neutrality Everyone Is Concerned About*, 17 ANTITRUST SOURCE 22, 23 (2017).

only value that net neutrality aims to address: end-to-end neutrality or nondiscrimination is a principle that many believe is worth protecting on its own.”⁹³

B. INDUSTRY-DRIVEN STANDARDIZATION IS CRITICAL TO ENSURING INTEROPERABILITY AND DATA PORTABILITY

Interoperability and data (and application) portability are critical to ensuring customers are not “locked-in” to a single IaaS provider or forced to purchase the IaaS provider’s other cloud offerings. Without recognized standards, IaaS providers with market power can dictate which interfaces, and therefore which providers, can operate atop their cloud infrastructure. As recommended by NIST, U.S. government agencies should encourage the development and adoption of “voluntary consensus standards and in conformity assessment activities,” to achieve interoperability and portability in cloud computing.⁹⁴ Just as standardization and federation concepts⁹⁵ enabled interoperability in the global telephone system and the Internet,⁹⁶ they too can help achieve cloud interoperability and data portability. Many international and domestic standards bodies, as well as industry consortia, are developing cloud interoperability standards.⁹⁷ For example, NIST and the Institute of Electrical and Electronic Engineers Standard Association (IEEE-SA) are partnering to address intercloud interoperability and create “an open, transparent infrastructure amongst cloud providers to support evolving technological and business models.”⁹⁸ This effort aims to define “topology, functions, and

93. *Id.*

94. NAT’L INST. OF STANDARDS & TECH., NIST CLOUD COMPUTING STANDARDS ROADMAP 76 (2013) [hereinafter NIST CLOUD COMPUTING STANDARDS ROADMAP].

95. *Federated Cloud*, NAT’L INST. OF STANDARDS & TECH., <https://collaborate.nist.gov/twiki-cloud-computing/bin/view/CloudComputing/CloudFederated> [<https://perma.cc/D9MF-B5TK>] (last visited Apr. 2, 2019) (“A Federation is multiple computing and/or network providers agreeing upon standards of operation in a collective fashion.”).

96. Press Release, IEEE Standards Ass’n, IEEE and National Institute of Standards and Technology (NIST) Team on Standards Development for Intercloud Interoperability and Federation (July 25, 2017), https://standards.ieee.org/news/2017/intercloud_interoperability_and_federation.html [<https://perma.cc/NUP8-LVRW>] [hereinafter IEEE Press Release] (IEEE and National Institute of Standards and Technology (NIST) Team on Standards Development for Intercloud Interoperability and Federation, Collaboration between NIST and IEEE P2302™ will help build consensus on creating an Intercloud—an open, transparent infrastructure amongst cloud providers to support evolving technological and business models).

97. See *Industry Standards for Cloud*, CLOUD INDUSTRY F., <https://www.cloudindustryforum.org/content/industry-standards-cloud> [<https://perma.cc/TWB6-MKL4>] (last visited Apr. 2, 2019).

98. IEEE Press Release, *supra* note 96.

governance for cloud-to-cloud interoperability and federation.”⁹⁹ NIST recommends that U.S. government agencies encourage the adoption of such standards by actively participating in standards development, specifying such standards in the agencies’ own procurements and grant guidance, and recommending specific cloud computing standards and best practices for government use.¹⁰⁰

C. INTEROPERABILITY IS ALSO DEPENDENT ON SERVICE LEVEL AGREEMENTS AND INTELLECTUAL PROPERTY LAW

Some of this platform standardization can also be achieved through the standardization of cloud Service Level Agreements, or “SLAs,” which serve as a blueprint and a warranty for the scope and details of the cloud services to be provided.¹⁰¹ These agreements usually detail the extent of the cloud customer’s access to the data, the portability of the data, and the exit strategy should the customer want to transition to a different provider.¹⁰² It is ultimately up to the customer, however, to be informed and vigilant when entering into SLAs. While sophisticated cloud customers may be increasingly savvy enough to demand important data portability provisions in their SLA’s, the fewer IaaS providers in the market, the less leverage customers will have to negotiate SLAs that address their potential needs to switch providers.

Intellectual property law also has a role to play in making interoperability possible. A dominant cloud IaaS provider holding intellectual property rights to specific Application Programming Interfaces (APIs),¹⁰³ for example, might use those rights to restrict the compatible PaaS and SaaS applications that may operate atop of its infrastructure, limiting competition. The Federal Circuit examined the question of whether APIs are subject to copyright in *Oracle America, Inc. v. Google Inc.*, holding that “the declaring code and the structure, sequence, and organization of the API packages are entitled to copyright

99. *Standard for Intercloud Interoperability and Federation (SIIF) Project Details*, IEEE STANDARDS ASSOCIATION, <https://standards.ieee.org/project/2302.html> [<https://perma.cc/7QEZ-3HK7>] (last visited Apr. 2, 2019).

100. See NIST CLOUD COMPUTING STANDARDS ROADMAP, *supra* note 94, at 3–4.

101. See *Service Level Agreements in the Cloud: Who Cares?*, WIRED (Dec. 2011), <https://www.wired.com/insights/2011/12/service-level-agreements-in-the-cloud-who-cares/> [<https://perma.cc/XC7H-98QP>].

102. See *id.*

103. An API (Application Programming Interfaces) is a specification of possible interactions that allow programs to communicate with each other. See Jonathan Freeman, *What Is an API? Application Programming Interfaces Explained*, INFOWORLD (May 9, 2018), <https://www.infoworld.com/article/3269878/apis/what-is-an-api-application-programming-interfaces-explained.html> [<https://perma.cc/9FYC-5PDV>].

protection.”¹⁰⁴ While the court left open the possibility that a competitive desire to achieve commercial interoperability may be relevant to a fair use analysis, it stated that it was not relevant given the facts of this case.¹⁰⁵ Many software companies use APIs from dominant cloud providers’ cloud services to ensure compatibility between products.¹⁰⁶ Whether Amazon would pursue an infringement suit is unpredictable, but some argue that the decision in *Oracle America, Inc. v. Google Inc.* creates an incentive for copyright trolls to pursue litigation.¹⁰⁷

D. U.S. REGULATORS MIGHT LOOK TO PUBLIC UTILITY REGULATIONS TO ENSURE OPEN AND FAIR ACCESS TO IAAS

As cloud computing becomes an integral part of disseminating information over the Internet, there is a question of whether the neutrality of IaaS providers deserves a higher level of scrutiny on the part of regulators. Lina Khan discusses the challenges facing our current antitrust framework at length in her article, arguing that “the current framework in antitrust—specifically its equating competition with ‘consumer welfare,’ typically measured through short-term effects on price and output—fails to capture the architecture of market power in the twenty-first century marketplace.”¹⁰⁸ One approach offered by Kahn to solve this problem is implementing public utility policies, such as nondiscrimination policies that prohibit platforms from privileging their own goods and discriminating among downstream industries. Another potential solution is imposing common carrier obligations that ensure open and fair access to an essential service.¹⁰⁹

Given the trends toward rapid consolidation in the IaaS market, regulators might look to public utility solutions to prevent ineffective competition from affecting competition in other downstream markets. Observers have seen many of the problems and potential problems inherent to the market structure of the IaaS market before in other markets, particularly in the context of traditional public utilities such as telecommunications and electricity. Regulators may find it helpful to take lessons learned from past approaches and apply them where appropriate in the cloud computing context.

104. *Oracle Am., Inc. v. Google Inc.*, 750 F.3d 1339, 1348 (Fed. Cir. 2014).

105. *See Oracle Am., Inc. v. Google LLC*, 886 F.3d 1179, n. 11 (Fed. Cir. 2018).

106. Klint Finley, *The Case That Never Ends: Oracle Wins Latest Round vs. Google*, WIRED (Mar. 27, 2018), <https://www.wired.com/story/the-case-that-never-ends-oracle-wins-latest-round-vs-google/> [https://perma.cc/TU8J-3DSW].

107. *See id.* (“This creates a tremendous incentive for lawyers and copyright trolls to look for litigation[.]”) (quoting Electronic Frontier Foundation legal director Corynne McSherry).

108. Lina M. Kahn, *Amazon’s Antitrust Paradox*, 126 YALE L.J. 710, 716 (2017).

109. *See id.* at 799.

One example is regulatory intervention in the form of mandated access to ensure third-party providers—including managed service providers, PaaS providers, and SaaS providers—have non-discriminatory access to cloud infrastructure. This mandatory non-discriminatory access might parallel the local loop unbundling in the Telecommunications Act of 1996, which required incumbent local exchange carriers (ILECs) to open up their “last mile” to new entrants.¹¹⁰ This is also an approach taken by many countries around the world to encourage competition in Internet services through the decoupling of Internet services from the last mile network.¹¹¹ This mandated access would require IaaS providers to provide non-discriminatory access to other smaller cloud providers, allowing them to resell the basic access to infrastructure along with their own differentiated services.

At the very least, regulatory solutions used in the past, such as the unbundling discussed in this Section, provide a concrete starting point from which to start building regulatory solutions for potential problems in the cloud computing market.

VI. CONCLUSION

This Note’s purpose is to illuminate the market structure of the burgeoning cloud IaaS market and the potential challenges facing industry and regulators in ensuring this essential service facilitates competition and innovation in the varied markets that will come to depend on access to IaaS. This Note merely scratches the surface in the discussion of all the likely challenges—and possible solutions—facing regulators in the context of cloud IaaS. Other important challenges in the cloud IaaS market include predatory pricing, data privacy, cybersecurity, and platform reliability. The article aimed to highlight that the future impact of cloud computing on the economy, and society, depends largely on what is done now to safeguard the principles of openness and accessibility that enabled its creation. Cloud computing promises to continue to be transformative in many ways, but in the wake of exciting and disruptive change, it is important regulators remain steadfast in the commitment to ensuring tomorrow’s innovators can reach consumers with tomorrow’s life-changing innovation.

110. See Emily Stewart, *Net Neutrality Isn’t the Only Way to Keep the Internet Fair. It’s Just the Only Way in America*, VOX (Dec. 14, 2017), <https://www.vox.com/policy-and-politics/2017/12/14/16692318/net-neutrality-local-loop-broadband-internet-access> [https://perma.cc/2HP5-PC2D].

111. See Peter Bright, *We Don’t Need Net Neutrality; We Need Competition*, ARS TECHNICA (June 2014), <https://arstechnica.com/tech-policy/2014/06/we-dont-need-net-neutrality-we-need-competition/> [https://perma.cc/W5YN-HAWP].