### FTC Adv

#### Disruptive antitrust is inevitable -- streamlining data evaluation under computational antitrust solves asymmetries

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Antitrust 1.0 appeared in 1890 with the Sherman Act and was introduced in Europe with the Treaty of Rome in 1957. It has been shaped by several schools of thought (antitrust 1.1 for the Brandeis School, antitrust 1.2 for the Roosevelt School...), but always within the framework of a textual interpretation. Antitrust 2.0 then came along with the Chicago School in the early 1960s (antitrust 2.1 being the Harvard School, antitrust 2.2 the post-Chicago School...). Antitrust law became more economical to fit with the dynamic sectors falling within its scope. The method matched the subject matter. Antitrust 3.0 is emerging but remains incomplete. It appeared in the early 2010s when antitrust agencies have shifted their focus on the issues related to the digital economy. But while there are passionate discussions about the practices implemented by digital players, the use of technological tools to address them is very little debated. This disconnection between diagnosis and treatment is becoming problematic. Antitrust agencies struggle to remedy anticompetitive practices in increasingly complex, fast-paced, and evolutive markets. Soon, firms will also suffer from this struggle leading to fewer decisions and well-informed guidelines. Legal certainty will decrease while the number of judicial errors will be on the rise. Against this background, one must increase antitrust law with new technologies to make antitrust 3.0 complete. Enters “computational antitrust.”1 The present article first explains what it is (I) before discussing its potential (II), and the challenges ahead (III). I. What is Computational Antitrust? First, this article discusses the core idea and concepts behind computational law (A), after which it introduces computational antitrust (B). As one shall explain, the challenges encountered by the jurists, philosophers, and mathematicians in computational law matters are also found in computational antitrust. A – Computational Law Computational law is a “branch of legal informatics concerned with the mechanization of legal analysis (whether done by humans or machines).”2 Computational law is today a subject of growing enthusiasm,3 although the idea to compute the law is centuries old. German philosopher Gottfried Wilhelm Leibniz (1646–1716), known for his defense of rationalism, argued in the 17th century that each legal question has a single answer.4 From then on, “if controversies were to arise, there would be no more need of disputation between two philosophers than 1 See between two accountants. For it would suffice for them to take their pencils in their hands and to sit down at the abacus and say to each other (with a friend if they wish): Let us calculate.”5 Other philosophers like Jeremy Bentham also argued that codifying the law would help make it more practical and accessible6—which Emperor Napoleon did in France.7 With that in mind, Leibniz and his descendants always faced the difficulty of codifying the entire law, which, being the product of natural languages, could not be fully consolidated. Today, digital technologies give new life to these ambitions aspiring to mechanize the rule of law in its entirety (enforcement included).8 Of course, technologies are subject to combinatorial evolution, making it very difficult to forecast which form they will take.9 One can nonetheless imagine a world in which artificial intelligence (“AI”)10 and blockchain combined with quantum computing will soon provide valuable support by enabling a better understanding of the world’s complexity, and eventually, capturing part of it. Today already, multiple computational tools are currently being deployed in legal fields, such as data mining, machine learning, deep learning simulations, natural language techniques, social epidemiology, document management, legal text analytics, computational game theory, network analysis, and information visualization.11 These tools capture rich and detailed data about the external world, make them computable,12 and process them to reach a broader and more granular level of analysis.13 In the end, all pointers indicate that computational methods will first supplement the functioning of our legal system and will end up taking over a large part of it.14 This substitution process will trigger critical questions. Getting ready for it—and, eventually, for shaping it—requires discussing which principles ought to be preserved and developed. The study of computational law as a complement, which it currently is (i.e., a way to automate processes and improve existing analyses), might be our best shot at it. B – Computational Antitrust Markets are becoming increasingly complex and dynamic in today’s economy.15 This complicates the task of antitrust agencies, each day a little more. Against this background, the implementation of computational methods is becoming necessary to maintain and improve antitrust agencies’ ability to detect, analyze, and remedy anticompetitive practices.16 These tools and methods are rarely used in antitrust law today, in fact, most antitrust agencies are just beginning to acquire the technical expertise to develop and use them. Eventually, computational tools should be widely adopted and allow the integration of more variables in anticompetitive cases, whether from economic theory, business and management science, computer science, statistics, or behavioral insights.17 These tools will also simplify merger control, freeing up some of the teams within each antitrust agency. Accordingly, one must want to explore where and how to develop computational antitrust—a specialist field of computational law that purports to improve antitrust analysis and procedures by assistance of legal informatics.18 II. The Potential of Computational Antitrust The development of computational antitrust benefit enforcers, policymakers, and companies in all areas of antitrust law. That applies to anticompetitive practices (A), merger control (B), and the design or monitoring of antitrust policies (C). A – Anticompetitive Practices First, computational tools benefit agencies by increasing the availability of data about markets. In doing so, they help creating new forensics capabilities by increasing the flow of information available to agencies (therefore reducing Hayekian informational asymmetries), and, as a result, improving their ability to detect antitrust infringements.19 These tools are most welcomed considering that antitrust agencies are (to this day) mostly relying on reactive methods (such as leniency applications) for detecting collusion20 whereas their effectiveness is declining.21 Considering that technologies—such as powerful AI systems and blockchain—help market players implement and sustain their anticompetitive practices, the use of computational tools (as a proactive response) is becoming necessary.22 Against this background, the development of new market screening tools could help to identify anticompetitive patterns and behaviors.23 Machine learning will prove helpful in that regard.24 Techniques of natural language understanding could also automate the identification of illegal intentions when analyzing companies’ internal documents.25 The more complex (and dynamic) the practices, the more useful these tools will be.26 In the long term, one can imagine that application programming interfaces (“APIs”) will facilitate the transformation of data into information and create new channels for the automatic sending of certain data from companies to agencies, and vice versa.27 Second, computational tools enable agencies to process data more efficiently and understand practices better.28 They are indeed improving the speed by which agencies analyze documents. For example, these tools have allowed the European Commission to study 1.7 billion search queries for its investigation in the Google Shopping case.29 In this respect, computational tools are bringing the “law time” closer to “market time.”30 Besides, computational tools increase agencies’ analytic capacities. They do so by allowing the comparison of large data sets across different periods and industries to detect anomalies.31 These tools also enable agencies to integrate data from other agencies.32 Much can be done to improve the cross-institutional use of data residing within different agencies from a same country. Similarly, the international dialogue between antitrust agencies, which is currently ensured by various networks such as the ICN, the OECD, and the ECN+, could be further automated. Simultaneously, computational tools enable market players to conduct more thorough internal audits. In the future, one could imagine the design of new tools for assessing compliance with antitrust laws (almost instantaneously). It would require companies to compute the known parameters of any practice and assess the associated legal liability risk thanks to algorithms trained to antitrust laws. One could imagine that antitrust agencies will provide companies with their own computational tools to evaluate the risk even more accurately. These tools could improve over time using deep reinforcement learning models.33 B – Merger Control Merger control differs from investigations of anticompetitive practices. As it turns out, these differences have implications for computational antitrust. First, antitrust agencies must make a decision in all the concentrations notified to them. And they have a limited time to do so. As a result, the probability that agencies are making decisions under uncertainty is greater in merger control than in anticompetitive cases where they pick investigations that may go on for long periods. The more documents there are, the greater the uncertainty considering that agencies may face great complexity during the analytical process.34 For example, the European Commission has examined over 2.7 million documents in the merger between Bayer and Monsanto.35 The Department of Justice has been facing similar issues.36 These difficulties in processing all the data (in the allotted time) is problematic considering that data are the backbone of merger analysis.37 Computational antitrust could then prove helpful by providing agencies with the tools to analyze extensive data sets within the time constraint.38 Second, companies are very much in charge of the data being sent—as there are no injunctions to produce specific records, no dawn raids, and no discovery procedures (where applicable). It creates a first asymmetry between companies and agencies. For example, the European Commission underlined in Dow/DuPont that “the Parties did not mention their internal databases on crop protection patents and did not provide their competitive intelligence reports on competitors’ crop protection patents in their responses to several initial Commission’s requests for information.”39 This made the analysis more “difficult” than it should have been.40 At times, this asymmetry even leads to questioning the integrity of the data. In the WhatsApp case, for instance, the Commission imposed a €110 million sanction on Facebook for providing misleading information.41 Once the agency has received the data, it processes it without sending it back to the companies.42 That triggers a second asymmetry, thus making merger procedures more obscure than they could be. Computational antitrust could fix these asymmetries by introducing a systematized communication tool between companies and antitrust agencies. It could ensure that companies send (in realtime) agencies all information in specified databases and that firms get access to it once it has been processed.43 Besides, one could use blockchain for creating immutable databases and ensure their integrity.44 Finally, one can imagine that computational tools will ultimately lead to more dynamic merger analyses.45 Automated processing of big data is already allowing agencies to understand market power better. The first advances in computational antitrust have been made in that field starting in the mid-1990s thanks to simulation models’ implementation.46 They are used, for example, to measure product substitutability or efficiency claims.47 Over time, computational methods will open new possibilities. One could think that they will allow companies and agencies to understand the competitive pressure between non-substitutable products, to quantify dynamic capabilities, and model pro-innovation policies.48 Static variables will slowly make room for dynamic ones, if so desired. C – Antitrust Policies Computational methods will benefit the design, monitoring, and evaluation of antitrust policies. This will be achieved thanks to a combination of retroactive and predictive analyses. First, computational techniques will improve retrospective of antitrust investigations, merger control decisions, and public policies. These retrospectives are notoriously challenging, and costly, to conduct. To be sure, antitrust agencies carry out high-level retrospective analyses in their annual activity reports, but these studies are mostly qualitative, and the level of aggregation is high. Recently, several agencies—including the Federal Trade Commission and the French antitrust agency49—have expressed their intention to conduct more targeted empirical studies for analyzing past merger decisions involving large digital firms.50 Using a computational approach, agencies could carry out similar studies regarding their jurisprudence in which anticompetitive practices have been punished. After sanctions have been imposed, the (automatic) collection of market data could, for example, provide valuable information on their effectiveness, whether they are strictly monetary or also including structural and behavioral remedies.51 They could also better estimate consumer savings thanks to their decisions and orient them accordingly.52 Furthermore, antitrust agencies could systematically audit their processes to ensure they stay effective in a fast-changing technological environment.53 Finally, they could carry out empirical studies of specific industries,54 for example, to understand what conditions have allowed the emergence of new players when the market was deemed to have tipped.55

#### Big data uses data asymmetries to crush nascent competitors.

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Before the Big Data era, dominant tech firms were less aware of what their customers and rivals were doing (or planning to do). As Chapter 2 discusses, some platforms have a relative advantage in accessing and analysing data to discern consumer trends well before others. As we saw, companies can nowcast, ie, ‘predict the present’ by using search inquiries, social network postings, tweets, etc. Nowcasting can yield a competitive advantage. Hedge funds, for example, are nowcasting to see in real- time how market forces are affecting portfolios, such as how many cars are in the Wal- Mart parking lots across the country.32 In monitoring search queries, Google can predict flu outbreaks well before the government health agencies can. Twitter’s data can help companies identify emerging trends. Google and Apple, in controlling the mobile phone app stores, immediately know when users download rivals’ apps. As the UK competition authority observed, A number of third party firms also now offer tools and services that enable first parties to gain insights on how their brands and products are being discussed online (sometimes referred to as ‘social listening’, ‘opinion mining’ or ‘sentiment tracking’). By analysing the extent to which they are mentioned in social media content (such as blogs, microblogs, forums, news sites and social network sites), whether trends are positive or negative and why, firms can adjust their marketing activity.33 Nowcasting represents a potent data- based weapon, not previously available for monopolies, to monitor new business models in real-time. The data- opoly can use its relative advantage in accessing and processing personal data (such as watching for trends in its proprietary data from posts on a social network, search queries, emails, etc) to quickly identify (and squelch) nascent competitive threats. The dominant firm can acquire entrants before they become significant competitive threats or blunt the entrant’s growth (such as manipulating its search engine results to make it harder to find the company34). For example, Facebook warns its investors that its ‘[p] latform partners may use information shared by our users through the Facebook Platform in order to develop products or features that compete with us’.35 Thus, it is as if the monopoly invented a radar system to monitor in real-time the competitive portals. It can track nascent competitive threats shortly after they take off, and intercept or shoot them down long before they become visible to regulators and others. Moreover, the courts and agencies, if they follow the UK competition authority’s logic in Google/ Waze, will find that the distant planes pose potential (yet speculative) threats, and will have insufficient evidence to prove that competition was likely harmed. The monopolist, however, is not troubled by the overall welfare effects in shooting down or intercepting the planes. Granted, the monopolist may damage its reputation, if it acts too brazenly, but reputational concerns generally do not inhibit some monopolies from raising prices. For entrants, there is the potential reward of being acquired. But there are also casualties when the monopoly shoots down others. If the blown-up planes come easier to mind, then some potential entrants (or funders), under the availability heuristic, may amplify the risk, and decide not to leave the runway. And the competition authority cannot force (or incentivize) entrants to fly towards the monopolist armed with this radar. The European Data Protection Supervisor asked competition officials to consider (in coordination with privacy and consumer protection officials) the following issues: • first ‘how the control of personal information contributes to market power in the digital economy and the implications for data protection’ and • second ‘the risks to the consumer posed by concentrations and the abuse of market dominance where firms process massive amounts of personal data’.36 Big Data can help prolong monopolies in at least two ways: data-driven network effects and this unique ‘nowcasting’ radar. In accessing consumer and other market data in real-time, some dominant firms can quickly detect and squelch competitive threats and close competitive portals. F. Keeping the Competitive Portals Open Competition law, when effectively enforced, can deter exclusionary and predatory practices and keep competitive portals open. After all, it is easier for the creative destruction to breeze through a window screen than topple a concrete wall. Big Data, as we saw, can confer power and a durable competitive advantage.37 Data-driven network effects can improve the product’s or service’s quality. Firms like Google thrive (and serve their users) by gathering as much data as possible to personalize search results. At times, consumers benefit from this competitive rivalry and drive to maintain a data-advantage. Companies innovate to expand their platform of services to secure a greater following. No one, for example, questions Google’s investment in technology.38 But when the stakes are greater, so too are the incentives to engage in unfair practices to tip the market in one’s favour and maintain a monopoly.39 Consequently, competition authorities must be alert to dominant companies’ unfair practices to thwart competitors and disruptive innovators. We outline below several potentially anticompetitive data-driven tactics. 1. Exclusive dealing toÂ€prevent rivals from accessing critical data One historic concern is when a monopoly, through exclusive dealing, deprives its rivals of a needed resource. For example, aluminium producers to extract aluminium from alumina, require a ‘very large amount of electrical energy, which is ordinarily, though not always, most cheaply obtained from water power’.40 To foreclose other aluminium producers, Alcoa in its contracts with several hydro-power companies, illegally added covenants binding the power companies not to sell or let power to anyone else for the manufacture of aluminium.41 Likewise, the European Commission considers that ‘such input foreclosure is in principle liable to result in anti-competitive foreclosure if the exclusive supply obligation or incentive ties most of the efficient input suppliers and customers competing with the dominant undertaking are unable to find alternative efficient sources of input supply’.42 Data in our industries is a critical input. Thus one obvious concern would be for a dominant firm to foreclose its rivals’ timely access to critical data. The DOJ had this concern in the Google/ITA Software case, where it prevented Google post-merger from restricting, through exclusive dealing, its rivals’ access to the airlines’ seat and booking class data.43 And in a merger between advertising firms, the European Commission inquired whether the competitors would still have access to ‘big data’ from other providers if post-merger, the merged entity were to develop its own ‘big data’ analytics platform, and deny access to its competitors.44 2.â•‡ Exclusionary practices toÂ€prevent rivals fromÂ€achievingÂ€scale As the US Court of Appeals for the Eleventh Circuit noted in 2015, a monopoly can violate section 2 of the Sherman Act when its exclusive dealing programme deprives smaller rivals of ‘distribution sufficient to achieve efficient scale, thereby raising costs and slowing or preventing effective entry’.45 So too a dominant data-driven company can use exclusionary tactics to prevent rivals from achieving the minimum efficient scale.46 Scale, as Chapter 12 discusses, can be especially important in data-â•‰driven industries, such as search and search advertising. We saw, for example, how increasing the volume of both ‘tail’ and popular search queries can improve the quality of the search algorithm’s results. In unfairly preventing smaller rivals and potential entrants from accessing critical data, the dominant firm can use the network effects (learning-by-doing, scope, and spill-over effects) to widen the quality gap over rivals, attract more users and advertisers, and expand its platform.47 The Federal Trade Commission (FTC) Bureau of Competition staff, from the released portions of its inadvertently produced report, recommended suing Google for several unfair practices. (The FTC Commissioners instead closed the investigation after Google voluntarily agreed to change some practices.) The FTC legal staff discussed the competitive significance of data and ‘substantial scale effects’ in the Internet search, search advertising, and search syndication markets.48 One alleged anticompetitive practice was Google’s use of exclusivity provisions to prevent its rival Microsoft from achieving scale, including the volume of search queries it received. Google used contractual restrictions, according to the FTC legal staff, to deny Microsoft critical scale and impair its ability to compete effectively in the markets for general search and search advertising.49 One can access a search engine in various ways, such as the browser one uses. Twenty companies (including AOL), the FTC legal staff found, account for 90 per cent of all search query volume. To steer users to its search engine, a search engine provider (like Google, Microsoft, or DuckDuckGo) can enter into distribution agreements with these entry points, namely hardware manufacturers, independent software vendors, and Internet service providers, ‘to distribute toolbars and establish default settings that direct user searches to [its] search engine’.50 Google, the FTC legal staff reported, had exclusive or restrictive agreements with four of the top five companies, and 12 of the top 20.51 Google, for example, is the default engine on Apple’s Safari Internet browser. Google reportedly paid Apple USD 82 million in 2009, and USD 1 billion in 2013 and 2014 for this partnership.52 Google’s internal documents, the FTC legal staff found, showed that ‘Google’s interest in renewing deals with some of its largest syndication customers may have been, in part, to keep Microsoft from gaining scale’.53 Interestingly, Amazon decided it was in its long- term interest to funnel some query volume to Microsoft’s Bing, even if it was losing money on each query.54 One wonders why others did not do this. Perhaps, as the European Commission generally noted from its market investigation, the distributors’ major concern was Google’s bargaining power.55 3. Dominant firm leverages its data- advantage in a regulated market to another market We saw in Chapter 9 how the regulated French energy monopoly GDF Suez was using its vast customer database to target customers in the unregulated market with deals on gas and electricity.56 Since 2007, French gas customers could opt for the regulated tariffs, which only the incumbent operator GDF Suez offered, or the ‘market’ offers, which GDF Suez and its new rivals offered. In making its market offers, GDF Suez had an unfair advantage over its rivals. It was using the data it collected as a regulated monopoly to target customers with customized offers based on their usage. The personal data in question was commercially valuable. With the data a company could precisely locate gas consumers, identify their consumption level, and propose offers better suited to their profile.57 The data was unavailable to the monopoly’s competitors. Nor could the competitors replicate this data. Moreover, the database was not the ‘product of a specific innovation that GDF Suez may have introduced’ but was ‘merely inherited from its former status as monopolistic gas supplier’.58 GDF Suez was found in 2014 to have abused its dominant position. In a similar case, the Belgian Competition Authority in 2015 fined the National Lottery EUR 1,190,000 for abusing its dominant position when launching its sports betting product Scooore!59 Here, too, the defendant used the data it collected as a legal monopoly in organizing public lotteries to enter the sports betting market. The monopoly used the contact details of persons registered in its database to email them about launching Scooore! The National Lottery ‘did not acquire these contact details following competition on the merits but in the context of its legal monopoly’.60 Nor could competitors reproduce the data ‘at reasonable financial conditions and within a reasonable period of time’.61 In both cases, the dominant firm acquired the data through its legal monopoly. Monopolies in other industries may distinguish these cases. For example, they might have amassed the data following competition on the merits, such as an innovative app. That would be a closer call. But if the firm used other unfair tactics to attain or maintain its dominant position, then arguably using the valuable consumer data from its illegally maintained or attained monopoly is not competition on the merits. Even here, the competition authority must show why competitors could not reproduce the data under reasonable financial conditions and within a reasonable time period. 4.â•‡ Increasing customers’ switchingÂ€costs To maintain its data-advantage and prevent rivals from attaining scale, a monopoly may make it harder for its customers to leave. Customers, if they are locked-in, will continue to supply the monopoly (rather than its competitors) with data. The basic premise is that as the time and cost needed to switch products or services increase, the greater the customer is locked- in, the harder it will be for rivals to attract users and achieve scale. This is especially the case where consumers cannot readily predict the long- run costs in using that platform or its quality levels over time.62 Network effects, as we saw, can increase users’ switching costs. For example, users concerned over Facebook’s privacy policies may want to switch to another social network. But unless they can get their friends, family, and acquaintances to switch, they will likely stick with Facebook (if they continue using a social network). This lock- in effect, by itself, does not violate the competition law. Other users’ utility can increase as more join the social network, as they have more people to befriend online. But a firm can abuse its dominant position by undertaking additional actions, the net effect of which is to increase users’ switching costs and the firm’s power. One way, in the European Commission’s case against Microsoft, is to reduce the interoperability with other systems or platforms.63 Likewise, in its Facebook/ WhatsApp investigation, the Commission inquired, among other things, whether: • users of the consumer communications apps were locked in to any particular physical network, hardware solution, or anything else that needed to be replaced in order to use competing products; • the parties controlled and limited the portability of users’ data; and • the parties had any means to preclude competitors from recreating a user’s network on the parties’ applications.64 Presumably, if the answer was yes, the risk of anticompetitive unilateral conduct increases. Facebook and WhatsApp users, the European Commission concluded, could easily port their contact data to other texting apps. (Moreover, texting data, the Commission found, had little long- term value.) But if consumers invested a lot of time and effort in the service, such as a homepage with photos, timeline, updates, etc, and the dominant firm blocked customers’ ability to port their data, when data portability was technologically feasible, that would raise antitrust concerns. The switching cost can be as subtle as setting the app or service as the default option, thereby requiring consumers to opt out each time they want to use another service. 5.â•‡ Vertical integration byÂ€a dominant platform operator We saw in Chapter 14 why platforms are worth billions, while apps are worth millions. Apple and Google have significant power in effectively controlling the respective mobile operating systems iOS and Android.65 Both Google and Apple have business interests in ‘targeted advertising’ and ‘run the two biggest services, by revenue, for putting advertisements on mobile phones’.66 Google especially relies on personal data for maintaining a competitive advantage for advertising.67 As such, they have a greater incentive to prevent the personal data being diverted (as well as individuals’ using rival apps). To maintain and secure fresh sources of valuable data, Apple and Google have greater opportunities to introduce their own applications and foreclose rival applications on their smartphone platforms. Thus there is a greater risk of exclusionary behaviour.68 Competition authorities are sensitive to vertical integration by a dominant platform operator (ie where it also becomes a seller on its platform). The platform’s incentives now change, as it may earn greater profits by steering users and advertisers to its own products and services to the detriment of rival sellers (and contrary to consumers’ wishes). The platform has a ‘frenemy’ relationship with the independent application developers.69 The platform and independent apps are friends—â•‰in that both benefit as more users and complementary software developers are attracted to that platform, as opposed to rival platforms. Such will be the case when it is costly or time- consuming for independent software developers to customize, promote, and update their apps across multiple platforms or where one platform imposes greater restrictions on functionality, terms of sale, advertising, etc. The platform operator, however, is also competing with the independent software developer’s app, and thus an enemy.70 As the Organisation for Economic Co- operation and Development (OECD) warned, the platform owner ‘may seek to exclude third- party applications developers, either to protect its own vertically integrated applications subsidiary or to prevent the emergence of a potentially competing platform’.71 Thus in its Facebook/ WhatsApp investigation, the European Commission inquired whether: • the parties controlled any essential parts of the network or any mobile operating system; and • the parties’ applications were pre- installed on a large base of mobile phones, tablets, or PCs, and if so whether ‘status quo bias’ could potentially affect consumers’ choices.72 Likewise, Facebook in 2015 warned investors of the risk of the dominant mobile platforms inhibiting Facebook’s apps or preferring their own programs or services.73 So did Twitter, LinkedIn, Yelp, and smaller online platforms, like Coupons.com. They all noted their dependence on the Apple and Android mobile platforms.74 They recognize that web usage is increasingly shifting to mobile platforms such as smartphones and other connected devices.75 Their business growth and success depend on their interoperability with the popular mobile operating systems that they do not control.76 So one significant business risk is if the mobile super- platforms— Apple and Google (and to a much lesser extent Microsoft)— change the mobile operating systems that degrade the functionality of the independent apps and online platforms— like Twitter, Yelp, or Coupons.com— or give preferential treatment to their own similar services or competitive services. Facebook identified several potential anticompetitive measures by the mobile superplatforms including: • degrading the independent app’s functionality, • reducing or eliminating the independent app’s ability to distribute its products, • giving preferential treatment to competitive products, or • limiting for any app whose revenues are primarily from advertising its ability to deliver, target, or measure the effectiveness of ads, or imposing fees or other charges related to its delivery of ads.77 In its 2012 Annual Report, Facebook warned that ‘[c] ertain competitors, including Google, could use strong or dominant positions in one or more markets to gain competitive advantage against us in areas where we operate including: by integrating competing social networking platforms or features into products they control such as search engines, web browsers, or mobile device operating systems; by making acquisitions; or by making access to Facebook more difficult.’78 Facebook, given its apps’ strong consumer appeal, has less to fear than smaller, lesser known apps. To make it harder for consumers to access and use the smaller independent apps on their smartphones, the super- platform could: • degrade the independent app’s functionality by having it run slower than the operating system’s app,79 • reduce or eliminate the independent app developer’s ability to distribute its app by making it harder for consumers to find the app on its search engine or app store,80 • limit a competing app’s revenue stream by excluding the app from its online wallets, such as Apple Pay and Google Wallet, or • give preferential treatment to its own products, by pre-loading its app on the smartphone, having it on the opening screen,81 or integrating its own products into its other popular products, including its search engine and the operating system. These concerns are real. One example is Bankrate Inc. Its website allows users to compare online the rates of over 300 financial products, including mortgages, credit cards, automobile loans, money market accounts, certificates of deposit, checking and ATM fees, home equity loans, and online banking fees. As the Internet’s ‘leading aggregator of financial rate information’, Bankrate, according to its website, ‘continually surveys approximately 4,800 financial institutions in all 50 states in order to provide clear, objective, and unbiased rates to consumers’.82 During the fourth quarter of 2015, Google began testing a competing service called Compare Credit Cards. Google’s search engine displayed its own service more prominently on credit card- related search results than Bankrate’s service.83 The fallout was significant. First, Google’s actions ‘adversely affected’ Bankrate’s ‘Credit Cards segment growth and profitability’.84 Second, Bankrate’s stock price, after this news was released, declined 48 per cent in one day, a record drop for the 40- year old company.85 Bankrate’s stock plummeted even though Google earlier announced that it was terminating its Compare services, including Compare Credit Cards.86 Investors were still jittery. Bankrate, along with many other companies, depends on Google’s search engine to attract a significant portion of visitors to its website. As one analyst commented, ‘Bankrate faces an uncertain future, in our opinion, as its ability to maintain low- cost traffic and consistent monetization appears threatened by changes over which it has little control’.87 The browser war between Microsoft and Netscape in the 1990s is another example. The DOJ challenged several actions Microsoft took in integrating its Internet Explorer browser into its Windows operating system. In technologically binding its browser to Windows, Microsoft, the district court found, both prevented original equipment manufacturers from pre- installing other browsers and deterred consumers from using them.88 The US Court of Appeals for the DC Circuit affirmed that Microsoft’s commingling of its browser and operating system code violated section 2 of the Sherman Act.89 So, too, the super- platform can abuse its dominant position by fusing its app with its operating system code, when it does not achieve any real integrative benefits, but helps maintain its data-advantage and monopoly by reducing users’ likelihood of using competing apps. Moreover, data- driven exclusionary conduct may unite some within the Chicago and post- Chicago Schools. University of Chicago professor Dennis Carlton is a member of the Chicago School. Like others in the Chicago School, Carlton is generally sceptical about antitrust enforcement directed towards exclusionary conduct by a monopolist. Carlton, however, accepts that there is a legitimate role for antitrust in refusal to deal cases in certain situations.90 Significantly, he has argued that antitrust enforcement is appropriate in dynamic industries (such as the computer industry) where network effects are present and where scale is especially important to the ability to compete. He argues that: in a dynamic model, the cost of being small initially can be magnified in later periods, especially with assumptions about network dependencies, importance of installed base, or scale economies. In those settings, strategic behavior designed to keep a rival small initially can yield later significant competitive advantage.91 Carlton finds these conditions satisfied (and enforcement appropriate) in Lorain Journal, where the owner of a local newspaper, which was the major local advertising vehicle, responded to the entry of a local radio station by refusing to deal with customers who advertised on the radio.92 Carlton notes that most commentators have viewed the case as suggesting that radio and newspapers are substitutes, but it is better to view them initially as complements for some advertisers— ways of reaching different demographic groups. However, over time, radio could grow into a substitute. So, Carlton suggests, the exclusionary conduct was ‘designed to so limit the size of the radio station that it could not survive as a vigorous competitor later on’.93 Similarly, Carlton argues that the government’s Microsoft cases were appropriate. The first case involved de facto exclusive dealing by Microsoft, which required computer manufacturers to pay Microsoft a licence fee based not on how many computers they shipped with the Windows operating system but based on how many computers they shipped in total. The second case involved contracts with computer manufacturers that either required or created incentives for exclusivity in browsers. Carlton notes that these cases, similar to Lorain Journal, are properly viewed as limiting potential rivals to the operating system monopoly from attaining efficient distribution.94 The European Commission in 2015 opened a formal investigation involving Google’s Android. Although Android is an open- source mobile operating system, which others can freely use and develop, Google controls the operating system through its licensing agreements. As the Commission stated, the ‘majority of smartphone and tablet manufacturers . . . use the Android operating system in combination with a range of Google’s proprietary applications and services. In order to obtain the right to install these applications and services on their Android devices, manufacturers need to enter into certain agreements with Google.’95 The European Commission is investigating whether Google has • ‘illegally hindered the development and market access of rival mobile applications or services by requiring or incentivising smartphone and tablet manufacturers to exclusively pre- install Google’s own applications or services’; • ‘prevented smartphone and tablet manufacturers who wish to install Google’s applications and services on some of their Android devices from developing and marketing modified and potentially competing versions of Android (so- called “Android forks”) on other devices, thereby illegally hindering the development and market access of rival mobile operating systems and mobile applications or services’; and • ‘illegally hindered the development and market access of rival applications and services by tying or bundling certain Google applications and services distributed on Android devices with other Google applications, services and/ or application programming interfaces of Google’.96 Besides Android, the Commission is investigating several other Google business practices: (i) The use by Google without consent of original content from third-party web sites in its own specialized web search services. (ii) Agreements that oblige third-party web sites (‘publishers’) to obtain all or most of their online search advertisements from Google. (iii) Contractual restrictions on the transferability of online search advertising campaigns to rival search advertising platforms and the management of such campaigns across Google’s AdWords and rival search advertising platforms.97 Moreover, the Commission in 2015 issued its statement of objections over Google degrading the quality of its search results by systematically favouring its own comparison shopping products in its general search results page.98 It bears noting that these allegations have not been proven in court. The Commission’s open investigations as of early 2016 have not reached statement of objections or formal action, and even the statement of objections are preliminary, with Google having the right to respond. Our point here is not Google’s potential liability, but to illustrate the types of abuses by dominant firms that touch on Big Data. To adequately assess these claims, the competition authority and court must understand the competitive significance of the four ‘V’s— volume, variety, velocity, and value— of data, the data- driven network effects, and how these data- driven strategies may help companies attain and maintain their dominant position and leverage their power across markets. G. An Object All Sublime, the Competition Authority Shall

Achieve in Time— to Let the Punishment Fit the Crime Lastly, competition authorities must respond swiftly to prevent data- opolies from benefitting from their unfair data- driven practices. As we saw, data- driven network effects increase firms’ incentives to resort to unfair tactics. As the benefits from illegality increase, so too must the magnitude and probability of punishment increase to deter the anticompetitive behaviour. Otherwise, monopolization pays. In the US, monopolization pays. The DOJ criminally prosecuted more persons in one year under the Migratory Bird Treaty Act (227 in 2012)99 than it has civilly and criminally prosecuted monopolies over the past 35 years (13 since 1980).100 Between 2005 and 2014, the DOJ opened only 19 monopolization investigations, and brought only one case (in 2011).101 Thus a monopoly has more to fear about its wind turbine killing a golden eagle102 than its executives killing off a competitor. In the US, executives conceivably could go to jail for monopolization. Over the past 50 years, Congress has increased the maximum criminal fines and term of incarceration for Sherman Act violations. From a misdemeanour, the criminal penalties now stand as a felony with up to ten years’ imprisonment and a fine up to USD 100 million for corporations and USD 1 million for individuals.103 The Sherman Act does not delineate which conduct should be criminally or civilly prosecuted; this has been left to the DOJ’s discretion. The DOJ, however, has not criminally prosecuted firms or individuals for violating section 2 since the 1970s.104 Since the Reagan administration, the DOJ has criminally prosecuted only horizontal, per se illegal agreements among competitors, such as price-fixing, bid rigging, and customer and territorial allocations. Nor has the FTC brought many monopolization cases.105 The antitrust fines likely represent a fraction of the monopoly profits. This is especially so, when dominant firms can avoid antitrust liability for their abuses in jurisdictions like the US. Class action antitrust lawsuits, under the recent Supreme Court decisions, are harder to bring. If there is a problem with class action settlements in antitrust cases, the American Antitrust Institute found, ‘it is that plaintiffs sometimes settle strong cases for too little, not weak cases for too much’.106 While running for president Barack Obama criticized the Bush administration for having ‘what may be the weakest record of antitrust enforcement of any administration in the last half century’. 107 Obama noted that ‘in seven years, the Bush Justice Department has not brought a single monopolization case’.108 Obama promised to ‘reinvigorate antitrust enforcement’ and ‘step up review of merger activity.’109 Now with his second term coming to an end, the same criticism has been made about his administration.110 Many tech firms’ business models depend on collecting and monetizing consumer data. Several network effects can enable the company to become so firmly entrenched, so dominant in a given market, that it has both the ability and incentive to squelch competition, including by mavericks who challenge that data- dependent business model. When that happens, the incentive to innovate and take on that data- opoly is diminished. Consumers, even though they continue to get many apps and services for free, are nonetheless harmed, including the loss of technology that advances their privacy interests. Although the EU is more active in investigating abuse of dominance cases, this cannot be left to one jurisdiction. Monopolization pays today. The incentives to abuse a dominant position, given the network effects, are even greater in datadriven industries. So, too, are the opportunities, especially for data- opolies with the nowcasting radar or controlling a critical platform, like smartphones. If the competition authorities ignore data- driven exclusionary and predatory conduct, then we will likely see more industries dominated by a few firms. Thus another signpost of progress is when the US and other jurisdictions investigate and swiftly prosecute data-driven abuses.

#### Antitrust big data reformation deters economy wide monopolization

**Stucke and Grunes** **2016**, (Maurice E. Stucke, Douglas A. Blaze Distinguished Professor of Law at the University of Tennessee, where he teaches antitrust, privacy, business torts, law and economics, and evidence, Allen P. Grunes, o-Founder of the Konkurrenz Group in Washington D.C. Mr. Grunes spent more than a decade at the U.S. Department of Justice Antitrust Division, where he led many merger and civil non-merger investigations. *Big Data And Competition Policy*, Oxford Press // DELO

Although some argue that Big Data is a passing fad with no antitrust implications, others, including the Organisation for Economic Co-â•‰operation and Development (OECD) and European Data Protection Supervisor (EDPS), recognize the need for a better understanding of the implications of a data-â•‰driven economy on competition policy, privacy law, and consumer protection.1 Given the rise of data-â•‰driven business models, and the risks and costs in ignoring or downplaying data-â•‰driven mergers, abuses by dominant firms, and anticompetitive business strategies, we cannot afford our competition officials to remain ignorant. Nor can competition agencies simply wait for the right case to present itself, which presents a good theory of harm. If the agency does not understand the competitive significance of the four ‘V’s of data, the competitive benefits and risks of data- â•‰ driven strategies, and the adequacy of its current tools, then it won’t necessarily know which case is the right case, nor will it know what to do with the ‘right’ case when its tools remain ‘price- centric’ for mainly single- sided markets. The competition agencies need to proactively increase their learning and refine their tools. So where should the competition authorities begin? We do not argue for more enforcement, simply for its own sake. We do believe that some competition officials and judges have overemphasized false positives and discounted false negatives. Nonetheless, there is a significant risk of false positives when competition authorities simply enjoin every merger by large tech firms. If Google or Facebook were to acquire Twitter, for example, the data- driven merger would raise many concerns. But we cannot say that the merger on its face violates the competition law. Instead we must have a theory of how the merger may increase entry barriers, help maintain dominance, degrade privacy protections, or empower exclusionary behaviour. So the first step is to recognize the antitrust implications of data- driven mergers and strategies. Competition agencies must avoid the ten myths and pitfalls that we examined in the earlier chapters, such as the temptation to examine the merger’s likely effects only on the ‘paid’ side of a multi- sided market, consider only ‘traditional’ entry barriers, assume that privacy considerations are irrelevant, treat data as essentially fungible, or even worse, assume that data is ubiquitous and inexpensive. Next the competition authorities must acknowledge that their price- centric analysis and categorization of mergers into horizontal, vertical, and conglomerate are ill- suited for data- driven mergers in multi- sided markets, where one side is free. Third, the competition authorities must recognize that firms, in markets characterized with data- driven network effects, may use anticompetitive tactics to tip the market in their favour, and use exclusionary practices to maintain or attain their dominance. Fourth, the competition authorities need to develop tools to screen data- driven mergers and identify categories of data- driven business strategies that likely yield significant pro competitive efficiencies. This last part outlines several steps to help competition authorities, courts, lawyers, and economists towards this end.

#### Ex-post cases fail - flipping presumption is needed to block algorithm collusion against nascent competitors

**ABA 21**, “Artificial Intelligence & Machine Learning: Emerging Legal and Self-Regulatory Considerations Part Two Competition Implications of Big Data and Artificial Intelligence/Machine Learning” Prepared By: American Bar Association, Antitrust Law Section Big Data Task Force February 2021, <https://www.americanbar.org/content/dam/aba/administrative/antitrust_law/comments/october-2019/clean-antitrust-ai-report-pt1-093019.pdf>

In 2020, the FTC began retrospective examinations of past acquisitions made by large technology companies, issuing orders to Alphabet (including Google), Amazon, Apple, Facebook, and Microsoft to provide the FTC with information and documents relating to prior acquisitions not reported to the antitrust agencies under the Hart-Scott-Rodino (HSR) Act.127 The FTC stated that one of the objectives of this investigation is to assess whether large tech companies are making potentially anticompetitive acquisitions of nascent or potential competitors that fall below HSR filing thresholds.128 Government enforcement and private actions involving monopolization and abuse of dominance allegations against large technology companies A threshold question in antitrust inquiries involving digital markets and platforms is the issue of market power. Can there be platform monopolies? As discussed in Section II.b, supra, key economic features of platforms include economies of scale, indirect network effects, and platform differentiation. These features affect the range of optimal antitrust policy. As always, assessments of market power must be grounded in the facts of each case and consider the competitive dynamics of the industries involved. In particular, relevant market definitions for platform services need to take into account multi-homing and network competition. For digital platforms, market share and pricing may not be accurate surrogates for determining market power because of how rapidly markets can shift. Conversely, free or even negative pricing (e.g., rewards for users) on one side of a multi-sided platform is not necessarily evidence of predation, as pricing on both sides of the platform should be considered. Similarly, exclusive contractual terms involving digital platforms reflect competitive necessities for protecting investments, rather than evidence of exclusionary conduct. Another question that often arises in market power inquiries involving digital platforms or services is whether a firm has a data monopoly. There are several challenges in carrying out that inquiry in practice. As a threshold matter, even if there were a data market where data is transacted from one firm to another,129 that market would likely not be a unitary one. That is, the data relevant for AI for self-driving cars would likely not be the same data set relevant for credit decisions. See Section II.b.i, supra. The following factors are likely to be relevant for inquiries of whether a firm has a data monopoly:

• There may be alternatives to the data at issue. For example, governments make available to the public at no cost a variety of data that may be used to develop AI applications.130 Moreover, myriad existing data and emerging data sources may exist because new products and services can generate new data sources, and because there may be many firms specializing in collecting and trading data. Adding to the complication is that the myriad of existing and emerging data sources may make it difficult to calculate market shares. • Platforms may not have control over the data they collect. For example, the right of data portability provided under Article 20 of the EU’s GDPR and other national and local laws131 allows customers to retain greater control over their data, and firms can dynamically bid for access. • Shelf-life for data may be short. Even if a company currently has the most extensive dataset, much of that data may become obsolete after a short time. As a result, even if one could measure market share and even if there was market concentration at a specific point in time, that might not shed any light on future market share/concentration. • Data needs to be processed and analyzed before it can yield valuable information. To that end, data may have little effect on competition. Rather, the availability of and accessibility to the technology for processing data (i.e., AI – technology and personnel) may present a more substantial constraint to new entrants than data. • It is also unclear what the relevant geographic market(s) might be for assessing data competition. While the market may be global since data can be collected, stored, and used in multiple national jurisdictions, certain data may be subject to data localization and cross-border transfer restrictions, creating localized data markets.132 Proper assessment of relevant geographic markets for data in each case should account for the industry conditions, the way data at issue is used, and what alternatives can act as economic substitutes.

Mergers and acquisitions

The predominant tool for competition law with respect to mergers and acquisition is government review. Common concerns about mergers in digital markets relate to the risk that an incumbent firm acquires new or potential future rivals. The pricing models of multi-sided markets, particularly “free” services, and ramp up to monetizing products that first become highly successful before generating much revenues, means that many mergers that might raise significant competition issues do not exceed merger notification thresholds that are set according to revenue. Some jurisdictions such as Germany have already introduced new thresholds based on the value of the transaction.133 In addition, the German Draft Bill (see Section III.d, infra) now proposed would allow the Bundeskartellamt to order certain companies to notify every merger (subject to a minimum revenue threshold) where there are indications that future concentrations may restrict domestic competition.134 In the United States, legislators have proposed creating higher merger thresholds for digital firms,135 and academics have proposed shifting presumptions for mergers and acquisitions in digital markets.136

The following is a summary of federal merger cases in the United States that implicate big data, machine learning, and artificial intelligence. Automatic Data Processing/AutoInfo (1995) In 1995 to 1996, Automatic Data Processing (ADP)’s acquisition of AutoInfo raised concerns that the firm would have an “information monopoly” on the systems used by scrapyards to trade salvage. This acquisition gave ADP control over the market for auto salvage yard 133 Press Release, Bundeskartellamt, Joint Guidance on New Transaction Value Threshold in German and Austrian Merger Control Submitted for Public Consultation, May 14, 2018, available at https://www.bundeskartellamt.de/SharedDocs/Meldung/EN/Pressemitteilungen/2018/14\_05\_2018\_TAW.html. 134 Section 39a of the German Draft Bill. 135 See Merger Enforcement Improvement Act, S.306 (116th Congress). 136 See J. Baker et al., Five Principles for Vertical Merger Enforcement Policy, ANTITRUST, Summer 2019. 45 information and management systems. These systems provided information that salvage yards use to take inventory of, buy, and sell parts. These systems included the ability of salvage yards to search a central database that pools inventory of subscribing yards. Most importantly, the information from this system could be collected and later sold.137 However, the FTC’s successful lawsuit against ADP, which resulted in a fine of $2.97 million, was not based on allegations of anticompetitive behavior. It was based on a violation of the HSR Act, which requires merging companies to submit, under item 4(c) of the HSR form, any documents they produced while assessing the benefits of the transaction. ADP did not file any 4(c) documents, even though the court later discovered that ADP did possess documents that it should have provided, including some that substantiated accusations the firm had behaved anticompetitively. DoubleClick/Abacus (1999) In the early days of the internet, many favored the development of online advertising models that could protect privacy. DoubleClick’s business model did not rely on the collection of personal information. In 1999, DoubleClick proposed to acquire Abacus, the largest catalog database firm in the United States Abacus collected detailed information about consumers’ offline purchases. At the end of 1998, the Abacus database contained over 88 million detailed buyer profiles compiled from records of over 2 billion catalog purchasing transactions. In its investigation, the FTC analyzed whether DoubleClick used “personal identifying information” from Abacus’ database to create user profiles for target advertising.138 The FTC, after eleven months of investigation, cleared DoubleClick of allegations it had invaded consumers’ privacy, arguing that DoubleClick never used or disclosed consumers’ personal identifying information for purposes other than those disclosed in its privacy policy. PayPal/eBay (2002) Data-related efficiencies was a key point in the DOJ’s clearance of eBay’s acquisition of PayPal. The merging companies both provided person-to-person payment systems used to complete transactions in connection with eBay auctions. Investigation concerns included eBay’s ability to control the use of PayPal on other sites. However, the DOJ concluded that the integration of the two companies “would make transactions more convenient for eBay 137 Press Release, Fed. Trade Comm’n, FTC Challenges ADP/Autoinfo Merger, Nov. 14, 1996, available at https://www.ftc.gov/news-events/press-releases/1996/11/ftc-challenges-adpautoinfo-merger. 138 Letter from Joel Winston, Acting Associate Director, Fed. Trade Comm’n, to Christine Varney, Esq., Hogan & Hartson, Jan. 21, 2001. 46 buyers and also improve the detection of fraud by combining the information that had been separately amassed by the two companies.”139 Google/DoubleClick (2007) Google already dominated search advertising, and both companies competed for online display advertising, although they concentrated on slightly different parts of the market. Both also held vast amounts of data. Opponents of the merger argued that the combination of this data raised privacy concerns and would give Google’s relevant ad intermediation product, AdSense, a competitive advantage over advertising rivals. In its investigation, the FTC analyzed relevant online advertising markets and found that all online advertising does not constitute a relevant antitrust market. This is because advertisers purchase different types of inventory for different purposes. Furthermore, AdSense was a leading provider of contextual advertising, and DoubleClick neither provided contextual advertising nor acted as an intermediary.140 On the other hand, the dissenting statement highlighted DoubleClick’s recent reentry into the intermediation market. In the end, the FTC voted 4–1 to close its investigation of Google’s proposed acquisition of DoubleClick after a thorough examination of the evidence bearing on the transaction. One of the arguments was that the evidence indicates that neither the data available to Google, nor the data available to DoubleClick, constitutes an essential input to a successful online advertising product. Reed Elsevier/ChoicePoint (2008) In 2008, the FTC challenged the $4.1 billion acquisition of ChoicePoint, a data aggregation company, by Reed Elsevier, a global provider of various professional information services. Although both companies provided many other products and services, both offered a subscription service to law-enforcement agencies to access public and nonpublic information on individuals and businesses. The FTC found that the merger would stifle competition between these competing offers to law enforcement by bringing them under a single owner, and required ChoicePoint to divest one of its key products, CLEAR, to Thompson Reuters, a competing information-service provider. Without divestiture, Reed Elsevier’s acquisition of 139 U.S. DEP’T OF JUSTICE & FED. TRADE COMM’N, COMMENTARY ON HORIZONTAL MERGER GUIDELINES (Mar. 2006), available at https://www.justice.gov/atr/commentary-horizontal-merger-guidelines. 140 Press Release, Fed. Trade Comm’n, Federal Trade Commission Closes Google/DoubleClick Investigation, Dec. 20, 2007, available at https://www.ftc.gov/news-events/press-releases/2007/12/federal-trade-commissioncloses- googledoubleclick-investigation. 47 ChoicePoint would allegedly give Reed Elsevier control over public and nonpublic information about individuals and businesses, including information regarding credit data, criminal records, motor vehicles, property, and employment records.141 Microsoft/Yahoo! (2008) The DOJ investigated and did not challenge the companies’ agreement to combine their backend search and paid search advertising technology. Combining back-end search and paid search advertising would be more likely to increase competition by creating an alternative to Google. The agency analyzed the relevant harm to and control of data of users of internet search functions, paid search advertisers, internet publishers and distributors of search, and paid search advertising technology.142 The agency concluded that the transaction would “enhance Microsoft’s competitive performance because it will have access to a larger set of [search] queries, which should accelerate the automated learning of Microsoft’s search and paid search algorithms.”143 The transaction would thereby create a more viable competitive alternative to Google. Dun & Bradstreet/Quality Education Data (2010) The FTC objected to the acquisition of QED, a company offering marketing services in the education sector, by MDR, a subsidiary of the business-information provider Dun & Bradstreet. The FTC alleged that the parties “were the only significant U.S. suppliers of [K- 12] educational marketing data,” and the merger would have created a monopoly in this market. The data sold by these companies is used to sell books, educational materials, and other products to teachers and other educators nationwide. Control over this data would allow Dun & Bradstreet power over not only access to data, but a say in how and what products are 141 Press Release, Fed. Trade Comm’n, FTC Challenges Reed Elsevier’s Proposed $4.1 Billion Acquisition of ChoicePoint, Inc., Sept. 16, 2008, available at https://www.ftc.gov/news-events/press-releases/2008/09/ftcchallenges- reed-elseviers-proposed-41-billion-acquisition. 142 Press Release, U.S. Dep’t of Justice, Statement of the Department of Justice Antitrust Division on Its Decision to Close Its Investigation of the Internet Search and Paid Search Advertising Agreement Between Microsoft Corporation and Yahoo! Inc., Feb. 18, 2010, available at https://www.justice.gov/opa/pr/statementdepartment- justice-antitrust-division-its-decision-close-its-investigation-internet. 143 Gregory Luib & Mike Cowie, Big (But Not Bad) Data and Merger Efficiencies, LEXOLOGY, Jan. 28, 2020, available at https://www.lexology.com/library/detail.aspx?g=3712daef-e9df-4584-83c3-ccfe465ea0f4. 48 sold to educators.144 In the final settlement, MDR agreed to divest some assets to MCH Strategic Data, to preserve competition in the market. Costar/LoopNet (2011) Costar, the largest provider of commercial real estate information services in the United States, acquired LoopNet, owner of the most-used commercial real estate information database in the country. The FTC challenged the transaction and required CoStar to sell some of LoopNet’s stake in Xceligent, another provider with a business model closely resembling CoStar’s, and which received data and financial investment from LoopNet. Both CoStar and Xceligent aggregate commercial real estate listings and property-specific information nationwide.145 Google/ITA (2011) The Antitrust Division of the DOJ filed a lawsuit to block Google’s acquisition of ITA Software, producer of QPX. The QPX software conducts searches for air travel fares, schedules, and availability. The DOJ’s complaint alleged that Google’s use of ITA’s software to provide its own price comparison service, which would compete with these firms, would give it the means and the incentive to cut off their access to QPX. The DOJ and Google reached a settlement whereby Google would be allowed to purchase ITA on the condition it licenses QPX to its competitors for five years. The DOJ’s focus was not that the data itself would give Google too much market power, but that access to QPX was excludable. The settlement allowed airfare websites to use this software on commercially reasonable terms.146 Bazaarvoice/PowerReviews (2012) In Bazaarvoice/PowerReviews, Bazaarvoice was the market-leading provider of ratings and review platforms that enable manufacturers and retailers to collect, organize, and display 144 See Press Release, Fed. Trade Comm’n, FTC Challenges Dun & Bradstreet's Purchase of Competing Education Data Provider, May 7, 2010, available at https://www.ftc.gov/news-events/pressreleases/ 2010/05/ftc-challenges-dun-bradstreets-purchase-competing-education-data. 145 Press Release, Fed. Trade Comm’n, FTC Places Conditions on CoStar’s $860 Million Acquisition of LoopNet, Apr. 26, 2012, available at https://www.ftc.gov/news-events/press-releases/2012/04/ftc-places-conditionscostars- 860-million-acquisition-loopnet. 146 Press Release, U.S. Dep’t of Justice, Justice Department Requires Google Inc. to Develop and License Travel Software in Order to Proceed with Its Acquisition of ITA Software Inc., Apr. 8, 2011, available at https://www.justice.gov/opa/pr/justice-department-requires-google-inc-develop-and-license-travel-softwareorder- proceed-its. 49 consumer-generated product reviews and ratings. Bazaarvoice and PowerReviews were the two largest providers of ratings and review platforms in this space. In 2013, the DOJ filed a lawsuit seeking to restore the competition that was extinguished by the transaction. The agreed-upon remedy required Bazaarvoice to sell all of the PowerReviews assets to a divestiture buyer, among other things, to allow for the divestiture buyer to quickly achieve the competitive position that PowerReviews would have occupied.147 Nielsen Holdings/Arbitron (2013) The FTC sued Nielsen, an audience-measurement company, because it feared Nielsen’s acquisition of Arbitron, a provider of cross-platform ratings services, would allow Nielson to become a nationwide monopoly provider of cross-platform audience-ratings services, a market that does not exist in the United States, but which Nielsen and Arbitron would have been positioned to develop. Nielsen was a leading provider in global media measurement and research services, and provides television, online, mobile, and cross platform audience measuring services to media companies. Arbitron was also a media measurement and research firm that provides radio rating services. The FTC alleged that combining both platforms to create a cross-platform rating service would have caused an uneven playing- field in the ability to provide this data to media companies.148 Google/Nest Labs (2014) In 2014 Google announced that it would pay $3.2 billion in cash to purchase Nest Labs Inc. Nest Labs is the manufacturer of a home thermostat that links to the internet. Unlike its predecessors, Nest’s device monitors residents’ behavioral patterns, including temperature preferences and comings and goings to optimize heating and cooling over the day. The company later introduced a smoke and carbon monoxide detector and a security camera that also collect data. At the time of the merger, privacy advocates worried that the merger would give Google intimate insight into the private offline behavior of Nest customers, giving it an unprecedented ability to target them for advertising. The FTC disagreed, quickly deciding not 147 Press Release, U.S. Dep’t of Justice, Justice Department and Bazaarvoice Inc. Agree on Remedy to Address Bazaarvoice’s Illegal Acquisition of PowerReviews, Apr. 24, 2014, available at https://www.justice.gov/opa/pr/justice-department-and-bazaarvoice-inc-agree-remedy-address-bazaarvoice-sillegal- acquisition. 148 Press Release, Fed. Trade Comm’n, FTC Puts Conditions on Nielsen’s Proposed $1.26 Billion Acquisition of Arbitron, Sept. 20, 2013, available at https://www.ftc.gov/news-events/press-releases/2013/09/ftc-putsconditions- nielsens-proposed-126-billion-acquisition. 50 to challenge the merger. Nest Labs promised not to share its data with Google without users’ permission.149 CoreLogic/DataQuick (2014) The FTC intervened in CoreLogic’s acquisition of DataQuick. Both CoreLogic and DataQuick were providers of property information and analytics to the real estate, mortgage lending, and secondary investor markets in the United States They were also two of the only three providers of national assessor and recorder bulk data. Although much of the data in question is generated regionally by many different companies, the FTC argued that the merger would have created a monopoly on national data because simply aggregating the available regional data did not provide national coverage. CoreLogic agreed to license some of its national bulk data to Renwood RealtyTrac, a competitor, in order to strengthen that firm and improve competition in this field. The shift in license to RealtyTrac halts DataQuick’s opportunity to control a majority of national assessor and recorder bulk data as well as several other ancillary data sets.150 The competition issue at the heart of this case was not the amount of data the companies held, but the reduced competition in the market to sell this information that would have occurred through the proposed merger. Therefore, the FTC cleared the transaction with a database divestiture. Facebook/WhatsApp (2014) Facebook uses the data generated by its network to offer better services to both users and advertisers. WhatsApp was a rival cross-platform messaging service that was rapidly gaining new users. Unlike Facebook, WhatsApp did not sell advertising space nor collect large amounts of personal data on its users. Instead it charged some users a small fee. When Facebook proposed to acquire WhatsApp in 2014, many privacy advocates worried that the merger would eliminate a main challenger to Facebook and reduce options for users who valued privacy. The FTC approved Facebook’s $19 billion dollar acquisition WhatsApp, stressing that WhatsApp must honor its commitment to maintain its pre-Facebook privacy practices. These policies include refraining from collecting names, emails addresses, or other 149 Rolfe Winkler & Alistair Barr, Nest to Share User Information with Google for the First Time, WALL ST. J., June 24, 2014, available at https://blogs.wsj.com/digits/2014/06/24/nest-to-share-user-information-with-google-forfirst- time/. 150 Press Release, Fed. Trade Comm’n, FTC Puts Conditions on CoreLogic, Inc.’s Proposed Acquisition of DataQuick Information Systems, Mar. 24, 2014, available at https://www.ftc.gov/news-events/pressreleases/ 2014/03/ftc-puts-conditions-corelogic-incs-proposed-acquisition-dataquick. 51 information from its users’ mobile address book or contact lists other than mobile phone numbers. Without this agreement, Facebook would have had access to hundreds of millions of more user profiles that it could sell or share otherwise.151 Microsoft/LinkedIn (2016) The investigation addressed data access and innovation of LinkedIn data that could, in theory, be used with Microsoft’s machine learning capabilities to improve lead generation capabilities of Microsoft’s Dynamics customer relationship management (CRM) software. The FTC found that the merged entity would not have the ability to foreclose competing providers of CRM software solutions if it reduced access to LinkedIn full data because it would be unlikely to negatively affect the overall availability of substitutable data required for machine learning in CRM software solutions. Therefore, the FTC cleared the transaction.152 CVS Health/Aetna (2018) U.S. District Judge Richard Leon, before approving the settlement that allowed the merger, explained that it offered substantial efficiencies, including efficiencies driven by data integration. One of the major problems plaguing the U.S. healthcare system is that information is siloed. For example, physicians and hospitals may lack access to pharmacy claims data. Pharmacies may lack access to medical records. These inefficiencies can harm patients and lead to higher-cost, lower-quality care. Both CVS Health and Aetna have a significant share of the market in the sale of Medicare Part D prescription drug plans. Although inefficiencies from information silos could be solved by this merger, it could lead to anticompetitive practices in the control of these subsets of data of millions of healthcare members nationwide.153

C. Multi-firm conduct

Government and non-government litigants often challenge collusive behavior by competitors as a violation of competition laws. As technology advances and the cost of storing and analyzing data decreases, companies are turning increasingly to computer-driven algorithms in order to optimize business decisions. This raises the question of how those algorithms intersect with traditional prohibitions on conspiracy and collusion. While the applications of algorithmic decision-making are broad, the focus of this section will be on the use of computer-driven algorithms for the purpose of pricing goods. In a typical case, a company collects real-time pricing data, including competitor pricing data, and utilizes an algorithm to process the information and respond in real time to changes in market conditions. While this practice may have certain procompetitive benefits, antitrust regulators and private (i.e., non-government) litigants have challenged firms that have allegedly used pricing algorithms in anticompetitive, collusive ways. The sections below discuss three forms of algorithm-driven collusion that have drawn criticism from regulators in the United States and abroad: (1) explicit, (2) hub and spoke, and (3) tacit. 1. Explicit collusion When parties agree explicitly to collude and maintain an anticompetitive policy, typically agreeing on price or supply, it is a direct and intentional antitrust violation. The algorithms that help increase market efficiency and provide procompetitive benefits can also be used to enforce the collusive agreement by quick detection of any deviation from the agreed terms and programmatic retaliation. For example, an algorithm that allows a supplier to monitor its competitors’ prices and react competitively to price drops can also be used as an enforcement device to detect defections and quickly retaliate. The programmatic nature of the enforcement mechanism increases the agreement’s stability.154 The market structure, demand factors, and supply factors will have an impact on the likelihood of an explicit collusion enforced with algorithms. Specifically, market transparency and the frequency of transactions increase the likelihood of a collusion since the algorithms can detect a defection and suppliers can react. In contrast, a market characterized with constant innovation will decrease the likelihood of a collusive agreement since it reduces the present value of the collusion (the product is constantly changing) and reduces the ability of the less innovative firms to retaliate. Similarly, a market characterized by a large degree of product or service differentiation between suppliers will decrease the likelihood of a collusion since deviations might be harder to detect and the value of collusion could vary substantially between the parties due to their product differences.155 Collusions are typically not stable in markets characterized with large demand or supply fluctuations or other factors that require frequent price or supply adjustments since they would require multiple agreement changes, meetings, or other communications.156 The main differentiator between algorithmic collusion, per-se antitrust violation, and other potentially lawful algorithm-based conduct examples discussed below is the presence of an agreement between parties to collude, whether in oral or written form. While proven communications or whistleblowers are not required for the court to find parties engaged in a collusive agreement,157 it is the main vehicle for law enforcements to prove the presence of the collusion For most cases, analysis of the code allegedly used to enforce the collusion is not sufficient to prove unlawful conduct since, as mentioned before, the same algorithms can be used for both lawful and unlawful purposes. In the United States, the DOJ has successfully prosecuted cases of overt, algorithmic driven collusion. For example, in July 2015, an e-commerce seller in the United States was charged with, and pled guilty to, conspiring to fix the prices of posters sold through Amazon Marketplace. According to the charge by the DOJ, “[t]o implement their agreements, the defendant and his coconspirators adopted specific pricing algorithms for the sale of certain posters with the goal of coordinating changes to their respective prices and wrote computer code that instructed algorithmbased software to set prices in conformity with this agreement.”158 Three-and-a-half years later, in January 2019, the DOJ (with the assistance of the FBI) concluded its investigation and prosecution of the online wall décor industry with the conviction of another co-conspirator.159 This case is considered the first case targeting e-commerce and a proven conspiracy implemented with the use of algorithms. Outside the United States Greece’s antitrust regulator, the Hellenic Competition Commission, fined retailer Carrefour Marinopoulos €12.5 million in 2010 for “resale price maintenance,” requiring its franchisees to follow recommended sales prices. It was alleged that Carrefour’s IT system enabled the franchisor to monitor any deviations from the recommended sales price by franchisees and made individual price management difficult and time-consuming, effectively enabling Carrefour to enforce a collusive price across its franchise.160 Similar to the Carrefour case, regulators in the EU prohibit (or allow at a narrow extent) the use of most-favored nation (MFN) clauses by online platforms, arguing that such clauses dampen price competition across sale channels.161 MFN clauses imposed by online marketplace platforms such as Amazon, Booking.com, and Expedia require the vendors to refrain from offering their products or services at lower prices by other distribution channels. While MFN clauses are not generally prohibited in the United States, regulators have expressed concerns when they are present in agreements governing online platforms, and the party imposing the MFN utilizes algorithms to detect defections and enforce penalties over violations.162 Such growing concerns led Amazon in early 2019 to abandon its “Price Parity” policy, which prohibited third-party sellers on its platform in the United States from selling the same products at a lower price elsewhere online.163 Amazon ended the “Price Parity” policy for its platform in Europe in 2013 after regulatory agencies in the U.K. and Germany investigated Amazon over the same policy.164 Investigations and enforcement actions involving explicit collusions enforced by algorithms are rare, either because parties are less likely to enter agreements that are per-se illegal or because the required evidence to prove the conspiracy is high. The next discussed theory of collusion, hub and spoke, is much more present in current investigations and decisions. 2. Hub-and-spoke collusion The “hub-and spoke conspiracy” is one “in which an entity at one level of the market structure, the ‘hub,’ coordinates an agreement among competitors at a different level, the ‘spokes.’”165 “These arrangements consist of both vertical agreements between the hub and each spoke and a horizontal agreement among the spokes ‘to adhere to the [hub’s] terms,’ often because the spokes ‘would not have gone along with [the vertical agreements] except on the understanding that the other [spokes] were agreeing to the same thing.’”166 In hub-and-spoke conspiracies involving pricing algorithms, the “hub” serves as the party sending the pricing signal, and the “spokes” are the parties that receive the signal. Upon receiving these signals, the spokes can set their prices, and coordinate directly through a hub. Antitrust regulators have been active in bringing enforcement actions involving hub-andspoke conspi**r**acies and pricing algorithms. There are issues, however, that have challenged regulators seeking to identify such conspiracies in the first instance. The technology relied upon to implement such conspiracies obviates the need for frequent communications between coconspirators, thereby making it more difficult for regulators to obtain communications that evidence the illegal agreement. On the other hand, the internet has increased pricing transparency, making it easier for the hub to detect and penalize non-compliant members of the conspiracy. Evidence of retaliation—“penalty evidence”—has proven to be of significant evidentiary value in successful investigations and enforcement actions. The first enforcement action involving a hub-and-spoke theory of algorithmic price coordination began in 1992, when the DOJ filed a complaint against eight airlines and the Airline Tariff Publishing Company (ATPCO). Among other things, the DOJ’s complaint alleged that the airlines used the ATPCO, a jointly-owned company, to facilitate the hub-and-spoke conspiracy. Specifically, the airlines used the ATPCO’s online fare dissemination service to communicate with one another, thereby facilitating their horizontal agreement to increase price, eliminate discounts, and set fare restrictions. The DOJ resolved the charges by consent decree, and the U.S. District Court for the District of Columbia approved the settlement in December 1993.167 Outside the United States, regulators have been active in putting an end to similar forms of coordination. For example, in 2016, Russia’s competition agency began an investigation surrounding allegations of price fixing among retail sellers of Apple smartphones.168 The investigation concluded that “since the start of official sales of the Apple iPhone 5s, iPhone 5c, iPhone 6, iPhone 6 Plus, iPhone 6s and iPhone 6s Plus in Russia, most resellers fixed and maintained the same prices for these products during nearly three months.” The investigation also found that the retailers’ prices “coincided with prices from press releases and price lists published and distributed by LLC ‘Apple Rus’ employees from e-mail addresses in the apple.com domain.” The investigation concluded in 2017, after which iPhone prices “significantly decreased” and LLC Apple Rus was forced to pay a fine. The hub-and-spoke conspiracy was enforced by LLC Apple Rus aggressively. After issuing price lists to the retail “spokes” of the conspiracy, LLC Apple Rus utilized price monitoring software to detect and penalize non-compliance. Participating retailers, too, used price-monitoring software to collect competitor-pricing data. Retailers would then use this data to inform LLC Apple Rus about pricing deviations, expecting that the company would take action against defecting retailers.169 As these cases illustrate, sellers may find themselves liable for their involvement in huband- spoke conspiracies when they use third parties to make algorithmically-driven pricing decisions. One case that has not been addressed definitively by courts is whether hub-and-spoke liability might attach to popular ride-sharing companies like Uber and Lyft, which provide car owners with an application platform that they can use to connect with individuals seeking rides. For their service, Uber drivers charge the ride-hailing individuals a fare that is determined by Uber’s pricing algorithm. Uber drivers are not allowed to negotiate individually with riders. In private litigation in the United States, a federal district court found that a plaintiff had “plausibly alleged a [hub-and-spoke] conspiracy in which drivers sign up for Uber precisely on the understanding that the other [drivers] were agreeing to the same pricing algorithm, and in which drivers’ agreements with Uber would be against their own interests were they acting independently.”170 While no competition agency has yet addressed whether this arrangement gives rise to hub-and-spoke liability, the Court of Justice of the European Union (CJEU) has expressed concern that Uber’s business model “might give rise to hub-and-spoke conspiracy concerns when the power of the platform increases[.]”171 Whether Uber’s ride-sharing platform becomes so dominant may determine whether competition authorities challenge Uber’s pricing practices under a hub-and-spoke theory of liability.

3. Tacit collusion There are two types of algorithmic tacit collusion. The first is where firms in the market unilaterally develop algorithms targeted to profit maximize, and at some market setting these algorithms deploy pricing or supply policies that are supra-competitive without any agreement between competitors. These algorithms increase price transparency, reduce the reaction time to price changes, and eliminate human biases in price setting, potentially resulting in supracompetitive pricing.172 The second is machine-learning algorithms that learn to collude although they have not been specifically instructed to do so.173 Prevailing law in the United States does not deem tacit collusion unlawful. Conventional law and economics theory posits that such supra-competitive pricing resulting from tacit collusion is not problematic because it is likely to be unstable and shorter lived than if it were achieved through joint conduct.174 However, others argue that such conduct can be more stable than formal human-based agreements and that companies must take responsibility for anticompetitive behavior deployed by their algorithms, even when they did not intend to collude.175

There are few, if any, actions that have resulted in antitrust liability based on the two types of algorithmic collusion discussed above. However, in Eturas, the CJEU provided guidance as to the circumstances under which the unilateral adoption of a pricing algorithm may give rise to liability. The case involved travel agencies that adopted the same online-booking platform, Eturas, to facilitate travel bookings.176 After adopting the platform, an Eturas administrator sent an email in 2009 to a limited number of the travel agencies, which included a voting option to limit the discount cap for certain services offered by the agencies.177 Two days later, the Eturas administrator circulated another email informing its recipients that the discount cap had been approved.178 Eturas then implemented the discount cap on its platform, and it applied the cap to all participating agencies. The discount cap, however, was not fixed, but if a travel agency sought to provide a customer with a discount in excess of the cap, it would have to take additional steps to do so.179 The Lithuanian Competition Council imposed fines on Eturas and thirty travel agencies that used its platform.180 The case was ultimately appealed to the CJEU, which was tasked with addressing, among other things, the factors that should be considered in determining whether the travel agencies engaged in illegal collusion.181 The CJEU focused on the travel agencies’ knowledge of the administrator’s messages about the discount caps.182 If they had knowledge, courts could presume that the travel agencies colluded among themselves and with Eturas, unless they took actions to distance themselves from the agreement.183 The court held that the presumption could be rebutted in a number of ways.184 For example, by voting against the discount cap, reporting the conduct to the authorities, or consistently offering discounts in excess of the cap.185 Experimental evidence suggests that in certain market settings, such as a small number of sellers and frequent transactions (“repeated games”), it is theoretically possible that machinelearning algorithms will learn to collude, without communicating, and without being programmed to do so.186 However, the Antitrust Division of the DOJ and the FTC expressed the view that “these scenarios seem[ed] too speculative.”187 These concerns may be driven by doubts as to whether machine-learning algorithms can sustain collusion without additional support from humans.188 Having said that, if such collusion arises, companies can be held responsible for the algorithms they deploy, and the anticompetitive outcome created by their algorithm.189 However, machine programs, such as pricing algorithms, will only become an antitrust issue if they are used as instruments of collusion or conspiracy; independent adoption of such pricing algorithms by itself is likely beyond the reach of the antitrust laws. Although doubts remain, the theoretical possibility of collusion should not be dismissed. In a February 2020 report issued by the Antitrust Section of the American Bar Association, the Section noted that the “effects of pricing algorithms on consciously parallel pricing” may warrant more attention in light of advances in technology, and recommended that regulators “continue to evaluate such effects closely in order to determine when they may require further scrutiny under existing competition laws.”190 D. International reports and proposals Numerous governments, competition authorities, special commissions, and international organizations have examined competition and antitrust issues arising from big data and artificial intelligence in recent years. Following a joint study of France’s Autorité de la concurrence and Germany’s Bundeskartellamt in 2016191 and of the OECD also in 2016,192 as well as a study by Japan’s Fair Trade Commission in 2017,193 government competition authorities and commissions issued a number of studies in 2018 and 2019: • the EC’s report on “Competition policy for the digital era” (also known as the Crémer Report);194 • the U.K. Competition and Markets Authority (CMA)’s Digital Expert Panel report on “Unlocking digital competition” (commonly known as the Furman Report);195 • the Australian Competition & Consumer Commission (ACCC)’s “Digital Platforms Report”196 (which complements a 2017 Australian Productivity Commission report on “Data Availability and Use”);197 • the German Commission’s “Competition Law 4.0” report;198 • the Competition Bureau of Canada’s report on “Big data and innovation” (reinforced by the 2019 Competition Policy Council Communique);199 and • the G7 competition authorities’ “Common Understanding” on “Competition and the Digital Economy.”200 In addition, in the United States, the FTC has conducted hearings (including international hearings) to examine the competition, consumer protection, and data privacy implications of new technologies and business practices, including those associated with digital platforms.201 The Stigler Center of the University of Chicago also issued a “Study of Digital Platforms.”202 These studies broadly opine on the dynamics of competition in digital markets, including multi-sided platforms and zero pricing, as described above. Several of these reports have explored whether competition law has been under-enforced. The Furman and Crémer Reports assert that the risk of under-enforcement (wrongly permitting anticompetitive behavior) has not been given sufficient weight against the risk of overenforcement (wrongly prohibiting procompetitive behavior, which could stifle innovation and efficiencies). The concern is that firms that successfully compete for the market enjoy market power that is more durable and less contestable than has been the case in other markets in the past. Other reports such as the Competition Bureau of Canada Report and the Canadian Competition Council Communique suggest that Canada’s competition law continues to provide an appropriate framework for potential anticompetitive behavior in the digital economy. The Competition Canada Report identified the need to adapt its tools and methods to this evolving area, while its antitrust investigations and analysis will continue to use its traditional framework for market definition, market power, and competitive effects. Common themes that have emerged in some reports include greater responsibilities (whether under ex-ante regulation or ex-post application of competition law) for firms that are dominant or have a particularly strategic role, increasing scrutiny over mergers in the digital sector, and changing presumptions in both merger and dominance cases. Some approaches—particularly where regulation is proposed—introduce institutional reform proposals to house regulatory powers in newly established agencies. Improving international cooperation has also been recognized as important. There is significant consensus on the view that data-driven innovation is more crucial than ever. Also, competition may sometimes depend on some form of access to data. In addition to competition interventions, concern about barriers to entry arising from a dominant firm’s control over data has led to proposals of data portability, interoperability, and open data.203 However, the various studies have differed in their view of how to approach such issues, not only in terms of these specific remedies, but also what body of law—competition law or ex-ante regulation— should give rise to such remedies.

The studies mentioned above range in their level of detail. Those with the most developed thinking and proposals for reform include the Crémer Report, the U.K. Furman Report, and the ACCC Digital Platforms Report, and so these receive the greatest attention. In early 2020, following the German Competition 4.0 report, Germany published its first legislative proposal in the “Digitalization Act” (the “German Draft Bill”), which addresses data access and portability, cross-market leveraging, and intermediation power. Other European countries have expressed support and are likely to follow suit.204 Given Germany’s leadership position in toughening the stance towards platforms (demonstrated, for example, by the Bundeskartellamt’s Facebook Decision205), the German Draft Bill is also discussed below. The sections that follow outline some of the key areas discussed in these reports, focusing first on the line between competition enforcement and regulation in the case of dominance, and then considering merger control. The discussion then turns to multi-firm conduct, particularly algorithms and competition law. It closes by discussing institutional proposals to develop new regulatory units or bodies, and procedural proposals to accelerate enforcement and streamline review of agency decisions. 1. Proposed frameworks for monopolization / abuse of dominance and suggested ex-ante regulation A common concern in the reports was that a firm’s collection and use of data, as well as network effects from platform economies, can result in that firm having significant and entrenched market power. In the case of a dominant platform, it may also effectively act as a regulator of the markets that operate on its platform while also competing in such downstream markets, giving the dominant platform operator power over participants in such markets. As might be expected, views on how to address abuse of dominance claims differed in emphasis on relying on the existing competition framework with some significant adjustments, or whether instead there should be greater emphasis on ex-ante regulation. The two broad areas of focus were, first, the presumption against anticompetitive conduct of dominant firms in competition law, and second, whether (and if so what kind of) ex-ante regulation might be necessary to address dominance problems. 2. Expanding abuse of dominance in the EU and Germany The Crémer Report suggested applying a duty on dominant platforms to ensure that their rules do not impede free, undistorted, and vigorous competition (such as impeding customers from switching to competing platforms, or multi-homing) without an objective efficiency justification. It focused on what can be achieved using existing legal provisions and powers while recognizing that it may be necessary to introduce complementary regulation. It sought a more vigorous approach to vertical theories of harm in order to assess how firms leverage their market power and self-preferencing in downstream product markets operating over their platforms. The Crémer Report also suggested that competition analysis focus less on market definition in digital platforms, and more on the impact of conduct on markets. Focusing on competition law rather than ex-ante regulation, the Crémer Report explored whether a fresh notion of “indispensable data” under a revised approach to the doctrine of “essential facility” under the competition law of dominance might be useful.206 It concluded that refusal to meet standardized requests for data might be viewed as abuse of dominance under Article 102 TFEU207 if the refusal of access is a way for the data gatekeeper to shield itself from competition. The Crémer Report recognized that, for ongoing data access, it would likely be necessary to have sector-specific regulation. It proposed that data portability requirements should be applied to dominant firms where there are substantial consumer lock-in effects in order to strengthen competition in secondary markets. However, these requirements could to some extent be applied under the GDPR, the recently introduced EU data protection framework.208 These findings echoed aspects of the Australian Productivity Commission, which found that introducing open data would be so specific to the type of data, its use, and the APIs and standards involved, that it could only be done on a sector-by-sector basis.209 The ACCC is responsible for leading the introduction of a new “Consumer Data Right.” The government decided that it would start with open banking, then turn to open data in the telecommunications and energy sectors.210 In 2018, the U.K.’s CMA introduced open banking, an initiative to enforce standardized interfaces that enable third parties to access a consumer’s bank data given their permission.211 The Crémer Report also proposed to reverse the burden of proof for anticompetitive conduct by dominant platforms, making it their responsibility to justify certain conduct with compensating efficiencies. To address network effect concerns, the Crémer Report suggested that dominant platforms should have to provide justification if they do not make their platform interoperable with their competitors. It also considered whether remedies for abuse of dominance might include a restorative element. The German Draft Bill reflects several of the Crémer Report’s elements. It builds on 2017 amendments to the competition law which established that zero-pricing of services should not preclude definition of a relevant market for these services, and identified network effects, singleand multi-homing, and access to data and innovation as factors relevant in determining dominance in multi-sided platform markets.212 The German Draft Bill provides that when considering market power of an intermediary in multi-sided markets, particular attention should be given to the importance of its intermediation services for accessing supply and sales markets.213 The German Draft Bill would introduce obligations for “undertakings with paramount importance for competition across markets.”214 Only a very small number of firms would likely have this status, which would be determined based on: • dominance in one or more markets; • financial strength or access to other resources; • vertical integration and activities on otherwise related markets; • access to data relevant for competition; and • the importance of its activities for third parties’ access to supply and sales markets. The German Draft Bill introduces five types of behaviors that the Bundeskartellamt (Federal Cartel Office) can prohibit if it finds a company satisfies this status: • self-favoring;215 • impeding competitors by leveraging market power (even where the provider is not dominant if the impediment is likely to significantly impair the competitive process);216 • using data collected in a market in which it is dominant to create or increase barriers to entry in other markets; • hindering interoperability and data portability if this restrains competition; and • providing insufficient information to other firms to evaluate its services. The prohibition is subject to an efficiency justification. Analogous to the recommendations in the Furman Report, the burden of proof for such justifications would lie on the companies. 3. Inclination towards ex-ante regulation in the U.K. Furman Report and Stigler Center Report The Furman Report was similarly inclined towards proactive intervention by introducing ex-ante regulation, especially for firms with “strategic market status” or SMS, under a new agency—a Digital Markets Unit—focused on digital markets (see below). A subsequent U.K. CMA report217 offered three criteria for SMS in the context of digital advertising: • the presence of enduring market power over a relevant market; • where the platform is a gatekeeper to a significant portion of consumers; and • where businesses depend on the platform to reach the other side of the market (i.e., the platform is not merely a gateway but a bottleneck gateway). The Furman Report’s expansive view of regulation could suggest that the Digital Markets Unit would have objectives relating to data mobility and data openness that would apply across the whole digital sector and not only SMS firms. The proposed new U.K. regulator would focus on level playing-field concern arising from “platform as regulator” issues. Other ex-ante initiatives would include requirements for dominant firms to employ open standards that would permit data portability and interoperability, aimed at reducing the entrenching effects of network externalities. With this ex-ante approach, the Furman Report did not propose to reverse the presumption against anticompetitive conduct in the manner of the Crémer Report, preferring to keep the current competition law approach. It would instead rely more on regulation than competition law as the mechanism to address the dominance concerns, as well as broader sector issues. Some have taken the view that both adjustments to the competition framework and ex-ante regulation are required. For example, the Stigler Center Report proposed reversing or at least relaxing the burden of proof for anticompetitive conduct by platforms with “bottleneck power.” These are conceived similarly to the Furman Report’s SMS and some scenarios of the German “companies with paramount importance for competition,” that is, where the platform has market power and acts as a gatekeeper that controls access to one or more sides of a multi-sided market. The Stigler Center Report envisaged greater focus on such bottleneck platforms, including in relation to refusal to deal, predatory pricing, loyalty rebates, and exclusive dealing.218 It also proposed more proactive intervention through ex-ante regulation for bottleneck firms by a new “Digital Authority.” The Stigler Center envisioned the Digital Authority having regulatory powers over all digital firms over data mobility and open standards, and then mandating data sharing only for firms with bottleneck power.

4. The potential and limits of competition law Although there is some disagreement as to how data privacy intersects with competition law, there has been significant consensus around the need to avoid using competition law to solve all problems in digital markets, such as privacy, and the reports, as described above, have calls for regulation and consumer protection. In addition, in jurisdictions where the abuse of dominance offence includes the imposition of exploitative business terms, enforcers may recognize that competition includes privacy terms, alongside the charging of excessive prices. For example, the German Bundeskartellamt found in February 2019 that Facebook’s aggregation of personal data from Facebook and Facebook-owned sites (such as Instagram) and from third-party websites with the “Like” or “Share” buttons amounted to an abuse of market power. Instead of viewing this as the domain of the newly introduced GDPR, the Bundeskartellamt found that the collection of such personal data without adequate consent amounted to exploitative business terms and an abuse of market power. The Bundeskartellamt’s decision has caused much controversy both by commentators and from German courts. 5. Issues and proposed frameworks for mergers and acquisitions The reports note common concerns about mergers in digital markets related to the risk that an incumbent firm acquires new or potential future rivals. The pricing models of multi-sided markets, particularly “free” services, and ramp up to monetizing products that first become highly successful before generating much revenues, means that many mergers that might raise significant competition issues do not exceed merger notification thresholds that are set according to revenue. Some governments and academics have proposed substantive changes to merger laws with respect to digital markets, and many commentators oppose such efforts to change the standards. See Section III.b, supra. The Crémer Report did not propose to change the revenue-based thresholds that trigger a notification of a merger to the EC at this time, but to keep them under review. Nor did it propose to change the substantive “significant impediment to effective competition” test for mergers. However, it did propose a “heightened degree of control” where an acquisition is plausibly part of a defensive entrenchment strategy. This would include considering the potential future horizontal impact of acquisitions by a dominant platform that may enhance its attractiveness as an ecosystem.219 The Crémer Report did not suggest increasing merger review focus on “potential competition,” and was more concerned about the possibility of a merger strengthening dominance in the ecosystem.220 Similar to its approach to dominance, it suggested shifting the burden of proof to merging parties. The U.K. Furman Report suggested moving to a “balance of harms” test (about which the U.K.’s CMA subsequently expressed reservations), and toning down the presumption that nonhorizontal mergers tend to be benign. It encouraged prioritizing the review of digital mergers, and putting greater weight on “potential competition.” It also proposed introducing a merger notification requirement for firms having “strategic market status” in order to make the CMA aware of all mergers, but not introducing a pre-clearance requirement. It did not, however, propose changing U.K. rules for applying jurisdiction to digital mergers, but to keep under review. It found that the reason why several high-value non-horizontal digital mergers had not been reviewed was not due to gaps in merger notification thresholds: the CMA could have required notification on the basis of a share of supply test. The report did suggest, however, that the CMA must make digital mergers a higher priority.221 Several of these proposals were echoed in the Stigler Center Report,222 although it went further to suggest that platform businesses with bottleneck power should have to notify every acquisition and, thus, would have to wait for pre-clearance independently of their size. The Australian Digital Platforms Report proposed a merger notification protocol for certain transactions (including using a transaction value threshold) of “large platform firms,” and to consider innovation, potential competition, and assets (data in particular) as factors in merger assessments. 6. Issues and proposed frameworks for multi-firm conduct While most of the antitrust concerns around digital markets focus on unilateral conduct and the area of merger control, the reports mentioned above have also expressed—somewhat unrelated—concerns with respect to multilateral conduct. These relate to the implications of (voluntary) data sharing and pooling among competitors and the competitive effects of the use of algorithms for pricing and other business decisions. 7. Issues in data sharing Acknowledging the potential efficiencies of data exchange among competitors, the Crémer Report also expresses the concern that data sharing or pooling may limit competition:223 • Data sharing and pooling constitutes an information exchange, which can favor collusion. As a remedy, the exchanged or pooled data can be limited in scope, provided at a higher level of aggregation, or be anonymized.224 • Data sharing and pooling may also align competitors’ costs or product features, thereby limiting competition on price, quality, or innovation.225 The Crémer Report suggests that growing experience with assessing (the net effect of) data sharing and pooling arrangements may at some point allow competition enforcers to take a more general stance on the permissibility of such arrangements (e.g., through a block exemption by the EC).226 8. Issues in algorithmic collusion A recent publication by the OECD and a joint paper by the French and German competition authorities focus on the concern that algorithms may foster explicit or tacit collusion.227 A key question underlying both publications is whether existing competition law and its interpretation are sufficient to capture potential anticompetitive threats from algorithms. These publications build on a relatively new but rapidly growing legal and economic literature on the topic. In line with that literature, the Franco-German paper distinguishes three scenarios in which algorithms may support supra-competitive pricing: • In the first scenario, firms design and use algorithms to implement an explicit agreement to collude. This includes the automated setting of collusive price levels, the monitoring of other cartel members’ price setting, the automatic punishment of deviations, the facilitation of communication, or the obfuscation of collusion.228 As the paper points out, “the involvement of an algorithm in such a scenario does not raise specific competition law issues” due to the existence of an explicit—and thus illegal— agreement.229 Focusing more narrowly on monitoring and retaliation algorithms, the OECD paper further concludes that “this behavior could be prevented using traditional antitrust tools.”230 • A second scenario involves “situations in which a third party provides the same algorithm or somehow coordinated algorithms to competitors.”231 This third party may be a pricing consultant or developer that provides similar advice on or implementations of pricing algorithms to competitors.232 As the paper points out, this scenario is often compared to a classic “hub-and-spoke cartel.” The paper warns that “even a straightforward use of the same pricing algorithm can lead to similar pricing decisions when the algorithm reacts in similar ways to external events, such as changes in input costs or demand.”233 The paper then discusses that antitrust liability may depend on the degree to which the competitors were aware of each other’s use of the same or similar algorithms.234 • The third scenario involves the parallel use of independent pricing algorithms with self-learning capabilities that may develop strategies to support tacit (through the formation of beliefs about competing algorithms’ reactions) or explicit (through some form of communication) collusion among each other without having explicitly been programmed to do so.235 Pointing to a growing economic literature on this topic that provides initial evidence supporting the feasibility of such learning in experimental settings, the paper nevertheless concedes that it remains an open question whether such learning can occur in real market settings.236 Even if so, the paper suggests that the unilateral adoption of such algorithms may have to be qualified as “intelligent adaptations to the market rather than coordination.”237 In addition to this potential legal loophole, the OECD paper adds that this form of collusion “becomes even harder to prevent using traditional antitrust tools” due to the black box nature of the algorithms. Focusing on the legal situation in the EU and its member states, the Franco-German paper does not suggest changes to competition law and enforcement. Instead, it states that “[t]he existing tools seem, at this stage, flexible in their application to cases involving algorithmic behaviour.”238 However, the paper leaves it open whether future developments, particularly in the area of selflearning algorithms, may require reconsidering the reach of competition law.239 The OECD paper similarly suggests that a legislative approach may be necessary to capture the problem of selflearning algorithms through a changed treatment of tacit collusion. Additionally, the paper proposes a role for ex-ante merger control in markets with algorithmic activities by suggesting to extend the analysis of coordinated effects to less concentrated markets and conglomerate mergers.240 9. Institutions and procedures a. New digital institutions As mentioned above, some reviews, such as the Crémer Report, preferred to rethink some elements of competition law than propose new regulation, which does not require establishing new powers or institutions. Others, such as the Furman Report, proposed to introduce new regulation, which provokes the question of where regulatory and enforcement powers would lie. These questions obviously depend on a given jurisdiction’s existing institutional landscape, in particular the remits of existing competition, data protection, information and communication technology, and media authorities. In the U.K.’s case, the Furman Report proposed a new body, the Digital Markets Unit, with appropriate powers to impose solutions and to monitor, investigate, and penalize non-compliance. These solutions could include a code of conduct for SMS firms, sector-based regulations on data mobility and open standards, and openness of data. The unit would not have a mandate over mergers. The Furman Report did not resolve the question of whether this could be achieved under existing agencies. The Furman Report suggested that the Digital Markets Unit could either be housed in the CMA, the communications regulator (Ofcom), or both. The Australian report envisaged a new specialist digital branch within the ACCC applying the current competition framework. The Stigler Center, in the United States, suggested a new Digital Authority with “clear and broad authority” to make regulations with bottleneck power, including in respect of data sharing. It also envisioned regulations for the tech sector more widely, such as relating to data mobility, open standards, interoperability, and data collection. It also saw the authority as having a role in mergers.

b. Accelerating enforcement and streamlining review

The high speed of change in digital markets risks enforcement intervention coming too late to prevent harm to competition. The U.K.’s Furman Report suggested enabling faster enforcement, such as reducing the thresholds for use of interim measures. The EC also subsequently indicated that it will more readily use interim measures.241 Improving the quality and speed of judicial review of agency decisions was the focus of both the Furman Report and the Stigler Center Report. The latter suggested introducing a specialized competition court. In the U.K., which already has the Competition Appeal Tribunal (CAT), the Furman Report proposed reducing the scope of the CAT’s review of antitrust enforcement. Currently, the CAT can reconsider the full merits of the CMA’s decision on legal and economic matters and make any decision the CMA could have made. A more limited role was proposed to allow the CMA an “appropriate margin of appreciation to reach decisions on digital cases that are likely to be particularly complex and may require elements of expert judgement.”242 10. Conclusion: the need for international coordination Although there are varying approaches, some governments and commentators have proposed complementing traditional ex-post application of competition law with specific ex-ante regulation of dominant platforms. For example, some have considered changing presumptions, including introducing presumptions that certain types of behavior of dominant platforms are anticompetitive, requiring the platform to bear the burden of proof to show otherwise. However, others have opposed efforts to recalibrate competition law for digital markets. Further, stricter antitrust treatment of companies in the digital space bears the risk of a patchwork situation with respect to the “rules of the game” that these companies will face around the globe. Indeed, while the proposals share some common themes, they also exhibit substantial differences. For example, several proposals include the designation of special status (alongside special obligations) to companies of strategic importance in a market. However, the criteria for SMS proposed in the U.K. and the obligations that come with it differ from the broader concept of “paramount importance for competition” encoded in the German Draft Bill and the more comprehensive behavioral rules that the Bundeskartellamt would be able to impose on such companies. In addition, even if the legislative frameworks were identical, the regulatory character of some of the new rules would leave room for interpretation to the regulatory bodies, potentially causing different decisions. Therefore, even if not all of the proposals described above will be implemented, there is a potential for considerable differences with respect to the leeway that digital companies will have across jurisdictions.

#### Big platforms stifle entry and are copycat innovators

Newman, Associate Professor, University of Miami School of Law, ‘19

(John, “Antitrust in Digital Markets,” 72 Vand. L. Rev. 1497) /// Anekah

Due in no small part to the entry barriers described above, digital giants cast long shadows. Even the mere presence—and certainly the activities—of an incumbent like Google or Facebook in a given market can hinder entry and stifle innovation. This dynamic may not be entirely unique to, but does appear to be particularly acute in, digital markets. Yet, perhaps because collecting sufficiently rigorous empirical evidence of consumer-welfare harm is difficult in this context,109 it has gone largely overlooked. The evidence gathered to date suggests that the presence of Google or Facebook in a market can hinder innovation in that market. Recent empirical work indicates that after Google vertically integrates into the market for an app that runs on its Android mobile OS, the developers of existing apps in that market reduce their own efforts to continue innovating.110 More broadly, angel and seed investment activity in the United States has declined since 2015, both in terms of overall deal value and (more precipitously) number of deals closed.111 As market concentration continues to rise, in part due to relatively lax antitrust enforcement, start-up rates are declining across **all sectors** **of** the economy.112 A particular type of strategic conduct by an incumbent—even if legal—can also disincentivize entry and innovation. Dominant digital firms are in a unique position to clone, or mimic, small startups’ features.113 Over time, such free-riding may dissuade startups from even attempting entry. A hypothetical illustrates the problem. Suppose a new platform, E, enters the social networking space with hopes of attracting users via an attractive, unique feature. If the social networking space were characterized by vigorous competition, E might stand a good chance of success. Even if an existing rival were to mimic E’s feature, E would remain the first mover as to that feature.114 The would-be copycat has no unique strategic advantage to exploit, leaving E free to compete on the merits. But, in the real world, the general social networking space has matured and yielded one dominant player, Facebook, Inc. Copycat strategies are far more likely to be successful when employed by a dominant incumbent with an installed base of over two billion users.115 The saga of Snapchat, a multimedia messaging app, provides a ready example. Noticing the traction Snapchat was gaining among teenage users, Facebook offered to buy it.116 When that attempt failed, Facebook turned instead to mimicking Snapchat’s features.117 Google reportedly offered to buy Snapchat as well,118 then similarly pivoted toward mimicry.119 Multiple analysts credited these tactics with depressing Snapchat’s user growth and share price.120 Emerging empirical evidence suggests this is not an isolated example.121 After surveying dozens of investors and entrepreneurs, one technology reporter concluded that Facebook’s free-riding “is having a profound impact on innovation in Silicon Valley, by creating a strong disincentive for investors and start-ups to put money and effort into creating products Facebook might copy.”122 According to a founder, Amazon casts a similarly long shadow: “People are not getting funded because Amazon might one day compete with them.”123 At a University of Chicago panel discussion, venture capitalist Albert Wenger depicted the shadows around digital giants like Google, Facebook, and Amazon as “Kill Zones,” that is, “areas not worth operating or investing in, since defeat is guaranteed.”124

#### Start-up innovation creates post-pandemic growth–generating a virtuous cycle of innovation and investment that locks in productivity gains.

Manyika ’21 [James; Chair and Director @ McKinsey Global Institute; and Michael Spence; Philip H. Knight Professor and Dean Emeritus @ Stanford University's Graduate School of Business; “A Better Boom: How to Capture the Pandemic's Productivity Potential,” *Foreign Affairs* 100(4), p. 107-117; AS]

Surprising as it may seem, out of the deepest economic crisis since World War II could come a new era of productivity gains and prosperity. Whether that happens will depend largely on the decisions that governments and businesses make as they prepare to exit the pandemic in the coming months. In the short and medium term, the prospects for increased productivity-and prosperity-are encourag2 ing, as the United States and other countries spend heavily on economic recovery and businesses reap the benefits of digitization. But the outlook is less optimistic over the long term, since governments cannot spend indefinitely and consumer and investment spending may not fill the gap. Governments and businesses must therefore seek to create the conditions for sustained productivity growth and prosperity, in particular by facilitating the diffusion of technological and organizational innovations and bolstering consumer demand. Out of a major global crisis could come a major jolt of productivity growth-but only if policymakers and business leaders make the most of this moment. THE PRODUCTIVITY PARADOX The history of productivity growth can be understood as a succession of technological revolutions, from the steam engine to the computer. Each offered the promise of accelerated productivity and economic growth, and each eventually delivered. But there has often been a delay between innovation and adoption, and another between adoption and economic impact. The economist Robert Solow summed up these apparent discrepancies in a 1987 article in The New York Times Book Review, writing, "You can see the computer age everywhere but in the productivity statistics." His formulation became known as "the Solow paradox." But then came the revolution in information and communication technologies between 1995 and 2005, a decade in which the Solow paradox was temporarily resolved. Widespread adoption of these technologies was accompanied by a simultaneous acceleration in productivity, which grew at an annualized rate of 2.5 percent in the United States, a full percentage point faster than the rate between 1970 and 1995. Companies invested heavily in information and communication technologies and reorganized their operations and managerial practices around them. They did so out of the desire to gain a competitive edge, but also because of relatively robust consumer demand for their products. Productivity growth accelerated in several sectors as a result, driving growth in the U.S. economy as a whole. This period was characterized by an unusual combination of large spurts in productivity growth in a few big sectors employing many workers, such as retail and wholesale, and even larger productivity growth in smaller sectors, such as those that produced computers and electronic products. In both bi and small sectors, there was a virtuous cycle of employment growth to meet demand and even faster growth in the value of the output from these sectors. The value of outputs across all sectors of the economy grew by 3.4 percent per year between 1995 and 2005, whereas the total number of hours worked grew by only 0.9 percent per year. But the boom did not last. Between 2005 and 2019, annual productivity growth in the United States fell by more than half, to 1.0 percent. In the aftermath of the 2008 global financial crisis, from 2010 to 2019, it was even lower, at 0.6 percent. Unlike the United States, z European countries had not experienced rapid productivity gains in the 1995-2005 period, but they did experience the postcrisis decline. r Between 2010 and 2019, annual productivity growth fell below one percent in France, Germany, and the United Kingdom. The Solow paradox was back. After a decade of rapid productivity gains, the information technology revolution had reached a point of diminishing returns. But the next wave of technology-the digitization of processes, big data and analytics, cloud computing, the Internet of Things-was not yet ready to fill the gap. Despite early breakthroughs in image recognition and natural language processing, few firms had begun to make use of artificial intelligence technologies, and digitization was proceeding slowly. We estimated, based on a sector-by sector assessment, that in 2015, the United States had reached only 18 percent of its digital potential and Europe had reached only 12 percent. Moreover, a gap had opened up between the firms that were digital leaders and those that were digital laggards-a gap that other researchers found was correlated with a gap in labor productivity. This gap in technology adoption was widening at a time of weak consumer demand for goods and services, in large part due to the aftereffects of the financial crisis. Firms scaled back their investments, and fewer new businesses were created. Making matters worse, the share of income that flowed to top earners and the owners of capital increased, while the share that went to labor decreased, further weakening demand. Across the United States and Europe, the vast majority of sectors experienced declines in productivity growth. Only four percent of all sectors recorded productivity jumps in 2014, compared with an average of 18 percent of sectors that achieved substantial increases in productivity in the previous two decades. Growth in gross value added-a measure of a firm's or a sector's contribution to GDP-declined from 3.4 percent annually between 1995 and 2005 to 1.8 percent between 2005 and 2019. Growth in hours worked remained roughly unchanged, at 0.7 percent, throughout both periods. These two very different periods of economic activity in the United States reveal much about the underpinnings of productivity growth. It stems first and foremost from the widespread adoption of technological innovations, especially general-purpose technologies such as electricity and the Internet. But it also stems from the managerial innovation and reorganization of functions and tasks that occur when firms adopt new technologies. Both of these processes must spur leaps in productivity growth in many sectors, or at least in a few large ones, so that productivity jumps in the economy as a whole. Finally, adoption and reorganization within and across sectors must be driven by competition, which incentivizes firms to innovate and helps spur technological diffusion. Not all productivity growth is created equal, however. Productivity growth can be achieved through gains in the volume or value of outputs for a given number of hours worked, or it can come about as a result of a reduction in hours worked for a given output. Often both happen at the same time. But it is when the former exceeds the latter that a virtuous cycle is created in which innovation and investment generate growth in employment and wages, which in turn generates demand for increased (or more valuable) output. This is what happened during the period from 1995 to 2005. When the latter source of productivity growth exceeds the former, however, a vicious cycle results in which firms reduce labor costs faster than they grow the volume or value of their outputs, which in turn puts pressure on employment and incomes. POST-PANDEMIC POTENTIAL The pandemic has primed advanced economies for another period of rapid productivity growth. It is too early to say for sure whether such growth will be the product of a virtuous or a vicious cycle, but signs point to the former. Despite uncertainty, stress, and plummeting economic activity in the early days of the covID-19 crisis, many firms boldly deployed and used new general-purpose technology-especially digital technology-in ways that have driven virtuous productivity gains in the past. In October 2020, we surveyed 900 C-suite executives in various sectors and countries and found that many had digitized their business activities 20 to 25 times as fast as they had previously thought possible. Often, this meant shifting their businesses to online channels, since roughly 60 percent of the firms we surveyed experienced a significant increase in customer demand for online goods and services as a result of the pandemic. Before the pandemic, e-commerce was forecast to account for less than a quarter of all U.S. retail sales by 2024. But during the first two months of the covID-19 crisis, e-commerce's share of retail sales more than doubled, from 16 percent to 33 percent. And that growth did not just reflect brick-and-mortar firms setting up shop online for the first time. Firms that were already highly digitized before the pandemic significantly expanded their online capabilities to meet the surge in demand. They also reorganized their operations, including their logistics, to complement what they were doing digitally-for example, by expanding their direct-to-home delivery capabilities. Businesses also strove to become more efficient and agile. In Europe and North America, nearly half of the respondents to our survey said that they had reduced their operating expenditure as a share of revenue between December 2019 and December 2020. Two-thirds of senior executives said they had increased investment in automation and artificial intelligence, whether to help warehouse and logistics operations cope with higher e-commerce volumes or to enable manufacturing plants to meet surging demand. Many companies used technology to reduce the physical density of their workplaces or to enable contactless service-for instance, by expanding self-checkout in grocery stores and pharmacies and employing online ordering apps for restaurants and hotels. Other businesses, such as meatpacking and poultry plants, accelerated the deployment of robotics to reduce their need for labor. If there was one lesson from the pandemic, it was that digital capability and resilience go hand in hand. But even as the arrival of vaccines has made it possible to imagine a return to relative normalcy in parts of the developed world, continued digitization and the adoption of other technological innovations promise to deliver still more productivity gains. The largest of these gains-roughly an additional two percentage points per year-could come in the health-care, construction, information technology, retail, pharmaceutical, and banking sectors. In health care, for instance, accelerating the use of telemedicine beyond the pandemic could drive incremental productivity growth for years. According to one recent U.S. poll, 76 percent of patients expressed interest in using telemedicine in the future, and industry experts project that the services for 20 percent of health-care spending could be delivered virtually-up from 11 percent before the pandemic. Other sectors, including automotive, travel, and logistics, show less-but still substantial-potential for productivity growth as a result of more flexible task scheduling, leaner operations, and smarter procurement. Overall, these innovations and organizational changes could accelerate productivity growth by around one percentage point per year between now and 2024 in the United States and the six large European economies that we analyzed (France, Germany, Italy, Spain Sweden, and the United Kingdom). This gain would result in a productivity growth rate twice as high as the rate after the 2008 global financial crisis, and in the United States, it would expand per capita GDP by roughly $3,500 by 2024. That would be a stunning outcome, but it will hinge on continued technology adoption by firms and the maintenance of robust demand. Even more productivity gains could be on the horizon thanks to other advancements. The accelerating revolution in biology, for instance, could transform sectors from health care and agriculture to consumer goods, energy, and materials. Biological innovation has already enabled the rapid development of new vaccines for covID-19. Equally impressive revolutions in energy could make possible the widespread adoption of solar and wind power, especially in light of recent progress toward better (and cheaper) batteries. Artificial intelligence is also advancing rapidly, but is still a long way from being deployed widely across companies and sectors. When and if that happens, the productivity gains could be enormous. FOLLOW THE DIGITAL LEADER Future gains in productivity, even those that boost overall growth, are likely to be uneven. We analyzed metrics that have the potential to unleash future productivity growth-such as research-and-development spending, revenue, capital expenditures (including digital expenses), and mergers and acquisitions-and found that especially in the United States, a small number of large superstar firms accounted for a disproportionately large share of the activity in all these categories. From the third quarter of 2019 to the third quarter of 2020, U.S. superstars (defined as the top ten percent of firms by profit) saw much shallower declines in capital expenditures and revenue than did other companies. During the same period, U.S. superstars spent $2.6 billion more on R & D than they did the previous year, while all other firms spent just $1.4 billion more. If this investment, innovation, and technology adoption gap between superstars and the rest of the large firms and smaller, less profitable firms persists, any post-pandemic acceleration in productivity growth could fall short of its potential. Small and mediumsized enterprises have been hit disproportionately hard by the covID-19 crisis. As a result, many of them are unable to make big investments in future productivity and are therefore liable to fall even further behind the superstars. This is what happened in the aftermath of the 2008 global financial crisis, when only a minority of companies achieved productivity growth. But there is room for cautious optimism about the ability of nonsuperstars to close some of the gap. Before the pandemic, the superstars tended to be highly digitized and innovative in their managerial approaches, as well as more profitable and resilient. They were therefore better placed to weather and even take advantage of the shock. But as the hardest-hit firms and sectors recover, and as early digital adaptors demonstrate the enormous potential of these technologies, many of the digital laggards could begin to catch up. Indeed, in another survey of executives we conducted in December 2020, about 75 percent of respondents in North America and Europe said they expected investment in new technologies to accelerate substantially between 2020 and 2024, up from 55 percent between 2014 and 2019. This expected uptick was similar across firm sizes. Another reason for optimism is that in 2020, a year that saw the darkest economic days of the pandemic, 24 percent more new businesses were created in the United States than in 2019. Europe lagged behind the United States on this metric, with new business creation staying roughly flat in 2020 in France, Germany, and the United Kingdom and declining by more than 15 percent in Italy and Spain. If the American increase in business dynamism persists, however, it should contribute to more productivity growth. Investment, innovation, and technology adoption are only one-half of the virtuous cycle of productivity growth, however. The other half is demand for the expanded output that results-in other words, income growth from increased productivity has to flow to people who will spend that additional money. In the short term, the outlook for demand is good, especially for countries that have made progress toward vaccinating their populations and could be among the first to open up their economies. Pent-up demand and savings from the pandemic could be unleashed all at once, resulting in a strong initial bounce in demand led by consumers. In the United States, President Joe Biden's $1.9 trillion economic support bill should push demand even higher. In the medium term, the outlook for demand is also relatively solid, although it will depend on the size, deployment, and longevity of government spending. In the United States, Biden now has set his sights on a large infrastructure package. As his administration shifts its focus from economic relief to investment in productive areas, it could also increase productivity growth by raising demand to match potential supply, creating a high-pressure economy, that is, one with low unemployment and high growth. The outlook in continental Europe, where large-scale government economic support is harder to coordinate, is less certain. Nonetheless, the EU has put in place an unprecedented plan totaling some $900 billion to boost investment in the digital and green energy transitions. But government spending on this scale will likely be time-limited, making the long-term outlook for demand less rosy. Moreover, long neglected problems, including the falling share of firms' income going to workers, rising inequality, and the long-term decline in private investment, could drag down demand. Roughly 60 percent of the postpandemic productivity gains that we estimate could come from innovations and organizational restructuring-the one percentage point of acceleration per year between now and 2024-would stem from firm-level measures, such as automation, designed to cut labor and other business costs. Unless firms do more to boost the volume or value of their output and help workers transition by acquiring new skills, the drive for efficiency will risk generating productivity gains through a vicious, rather than a virtuous, cycle, undermining wages and jobs and weakening consumption-driven demand and investment. A NEW AGE OF DYNAMISM? What can businesses and governments do to capitalize on the positive short- and medium-term outlook for productivity and to improve the long-term outlook? First, they should work to speed up technology adoption and managerial innovation, helping these changes spread within and across sectors. As the recovery begins, firms that have until recently been focused on crisis management and survival should follow the lead of superstar firms by investing in technology and reorganization. The superstars can assist in this process by supporting their broader ecosystems, in particular by doing business with smaller firms that offer complementary products and services. Governments can support the process, as well, by investing in research and development. Policymakers should also seek to strengthen competition and business dynamism. In a healthy economy, the firms that add the most value prosper and grow, while the firms that add the least value shrink or disappear: so-called creative destruction. Policymakers can revive and reinforce this natural sorting process by revising competition rules, bankruptcy procedures, and product and labor-market regulations.

#### Slow growth causes extinction.

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Four structural forces will shape the future of International Relations: globalization (but without liberal rules, institutions, and leadership)1; multipolarity (the end of American hegemony and wider distribution of power among states and non-states2); the strengthening of distinctive, national and subnational identities, as persistent cultural differences are accentuated by the disruptive effects of Western style globalization (what Samuel Huntington called the “non-westernization of IR”3); and secular economic stagnation, a product of longer term global decline in birth rates combined with aging populations.4 These structural forces do not determine everything. Environmental events, global health challenges, internal political developments, policy mistakes, technology breakthroughs or failures, will intersect with structure to define our future. But these four structural forces will impact the way states behave, in the capacity of great powers to manage their differences, and to act collectively to settle, rather than exploit, the inevitable shocks of the next decade. Some of these structural forces could be managed to promote prosperity and avoid war. Multipolarity (inherently more prone to conflict than other configurations of power, given coordination problems)5 plus globalization can work in a world of prosperity, convergent values, and effective conflict management. The Congress of Vienna system achieved relative peace in Europe over a hundred-year period through informal cooperation among multiple states sharing a fear of populist revolution. It ended decisively in 1914. Contemporary neoliberal institutionalists, such as John Ikenberry, accept multipolarity as our likely future, but are confident that globalization with liberal characteristics can be sustained without American hegemony, arguing that liberal values and practices have been fully accepted by states, global institutions, and private actors as imperative for growth and political legitimacy.6 Divergent values plus multipolarity can work, though at significantly lower levels of economic growth-in an autarchic world of isolated units, a world envisioned by the advocates of decoupling, including the current American president.7 Divergent values plus globalization can be managed by hegemonic power, exemplified by the decade of the 1990s, when the Washington Consensus, imposed by American leverage exerted through the IMF and other U.S. dominated institutions, overrode national differences, but with real costs to those states undergoing “structural adjustment programs,”8 and ultimately at the cost of global growth, as states—especially in Asia—increased their savings to self insure against future financial crises.9 But all four forces operating simultaneously will produce a future of increasing internal polarization and cross border conflict, diminished economic growth and poverty alleviation, weakened global institutions and norms of behavior, and reduced collective capacity to confront emerging challenges of global warming, accelerating technology change, nuclear weapons innovation and proliferation. As in any effective scenario, this future is clearly visible to any keen observer. We have only to abolish wishful thinking and believe our own eyes.10 Secular Stagnation This unbrave new world has been emerging for some time, as US power has declined relative to other states, especially China, global liberalism has failed to deliver on its promises, and totalitarian capitalism has proven effective in leveraging globalization for economic growth and political legitimacy while exploiting technology and the state’s coercive powers to maintain internal political control. But this new era was jumpstarted by the world financial crisis of 2007, which revealed the bankruptcy of unregulated market capitalism, weakened faith in US leadership, exacerbated economic deprivation and inequality around the world, ignited growing populism, and undermined international liberal institutions. The skewed distribution of wealth experienced in most developed countries, politically tolerated in periods of growth, became intolerable as growth rates declined. A combination of aging populations, accelerating technology, and global populism/nationalism promises to make this growth decline very difficult to reverse. What Larry Summers and other international political economists have come to call “secular stagnation” increases the likelihood that illiberal globalization, multipolarity, and rising nationalism will define our future. Summers11 has argued that the world is entering a long period of diminishing economic growth. He suggests that secular stagnation “may be the defining macroeconomic challenge of our times.” Julius Probst, in his recent assessment of Summers’ ideas, explains: …rich countries are ageing as birth rates decline and people live longer. This has pushed down real interest rates because investors think these trends will mean they will make lower returns from investing in future, making them more willing to accept a lower return on government debt as a result. Other factors that make investors similarly pessimistic include rising global inequality and the slowdown in productivity growth… This decline in real interest rates matters because economists believe that to overcome an economic downturn, a central bank must drive down the real interest rate to a certain level to encourage more spending and investment… Because real interest rates are so low, Summers and his supporters believe that the rate required to reach full employment is so far into negative territory that it is effectively impossible. …in the long run, more immigration might be a vital part of curing secular stagnation. Summers also heavily prescribes increased government spending, arguing that it might actually be more prudent than cutting back – especially if the money is spent on infrastructure, education and research and development. Of course, governments in Europe and the US are instead trying to shut their doors to migrants. And austerity policies have taken their toll on infrastructure and public research. This looks set to ensure that the next recession will be particularly nasty when it comes… Unless governments change course radically, we could be in for a sobering period ahead.12 The rise of nationalism/populism is both cause and effect of this economic outlook. Lower growth will make every aspect of the liberal order more difficult to resuscitate post-Trump. Domestic politics will become more polarized and dysfunctional, as competition for diminishing resources intensifies. International collaboration, ad hoc or through institutions, will become politically toxic. Protectionism, in its multiple forms, will make economic recovery from “secular stagnation” a heavy lift, and the liberal hegemonic leadership and strong institutions that limited the damage of previous downturns, will be unavailable. A clear demonstration of this negative feedback loop is the economic damage being inflicted on the world by Trump’s trade war with China, which— despite the so-called phase one agreement—has predictably escalated from negotiating tactic to imbedded reality, with no end in sight. In a world already suffering from inadequate investment, the uncertainties generated by this confrontation will further curb the investments essential for future growth. Another demonstration of the intersection of structural forces is how populist-motivated controls on immigration (always a weakness in the hyper-globalization narrative) deprives developed countries of Summers’ recommended policy response to secular stagnation, which in a more open world would be a win-win for rich and poor countries alike, increasing wage rates and remittance revenues for the developing countries, replenishing the labor supply for rich countries experiencing low birth rates. Illiberal Globalization Economic weakness and rising nationalism (along with multipolarity) will not end globalization, but will profoundly alter its character and greatly reduce its economic and political benefits. Liberal global institutions, under American hegemony, have served multiple purposes, enabling states to improve the quality of international relations and more fully satisfy the needs of their citizens, and provide companies with the legal and institutional stability necessary to manage the inherent risks of global investment. But under present and future conditions these institutions will become the battlegrounds—and the victims—of geopolitical competition. The Trump Administration’s frontal attack on multilateralism is but the final nail in the coffin of the Bretton Woods system in trade and finance, which has been in slow but accelerating decline since the end of the Cold War. Future American leadership may embrace renewed collaboration in global trade and finance, macroeconomic management, environmental sustainability and the like, but repairing the damage requires the heroic assumption that America’s own identity has not been fundamentally altered by the Trump era (four years or eight matters here), and by the internal and global forces that enabled his rise. The fact will remain that a sizeable portion of the American electorate, and a monolithically proTrump Republican Party, is committed to an illiberal future. And even if the effects are transitory, the causes of weakening global collaboration are structural, not subject to the efforts of some hypothetical future US liberal leadership. It is clear that the US has lost respect among its rivals, and trust among its allies. While its economic and military capacity is still greatly superior to all others, its political dysfunction has diminished its ability to convert this wealth into effective power.13 It will furthermore operate in a future system of diffusing material power, diverging economic and political governance approaches, and rising nationalism. Trump has promoted these forces, but did not invent them, and future US Administrations will struggle to cope with them. What will illiberal globalization look like? Consider recent events. The instruments of globalization have been weaponized by strong states in pursuit of their geopolitical objectives. This has turned the liberal argument on behalf of globalization on its head. Instead of interdependence as an unstoppable force pushing states toward collaboration and convergence around market-friendly domestic policies, states are exploiting interdependence to inflict harm on their adversaries, and even on their allies. The increasing interaction across national boundaries that globalization entails, now produces not harmonization and cooperation, but friction and escalating trade and investment disputes.14 The Trump Administration is in the lead here, but it is not alone. Trade and investment friction with China is the most obvious and damaging example, precipitated by China’s long failure to conform to the World Trade Organization (WTO) principles, now escalated by President Trump into a trade and currency war disturbingly reminiscent of the 1930s that Bretton Woods was designed to prevent. Financial sanctions against Iran, in violation of US obligations in the Joint Comprehensive Plan Of Action (JCPOA), is another example of the rule of law succumbing to geopolitical competition. Though more mercantilist in intent than geopolitical, US tariffs on steel and aluminum, and their threatened use in automotives, aimed at the EU, Canada, and Japan,15 are equally destructive of the liberal system and of future economic growth, imposed as they are by the author of that system, and will spread to others. And indeed, Japan has used export controls in its escalating conflict with South Korea16 (as did China in imposing controls on rare earth,17 and as the US has done as part of its trade war with China). Inward foreign direct investment restrictions are spreading. The vitality of the WTO is being sapped by its inability to complete the Doha Round, by the proliferation of bilateral and regional agreements, and now by the Trump Administration’s hold on appointments to WTO judicial panels. It should not surprise anyone if, during a second term, Trump formally withdrew the US from the WTO. At a minimum it will become a “dead letter regime.”18 As such measures gain traction, it will become clear to states—and to companies—that a global trading system more responsive to raw power than to law entails escalating risk and diminishing benefits. This will be the end of economic globalization, and its many benefits, as we know it. It represents nothing less than the subordination of economic globalization, a system which many thought obeyed its own logic, to an international politics of zero-sum power competition among multiple actors with divergent interests and values. The costs will be significant: Bloomberg Economics estimates that the cost in lost US GDP in 2019- dollar terms from the trade war with China has reached $134 billion to date and will rise to a total of $316 billion by the end of 2020.19 Economically, the just-in-time, maximally efficient world of global supply chains, driving down costs, incentivizing innovation, spreading investment, integrating new countries and populations into the global system, is being Balkanized. Bilateral and regional deals are proliferating, while global, nondiscriminatory trade agreements are at an end. Economies of scale will shrink, incentivizing less investment, increasing costs and prices, compromising growth, marginalizing countries whose growth and poverty reduction depended on participation in global supply chains. A world already suffering from excess savings (in the corporate sector, among mostly Asian countries) will respond to heightened risk and uncertainty with further retrenchment. The problem is perfectly captured by Tim Boyle, CEO of Columbia Sportswear, whose supply chain runs through China, reacting to yet another ratcheting up of US tariffs on Chinese imports, most recently on consumer goods: We move stuff around to take advantage of inexpensive labor. That’s why we’re in Bangladesh. That’s why we’re looking at Africa. We’re putting investment capital to work, to get a return for our shareholders. So, when we make a wager on investment, this is not Vegas. We have to have a reasonable expectation we can get a return. That’s predicated on the rule of law: where can we expect the laws to be enforced, and for the foreseeable future, the rules will be in place? That’s what America used to be.20 The international political effects will be equally damaging. The four structural forces act on each other to produce the more dangerous, less prosperous world projected here. Illiberal globalization represents geopolitical conflict by (at first) physically non-kinetic means. It arises from intensifying competition among powerful states with divergent interests and identities, but in its effects drives down growth and fuels increased nationalism/populism, which further contributes to conflict. Twenty-first-century protectionism represents bottom-up forces arising from economic disruption. But it is also a top-down phenomenon, representing a strategic effort by political leadership to reduce the constraints of interdependence on freedom of geopolitical action, in effect a precursor and enabler of war. This is the disturbing hypothesis of Daniel Drezner, argued in an important May 2019 piece in Reason, titled “Will Today’s Global Trade Wars Lead to World War Three,”21 which examines the preWorld War I period of heightened trade conflict, its contribution to the disaster that followed, and its parallels to the present: Before the First World War started, powers great and small took a variety of steps to thwart the globalization of the 19th century. Each of these steps made it easier for the key combatants to conceive of a general war. We are beginning to see a similar approach to the globalization of the 21st century. One by one, the economic constraints on military aggression are eroding. And too many have forgotten—or never knew—how this played out a century ago. …In many ways, 19th century globalization was a victim of its own success. Reduced tariffs and transport costs flooded Europe with inexpensive grains from Russia and the United States. The incomes of landowners in these countries suffered a serious hit, and the Long Depression that ran from 1873 until 1896 generated pressure on European governments to protect against cheap imports. …The primary lesson to draw from the years before 1914 is not that economic interdependence was a weak constraint on military conflict. It is that, even in a globalized economy, governments can take protectionist actions to reduce their interdependence in anticipation of future wars. In retrospect, the 30 years of tariff hikes, trade wars, and currency conflicts that preceded 1914 were harbingers of the devastation to come. European governments did not necessarily want to ignite a war among the great powers. By reducing their interdependence, however, they made that option conceivable. …the backlash to globalization that preceded the Great War seems to be reprised in the current moment. Indeed, there are ways in which the current moment is scarier than the pre-1914 era. Back then, the world’s hegemon, the United Kingdom, acted as a brake on economic closure. In 2019, the United States is the protectionist with its foot on the accelerator. The constraints of Sino-American interdependence—what economist Larry Summers once called “the financial balance of terror”—no longer look so binding. And there are far too many hot spots—the Korean peninsula, the South China Sea, Taiwan—where the kindling seems awfully dry. Multipolarity We can define multipolarity as a wide distribution of power among multiple independent states. Exact equivalence of material power is not implied. What is required is the possession by several states of the capacity to coerce others to act in ways they would otherwise not, through kinetic or other means (economic sanctions, political manipulation, denial of access to essential resources, etc.). Such a distribution of power presents inherently graver challenges to peace and stability than do unipolar or bipolar power configurations,22 though of course none are safe or permanent. In brief, the greater the number of consequential actors, the greater the challenge of coordinating actions to avoid, manage, or de-escalate conflicts. Multipolarity also entails a greater potential for sudden changes in the balance of power, as one state may defect to another coalition or opt out, and as a result, the greater the degree of uncertainty experienced by all states, and the greater the plausibility of downside assumptions about the intentions and capabilities of one’s adversaries. This psychology, always present in international politics but particularly powerful in multipolarity, heightens the potential for escalation of minor conflicts, and of states launching preventive or preemptive wars. In multipolarity, states are always on edge, entertaining worst-case scenarios about actual and potential enemies, and acting on these fears—expanding their armies, introducing new weapon systems, altering doctrine to relax constraints on the use of force—in ways that reinforce the worst fears of others. The risks inherent in multipolarity are heightened by the attendant weakening of global institutions. Even in a state-centric system, such institutions can facilitate communication and transparency, helping states to manage conflicts by reducing the potential for misperception and escalation toward war. But, as Waheguru Pal Singh Sidhu argues in his chapter on the United Nations, the influence of multilateral institutions as agent and actor is clearly in decline, a result of bottom-up populist/nationalist pressures experienced in many countries, as well as the coordination problems that increase in a system of multiple great powers. As conflict resolution institutions atrophy, great powers will find themselves in “security dilemmas”23 in which verification of a rival’s intentions is unavailable, and worst-case assumptions fill the gap created by uncertainty. And the supply of conflicts will expand as a result of growing nationalism and populism, which are premised on hostility, paranoia, and isolation, with governments seeking political legitimacy through external conflict, producing a siege mentality that deliberately cuts off communication with other states. Finally, the transition from unipolarity (roughly 1989–2007) to multipolarity is unregulated and hazardous, as the existing superpower fears and resists challenges to its primacy from a rising power or powers, while the rising power entertains new ambitions as entitlements now within its reach. Such a “power transition” and its dangers were identified by Thucydides in explaining the Peloponnesian Wars,24 by Organski (the “rear-end collision”)25 during the Cold War, and recently repopularized and brought up to date by Graham Allison in predicting conflict between the US and China.26 A useful, and consequential illustration of the inherent challenge of conflict management during a power transition toward multipolarity, is the weakening of the arms control regime negotiated by the US and the Soviet Union during the Cold War. Despite the existential, global conflict between two nuclear armed superpowers embracing diametrically opposed world views and operating in economic isolation from each other, the two managed to avoid worst-case outcomes. They accomplished this in part by institutionalizing verifiable limits on testing and deployment of both strategic and intermediate-range nuclear missiles. Yet as diplomatically and technically challenging as these achievements were, the introduction of a third great power, China, into this twocountry calculus has proven to be a deal breaker. Unconstrained by these bilateral agreements, China has been free to build up its capability, and has taken full advantage in ramping up production and deployment of intermediate-range ground-launched cruise missiles, thus challenging the US ability to credibly guarantee the security of its allies in Asia, and greatly increasing the costs of maintaining its Asian regional hegemony. As a result, the Intermediate Nuclear Force treaty is effectively dead, and the New Start Treaty, covering strategic missiles, is due to expire next year, with no indication of any US–Russian consensus to extend it. The US has with logic indicated its interest in making these agreements trilateral; but China, with its growing power and ambition, has also logically rejected these overtures. Thus, all three great powers are entering a period of nuclear weapons competition unconstrained by the major Cold War arms control regimes. In a period of rapid advances in technology and worsening great power relations, the nuclear competition will be a defining characteristic of the next decade and beyond. This dynamic will also complicate nuclear nonproliferation efforts, as both the demand for nuclear weapons (a consequence of rising regional and global insecurity), and supply of nuclear materials and technology (a result of the weakening of the nonproliferation regime and deteriorating great power relations) will increase. Will deterrence prevent war in a world of several nuclear weapons states, (the current nuclear powers plus South Korea, Iran, Saudi Arabia, Japan, Turkey), as it helped to do during the bipolar Cold War? Some neorealist observers view nuclear weapons proliferation as stabilizing, extending the balance of terror, and the imperative of restraint, to new nuclear weapons states with much to fight over (Saudi Arabia and Iran, for example).27 Others,28 examining issues of command and control of nuclear weapons deployment and use by newly acquiring states, asymmetries in doctrines, force structures, and capabilities between rivals, the perils of variable rates in transition to weapons deployment, problems of communication between states with deep mutual grievances, the heightened risk of transfer of such weapons to non-state actors, have grave doubts about the safety of a multipolar, nuclear-armed world.29 We can at least conclude that prudence dictates heightened efforts to slow the pace of proliferation, while realism requires that we face a proliferated future with eyes wide open. The current distribution of power is not perfectly multipolar. The US still commands the world’s largest economy, and its military power is unrivaled by any state or combination of states. Its population is still growing, despite a recent decline in birth rates. It enjoys extraordinary geographic advantages over its rivals, who are distant and live in far worse neighborhoods. Its economy is less dependent on foreign markets or resources. Its political system has proven—up to now—to be resilient and adaptable. Its global alliance system greatly extends its capacity to defend itself and shape the world to its liking and is still intact, despite growing doubts about America’s reliability as a security guarantor. Based on these mostly material and historical criteria, continued American primacy would seem to be a good bet, if it chooses to use its power in this way.30 So why multipolarity? The clearest and most frequently cited evidence for a widening distribution of global power away from American unipolarity is the narrowing gap in GDP between the US and China. The IMF’s World Economic Outlook forecasts a $0.9 trillion increase in US GDP for 2019–2020, and a $1.3 trillion increase for China in the same period.31 Many who support the American primacy case argue that GDP is an imperfect measure of power, that Chinese GDP data is inflated, that its growth rates are in decline while Chinese debt is rapidly increasing, and that China does poorly on other factors that contribute to power—its low per capita GDP, its political succession challenges, its environmental crisis, its absence of any external alliance system. Yet GDP is a good place to start, as the single most useful measure and long-term predictor of power. It is from the overall economy that states extract and apply material power to leverage desired behavior from other states. It is true that robust future Chinese growth is not guaranteed, nor is its capacity to convert its wealth to power, which is a function of how well its political system works over time. But this is equally the case for the US, and considering recent political developments is not a given for either country. As an alternative to measuring inputs—economic size, political legitimacy, technological innovation, population growth—in assessing relative power and the nature of global power distribution, we should consider outputs: what are states doing with their power? The input measures are useful, possibly predictive, but are usually deployed in the course of making a foreign policy argument, sometimes on behalf of a reassertion of American primacy, sometimes on behalf of retrenchment. As such, their objectivity (despite their generous deployment of “data”) is open to question. What is undeniable, to any clear-eyed observer, is a real decline in American influence in the world, and a rise in the influence of other powers, which predates the Trump administration but has accelerated into America’s free fall over the last four years. This has produced a de facto multipolarity, whether explainable in the various measures of power—actual and latent—or not. This decline results in part from policy mistakes: a reckless squandering of material power and legitimacy in Iraq, an overabundance of caution in Syria, and now pure impulsivity. But more fundamentally, it is a product of relative decline in American capacity—political and economic—to which American leadership is adjusting haphazardly, but in the direction of retrenchment/restraint. It is highly revealing that the last two American presidents, polar opposites in intellect, temperament and values, agreed on one fundamental point: the US is overextended, and needs to retrench. The fact that neither Obama nor Trump (up to this point in his presidency) believed they had the power at their disposal to do anything else, tells us far more about the future of American power and policy—and about the emerging shape of international relations—than the power measures and comparisons made by foreign policy advocates. Observation of recent trends in US versus Russian relative influence prompts another question: do we understand the emerging characteristics of power? Rigorously measuring and comparing the wrong parameters will get us nowhere at best and mislead us into misguided policies at worst. How often have we heard, with puzzlement, that Putin punches far above his weight? Could it be that we misunderstand what constitutes “weight” in the contemporary and emerging world? Putin may be on a high wire, and bound to come crashing down; but the fact is that Russian influence, leveraging sophisticated communications/social media/influence operations, a strong military, an agile (Putin-dominated) decision process, and taking advantage of the egregious mistakes by the West, has been advancing for over a decade, shows no sign of slowing down, and has created additional opportunities for itself in the Middle East, Europe, Asia, Latin America, the Arctic. It has done this with an economy roughly the size of Italy’s. There are few signs of a domestic political challenge to Putin. His external opponents are in disarray, and Russia’s main adversary is politically disabled from confronting the problem. He has established Russia as the Middle East power broker. He has reached into the internal politics of his Western adversaries and influenced their leadership choices. He has invaded and absorbed the territory of neighboring states. His actions have produced deep divisions within NATO. Again, simple observation suggests multipolarity in fact, and a full explanation for this power shift awaiting future historians able to look with more objectivity at twenty-first-century elements of power. When that history is written, surely it will emphasize the extraordinary polarization in American politics. Was multipolarity a case of others finding leverage in new sources of power, or the US underutilizing its own? The material measures suggest sufficient capacity for sustained American primacy, but with this latent capacity unavailable (as perceived, I believe correctly, by political leadership) by virtue of weakening institutions: two major parties in separate universes; a winnertake-all political mentality; deep polarization between the parties’ popular bases of support; divided government, with the Presidency and the Congress often in separate and antagonistic hands; diminishing trust in the permanent government, and in the knowledge it brings to important decisions, and deepening distrust between the intelligence community and policymakers; and, in Trump’s case, a chaotic policy process that lacks any strategic reference points, mis-communicates the Administration’s intentions, and has proven incapable of sustained, coherent diplomacy on behalf of any explicit and consistent set of policy goals. Rising Nationalism/Populism/Authoritarianism The evidence for these trends is clear. Freedom House, the go-to authority on the state of global democracy, just published its annual assessment for 2020, and recorded the fourteenth consecutive year of global democratic decline and advancing authoritarianism. This dramatic deterioration includes both a weakening in democratic practice within states still deemed on balance democratic, and a shift from weak democracies to authoritarianism in others. Commitment to democratic norms and practices—freedom of speech and of the press, independent judiciaries, protection of minority rights—is in decline. The decline is evident across the global system and encompasses all major powers, from India and China, to Europe, to the US. Right-wing populist parties have assumed power, or constitute a politically significant minority, in a lengthening list of democratic states, including both new (Hungary, Poland) and established (India, the US, the UK) democracies. Nationalism, frequently dismissed by liberal globalization advocates as a weak force when confronted by market democracies’ presumed inherent superiority, has experienced a resurgence in Russia, China, the Middle East, and at home. Given the breadth and depth of right-wing populism, the raw power that promotes it—mainly Russian and American—and the disarray of its liberal opponents, this factor will weigh heavily on the future. The major factors contributing to right-wing populism and its global spread is the subject of much discussion.32 The most straightforward explanation is rising inequality and diminished intergenerational mobility, particularly in developed countries whose labor-intensive manufacturing has been hit hardest by the globalization of capital combined with the immobility of labor. Jobs, wages, economic security, a reasonable hope that one’s offspring has a shot at a better life than one’s own, the erosion of social capital within economically marginalized communities, government failure to provide a decent safety net and job retraining for those battered by globalization: all have contributed to a sense of desperation and raw anger in the hollowed-out communities of formerly prosperous industrial areas. The declining life expectancy numbers33 tell a story of immiseration: drug addition, suicide, poor health care, and gun violence. The political expression of such conditions of life should not be surprising. Simple, extremist “solutions” become irresistible. Sectarian, racial, regional divides are strengthened, and exclusive identities are sharpened. Political entrepreneurs offering to blow up the system blamed for such conditions become credible. Those who are perceived as having benefited from the corrupt system—long-standing institutions of government, foreign countries and populations, immigrants, minorities getting a “free ride,” elites—become targets of recrimination and violence. The simple solutions of course, don’t work, deepening the underlying crisis, but in the process politics is poisoned. If this sounds like the US, it should, but it also describes major European countries (the UK, France, Italy, Germany, Poland, Hungary, the Czech Republic), and could be an indication of things to come for non-Western democracies like India. We have emphasized throughout this chapter the interaction of four structural forces in shaping the future, and this interaction is evident here as well. Is it merely coincidence that the period of democratic decline documented by Freedom House, coincides precisely with the global financial and economic crisis? Lower growth, increasing joblessness, wage stagnation, superimposed on longer-term widening of inequality and declining mobility, constitute a forbidding stress test for democratic systems, and many continue to fail. And if we are correct about secular stagnation, the stress will continue, and authoritarianism’s fourteen-year run will not be over for some time. The antidemocratic trend will gain additional impetus from the illiberal direction of globalization, with its growth suppressing protectionism, weaponization of global economic exchange, and weakening global economic institutions. Multipolarity also contributes, in several ways. The former hegemon and author of globalization’s liberal structure has lost its appetite, and arguably its capacity, for leadership, and indeed has become part of the problem, succumbing to and promoting the global right-wing populist surge. It is suffering an unprecedented decline in life expectancy, and recently a decline in the birth rate, signaling a degree of rot commonly associated with a collapsing Soviet Union. While American politics may once again cohere around its liberal values and interests, the time when American leadership had the self-confidence to shape the global system in its liberal image is gone. It may build coalitions of the like-minded to launch liberal projects, but there will be too much power outside these coalitions to permit liberal globalization of the sort imagined at the end of the Cold War. In multipolarity, the values around which global politics revolve will reflect the diversity of major powers, their interests, and the norms they embrace. Convergence of norms, practices, policies is out of the question. Global collective action, even in the face of global crises, will be a long shot. To expect anything else is fantasy Unbrave New World and Future Challenges At the outset of this chapter we described these structural forces as interacting to produce more conflict and diminished prosperity. We also predicted a world with shrinking collective capacity to address new challenges as they arise. What specifically will such a world look like? We address below three principal challenges to global problem solving over the next decade. Interstate Conflict In the world experienced by most readers of this volume, conflict is observed within weak states, sometimes promoted by regional competitors, by terrorist groups, or by great powers, acting through surrogates or by indirect means. Sometimes, as in Syria, this conflict spills over to contiguous states and contributes to regional instability, and challenges other regions to respond effectively, a challenge that Europe has not met. Much of this will continue, but the global significance of such local conflicts will be greatly magnified by increasing great power conflict, which will feed—rather than manage or resolve—local instabilities and will in turn be exacerbated by them. Great powers will jockey for advantage, support their local partners, escalate preemptively. Conflicts initially confined to failing states or unstable regions will be redefined by great powers as global in scope and significance. This tendency of states to view local conflicts in the context of a zero-sum, global struggle for power is familiar to students of the Cold War, but now with the additional challenges to collective action, expanded uncertainty and worst-case thinking associated with the power transition to multipolarity. We can easily observe increased conflict in US–China relations, as we will in US–Russia relations as future US administrations try to make up for ground lost during the Trump presidency, especially in the Middle East. We can observe it among powerful states with mutual historical grievances, now with a weakening presence of the hegemonic security guarantor and having to consider the renationalization of their defense: Japan-South Korea, Germany-France. We can observe it among historical rivals operating in rapidly changing security landscapes: India-China. We can observe it within the Middle East, as internal rivalries are appropriated by regional powers in a contest for regional dominance. We can observe it clearly in Syria, where the regime’s violent suppression of Arab Spring resistance led to all-out civil war, attracted outside support to proxy forces by aspiring regional hegemons Saudi Arabia and Iran, enabled the rise of ISIS, and eventually to great power intervention, principally by Russia. In a world of effective great power collaboration or American primacy, the Syrian civil war might have been settled through power sharing or partition, or if not, contained within Syria. The collapse of Yugoslavia, occurring during a period of US “unipolarity” and managed effectively, demonstrates the possibilities. Instead, with the US retrenching, Middle East rivals unconstrained by great powers, and great power competition rising, the Syria civil war was fed by outside powers, then metastasized into the region, and—in the form of refugee flows—into Europe, fundamentally altering European politics. Libya may be at the early stages of this scenario. This is not the end of the Syria story. Russia has established itself as a major player in Syria and the Middle East’s power broker, the indispensable country with leverage throughout the region. China is poised to reap the financial and power benefits of Syrian reconstruction. The US has just demonstrated, in its act of war against the Iranian regime, its willingness, without consultation, to put its allies’ security in further jeopardy, accentuating the risks of security ties with Washington and generating added opportunities for Russia and China. The purpose here is not to critique US policy, but to point out the dramatically shifting power balance in a critical region, toward multipolarity. The dangers of such a shift will become apparent as some future US president attempts to reassert US influence in the region and finds a crowded playing field. Can a multipolar distribution of power among several states whose interests, values, and political practices are divergent, all experiencing bottom-up nationalist pressures, all seeking advantages in the oversupply of regional instability, be made to work? I think not. Will this more dangerous world descend into direct military confrontation between great powers, and could such confrontation lead to use of nuclear weapons? Here the question becomes, what will this more dangerous world actually look like; what instruments of coercion will be available to states as technology change accelerates; how will states employ these instruments; how will deterrence work (if at all) among several states with large but unequal levels of destructive capacity, weak command, and control, disparate— or opaque—strategies and simmering rivalries; can conflict management work in a world of weak institutions? The collapse of the Cold War era nuclear arms control regime, the threat to the Non-Proliferation Treaty represented by the demise of the JCPOA, and multiple indications of an accelerating nuclear arms race among the three principle powers, augurs badly. Given the structural forces at play, and without predicting the worst, we are indeed entering perilous times. Global Poverty and Inequality Despite the challenges of volatility and disruptive change inherent in globalization, the world under American liberal leadership has managed a dramatic reduction of extreme poverty. According to World Bank estimates, in 2015, 10 percent of the world’s population lived on less than $1.90 a day, down from nearly 36 percent in 1990.34 In fact, as of September 2018, half the world is now middle class or wealthier.35 The uneven success of the UN Millennium Development Goals (MDGs) exemplifies this achievement, and demonstrates what is possible when open markets are managed through strong global institutions, effective leadership and interstate collaboration. What this liberal hegemonic system did not achieve, however, was a fair distribution of the gains from globalization within states, and among those states that for various reasons were not full participants in this system. This record of partial achievement leaves us with a full agenda for the next fifteen years, but without the hegemonic leadership, strong institutions, ascendant liberalism or robust global growth that enabled previous gains. There are powerful reasons to question the sustainability of these poverty reduction gains, leading to doubts about the realization of the Sustainable Development Goals, which have replaced the MDGs as global development targets.36 (See Jens Rudbeck’s chapter and Sidhu’s UN chapter for SDGs). Skeptics have pointed to slowing global growth, specifically in China, whose demand for imported commodities was a major factor in developing country growth and job creation; growing protectionism in developed country markets, fueled by bottom-up forces of nationalism, and from top-down by a weakened global trading regime and increased geopolitical rivalry; the effects of accelerating climate change on agriculture, migration and communal conflict in poor countries; and the growth burst among poor countries from the rapid transition to more efficient use of resources, a transition that is now slowing down.37 Perhaps the greatest concern in this scenario is a general deterioration in the developing country foreign investment climate. Foreign direct investment (FDI) has been a major contributor to growth, job creation, and poverty alleviation among poor countries. It has incentivized growthfriendly policies, reduced corruption, introduced technology and effective management practices, and linked poor countries to foreign markets through global supply chains.38 It has stimulated growth of indigenous manufacturing and service companies to supply new foreign investments. It has been the major cause of economic convergence between rich and poor countries. From 2000 to 2009, developing economies’ growth rates were more than four percentage points higher than those of rich countries, pushing their share of global output from just over a third to nearly half.39 However, FDI flows into poor countries are imperiled by the structural forces discussed here. Political instability arising from slower growth and environmental stress will increase investors’ perception of higher risk, reinforcing their developed country bias. Protectionism among developed countries will threaten the global market access upon which manufacturing investment in developing countries is premised, causing firms to pare back their global supply chains. As companies retrench from direct investment in poor countries, the appeal to those countries of Chinese debt financed infrastructure projects, under the Belt-Road Initiative with little or no conditionality, but at the risk of “debt traps,” will increase. Global Warming The question posed at the beginning of this section is whether the international system, evolving toward multipolarity and rising nationalism, will find the collective political capital to confront challenges as they arise. Global warming is the mother of all challenges, and the weakness in the system’s capacity to respond is clear. With the two major political/economic powers and greenhouse gas emitters locked in deepening geopolitical conflict (and with one of them locked in climate change denial, possibly through 2024), the chances of significantly slowing global warming or even ameliorating its effects are very slim. We are reduced to the default option, nation-specific adaptation to climate change, which will impose rising human, political and economic costs on all, and will widen the gap between rich countries with adaptive capacity (of varying degrees), and the poor, who will suffer deteriorating economic, political, and social conditions. (For a contrary, optimistic view see Michael Shank’s chapter, which credits new actors—like cities—as playing a more constructive role in climate mitigation.) This would bring to a close liberal globalization’s greatest achievement; the raising of 1.1 billion people out of extreme poverty since 1990,40 with all its associated gains in quality of life (in the WHO Africa region, for example, life expectancy rose by 10.3 years between 2000 and 2016, driven mainly by improvements in child survival and expanded access to antiretrovirals for treatment of HIV).41 Several forces are at work here. The problem itself is graver—in magnitude and in rate of worsening—than predicted by climate scientists. The UN Intergovernmental Panel on Climate Change (IPCC), the major source of information on global warming, has consistently underpredicted the rate of climate deterioration. This holds true even for its “worst-case scenarios,” meaning that what was meant as a wake-up call has in fact reinforced complacency.42 (see Michael Shank’s chapter for further discussion of climate change). The IPCC, in its 2019 report, has tried to undo the damage by emphasizing the acceleration in the rate of warming and its effects, the only partially understood dynamic of climate change, and—given wide uncertainty—the possibility of unpleasant surprises yet to come. This strengthens the scientific case for urgency—to both severely limit greenhouse gas emissions, and to increase investment in ameliorating the effects. Unfortunately, the crisis comes at a moment when the climate for collective action is ice cold. Geopolitical competition incentivizes states to out produce each other, regardless of the environmental effects. Multipolarity complicates collective action. Economic stagnation mandates job creation, making regulation politically toxic. Bottom-up nationalism/populism causes states to pursue “relative gains,” meaning that if the nation is seen as gaining in a no-holds-barred economic competition with others, the negative environmental effects can be tolerated. A post-Trump presidency would help, with the US rejoining the Paris Agreement, and lending its weight to tighter regulation, increased R and D, and stronger economic incentives to reduce carbon emissions. Keep in mind, however, that President Obama was fully behind such efforts, but in a deeply polarized America was unable to implement measures needed to fulfill the Paris obligations through legislation, and his executive orders to do this were swiftly overturned by Trump. Conclusion It may be tempting to hope that post-Trump, the US can regain its global leadership and exert its considerable power in a liberal direction, but with enough self-awareness of its relative decline to share responsibility with others. This was, I believe, the broad direction of the Obama strategy, evidenced by the JCPOA and the Trans-Pacific Partnership: liberal, collective solutions to global problems, as US dominance receded. This would constitute an optimistic scenario, and it confronts two major problems: can US internal politics support it (can, for example, the country legislate controls on carbon, essential for the global credibility and durability of such commitments); and is the world ready to reengage with American leadership, given the damage to its reputation and the structural forces discussed in this chapter? My educated guess is no, on both counts. The rot within is extensive, the concrete evidence clear in the economic inequality/immobility numbers, the life expectancy numbers, the deep political polarization, between the two major parties, between regions, between cities and rural areas. We are in fact a long way from fitness for global leadership, and the recognition of this by others will accelerate the decline of American influence. The rest of the world is well on its way toward adjusting to post-American hegemony, some by renationalizing their defense, or by cutting deals with adversaries, by building new alliances or by seizing new opportunities for influence in the vacuum left by American retrenchment. The evidence for this will accumulate. Observe the current and emerging Middle East, where all these post-hegemonic strategies are visible.

### AI/Data Adv

#### Data hording inhibits US AI Innovation

**Wheeler 20** (Tom Wheeler served as 31st Chairman of the Federal Communications Commission (FCC) from 2013-2017. He is a visiting fellow at the Brookings Institution and a senior fellow at the Harvard Kennedy School.; “DIGITAL COMPETITION WITH CHINA STARTS WITH COMPETITION AT HOME”; APRIL 2020; <https://www.brookings.edu/research/digital-competition-with-china-starts-with-competition-at-home/>; AS)

America’s dominant tech companies have seized upon the competition with China as a rationale for why their behavior should not be subject to regulatory oversight that would, among other things, promote competition. “China doesn’t regulate its companies” has become a go-to policy response. When coupled with “of course, we support regulation, but it must be responsible regulation,” it throws up a smokescreen that allows the dominant tech companies to make the rules governing their marketplace behavior. At the heart of digital competition — both at home and abroad — is the capital asset of the 21st century: data. Initiatives such as machine learning and artificial intelligence are data-dependent, requiring a large data input to enable algorithms to reach a conclusion. China’s immense population of almost 1.5 billion gives it an advantage in this regard. By definition, a population that approaches five times the size of the U.S. population produces more data. The previously “backward” nature of the Chinese economy has resulted in another Chinese data advantage: New smartphone-based apps, created in place of the digital integration that China previously lacked, produce a richer collection of data. This bulk and richness of Chinese data creates an inherent digital advantage when compared to the United States. If the United States will never out-bulk China in the quantity and quality of data, it must out-innovate China. Here, the United States has an advantage, should it choose to take it. The centralized control of the Chinese digital economy is an anti-entrepreneurial force. In contrast, innovation is the hallmark of a free and open market. But the domestic market must, indeed, be free, open, and competitive. Currently, the American digital marketplace is not competitive. A handful of companies command the marketplace by hoarding the data asset others need to compete. As innovative as America’s tech giants may be, they represent a bottleneck that starves independent innovators of the mother’s milk of digital competition. If America is to out-innovate China, then American innovators need access to the essential data asset required for that innovation. The nation’s response to Chinese competition must not be the adoption of China-like national champions, nor the “China doesn’t regulate its companies that way” smokescreen. American public policy should embrace the all-American concept of competition-driven innovation. This begins with breaking the bottleneck that withholds data from its competitive application. This does not necessarily mean breaking up the dominant companies, but it does mean breaking open their mercenary lock on the assets essential for competition-driven innovation.

#### Data is king for AI–smart cities and a laundry list of emerging innovation potential

**Lucas and Waters** **2018**, Louise Lucas in Hangzhou and Richard Waters in San Francisco, Financial Times, “China and US compete to dominate big data” May 1, 2018, NexisUni. <https://www.ft.com/content/e33a6994-447e-11e8-93cf-67ac3a6482fd> //DELO

Chinese attitudes to data privacy are becoming slightly less lax, but regulations are still a million miles from Europe, which is at the other end of the spectrum and will introduce tough privacy rules later this month known as General Data Protection Regulation. Yet American companies like Facebook, Google and Amazon also have masses of data, says Mr Wu at Yitu. That suggests that general-purpose AI applications like facial recognition will be the preserve of all “the big platforms”, regardless of their country of origin, says James Manyika, a partner at McKinsey. By contrast, more specialised applications could be perfected where the data are the richest. When it comes to manufacturing, for instance, China is “collecting a lot more data”, he says. This data advantage could be greatest in fields where regulation has made access to information harder, or prevented it being collected in the first place, according to some experts. Earlier this year, Google published promising research suggesting it could predict the risk of heart attack by using image-recognition software to study retinal blood vessels. The research relied heavily on UK Biobank, a database drawing on a detailed study of volunteers in Britain beginning in 2006. Yet only 631 people in the Biobank had medical conditions relevant to the research. That made the data set “relatively small for deep learning”, Google said, reducing the effectiveness of the algorithm it was able to train on the information. Chinese medical AI researchers, by contrast, have been able to tap into far bigger data sets, according to one expert. If China is rich in data, then it also has the economic opportunities to exploit it — something that has helped lure back many haigui, or returning “sea turtles”, like Mr Jin. AI is being harnessed in law, where machines have replaced stenographers in more than 6,000 courts; on the roads to manage traffic; in hospitals to detect tumours; and in Shanghai subway stations where you can buy tickets by talking to the machine. “AI has the biggest opportunity in China versus any western countries,” says Mr Rong. Chinese executives talk about a smart city scheme that halved the time it takes to speed ambulances from depot to patient to hospital, by dint of switching traffic flows and traffic lights. The smart cities scheme also offers another point of difference with the US: collaboration between state and private companies on a large scale. In addition to projects aimed at traffic management, crowd control, finding missing children and elderly, cutting down hospital waiting times — the list goes on — all the big tech players have joint research labs with government. This is part of a broader experimentation that is lacking in the US, says Mr Wu. “Overall, the Chinese tech scene is more dynamic right now, particularly in terms of trying out new ideas and new products,” he says. “People are just trying out more new things.” That has not been lost on investors in the US. One leading Silicon Valley venture capitalist puts the difference in AI opportunities bluntly: “The business is bigger and better in China.” This economic momentum behind AI is closely aligned with a second powerful force: a sense of national mission. That has brought a hydrant of money and clear industrial policy. This state-led strategy is also closely aligned with national champions Baidu, Alibaba and Tencent — all private companies. Washington has done much less to promote a national agenda. “What’s the national direction around AI and robotics [in the US]? It’s nothing. It’s missing,” says the Silicon Valley investor. “The government is flailing around.” Worse, the Trump administration’s attempts to clamp down on immigration has upset the US tech industry, which has drawn heavily on overseas talent — not least Indian and Chinese engineers. The heads of AI at Apple, Facebook and Microsoft, as well as Google’s cloud computing division, were all born outside the US. “We’ve seen more and more students choosing not to come to the US,” says Mr Etzioni. “We’re in the process of shooting ourselves in the head.” He points to one sign of how the talent pendulum is swinging away from the US: Google and Microsoft have both opened AI research centres in China to tap the AI workforce there. Yet the expertise advantage that the US has will not disappear overnight. Companies like Yitu are moving in the opposite direction because they believe the US west coast is still the magnet for many of the world’s top engineering brains. “Half the AI engineers in Silicon Valley are Chinese,” says Mr Wu.

#### Changing Polarity in Asia causes US-China Nuclear War and Extinction—MAD and Interdependence Don’t Check

Van Ness ‘17 (Peter, Visiting Fellow in the Department of International Relations at the Coral Bell School, The Australian National University, “Is a War between China and America Simply Unstoppable?”; August 17, 2017; <http://nationalinterest.org/blog/the-buzz/war-between-china-america-simply-unstoppable-21935>; RMW)

Building his analysis on Thucydides’ study of the Peloponnesian War, Graham Allison and his colleagues have studied the classic international relations problem of military conflict between a rising power and an established dominant power. They identified 16 such situations over the past 500 years, and found that 12 of them ended in war — painting a gloomy picture of the future of US–China relations. Critics of Allison’s work have argued that the relationship between the United States and China is very different. They are deeply interdependent both economically and politically, with sustained communication between the US and Chinese militaries. Others note that mutual assured destruction means that a US–China nuclear war would be suicidal, making even the suggestion of war between the two countries unthinkable. These are valid reservations but there are three key points missing in [critics’ dismissal](http://www.eastasiaforum.org/2015/11/06/south-china-sea-tensions-unlikely-to-lead-to-war/) of Allison’s warnings. These are the unprecedented risk involved in nuclear war, the positioning of today’s militaries and the reality of an erratic and unpredictable president of the United States. Since the sole [use of nuclear weapons](http://www.eastasiaforum.org/2016/08/24/no-first-use-nuclear-pledge-bad-for-us-standing-in-asia/) in wartime — the 1945 attacks on Hiroshima and Nagasaki — scholars have meticulously assessed the likely human cost of any subsequent use of nuclear weapons. Such studies have become of particular importance considering that the capacity of the weapons held in the arsenals of the nine nuclear powers today is many times more destructive than what was unleashed in the World War II bombings. The consensus is that a nuclear exchange between any two of the major powers would result in the deaths of hundreds of thousands — if not millions — of civilians, as well as the likely advent of a so-called ‘nuclear winter’ in at least the Northern Hemisphere that would make human existence difficult, if not impossible**.** Never have we faced such possibilities of mass destruction. The Bulletin of the Atomic Scientists’ Doomsday Clock is set at three minutes to midnight, the closest to disaster since the 1980s. The second point that many critics ignore is that the United States, China and Russia have all trained and positioned their militaries to launch a nuclear attack on the others at literally a moment’s notice. Admiral Scott Swift, Commander of the US Pacific fleet, [was once asked](http://www.npr.org/sections/thetwo-way/2017/07/27/539733586/admiral-says-hed-launch-a-nuclear-strike-on-china-if-trump-ordered-it) whether he would follow through if US President Donald Trump ordered him to launch a nuclear attack on China. He replied in the affirmative, citing the foundational principle of civilian control over the military. US military forces, like the militaries of all nuclear powers, are trained to engage in nuclear war in obedience to the command of their political leader, without hesitation or reconsideration. Third, the Thucydides Trap argument is a structural analysis, focused on the changing material capabilities of competing powers. But [the presidency of Donald Trump](http://www.eastasiaforum.org/2017/08/06/how-has-china-managed-to-get-along-with-trump/) requires us to add another dimension to the problem: the role of political leaders. To date, Trump’s presidency has been inept and [dangerously destabilising](http://www.eastasiaforum.org/2017/01/26/trumps-twitter-diplomacy-troubles-us-china-relations/)**.** Moreover, public criticism of his behaviour has apparently caused him to behave even more erratically and defensively. This kind of leadership makes the likelihood of confrontation and conflict even greater. It is vital to understand just how extraordinary are the times in which we live. Unlike the 5th century BC of Thucydides’ Greece, the stakes today are higher, the dangers are greater, and the need to take constructive action is more urgent than at any time before.

#### Data-Rich AI Models Lead to Accelerated Vaccine Delivery

MIT et al 20 (MIT Technology Review Insights is the custom publishing division of MIT Technology Review, the world’s longest-running technology magazine, backed by the world’s foremost technology institution—producing live events and research on the leading technology and business challenges of the day. Insights conducts qualitative and quantitative research and analysis in the US and abroad and publishes a wide variety of content, including articles, reports, infographics, videos, and podcasts. And through its growing MIT Technology Review Global Panel, Insights has unparalleled access to senior-level executives, innovators, and thought leaders worldwide for surveys and in-depth interviews; Genesys is the global leader in cloud customer experience and contact center solutions; Philips; "The global AI agenda: Promise, reality, and a future of data sharing”; March 26, 2020; https://mittrinsights.s3.amazonaws.com/AIagenda2020/GlobalAIagenda.pdf; AS)

Share your data to help AI work for everyone. Hoarding data will eventually prove self-defeating, as companies come to find that the gains to AI model performance from data sharing outweigh any risks involved. Beyond commercial gains, societies will also benefit when data-rich AI models lead to accelerated vaccine discovery, for example, safer roads, or more reliable public transport. Much needs to be done to build confidence in data sharing, but technology advances in areas such as blockchain and federated learning are likely to make it a safer proposition.

#### Vaccines are also crucial to stopping future pandemics—but reassuring the public about their safety is crucial:

Julie L. Gerberding, M.D., M.P.H., and Barton F. Haynes, M.D., 2/4/2021 (New England Journal of Medicine, “Vaccine Innovations — Past and Future,” <https://www.nejm.org/doi/full/10.1056/nejmp2029466>, Retrieved 8/2/2021)

Vaccination is a powerful method of disease prevention that is relevant to people of all ages and in all countries, as the Covid-19 pandemic illustrates. Vaccination can improve people’s chances of survival, protect communities from new and reemerging health threats, and enhance societal productivity. But achieving the promise of vaccination requires much more than the vaccines themselves. It requires appropriate incentives to encourage the timely discovery and development of innovative, effective, safe, and affordable products; effective financing and delivery programs; and credible scientific leaders who can provide evidence-based policy recommendations and reassure the public about the value of the vaccines. Since its inception 50 years ago, the National Academy of Medicine (NAM), previously known as the Institute of Medicine (IOM), has been an authoritative resource on medical issues, including vaccination, and a global leader in vaccine-policy development. FDA Licensure Dates for Selected Innovative Vaccines since 1970. It’s hard to overstate the benefits that innovative vaccines deployed in the past five decades have had on morbidity and mortality (see timeline).1 The incidence of vaccine-preventable diseases among U.S. children has decreased dramatically, an achievement that is attributable in part to high vaccine-coverage rates. By the 2018–2019 school year, coverage rates among kindergarteners exceeded 90% in all but two states, according to data from the Centers for Disease Control and Prevention (CDC). Four vaccine-preventable illnesses have been eliminated from the Americas: smallpox in 1971, poliomyelitis in 1994, and rubella and congenital rubella syndrome in 2015 (one of us is an executive vice president at Merck, which produces vaccines for rubella, among other vaccines). Moreover, between 2011 and 2020, immunization programs in low-income countries saved an estimated 23.3 million lives.2 Perhaps the most notable immunization-related accomplishment during the past half century was the eradication of smallpox, which was verified by the World Health Organization (WHO) in 1980. In addition, global cases of paralytic polio have decreased by 99.95% from the estimated 350,000 cases in 1988,3 when the global polio-eradication program was announced, and two of the three wild-type polioviruses, WPV types 2 and 3, have been eradicated. Other important achievements during this period include the 1986 approval of the first vaccine based on recombinant technology, a hepatitis B vaccine that not only has reduced rates of the infection in many countries but was also the first vaccine to reduce cancer risk. In 1987, the first polysaccharide-protein conjugate vaccine was licensed; since then, the incidence of invasive Haemophilus influenzae type b disease among children has fallen dramatically. In 2009, a vaccine for Neisseria meningitidis group A became the first licensed vaccine specifically designed for certain people in low-income countries. Achieving broad population health benefits associated with vaccination requires effective policies that create incentives for vaccine development, ensure financing of vaccines, and improve access. After a measles outbreak in 1989–1991, the U.S. Vaccines for Children Program was authorized in 1993 to ensure that eligible children would have free access to all CDC-recommended vaccines. To address remaining gaps, the IOM in 2000 issued a landmark report that recommended policy and programmatic improvements to strengthen U.S. immunization programs. One outcome of this effort was the requirement included in the 2010 Affordable Care Act that plans provide first-dollar coverage (coverage without copayments or other cost sharing) for vaccines recommended by the CDC’s Advisory Committee on Immunization Practices for children and adults up to age 26. Policy advances have also enhanced the effects of vaccination globally. The WHO launched the Expanded Program on Immunization in 1974 to increase access to vaccines. Beginning in 2000, the benefits of this program were greatly enhanced by the creation of Gavi, the Vaccine Alliance, an international public–private partnership that provides financial and programmatic support to ensure that children in the poorest countries have access to vaccines. In 2017, with the support of the NAM and other organizations, this model was used as a framework for the creation of the Coalition for Epidemic Preparedness Innovations to fund innovative vaccines and other countermeasures against pathogens that cause devastating public health consequences, such as the Ebola virus and now SARS-CoV-2. Because vaccines are usually administered to healthy people, maintaining the highest safety standards isn’t only an ethical imperative but is also essential to sustaining public trust. The story of vaccine progress has been punctuated by both real and misguided safety concerns for as long as vaccines have been in use. Such concerns have included adverse events associated with vaccination itself, quality lapses in the manufacturing process, and false alarms regarding vaccine safety. The potential for financial gain has fueled liability suits related to putative safety concerns. The NAM has conducted ongoing objective assessments of vaccine safety to help address concerns. Between 2000 and 2004, its Immunization Safety Review Committee evaluated evidence pertinent to various vaccine-safety topics and set a new standard for independent scientific review that remains relevant as the NAM contributes to coronavirus-related policies. Vaccine confidence depends on trust in the safety and efficacy of the products themselves, trust in vaccine manufacturers and the clinicians who administer vaccines, and trust in policymakers who assess the scientific evidence and promulgate vaccination recommendations. Failures in any of these areas can have substantial long-term public health consequences, as was the case with misinformation about measles vaccines. Enduring mistrust stemming from a discredited study that associated childhood vaccination with autism has been linked to recent outbreaks of measles in the United States. Sustaining both vaccine safety and trust in vaccination will become increasingly complex. Vaccines continue to be approved, and more vaccines have become accessible in resource-limited countries, but safety surveillance systems are less evolved in many low-income regions than in high-income regions. Similarly, vaccines are being manufactured in regions where regulatory oversight isn’t always optimal, and counterfeit vaccines remain a threat. Emerging infections may require rapid availability of new vaccines before comprehensive safety studies are complete. Perhaps most important, the speed and reach of communication on social media platforms have created unprecedented opportunities for users to amplify misinformation and flame the fears of parents and other stakeholders in the immunization ecosystem. Moving forward, vaccines against a range of infectious agents will need to be developed. New and reemerging pathogens, such as SARS-CoV-2 and new influenza strains, regularly appear. Viruses that are capable of spreading by vector or airborne routes — one of the most important pandemic threats — continue to emerge. More than 1.5 million as yet unknown viruses are estimated to exist in animals worldwide, and 38 to 50% of them are candidates to spread to humans.4 Global-surveillance and virus-discovery programs are therefore important, and they may be able to predict pandemics. In 2011, the IOM commissioned the development of a strategic multiattribute ranking tool for vaccines to facilitate evaluation of new vaccine targets and help guide decisions about prioritizing vaccine-development efforts. When pandemics emerge, rapid responses are necessary. Vaccines aren’t the only available tool: passive administration of antibodies for prevention or treatment of infectious diseases has been used for many years. The Pandemic Prevention Platform program of the Defense Advanced Research Projects Agency aims to develop a new form of passive antibody protection that can slow viral epidemics starting within 60 days after identification of the pathogen and until a vaccine can be made. Thanks to new technology, the vaccine-development process is also being condensed. Experimental vaccines were developed and ready for phase 1 clinical trials in 20 months for SARS after the epidemic began in 2003 and in slightly more than 3 months for Zika virus in 2016. The response to the Covid-19 pandemic is a prime example of how rapidly new vaccines can now be designed. By the time the WHO declared Covid-19 a pandemic on March 11, 2020, at least 37 groups from biotechnology companies and academic institutions were working on vaccine candidates.5 These candidates include live attenuated, inactivated, DNA, messenger RNA, viral vector, and spike-protein–based vaccines. Less than 1 year later, the first Covid-19 vaccine-efficacy trials have now been completed, and the first vaccines are authorized for emergency use. Many approved vaccines, such as those against measles and polio, were made using attenuated or killed versions of the virus without detailed knowledge of viral pathogenesis. In contrast, current strategies for vaccine design rely on new technologies that lead to a deeper understanding of the immune system and of host–pathogen interactions. For new experimental HIV and respiratory syncytial virus (RSV) vaccines, a detailed structural understanding of antibody interactions with the HIV envelope or the RSV prefusion form of the fusion (F) protein is needed. Vaccines remain the most effective tool for preventing infectious diseases and improving global health. Remarkable progress has been made with the use of vaccines, including the eradication of smallpox and the control of childhood diseases such as measles, mumps, rubella, and polio. New insights into the functioning of the immune system on a cellular and molecular level have made possible the rapid development of new vaccines. Difficulties facing vaccinologists include predicting the type and timing of the next pandemic; developing vaccines to combat rapidly changing pathogens such as HIV-1, influenza, and multidrug-resistant bacteria; and establishing rapid-response strategies to control emerging and reemerging infectious diseases. The future holds great promise for vaccine-mediated control of global pathogens, but providing affordable access to effective vaccines for everyone who could benefit from them remains an important challenge.

#### Future pandemics cause extinction

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The recent SARS-CoV-2 pandemic, which is causing COVID 19 disease, has taught us unexpected lessons about the dangers of human extinction through highly contagious and lethal diseases. As the COVID 19 pandemic is now being controlled by various isolation measures, therapeutics and vaccines, it became clear that our current lifestyle and societal functions may not be sustainable in the long term. We now have to start thinking and planning on how to face the next dangerous pandemic, not just overcoming the one that is upon us now. Is there any evidence that even worse pandemics could strike us in the near future and threaten the existence of the human race? The answer is unequivocally yes. It is not necessary to get infected by viruses of bats, pangolins and other exotic animals that live in remote forests in order to be in danger. Creditable scientific evidence indicates that the human gut microbiota harbor billions of viruses which are capable of affecting the function of vital human organs such as the immune system, lung, brain, liver, kidney, heart etc. It is possible that the development of pathogenic variants in the gut can lead to contagious viruses which can cause pandemics, leading to destruction of vital organs, causing death or various debilitating diseases such as blindness, respiratory, liver, heart and kidney failures. These diseases could result n the complete shutdown of our civilization and probably the extinction of human race. In this essay, I will first provide a few independent pieces of scientific facts and then combine this information to come up with some (but certainly not all) hypothetical scenarios that could cause human race misery, even extinction. I hope that these scary scenarios will trigger preventative measures that could reverse or delay the projected adverse outcomes.

#### Smart cities key to make urban growth sustainable

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A large amount of land-use, environment, socio-economic, energy and transport data is generated in cities. An integrated perspective of managing and analysing such big data can answer a number of science, policy, planning, governance and business questions and support decision making in enabling a smarter environment. This paper presents a theoretical and experimental perspective on the smart cities focused big data management and analysis by proposing a cloud-based analytics service. A prototype has been designed and developed to demonstrate the effectiveness of the analytics service for big data analysis. The prototype has been implemented using Hadoop and Spark and the results are compared. The service analyses the Bristol Open data by identifying correlations between selected urban environment indicators. Experiments are performed using Hadoop and Spark and results are presented in this paper. The data pertaining to quality of life mainly crime and safety & economy and employment was analysed from the data catalogue to measure the indicators spread over years to assess positive and negative trends. Introduction ICT is becoming increasingly pervasive to urban environments and providing the necessary basis for sustainability and resilience of the smart future cities. With the rapid increase in the presence of Internet of Things (IoT) and future internet [1,2] technologies in the smart cities context [3-5], a large amount of data (a.k.a. big data) is generated, which needs to be properly managed and analysed for various applications using a structured and integrated ICT approach. Often ICT tools for a smart city deal with different application domains such as land use, transport and energy, and rarely provide an integrated information perspective to deal with sustainability and socioeconomic growth of the city. Smart cities can benefit from such information using big, and often real-time, cross-thematic data collection, processing, integration and sharing through inter-operable services deployed in a cloud environment. However, such information utilisation requires appropriate software tools, services and technologies to collect, store, analyse and visualise large amounts of data from the city environment, citizens and various departments and agencies at city scale to generate new knowledge and support decision making. The real value of such data is gained by new knowledge acquired by performing data analytics using various data mining, machine learning or statistical methods. However, the field of smart city based data analytics is quite broad, complex and is rapidly evolving. The complexity in the smart city data analytics manifests due to a variety of issues: i) Requirements of cross-thematic applications e.g. energy, transport, water, urban etc, and ii) multiple sources of data providing unstructured, semi-structured or structured data, and iii) trustworthiness of data [6,7]. In this regard, this paper provides a data oriented overview of smart cities and provides a cloud based analytical service architecture and implementation for the analysis of selected case study data. Smart cities provide a new application domain for big data analytics and relatively not much work is reported in literature. A review of the state of the art provides very promising insights about applying cloud computing resources for large scale smart city data analytics. For instance, Lu et al. [8] focus on using computational resources for large scale data for climate having complex structure and format. Using a multi scale dataset for climate data, they demonstrated a cloud based large scale data integration and analytics approach where they made use of tools such as RapidMiner and Hadoop to process the data in a hybrid cloud. Among others, the COSMOS project [9] provides a distributed on-demand cloud infrastructure based on Hadoop for analysing Big Data from social media sources. The infrastructure has the capability to process millions of data-points that would take much longer on a desktop computer. It allows social scientists to integrate and analyse data from multiple non-interoperable sources in a transparent fashion. Such a Big Data analysis platform can also be useful for smart cities as it would allow decision-makers to collect and analyse data from many sources in a timely manner. Ahuja and Moore [10] provide a state of the art review of the technologies being used for big data storage, transfer and analysis. Qin et al. [11] present challenges of Big data analytics and acknowledge the capabilities of MapReduce and RDBMS to solve these challenges. The main contribution of their work is that they have provided a unified MapReduce and RDBMS based analytic ecosystem to avail complementary advantages from both systems. Recently some studies have investigated the usefulness of data mining techniques to combine data from multiple sources such as by Moraru and Mladenic [12]. They applied Apriori technique, which is rule based data mining technique, to learn rules from data. Although they are able to extract some rules from small scale but they’re unable to learn much on large scale data due to high volume of the data and the limited memory on a single system. We use a similar approach that is based on MapReduce. Our prototype implementation analyses the Bristol open dataset to identify correlations between selected urban environment indicators such as Quality of Life. We have developed two implementations using Hadoop and Spark to compare the suitability of such infrastructures for Bristol open data analysis. The remainder of this paper is structured as follows: the next section provides background and rationale in the context of smart cities. Section “An abstract architectural design of the cloud-based big data analysis” provides a data analytics service architecture and design for analytical processing of big data for smart cities. After this, a simple use case based on Bristol open data by identifying needs of information processing and knowledge generation for decision making is presented in Section “A use case: analytics using Bristol open data”. In Section “Prototype implementation” we present the applicability of the proposed solution by implementing a MapReduce based prototype for Bristol open data and discuss outcomes. Finally, we conclude our discussion and present future research directions in Section “Conclusions and future directions”. ICT and smart cities Approximately 50% of world’s population live in urban areas, a number which is expected to increase to nearly 60% by 2030 [13]. High levels of urbanisation are even more evident in Europe where today over 70% of Europeans live in urban areas, with projections that this will increase to nearly 80% by 2030 [13,14]. A continuous increase in urban population strains the limited resources of a city, affects its resilience to the increasing demands on resources and urban governance faces ever increasing challenges. Furthermore, sustainable urban development, economic growth and management of natural resources such as energy and water require better planning and collaborative decision making at the local level. In this regard, the innovation in ICT can provide integrated information intelligence for better urban management and governance, sustainable socioeconomic growth and policy development using participatory processes [15]. Smart cities [4] use a variety of ICT solutions to deal with real life urban challenges. Some of these challenges include environmental sustainability, socioeconomic innovation, participatory governance, better public services, planning and collaborative decision-making. In addition to creating a sustainable futuristic smart infrastructure, overcoming these challenges can empower the citizens in terms of having a personal stake in the well-being and betterment of their civic life. Consequently, city administrations can get new information and knowledge that is hidden in large-scale data to provide better urban governance and management by applying these ICT solutions. Such ICT enabled solutions thus enable efficient transport planning, better water management, improved waste management, new energy efficiency strategies, new constructions and structural methods for health of buildings and effective environment and risk management policies for the citizens. Moreover, other important aspects of the urban life such as public security, air quality and pollution, public health, urban sprawl and bio-diversity loss can also benefit from these ICT solutions. ICT as prime enabler for smart cities transforms application specific data into useful information and knowledge that can help in city planning and decision-making. From the ICT perspective, the possibility of realisation of smart cities is being enabled by smarter hardware and software e.g. IoTs i.e. RFIDs, smart phones, sensor nets, smart household appliances, and capacity to manage and process large scale data using cloud computing without compromising data security and citizens privacy [16]. With the passage of time, the volume of data generated from these IoTs is bound to increase exponentially and classified as Big data [17]. In addition, cities already possess land use, transport, census and environmental monitoring data which is collected from various local, often not interconnected, sources and used by application specific systems but is rarely used as collective source of information (i.e. system of systems [18]) for urban governance and planning decisions. Many local governments are making such data available for public use as “open data” [19]. Managing such large amount of data and analysing for various applications e.g. future city models, visualisation, simulations, provision of quality public services and information to citizens and decision making becomes challenging without developing and applying appropriate tools and techniques.

#### Climate change is anthropogenic and causes extinction---5G-enabled smart cities are critical for mitigation and adaptation.

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Currently, the entire planet is at risk due to continual climate change [1–3]. The recorded increase in average temperature across the world in the past hundred years, and the associated changes attributed to this, are known as global warming. Many scientists are convinced by the published evidence that this change is anthropogenic and resulted from the elevated emission levels of global greenhouse gases (GHGs) [4,5]. Gases such as water vapor, carbon dioxide, methane, nitrous oxide, and ozone are responsible for the absorption and emission of thermal radiation. These changes in the relative quantities of the GHGs induce a proportional change in the amount of preserved solar energy. Presently, the accepted indicator for global warming is the sustained rise in the mean temperature worldwide. This definition is designed to account for the fact that there may be some localized exceptions to this rise. For example, there may be cooling experienced in a region while the global temperature may increase altogether, hence the need for average temperature. A key concern with the GHGs trapping of more heat in the atmosphere is that it affects both climate and short scale weather patterns. Consequently, it results in greater numbers of adverse weather events such as storms, heat waves, cold snaps, droughts, and fires [6]. Climate-related risks to health, livelihoods, food security, water supply, human safety, and economic growth are projected to increase with global warming of 1.5 ◦C [7] and further increase further at 2 ◦C, as shown in Figure 1. In addition, the risks to global aggregated economic growth due to the climate change impacts are projected to be lower at 1.5 ◦C than at 2 ◦C by the end of this century. Carbon dioxide has the most substantial effect on global warming [8]. Although it was once assumed to have an ~100 year lifespan in the atmosphere, careful studies revealed that the situation is far worse, with three-quarters of the gas expected to remain for a time in the region of up to ~1000 years, with the remainder lasting for an indefinite period of time [9]. It was indicated that the present impacts of humanity on the atmosphere can certainly cause a long term problem [10]. Carbon dioxide is released when oil, coal, and other fossil fuels are burnt for the energy we use to power our homes, cars, and smartphones. By lessening its usage, we can curb our own contribution to climate change while saving money. The first challenge is eliminating the burning of coal, oil, and, eventually, natural gas. Oil is the lubricant of the global economy as it is hidden inside such ubiquitous items as plastic and corn, fundamental to the transportation of both consumers and goods. Coal is the substrate, supplying roughly half of the electricity worldwide, a percentage that is likely to grow according to the International Energy Agency (IEA). In fact, buildings contribute up to 43% of all the greenhouse gas emissions worldwide [11], even though investing in thicker insulation and other cost-effective as well as temperature-regulating strategies can save money in the long run. Investment in new infrastructures, or radical upgradation of the existing highways and transmission lines, may help to reduce greenhouse gas emissions, yielding economic growth in the developing countries. Nations across the globe have kept very high targets to reducing their GHG discharges [12,13]. In order to meet these goals, considerable reductions in city energy usage is required. At a global scale, urban communities represent over half (55%) of the population, which is predicted to reach 68% by the middle of this century [14]. Urban areas claim ownership of the highest levels of energy use, gas emission, and also the largest local economy. As such, it is crucial for urban areas to reduce their consumption and utilize renewable sources wherever available to reduce their gas discharge levels. Smart cities often utilize digital sensors to measure and transmit data about the levels of GHGs in the city at that moment, as a means of tackling them [15]. The efficacy of such a system is thus reliant on the network used to collate and analyze the data collected as an extant network. The mobile telecommunications networks offer a convenient solution to this desire, as their pre-existence has the clear benefit of reducing costs compared to the design and implementation of a novel system. It is recognized that smart cities will certainly act as the key players meeting these ambitious targets [16,17]. In this study, we focused primarily on the potential applications of 5G network technology to control climate change in Singapore. In addition, a clear overview of the sustainability benefits of introducing 5G technology compatible smart cities, buildings, and farms in all aspects of urbanization is provided. Herein, the main purpose is to tackle the negative outcomes associated with anthropogenic climate change, with a particular focus on the contributions that are best made by the telecoms network operators. Climate change is one of the most challenging problems that humanity has ever faced. Presently, hundreds of millions of lives, innumerable species, entire ecosystems, health, economy, and the future habitability of this planet are at risk. Fortunately, climate change is solvable, we just need to wisely exploit the existing technologies and sciences. Climate change mitigation is a pressing international need in which many management actions are required. The development of 5G technology has been largely driven by smart mobile devices and advanced communication technologies. It may thus serve as a technical enabler for a whole new range of business opportunities, energy, and facilities management, together with industrial applications. Moreover, it may enable different devices to work together seamlessly. Definitely, the 5G cellular network technology is expected to revolutionize the global industries with profound effects on the savings of energy, waste generation and recycling, and water resources management, thus reducing the climate change impacts.

#### Unsustainable megacities cause extinction – litany of reasons

Cribb, 2017 (Julian Cribb, Julian Cribb is an Australian science writer, the author of nine books and over 8000 media articles. He is a Fellow of the Australian Academy of Technological Sciences and Engineering and of the Australian National University Emeritus Faculty.From 1996-2002 he was Director, National Awareness, for Australia's national science agency, CSIRO. He has received more than 30 awards for journalism including the Order of Australia Association Media Prize, the inaugural Eureka Prize for environmental journalism, the inaugural AUSTRADE award for international business journalism, the Dalgety Award for rural journalism, two MBF Awards for medical journalism and five Michael Daley Awards for science journalism., “The Urbanite (Homo urbanus),” Surviving the 21st Century, pp 147-169, Print ISBN: 978-3-319-41269-6, <https://link.springer.com/chapter/10.1007/978-3-319-41270-2_8#citeas>, accessed on 11/21/2019)

By the mid-twenty-first century the world’s cities will be home to approaching eight billion inhabitants and will carpet an area of the planet’s surface the size of China. Several megacities will have 20, 30, and even 40 million people. The largest city on Earth will be Guangzhou-Shenzen, which already has an estimated 120 million citizens crowded into in its greater metropolitan area (Vidal 2010 ). By the 2050s these colossal conurbations will absorb 4.5 trillion tonnes of fresh water for domestic, urban and industrial purposes, and consume around 75 billion tonnes of metals, materials and resources every year. Their very existence will depend on the preservation of a precarious balance between the essential resources they need for survival and growth—and the capacity of the Earth to supply them. Furthermore, they will generate equally phenomenal volumes of waste, reaching an alpine 2.2 billion tonnes by 2025 ( World Bank )—an average of six million tonnes a day—and probably doubling again by the 2050s, in line with economic demand for material goods and food. In the words of the Global Footprint Network “The global effort for sustainability will be won, or lost, in the world’s cities” (Global Footprint Network 2015 ). As we have seen in the case of food (Chap. 7), these giant cities exist on a razor’s edge, at risk of resource crises for which none of them are fully- prepared. They are potential targets for weapons of mass destruction (Chap. 4). They are humicribs for emerging pandemic diseases, breeding grounds for crime and hatcheries for unregulated advances in biotechnology, nanoscience, chemistry and artificial intelligence. Beyond all this, however, they are also the places where human minds are joining at lightspeed to share knowledge, wisdom and craft solutions to the multiple challenges we face. For good or ill, in cities is the future of civilisation written. They cradle both our hopes and fears. Urban Perils The Brazilian metropolis of Sao Paulo is a harbinger of the challenges which lie ahead for Homo urbanus, Urban Human. In a land which the New York Times once dubbed “the Saudi Arabia of water” because its rivers and lakes held an eighth of all the fresh water on the planet, Brazil’s largest and wealthiest city and its 20 million inhabitants were almost brought to their knees by a one-in-a-hundred-year drought (Romero 2015 ). It wasn’t simply a drought, however, but rather a complex interplay of factors driven by human overexploitation of the surrounding landscape, pollution of the planetary atmosphere and biosphere, corruption of officialdom, mismanagement and governance failure. In other words, the sort of mess that potentially confronts most of the world’s megacities. In the case of Sao Paulo, climate change was implicated by scientists in making a bad drought worse. This was compounded by overclearing in the Amazon basin, which is thought to have reduced local hydrological cycling so that less water was respired by forests and less rain then fell locally. Th is reduced infiltration into the landscape and inflow to river systems which land-clearing had engorged with sediment and nutrients. Rivers running through the city were rendered undrinkable from the industrial pollutants and waste dumped in them. The Sao Paulo water network leaked badly, was subject to corruption, mismanagement and pilfering bordering on pillage. Government plans to build more dams arrived 20 years too late. “Only a deluge can save São Paulo,” Vicente Andreu, the chief of Brazil’s National Water Agency (ANA) told The Economist magazine (Th e Economist 2014). Depopulation, voluntary or forced, loomed as a stark option, officials admitted. Although the drought eased in 2016, water scarcity remained a shadow over the region’s future. Sao Paulo is far from alone: many of the world’s great cities face the spectre of thirst. The same El Nino event also struck the great cities of California, leading urban planners—like others all over the world—to turn to desalination of seawater, using electricity and reverse osmosis filtration (Talbot 2014). This kneejerk response to unanticipated water scarcity echoed the Australian experience where, following the ‘Millennium Drought’ desalination plants were producing 460 gigalitres of water a year in four major cities (National Water Commission 2008)—only to be mothballed a few years later when the dry eased. By the early 2010s there were more than 17,000 desalination plants in 150 countries worldwide, churning out more than 80 gigalitres (21 billion US gallons) of water per day, according to the International Desalination Association (Brown 2015). Most of these plants were powered by fossil fuels which supply the immense amount of energy needed to push saline water through a membrane filter and remove the salt. Ironically, by releasing more carbon into the atmosphere, desalination exacerbates global warming and so helps to increase the probability of fiercer and more frequent droughts. It thus defeats its own purpose by reducing natural water supplies. A similar irony applies to the city of Los Angeles which attempted to protect its dwindling water storages from evaporation by covering them with millions of plastic balls (Howard 2015)—thus using petrochemicals in an attempt to solve a problem originally caused by … petrochemicals. These examples illustrate the ‘wicked’ character of the complex challenges now facing the world’s cities—where poorly-conceived ‘solutions’ may only land the metropolis, and the planet, in deeper trouble that it was before. This is a direct consequence of the pressure of demands from our swollen population outrunning the natural capacity of the Earth to supply them, and shortsighted or corrupt local politics leading to ‘bandaid’ solutions that don’t work or cause more trouble in the long run. Other forms of increasing urban vulnerability include: storm damage, sea level rise, flooding and fire resulting from climate change or geotectonic forces; governance failure, civic unrest and civil war exemplified in Lebanon, Iraq and Syria over the 2010s; disruption of oil supplies and consequent failure of food supplies; worsening urban health problems due to the rapid spread of pandemic diseases and industrial pollution and still ill-defined but real threats posed by the rise of machine intelligence and nanoscience (Gencer 2013). The issue was highlighted early in the present millennium by UN Secretary General Kofi Annan, who wrote: Communities will always face natural hazards, but today’s disasters are often generated by, or at least exacerbated by, human activities… At no time in human history have so many people lived in cities clustered around seismically active areas. Destitution and demographic pressure have led more people than ever before to live in flood plains or in areas prone to landslides. Poor land-use planning; environmental management; and a lack of regulatory mechanisms both increase the risk and exacerbate the effects of disasters (Annan 2003). These factors are a warning sign for the real possibility of megacity collapses within coming decades. With the universal spread of smart phones, the consequences will be vividly displayed in real time on news bulletins and social media. Unlike historic calamities, the whole world will have a virtual ringside seat as future urban nightmares unfold.

### Solvency

#### Plan: The United States Federal Government should substantially increase its prohibitions on anticompetitive business practices by expanding the scope of its core antitrust laws to include nascent competitors by lowering HSRA filing requirements by establishing that it is a per se violation for companies to own significant portions of market data and fail to open their data for computational antitrust auditability in a data trust.

#### Plan allows proactive antitrust, simplifies merger analysis, and helps protect consumers

**Carey 21, [**Maura Carey is an academic outreach chair of the Stanford Computational Antitrust Project. “The Computational Antitrust Project” American Bar Association, April 05, <https://www.americanbar.org/groups/business_law/publications/committee_newsletters/legal_analytics/2021/202104/fa_2/>] //Aryan

Technology has led to an explosion in the volume of data that antitrust regulators need to process in order to enforce antitrust laws. Legal practitioners in other fields are already seeing how computational techniques like information visualization, natural language processing, deep learning simulations, and machine learning can enhance their work.

The Computational Antitrust Project at the Stanford Codex Center seeks to develop ways to help antitrust enforcers, policymakers, and firms subject to antitrust harness the power of legal informatics. The Project brings together over 50 agencies from around the world and 35 leading academics in economics, law, and computer science to foster the automation of antitrust procedures and improve antitrust analysis.

Legal informatics are not intended to replace human value judgments and decision-making processes as the primary mode of economic regulation. Rather, computational tools can empower regulators and practitioners to conduct the kind of analysis necessary to apply existing antitrust frameworks to the 21st century economy. The Stanford Computational Antitrust Project is bringing together technologists, legal scholars, and economists to think creatively about how to equip agencies with the tools they need to bring global antitrust enforcement into the digital world. Legal informatics will prove especially helpful in three areas of antitrust law: anticompetitive practices, merger control, and the design and monitoring of antitrust policies.

First, computational antitrust can help antitrust agencies shift to a proactive model of policing anti-competitive practices. Antitrust agencies today often rely on reactive methods of identifying anti-competitive practices like leniency applications. **Blockchain-based**

**smart contracts and algorithmic pricing mechanisms have made it easier for companies to implement and sustain collusive agreements—making reactive methods far less effective.** Natural language **processing technology can boost antitrust agencies’ ability to detect patterns that suggest illegal intent.**

Second, computational antitrust can make it easier for agencies to assess the legality of a merger when confronted with millions of documents to review and a limited time in which to review them. Agencies can use also **computational tools to create dynamic models to better predict the competitive effects of proposed mergers**.  Computational tools can also help **address information asymmetries in the merger review process by allowing agencies and companies to share data in real time**. Blockchain technology could facilitate this data-sharing by creating immutable databases that both enforcers and firms can trust.

Finally, computational techniques can help agencies learn from past decisions and design new approaches based on those lessons. Computational models can help agencies analyze the impact of different enforcement mechanisms, understand dynamics in specific industries, and estimate consumer savings from different policy approaches. Agencies can also use these tools to systematically audit the effectiveness of their own internal processes.

Robust antitrust enforcement is essential to promoting resilient, competitive markets, and to making sure that all market participants can compete on a level playing field. Technology has revolutionized the way by which firms do business throughout the world. The Stanford Computational Antitrust Project is dedicated to ensuring that antitrust enforcement can keep up with the rapid pace of chance.

#### Comp antitrust addresses judicial ineptitudes with pattern recognition

CodeX ‘21. TRANSCRIPT. Computational Antitrust First Annual Conference: Exploring Antitrust 3.0 On December 13, 14, and 15, 2021, The Stanford Center for Legal Informatics (CodeX). <https://law.stanford.edu/wp-content/uploads/2022/02/first-annual-conference-transcript.pdf>. This section is Daryl Lim speaking. /// Anekah

Computational Antitrust brings together the maximum precision of artificial intelligence to address Chicago and fears of judicial ineptitude and false positives. The age-old tension between dynamic and static efficiency that informs everything from killer acquisitions in the not-too-distant past to antitrust in the Metaverse in the not-too-distant future is where I think computational antitrust can do its role in everything from detection, to assessment, to investigation, to recommending whether to launch an investigation, to prosecution, to adjudication, [and] to the implementation of remedies. And let me just give you four quick examples. First, with detection, natural language processing can analyze consumer complaints and media reports with antitrust potential. To use a facetious example, say you saw tens of thousands of people amassing together, and you’re trying to figure out what was going on. So, you go to their leader. He denies there’s anything untoward, but your algorithm picks up that he had lamented about the disintegration of a hegemonic Empire he was part of and describes how he was affected personally by the tough economic times that followed the collapse of when his country suffered double-digit inflation. He says to you, “sometimes I had to moonlight and drive a taxi.” It’s unpleasant to talk about it. But unfortunately, this also took place, and then you realize this is probably more than a group of enthusiasts. In the same way, artificial intelligence can learn and analyze language patterns and tones of informants that applied for antitrust leniency. With respect to adjudication, computational antitrust can scour reported cases to assess how past courts weigh competitive effects and identify influential factors. Some factors may be conventional; others may be previously unobserved. For example, algorithms could scour cases and match them against depositions and other preprocessed evidence to provide a more quick and consistent analysis. So, whether you’re talking about big data, deep learning, data mining, that can help to identify relevant market variables, even in the absence of an established theory. More broadly, you can detect connections without the current legal significance that parties do not know or have no capacity to examine. Algorithms can also account for interactions about the indicators that escape expert witnesses, contextualize and associate information with the familiar and provide predictions based on entering parameters. Eventually, this will coalesce to create per se rules of illegality or legality or find more appropriate cases for burden-shifting under the quick look approach. Courts have devised per se rules, for example, by using the damning presence of an agreement to fix prices as a sign of market inefficiency. There’s no need then to engage in a counterfactual exercise giving defendants no opportunity to prove the value of those restraints. A judge’s unfamiliarity of the industry at issue will then become of less importance, less of an impediment as they will be able to apply precedent across industries and, in fact, in the Supreme Court words, establish one uniform rule applicable to all industries alike. So indeed, far from a reason not to apply the per se rule, a judge’s lack of experience in the industry is precisely the reason why they should do so, and computational antitrust can provide a reasoned, evidence-based approach. To do that, of course, the opposite could happen, and you could eliminate per se rules if computational antitrust determines that these are not manifestly anticompetitive or procompetitive effects. To build up a database, algorithms can creep and mine reports on Westlaw. In fact, if you look at Westlaw, this year, they have unveiled a quick check document analysis tool that identifies patterns and connections that users do not detect. And it enables judges and attorneys to determine the merits of a case efficiently. Importantly, the results from the AI recommendations are there to challenge prior assumptions to provide a check against what behavioral scientists called coherence-based reasoning. Because research shows that confronting people with the merits of the opposite side reduces the effects of these coherence biases by about 50%. Third, with recommendations, AI can also predict the impact of things like killer acquisitions by running simulations to determine the optimal contestability conditions and better map synergies that help innovation pathways by tracing the user adoption of technology and Thibault mentioned my paper, where you can look at that for more detail and discussion. Fourth, in exploring counterfactuals and crafting remedies, AI-enabled antitrust can also maximize a preset reward. And in the paper, I also talked about that. Now, the point is, how do we know if computational antitrust has met the great? Well, one is you should have a robust data set. And with data set, there’s always that concern about bias. But my response is that algorithms do operate in a black box, but so do judges. And even that general trend of judges engaging in post hoc reasoning is well documented and discussed. In contrast, AI provides a more objective anchor to the rule or rule of reason or some other formulation in the face of coherence-based reasoning. And if you are seeking transparency, you might find accountability instead to be a more realistic and helpful goal. And recognize that case law only provides a starting point because the precedent may or may not be based on sound economic analysis and, as I mentioned, ideology. But what happens is judges that are adjudicating life cases can compare the model’s prediction with the ground truth and adjust the model’s parameters, minimizing the error between those two values over time, and eventually, the parameters of the model will be sufficiently fine-tuned. And remember that perfect is the enemy of the good. It is progress, not perfection that we seek.

#### Auditability and a data trust inhibits anti-competitive practices and allows data science and sharing

**Mahari et al 21**-[Mahari, Graduate student, Human Dynamics Group, MIT Media Lab and JD Candidate, Harvard Law School; Lera, Assistant professor at the Shenzhen-based ETH Zurich-SUSTech Risks-X Institute and visiting researcher at MIT Connection Science and Human Dynamics;Pentland, Professor at Massachusetts Institute of Technology, Director of Connection Science and Human Dynamics, MIT Media Laboratory, Sloan School, and Institute for Data Systems and Society] //Aryan

B – Disincentivizing Data Control As discussed in Part II, we view control over data in a given market to be analogous to monopoly power. However, certain types of data and certain approaches to storing and utilizing data are more likely to undermine competition than others. The most problematic type of data control is direct ownership of data that is difficult for competitors to obtain or use and which can be used to create barriers to competition. When a company owns data outright, it is difficult to ascertain whether the data is used to lessen competition. When this data is not available to any competitors, then the likelihood that it might be used to undermine competition is especially high. Data trusts represent a relatively new approach to storing and utilizing data that reduces the probability of data misuses (not only in the context of antitrust) while facilitating auditability.42 Put simply, a data trust is a third-party entity that controls data while allowing other entities to extract insights from it. Crucially, data trusts create transparency by allowing the use of data to be audited. Through new computational techniques such as federated learning, a data trust could control data and allow outside entities to derive insights without ever sharing the raw data. In our view, companies that control a significant portion of relevant data in a market but chose to silo it in an auditable data trust that is open for business with competitors should be presumed not to use the data to gain monopoly power,43 provided they allow relevant regulatory agencies to audit data use. This solution does not deprive companies of the ability to use data science to gain legitimate business advantage, but it creates accountability and transparency while generally discouraging anticompetitive behavior.

#### Antitrust is a key testing ground for government AI adoption

Massarotto, 21 -- University of Iowa business professor

[Giovanna, international expert on antitrust law and economic regulation in the field of information technology, affiliate of the UCL Centre for Blockchain Technologies, and Ashwin Ittoo, University of Liege professor, Machine Learning, Natural Language Processing (NLP) specialist, “Gleaning Insight from Antitrust Cases Using Machine Learning,” Stanford Computational Antitrust, Vol 1., 2021, https://law.stanford.edu/wp-content/uploads/2021/03/Computational-Antitrust-Article-2-Gleaning-Insight-1.pdf, accessed 7-3-21]

The 2020s have seen vast increases in investment and interest in AI and the data industry. Data is creating a variety of new opportunities for businesses, transforming markets with faster and more sophisticated technologies, including machine learning algorithms. These new data-driven markets, in turn, create new challenges for government agencies.5

Antitrust agencies are in the spotlight because they are charged with identifying and reducing monopolistic and collusive practices in cutting edge markets, where such practices might occur at scale through algorithms (e.g. algorithmic collusion).6 A question the antitrust community is asking is whether antitrust agencies are equipped with the right tools and powers to tackle the present challenges in such a fast-moving technological environment.7 Our study aims to respond to this question by building and testing an ML antitrust algorithm.

Before diving into the explanation of our ML antitrust algorithm developed in Part III, it is helpful to clarify why we focused on FTC enforcement actions, and why antitrust can be a good testing ground for future AI applications in the regulatory domain. This evaluation requires having a brief background on the role of antitrust economic regulation and the main AI techniques available.

A - Antitrust

i. Antitrust Economic Regulation

U.S. antitrust enforcement action is primarily economic in nature because it occurs mostly outside of courts and it is explicitly grounded in economics.8 In the U.S., “over the last three decades the Agencies [DOJ and FTC] have resolved nearly their entire civil enforcement docket by consent decrees.”9 Specifically, more than ninety percent of civil antitrust lawsuits filed by the U.S. government (excluding mergers) are settled by means of an agreement.10 This consent solution puts in place remedies agreed on by the company under investigation and the agency before or during a trial. The wide adoption of consent decrees results in a regime of minimal case law," leaving the same antitrust agencies and companies to regulate markets through agreed remedies enshrined in a consent decision.12 Unlike the DOJ, the FTC can settle proceedings without the need for adjudication by a court.'3 Consent decrees identify certain behavioral or structural remedies based on economic analysis, which de facto imposes an economic regulatory regime.'4

Because antitrust agencies are empowered to enforce competition principles in any market, antitrust is often the first type of regulation to reach a new market.'5 For example, while the Federal Communication Commission (FCC) has the authority and duty to regulate the telecommunications industry specifically,'6 the FTC, through Section 5 of the FTC Act, may exercise wide discretion in regulating markets generally.'7 As a result, antitrust may be considered the “first arm” of government regulation because it reaches new markets for which Congress has yet to draft a more specific regulatory scheme.

In summary, FTC antitrust enforcement mechanisms resemble economic regulation because, as outlined above, the FTC enforcement action occurs mostly outside of courts and its decisions are grounded in economics. Economic concepts drive decisions on what the FTC considers anticompetitive conduct as well as the types of antitrust remedies to adopt.

2. The FTC and Section 5 of the FTC Act

In contrast to the DOJ Antitrust Division, which represents the U.S. in criminal as well as civil antitrust cases and traditionally plays a prosecuting role, the FTC is an administrative agency with regulatory powers in addition to its prosecutorial powers.'8 Our study specifically focuses on FTC antitrust enforcement action under Section 5 of the FTC Act, because the FTC is the only agency with authority to enforce the FTC Act and it is not technically in charge of enforcing the Sherman Act.'9

According to Section 5, the FTC has exclusive authority to regulate “unfair methods of competition ... and unfair or deceptive acts or practices,”20 preventing individuals, partnerships, or corporations from unfairly disrupting competitive markets.21 In other words, Section 5 grants the FTC a wide range of discretion in controlling and regulating markets generally.22 Since there are almost no litigated Section 5 cases,25 our ML algorithm was trained mainly on regulatory settlements, known as consent decrees.

The structure and powers of the FTC resemble those of many antitrust agencies all over the world. EU National Antitrust agencies are mostly administrative agencies with similar powers, although they generally enjoy less open-ended delegations of power than does the FTC. Therefore, the same or similar AI techniques that have been applied in building the ML algorithm at hand are likely to be helpful for many other agencies across the world.

B - AI - Primary Concepts

We now provide a brief overview of the primary AI concepts relevant for our AML algorithm. In particular, we provide an overview of ML and the main approaches and techniques available in the learning process. The following discussion is limited to the main concepts and terminology relevant to the construction of our AML model.

1. Machine Learning

Today, ML is the main AI paradigm for a wide variety of applications, such as speech recognition (Alexa or Siri) or machine translation (Google Translate). ML algorithms enable machines to learn how to perform a task, such as playing chess or translating text, through experience. Experience here manifests itself from large volumes of data, annotated or labeled with some information of interest (e.g., credit risk score). Models are trained on the data and subsequently used to make predictions concerning the information of interest.24 Deep Learning (DL) is a specific form of machine learning, relying solely on complex neural network architectures.25

There are three main ML approaches: I) supervised learning (SL); 2) unsupervised learning (UL); and 3) reinforcement learning (RL). Below, we describe only the SL and UL paradigms as they adopt completely opposite learning procedures, and our proposed method is based on UL. The comparison between SL and UL better explains our motivation in opting for the method described in Part III.B.26

2. Supervised Leaning (SL)

In SL, an algorithm is presented with huge volumes of example data collected from the past. These data will consist of a number of variables (e.g., age, education level, salary) as well as a label, which corresponds to the information of interest (e.g., credit risk level).

The peculiarity of SL is its requirement for large volumes of training data, annotated with the label of interest. There are several different types of SL algorithms, such as random forests, neural networks, and support vector machines. These algorithms differ in the way in which they learn the relationships between variables.

). Unsupervised Leaning (UL)

Unlike SL and RL methods, Unsupervised Learning (UL) algorithms are generally not concerned with learning how to perform specific tasks. As such, there is neither a training phase in which the algorithms learn from past annotated data nor an exploration phase in which they explore their environments to determine an optimal action sequence to maximize specific rewards. Indeed, UL algorithms operate without any type of supervision or external reward signal. The main aims in UL are to discover latent structures and extract rules or associations from data, without any prior training or exploration phases. That is, the algorithms operate completely on their own (in an “unsupervised” manner). Whereas SL algorithms typically try to predict outcomes, UL algorithms are typically used to describe data.

The approach we have adopted in our algorithm is known as clustering, which identifies latent structures within a dataset and involves estimating the similarity between various data points and grouping similar data points into clusters. Clustering is widely adopted in marketing in order to identify groups of consumers with similar price or product preferences. The similarity between data points is often estimated by first projecting these data points as vectors in a multidimensional space and then computing the distance between them using measures like Euclidean distance. Subsequently, data points that are found to be close to each other (based on the computed distance) are grouped into clusters.

Several clustering algorithms exist, including K-means and bisecting K-Means (both partitional) and divisive and agglomerative methods (both hierarchical), all of which we have applied to our AML model. Clustering algorithms will be described in more detail in Part III.B.

C - Why Antitrust and AI?

Having clarified the role and powers of the FTC within the U.S. antitrust law enforcement framework and the main AI techniques relevant for our project, we now explain why AI techniques may be relevant to antitrust enforcement.

As already mentioned, AI algorithms have been applied to other areas of law enforcement unsuccessfully, causing some to question the usefulness of AI in the law. For example, Compas is an algorithm employed in the U.S. legal system with the aim to make judicial decisionmaking more efficient. Compas was trained to assist judges in Florida in deciding whether a defendant was likely to re-offend27 and should remain in jail or be released while the trial was pending.28 However, the algorithm showed a clear bias. According to a study conducted by Propublica, “defendants predicted to re-offend who actually did not were disproportionately black.”29 This algorithm exhibits the risks related to the adoption of AI techniques, which can lead to bias at scale if the algorithm is not correctly built and trained.

Despite initial skepticism of the utility of AI applied to law enforcement, as observed in Part II.A.i, FTC antitrust enforcement resembles economic regulation, which means it is neither a law nor best practice, but “the pattern of government intervention in the market”30 designed to achieve market efficiency.3' Therefore, antitrust enforcement might serve as a safer testing ground for the exploitation of AI techniques in future regulatory interventions based on economic reasoning and goals rather than on protecting human rights. In this way, government agencies can potentially gain in efficiency and companies can have a better understanding of what constitutes an anticompetitive practice.