The Reign of Cerberus: International Law and Technological Innovation

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Abstract

This Essay sketches an informal theory of the impact of technological change on international economics, and hence international relations expressed as international law. The theory points to a policy trilemma, something that I call Cerberus in a perhaps futile attempt at an arresting metaphor. The Essay uses the trilemma to illuminate the general trends in technology policy we see playing out in China, Europe, and the United States. It argues that we have the privilege of witnessing an ongoing natural experiment in optimal technology regulation and legal policy, with no guarantee as to which approach will prevail.

Of course, like all natural experiments, the signal struggles to emerge against a background of geopolitical noise. Events and projects unrelated to policy competition might decide the game, and we might never find out what an optimal strategy may entail. Still, we can't rule out the chance that we might learn something as the great game plays out

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I. INTRODUCTION: WHAT WE MEAN WHEN WE TALK ABOUT TECHNOLOGY

This symposium being dedicated to a supposed fourth industrial revolution based on new technologies, it makes sense to start with an understanding of what technology means. From Greek, the term translates as what we say about craft.[1] Craft rests, fundamentally, on information, which is to say, transmitted knowledge. At this point, we can nod to Claude Shannon and his brainchild, information theory.[2] Shannon formalized the process of passing information from sender to audience and introduced (or at least made famous) the distinction of signal and noise. Technological innovation fundamentally is about information transmission, a process that has social, economic, and cultural aspects.

A theory about the impact of technology on economic change, then, might begin by considering how the production of information works, based on ideas about the creation and sharing of useful knowledge. It focuses on optimal information transmission. This Essay embraces evidence that this has something to do with the localization of technological innovation, the rise of high-tech nodes.

Useful knowledge means anything that has the potential to make people better off. In an economic theory, we usually mean better off in the social or material sense, as economics does not help much when thinking about improving people's relationship with high ideals or prospects for salvation. It does, however, take into account the full range of social life, and thus can treat concepts such as empathy and solidarity as relevant to the construction of a better life. Basically, economics asks only if something can be observed for it to be potentially relevant. Knowledge thus is useful if it makes people happy, but we need some observable evidence, and not simply our rational judgment or moral intuitions, to sustain a finding of happiness.

Understanding useful information in this way, it becomes clear that, when looking for the production of useful knowledge, we must range well beyond Silicon Valley and research labs where people wear white coats or hazmat gear. For students of the transnational economy, a powerful example of technological innovation is containerization.[3] The basic engineering for modular transportation of cargo emerged in the 1920s. Its economic impact would not be realized until the 1950s, when Malcolm McLean identified that a glut of retired and modifiable World War II seacraft, America's construction of an interstate road network to

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1 *Technology*, MERRIAM-WEBSTER (ONLINE) https://perma.cc/Y5TN-YQX4 (last visited Apr. 16, 2025).

2 *See* CLAUDE E. SHANNON & WARREN WEAVER, THE MATHEMATICAL THEORY OF COMMUNICATION (1949).

3 *See* PAUL B. STEPHAN, THE WORLD CRISIS AND INTERNATIONAL LAW – THE KNOWLEDGE ECONOMY AND THE BATTLE FOR THE FUTURE 108–09 (2023).

complement railroads, and accelerating demand for goods driven by postwar reconstruction offered great opportunities for new methods to organize the conveyance of cargo. An economic revolution followed, with lower shipping costs boosting trade expansion.[4]

Another salient (negative) example of the centrality of the production of information in economic change is the collapse of Soviet-style central planning as a model for economic management. Central planning in practice created large agency costs, because the system induced managers of state firms to maximize planning-based inputs and minimize planning-based outputs, rather than to add value at the stage of the chain of production that they controlled. These incentives encouraged managers to cook their books, embezzle, and bribe superior officials to adjust favorably planning demands and support. To fight these manifestations of agent disloyalty, policymakers increasingly sought to hold methods of production constant so as to reduce the costs of monitoring the firms. They did so in part by raising the cost of interfirm information transmission, including taxing managers foolish enough to discover valuable new methods of production.[5] Such a strong commitment to suppressing innovation could not survive contacts with the "non-socialist" world, which discredited the system as a whole.

II. TRADE, TECHNOLOGY, AND THE PRODUCTION OF INFORMATION

As the self-described socialist world stagnated, the so-called capitalist world expanded and innovated. Several researchers won Nobel prizes for insights into particular aspects of the transnational economy that emerged after World War II and blossomed from the 1970s on. Here I distill (some might say grossly oversimplify) the key insights as they relate to the knowledge economy and transnational intercourse, both economic and sociological.

First, as a general rule the costs of knowledge creation and dissemination come more at the front end of production and decline as the process moves from discovery to transmission. Think of Big Pharma and the billions burned in research, with only a few products surviving a Darwinian bottleneck to enter the marketing stage. The saleable products are generally susceptible to reverse engineering, informed by general knowledge as to how research works. Generics thus cost much less to make than the spawn of the research, especially if one takes into account discovering dead ends as part of the total investment outlay in the successful products. But the generic exists only because of the vastly expensive groundbreaking. One can discern here a general pattern of integrating knowledge into production.

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4 *Id.* at 109–11.

5 Olympiad S. Ioffe, *Law and Economy in the USSR*, 95 HARV. L. REV. 1591 (1982); John H. Moore, *Agency Costs, Technological Change, and Soviet Central Planning*, 24 J.L. & ECON. 189 (1981).

Second, knowledge transmission entails a great deal of learning by doing, often through collaboration. Trial and error and quick course corrections work better face-to-face than at a distance. Paul Krugman drew our attention to the geography of technological innovation, drawing on the work of earlier researchers.[6] Looking at knowledge clusters led to research into the characteristics that optimize their value. A few insights include the value of labor mobility, fluid boundaries of the firm and its make-or-buy choices (kudos to Coase), and the possibilities of polycentric structures (with a nod to Ostrom).[7] Appreciation of labor mobility points in the direction of lowering barriers, including, in the contemporary world, national borders.

Third, in material pursuits (production) where knowledge makes up a growing share of both inputs and outputs, economies of scale manifest and even dominate.[8] This reverses the conventional conception of diminishing marginal returns on exhaustible inputs, such as material goods or unskilled labor, and from outputs in a saturated market. It turns out knowledge embodied in skilled labor can enhance its value the more it is deployed, and, due to network effects, the potential for profits from production goes up as the size of the operation grows. Krugman explored some of the implications of this insight, including the need to rethink competition policy in a world where large-scale production, bordering on monopolization, coincides with greater consumer welfare.[9]

Fourth, as Paul Romer demonstrated, an important strategy for realizing the benefits from increasing returns to scale is to increase the size of markets, including by lowering national barriers to output, input, and, increasingly, capital mobility (human and financial).[10] A theoretical explanation results for the emergence of the modern supply chain, a form of integrated production that entails less than full vertical integration but more than anarchic contracting. Production becomes a series of relational contracts, complicating the make-or-buy barrier. Meanwhile, the dictates of value added and positive returns from scale (to suppliers of knowledge, not necessarily renters of capital and the unskilled labor force) pushes law in the direction of fewer obstructions to cross-border flows of goods, services, people, and capital as well as greater protection of foreign

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6 PAUL R. KRUGMAN, GEOGRAPHY AND TRADE (1991).

7 ELINOR OSTROM, GOVERNING THE COMMONS (1990); Alfred Marshall, *The Concentration of Specialized Industries in Specific Localities, in* PRINCIPLES OF ECONOMICS, bk IV, ch. X (Liberty Fund Inc. 8th ed. 1920) (1890); Ronald Coase, *The Nature of the Firm*, 4 ECONOMICA 386 (1937).

8 Paul M. Romer, *Increasing Returns and Long-Term Growth*, 94 J. POL. ECON. 1002, 1015 (1986).

9 Paul R. Krugman, *Increasing Returns, Monopolistic Competition, and International Trade*, 9 J. INT'L ECON. 469 (1979).

10 *Accord* Paul M. Romer, *Origins of Endogenous Growth*, 8 J. ECON. PERSP. 3 (1994); Paul M. Romer, *Endogenous Technological Change*, 98 J. POL. ECON. S71 (1990); Paul M. Romer, *Increasing Returns and Long-Term Growth*, 94 J. POL. ECON. 1002 (1986).

investment, the latter to compensate for the new entrant's lack of local knowledge compared to that of domestic insiders.[11]

Fifth, competition policy confronts a challenge for which contemporary theory and research still need further development. Do the factors leading the world toward production monopolies, a result of positive returns to scale, leave us in a place where the bracing discipline of competition disappears? If the answer is yes, we must consider the various forms of abuse that accompanies monopoly power and think of policies that will reduce that waste and, perhaps, the scale of producers generally. In particular, how easy will it be for the monopolies to invest in entrenchment so as to ward off prospective competitive pressure?

If we can think of ways of maintaining competitive pressure on monopolies in the knowledge economy, we might be a bit more sanguine about the apparently inevitable triumph of economies-of-scale production. Here it seems appropriate to nod in the direction of Aaron Director, one of Hyde Park's great centenarian economists. He was more of an intellectual entrepreneur than a theorist or researcher, but his one unquestioned conceptual achievement was the idea that a market for the market could exist. That is to say, it is possible to imagine factors outside a monopolist's control that overcome what barriers to entry the monopolist might construct, forcing the incumbent to further innovate or surrender market power to another quasi-monopolist.[12]

The application of the Director conjecture to technological monopolists is, to say the least, deeply controversial. A whole body of hipster antitrust stands resolutely in opposition, with Tim Wu as its guru and Lina Khan as its principal apostle.[13] Tim is my sometimes colleague and good friend; I do not intend to go to war with him. For now, it should suffice to say that we have not yet arrived in a happy place where we can say with confidence that the tools of competition law, especially compelled firm breakup, are either necessary or sufficient to respond effectively to the possible evils of firm concentration in the knowledge economy. It may be that Alphabet, Amazon, Meta, and Microsoft, not to mention their Chinese counterparts, have built their homes on foundations of sand, and that new technological innovations not dissimilar from those that brought them market domination are aborning and poised to unseat them. If so, the need for a more interventionist competition policy dissipates. Only time will tell.

As a thought experiment, we might consider how these arguments might apply to future development of artificial intelligence. At the moment great fortunes are being wagered on this project. Visionaries foresee not simply a

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11 Paul B. Stephan, *supra* note 3, at 122–31.

12 Edmund W. Kitch (ed.), *The Fire of Truth: A Remembrance of Law and Economics at Chicago, 1932–1970*, 26 J. L. & ECON. 163, 202–08 (1983).

13 TIM WU, THE CURSE OF BIGNESS: ANTITRUST IN THE NEW GILDED AGE (2018); Lina M. Khan, *Amazon's Antitrust Paradox*, 126 YALE L.J. 710 (2017).

profound economic transformation but deep security issues. I have not yet seen enough evidence to convince me that either the hopes or fears are as great as some think, but I admit I may have missed the boat.

If AI is to become something important, perhaps even evolve into artificial general intelligence (AGI) or beyond, there is no reason at present not to expect the general principle of positive returns to scale to apply to the creation and deployment of that capacity. Much of the excitement in national security circles turns on expectations that whoever controls AGI will control the world, at least implying a progression toward monopoly power. Would such a development make Director effects impossible or instead even more likely, as the gains from AGI breakthroughs become greater?

One of the components on which the development of AI depends is large and well curated data bases. Is it possible to imagine data monopolies, massive collections of data over which a monopolist exercises access and which starves other researchers who lack access to it? Or is it in the nature of data to degrade over time, requiring constant replenishment and reorganization for a big data asset to retain its value? These are important questions, and I don't think current research provides us with reliable answers.

III. CERBERUS: THE POLICY TRILEMMA

This quick sketch of the underlying economics of the knowledge economy, its impact on market structure, and the possible trajectories of technological innovation suggests various policy options. To keep things simple, as well as to enable a geopolitical perspective, this Essay considers three categories of responses, namely deference to the private sector in hope of optimal innovation; vigilant regulation of the private sector based on the precautionary principle; and robust pro-innovation policies run by the state, with the expectation of private sector subservience rather than leadership. Crudely speaking, these strategies map on to the policy status quo of the United States, Europe, and China, respectively.

A. Looking to the Private Sector

A policymaker might look at the relentless progress of technological innovation and say; what's not to like? This seems the U.S. approach. In spite of the Biden administration's gestures in the direction of an industrial policy, the last four years have not given us significant legal interventions that might match the strides of technological progress, especially with respect to the collection and interrogation of data resources. Friendshoring became a thing, but more as a rhetorical flourish than a concrete policy. The U.S. Steel debacle put a stake in its heart, if there ever were a pulse. It is impossible to predict what the incoming Trump administration, with all its chaos and contradictions, is likely to provide us. The modal projected outcome, however, probably is no significant policy changes.

To be sure, the near future might bring some marginal adjustments. The lower courts' generous interpretation of Section 230, which takes the statutory common-carrier immunity beyond reasonable limits, might fall prey to Supreme Court correction, although legislative revision does not seem in the cards.[14] Lina Khan's FTC might make some of its interventions stick, although her success in the courts so far does not foster optimism.[15] Attempts to throw a spanner in the growth of training databases through aggressive application of copyright law, with accompanying shrinking of fair use, seems possible, although not likely. J.D. Vance's version of anticorporate populism might prevail over Team Musk, although that seems a remote prospect.

On the whole, then, it's not crazy to imagine a future tech policy for the U.S. that looks to the private sector for optimal innovation and imposes few guardrails on industry consolidation and concentration. As many have observed, including our most recent Nobel laureates Daron Acemoglu and Simon Johnson, this approach runs serious risks.[16] Mergers might move innovators into large corporate structures that suppress mold-breaking work. Dominant firms might buy up competitors before they can develop the new ideas that could overthrow the incumbents. Monopoly superprofits might go to buy off government regulators, protecting failing monopolists from the consequences of competition. We might not end up with the kind of stagnation that brought low the Soviet Union, but we might get far less innovation and technological value added than a more directly competitive environment might engender.

B. Deconcentration *Uber Alles*

If concentration in the knowledge economy presents a risk of harm, then fight concentration root and branch. If technological innovation promotes concentration by giving innovators a (transitory) market edge due to economies of scale, then make technological innovation costly. Especially if one's part of the world doesn't produce world-leading technological innovation, a policy of throwing up roadblocks to the development and dissemination of new technologies, as well as applying the precautionary principle to any moves in the direction of industrial consolidation or the emergence of new technologies seems compelling.

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14 *See* Stephan, *supra* note 3, at 202.

15 *E.g.,* Fed. Trade Comm'n v. Endo Pharmaceuticals Inc., 82 F.4th 1196 (D.C. Cir. 2023); Fed. Trade Comm'n v. Tempur Sealy International, Inc., No. 4:24-cv-02508, 2025 U.S. Dist. LEXIS 19371 (S.D. Tex. Jan. 31 2025); Fed. Trade Comm'n v. U.S. Anesthesia Partners, Inc., No. 4:23-CV-03560 , 2024 U.S. Dist. LEXIS 85714 (S.D. Tex. May 13, 2024); Fed. Trade Comm'n v. Microsoft Corp., 681 F. Supp. 3d 1069 (N.D. Cal. 2023).

16 *See* DARON ACEMOGLU & SIMON JOHNSON, POWER AND PROGRESS: OUR THOUSAND-YEAR STRUGGLE OVER TECHNOLOGY AND PROSPERITY 392–96 (2023).

The European Union does not, of course, oppose technological innovation *tout court*. A recent report authored by economic policy superstar Mario Draghi deplores the growing technological gap between the EU and the rest of the rich world and calls for rectification.[17] Yet various structural features of European governance push in the direction of resistance rather than competition.

Human rights, including protection of the individual from the encroachment of society (not only the state) lie at the heart of the European project. We can see this as part of the secret sauce, along with the fundamental promise to put an end to European war, that drives the willful surrender of sovereignty to technocrats more than politicians. Here this means wielding privacy rights as an impediment to data collection, data analysis, and the attendant rents that attach to most social media projects. Indeed, the EU has led the world in designing safeguards to prevent data harvesters from making useful observations about society for potential monetization or other forms of exploitation. It also has lapped the rest of the world in invoking the precautionary principle to limit the development of AI.

One need not see rights-oriented regulation as simply a pretext for failed technology policy. Anu Bradford argues with great force that privacy rights are not incompatible with technological innovation, and that Europe's manifest shortcomings stem more from the absence of financial and cultural structures that encourage risk taking.[18] The combination of a rights focus with the application of the precautionary principle, though, explains a lot of the EU's current problems.

The payoffs from technological innovation are speculative until they happen. To a large extent, so are the potential harms. But if we apply an analytic construct that discounts the upside more than the downside—and this is exactly what the precautionary principle does—we end up with a brake against the future. In a stable and prosperous world, perhaps this is good. But in a dynamic and competitive environment—a three-way race towards innovative dominance, as this Essay supposes—the cost of costs may become a much unneeded anchor.

Still, we cannot rule out the EU approach. It may be that delaying innovation until others have exposed the risks works out best. To repeat the refrain of this Essay, it remains to be seen.

C. State-Managed Technological Innovation

China, however, would like a word. It traces its economic achievements to public leadership, which directs and manages market forces. It combines public investment in knowledge acquisition, including the copying portion of the

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17 MARIO DRAGHI, THE FUTURE OF EUROPEAN COMPETITIVENESS 5 (2024).

18 ANU BRADFORD, DIGITAL EMPIRES: THE GLOBAL BATTLE TO REGULATE TECHNOLOGY 137 (2023).

production process, with targeted collaboration on state-designated goals. China expects to dominate fields such as quantum computing, green energy, and artificial intelligence through state direction of inputs and rewards, rather than leaving it to private markets to provide the right incentives to technology workers.

China also sees no problem with the collection of information on people for the purpose of regulating them. It regards individual flourishing as unthinkable except in the context of a nourishing society. Privacy undermines that value and thus must give way to data accumulation and mining. The social credit score is a feature, not a bug.

What evidence do we have to support state-directed technological innovation? The economic literature on industrial policy expresses plenty of skepticism. During the 1980s, many observers fell in love with Japan's MITI (since 2001, METI), a supposedly ideal partnership between government technocrats and the private sector.[19] When the wheels came off Japan's economy in the 1990s, that model seemed less attractive.

In the case of China, not-so-distant history is even less reassuring. Absent structural checks on strong leaders, what is to prevent another foray down the tragic, murderous road of the Great Leap Forward and the Cultural Revolution? Perhaps great trauma has inoculated China from future misadventures. But an authoritarian regime, without effective accountability loops, runs the risk of stagnation, even if social and political catastrophe is not necessarily in the cards.

Still, China has had a good forty years and made great leaps in important technologies, such as civil engineering, solar energy, electric vehicles, and big data. Where it stands on AI is anyone's guess. Its progress has the U.S. worked up, if nothing else.

D. Enter Cerberus

Here then are the three heads of Cerberus, the fierce watchdog guarding the gates of hell (or, for us, the future). We might look to the private sector to promote innovation through the conventional capitalist rewards, with only gentle public interventions to limit abuses of monopoly power but not attacking market concentration as fundamentally unhealthy. We might harry technological innovation with privacy rights, incumbent-friendly copyright, and forward-leaning applications of the precautionary principle. We might limit monopoly power with intrusive government regulation and industrial policy, counting on technocrats to save us from the technologists. Figuratively if not literally, the three great geopolitical centers of the contemporary world have each embraced one of these paths.

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[19] CHALMERS JOHNSON, MITI AND THE JAPANESE MIRACLE: THE GROWTH OF INDUSTRIAL POLICY, 1925–1975 3–34 (1982).

Each approach has a potential downside, compromising the goal of optimizing technological innovation. The knowledge economy, unburdened by complementary policies to advance social solidarity, creates deep, even pathological divides between the swift and the thick, the lucky and the luckless. Destructive populism ensues. The European approach to rights and social security does all right in homogenous societies but does not cope so well with significant multiculturalism and instead spawns its own backlash politics. Authoritarians too often find the great leader out on a limb, a victim of bad unchecked choices that only upheaval can undo.[20] Getting the right mix of economic and social policy turns out to be hard.

IV. TECHNOLOGY AS LIBERATOR AND THREAT

As this natural experiment in innovation policy proceeds, lawmakers need to consider their options. Here, this Essay speculates about possible legal interventions both to support and to limit technological innovation. It focuses on choices, not on the choosing.

A. Promoting Technological Innovation

Over the years countries have deployed a variety of legal instruments to encourage desired economic practices. Methods used fit generally into the categories of protection, subsidies, and legal clarity. How one regards each rests on which political-economy story seems most plausible in the particular context.

1. Monopolies

Letters patent, once granted by the Crown and later disbursed by the legislature, grant an entrepreneur pursuing technological innovation some degree of protection from competition. The scope of the protection turns on issues such as term, scope, the required disclosures, and the kinds of defenses available to infringers. In the modern era, legislatures occasionally dispense industry-wide dispensation from competition law, supposedly to encourage their development. A century ago, U.S. goods exporters got permission to form cartels courtesy of the Webb-Pomerene Act.[21] Sixty-five years later, the Reagan administration and Congress extended the antitrust exemption through the Export Trading Company Act of 1982, which allowed exporters to collaborate on certain support services.[22] Shortly thereafter, Congress bestowed similar privileges on the semiconductor

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20 Stephan, *supra* note 3, at 253–65.

21 Webb-Pomerene Act, 15 U.S.C. §§ 61–66 (1918).

22 Export Trading Company Act of 1982, 15 U.S.C. §§ 4001–03.

industry.[23] And then there's the Jones Act, another legacy of the Wilson era, which protects U.S. merchant-marine domestic routes from foreign competition.[24]

During the late twentieth century as much as the reign of Charles I, the political economy of the industry-based exemptions has faced much critical scrutiny. The beneficiaries are more likely to be incumbents than innovation-driven new entrants. Freed from competition, the protected firms defer experimentation and other investments in competitiveness. The Jones Act offers an exemplary story: in spite of the breakthroughs in containerization, the international market share of U.S. marine carriers has collapsed over the last half-century.[25] More recently, the Biden administration turned to massive subsidies, which the Trump administration promises to expand and support with greater protection, to try to lure semiconductor manufacturing back to the U.S., manifest evidence of the failure of the 1980s project.

2. Payouts

An alternative to legal protection is government money. Going back to the Nixon administration, the U.S. has attempted to design income tax benefits for goods exporters that could survive GATT, then WTO scrutiny. The investment tax credit was a fixture of the Internal Revenue Code, until it wasn't. The major legislative initiative of the Biden administration featured tax benefits or direct benefits as a reward to designated classes of innovators, including promoters of green production and semiconductors. Defenders of this foray into industrial policy argue, correctly, that investments by their nature take years to pay off, rendering any immediate assessment of the strategy beside the point.

Skeptics look at these payouts through the same lens as they do protection from competition. Incumbents, perhaps the beneficiaries of past innovation, have an inherent structural advantage over new entrants, perhaps the originators of cutting-edge but largely unproven technology. The incumbents tend to have significant stakeholders, including large numbers of employees (voters), while the new entrants have yet to acquire such dependencies. It's not clear that technocrats embedded in liberal democratic governments have a significant advantage in spotting winning technologies, in contrast to private providers of finance. Indeed, the lack of real skin in the game, compared to people whose own money is at stake, may leave government actors without the right incentives to make bets on the future and then to back them with rapid roll-outs.

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23 National Cooperative Research Act of 1984, Pub. L. 98-462, § 2, 98 Stat. 1815 (1984).

24 Jones (Merchant Marine) Act, Pub. L. No. 66-261, § 27, 41 Stat. 988 (1920).

25 *See* MARC LEVINSON, THE BOX: HOW THE SHIPPING CONTAINER MADE THE WORLD SMALLER AND THE WORLD ECONOMY BIGGER 298–309 (2d ed. 2015).

3. Legal foundations

At the end of the day, this Essay has nothing original or interesting to contribute to the debate over protection and subsidies as instruments of industrial policy. Instead, it will address a somewhat neglected alternative. Private-law reforms might support technological innovation by making markets more reliable and investments less risky. Markets work, however, only if reasonably stable and reliable private rights, mostly property and contract, are available. This Essay explores how better development of private law might induce more, and better, investment in technology.

There is much more to innovation than the collection and interrogation of data. Yet the legal framework for big data remains crucial. Without taking a position on the prospects for AI, and especially AGI, it seems reasonable to anticipate that discovering new ways to draw useful information from well-curated, massive data sets will form one of the frontiers of innovation over the near and medium term. It is exactly in this space that contemporary private law seems inadequate.

At present, there is no clear consensus on who owns data generated by interactions between people and data collectors. Nor are existing contracts involving such data free from attacks as lacking in consent or violative of public policy. Collectors generally take the approach that any data they can grab becomes theirs to play with, unless the grabbing breaches some clear legal obligation (such as statutory duties to respect encryption and other safeguards).[26] They also rely on form contracts, such as those stating terms of service, that might be seen as adhesive. Substituting more stable rules, no matter what their substantive content, should facilitate investment in big data.

The other branch of private law relevant to big data is tort. The importance of inducing the builders of big data to internalize the negative externalities derived from the use of this resource should go without saying. Nor is the case for clarity and stability of tort rules nearly as strong as those governing transactions in data. Society needs to update risk-allocation rules as risks reveal themselves, and strong arguments point in the direction of tolerating judicial innovation in the face of legislative dysfunction and, perhaps, capture.[27]

One challenge for tort law in the cyber world will be issues of proximate causation. Imagine the progressive development of a duty not to publish, with an intent to harm, private information. This duty could be adjacent to but distinct from defamation. It would have as an element the existence of a duty to respect privacy, and its definition of recoverable harm might be more stringent than that

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26 *E.g.*, Counterfeit Access Device and Computer Fraud and Abuse Act of 1984, Pub. L. No. 98-473, Ch. XXI, 98 Stat. 2190 (1984).

27 *See* Saul Levmore, *Changes, Anticipations, and Reparations*, 99 COLUM. L. REV. 1657 (1999).

associated with old-school reputational torts before the day of *New York Times v. Sullivan*.[28] Would the tort treat as private information that which the subject regarded as private but allowed to creep into someone else's hands? Would the act of collecting such information be an independent tort? It seems to me that answering the first question with a strong yes would justify a negative answer to the second.

B. Responding to Technological Harms

Keeping things at a high level of abstraction, this Section divides technological threats into two categories. For some threats, the optimal response to its gravest risks is more technological innovation, not less. This approach admittedly leads to potentially wasteful arms races. On the margin, arms races are rational whenever the value of deterrence exceeds the cost of innovation, but finding a means to end an arms race altogether surely benefits society as a whole (assuming deterrence-motivated investments do not generate substantial positive externalities such as gains from unanticipated information discovery).

The alternative to deterrence is neutralization. In some, perhaps most, cases, neutralization functions as a complement to, not a substitute for, deterrence. Consider threats of ransomware attacks. An optimal response probably would include investment in technologies that block the attacks plus the creation of a credible threat of retaliation against attackers. Both investments are costly and might be shared between the state (which may have an advantage in attaining economies of scale) and private actors (who have incentives to avoid the cost of attacks).

A brief review of several kinds of technology-based dangers suggests how states might respond to these threats. The responses are likely to be expensive and possibly futile. Their prospects will depend on further technological innovation, perhaps leading to new legal structures.

1. Surveillance

Most states with a substantial capacity to conduct espionage maintain that the practice transgresses no norm of international law. Pushback comes in two forms; the assertion that the principle of state sovereignty limits unwelcome intrusions, and a human-rights argument based on individual rights and dignity. A relaxed approach to espionage has the practical effect of privileging powerful states at the expense of the rest.

Each of the heads of Cerberus points to different approaches to surveillance. China seems most all-in, using both state power and its private sector to accumulate data. Its motivations include greater geopolitical influence, enhanced

[28] New York Times Co. v. Sullivan, 376 U.S. 254 (1964).

copying of others' technological accomplishments, and improved social control. Europe looks in the opposite direction, adopting various regulatory requirements, some focused on privacy protection and restriction of data flows. It hopes to leverage access to its enormous market, rather than technological competition, as the means to pursue its goals. The U.S. seems closer to China than Europe, although it opposes, at least in principle, Chinese efforts to accelerate technological innovation through appropriation of others' intellectual property.

2. Destruction

I am not aware of any credible claims that China or any European country has carried out cyber-attacks with kinetic effects, that is, operations that have produced death or destruction in the material world. By contrast, there are a few episodes where the U.S. probably took part in such operations, the most famous of which is the Stuxnet attack on Iran. Most ransomware and other destructive attacks seem to originate from Russia, North Korea, and Iran, although secrecy and difficulties in attribution make such an assessment tentative at best.

The Russian war on Ukraine represents an interesting laboratory for the use of cyber-based offensive weapons. Before the conflict, many believed that Russia would use the opportunity to test-drive its warfighting technological innovations. The disparity between the two countries seemed manifest, and no one expected NATO to provide Ukraine with cutting-edge technologies due to the risk of revealing too much to Russia. Yet to date, the battle seems to have been fought largely in mud-and-blood terms and close to a standstill. The drones used by both sides seem fairly low-tech, and news of cyber operations is scant.

One can only speculate why this seems to be so. NATO may have supported Ukrainian efforts to neutralize Russian cyber-attacks through security upgrades and new detection tools. Alternatively, or in addition, an implicit retaliatory threat based on U.S. offensive cyber capabilities may have deterred Russia from throwing too much technology into this fight.

3. Triggers

Technological innovation, whatever its prospects for enriching humanity, can also induce interstate competition that, taken to the extreme, may bring about catastrophes such as war and immiseration. Competition over optimal naval capacities between Imperial Germany and the United Kingdom at the dawn of the twentieth century contributed to the insanity that was World War I. Today, fears about technological gains drive the supposed New Cold War between China and, depending on your perspective, the U.S. or the West as a whole.

One path that joined the first Trump and Biden administration was the reconfiguring of international obligations and deployment of resources to discourage Chinese technological advances thought to pose a strategic threat to the U.S. The fields of contestation included access to rare minerals, the availability

of semiconductor chips, and naval bases. It is not unreasonable to expect the second Trump administration to escalate these conflicts, although nothing is certain about its policies and commitments. For example, the present kerfuffle over the Panama Canal, however bumptious its articulation, rests on concerns about Chinese engineering and construction capacities evolving into domination of a facility of strategic significance to the U.S.

Another abiding problem is the risk that advances in cyber operations, extending to destructive (but not kinetic) activities such as the interruption of financial services, might provoke retaliation in the form of armed force. Stating the issue in legal terms, under what circumstance might a cyber-attack, having no immediate effects in the material world but causing great economic harm and social disruption, trigger a state's "inherent right" to self-defense? Opening this door would allow states that lack the capacity to respond in kind to such operations to deploy old-school destructive assets, with great potential for mischief and misery.[29]

V. CONCLUSION

The Fourth Industrial Revolution, like all fundamental transformations of the world, invites us lawyers to reflect on what we do. Does law mostly respond to the dictates that the new world compels, or can it shape, in some way, the world to come? Does the social process that we call lawmaking enable some control over great events, or does it only memorialize and codify the consequences of the massive changes that new forms of production bring about?

This Essay considers what exercises of this agency might look like. It recognizes that the aspirations of the various policies and the outcomes might not match, and that riding the wave of technological transformation is inherently risky. It is only fitting, however, that we approach the knowledge economy through trial and error, hoping to learn as we take chances. Our fate may be beyond our control, but that does not bar us from trying to fashion a better world. Cerberus may stand between us and the future, but we have no path but to go forward.

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[29] Paul B. Stephan, *Big Data and the Future Law of Armed Conflict in Cyberspace, in* THE FUTURE LAW OF ARMED CONFLICT 80 (Matthew C. Waxman & Thomas W. Oakley eds., 2022).