Regulation & Governance

Regulation & Governance (2021) doi:10.1111/rego.12392

Assessing the regulatory challenges of emerging disruptive technologies

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Abstract

The past decade has witnessed the emergence of many technologies that have the potential to fundamentally alter our economic, social, and indeed personal lives. The problems they pose are in many ways unprecedented, posing serious challenges for policymakers. How should governments respond to the challenges given that the technologies are still evolving with unclear trajectories? Are there general principles that can be developed to design governance arrangements for these technologies? These are questions confronting policymakers around the world and it is the objective of this special issue to offer insights into answering them both in general and with respect to specific emerging disruptive technologies. Our objectives are to help better understand the regulatory challenges posed by disruptive technologies and to develop generalizable propositions for governments' responses to them.

Keywords: disruptive technology, emerging technology, governance, policy, regulation, technological disruption.

1. Introduction

How should governments respond to emerging technologies which may fundamentally and quickly change economies and societies? What ought to be the role of the state in managing the adoption of such disruptive technologies? Are there generalizable principles about regulation and the construction of regulatory regimes are available to policy designers as they navigate the challenges posed by these technologies? These are some of the questions that confront regulators and governments across the world on which the existing literature on regulation and governance offers little guidance. It is the objective of this paper to contextualize these questions and offer a framework for conceptualizing and eventually answering them.

Recent emerging disruptive technologies – such as autonomous vehicles, autonomous weapon systems, blockchain technology, ride-sharing, genomics, and the Internet of Things (IoT) – have triggered changes that are threatening existing socio-economic systems. The heightened pace of technological innovation poses serious challenges to governments that must cope with the disruptive speed and scope of the transformations occurring in many domains. While these technologies offer opportunities for improvements to economic efficiency and quality of life, they also generate many unexpected consequences and pose new forms of risks (Li *et al.* 2018; Taeihagh & Lim 2019). Government responses to these technologies must consider citizen's safety, privacy, and security as well as protection of their livelihood and health. However, regulating and governing these technologies is challenging due to high levels of risk and uncertainty associated with them (Li *et al.* 2020; Tan & Taeihagh, 2020) and that often the beneficiaries of these technologies – the investors, producers and users – do not bear the costs of their risks, transferring them instead to the society at large or to governments. Moreover, the "pacing problem" or the lag between the state's regulatory agencies (often slow) responses to challenges of these technologies further exacerbate the situation (Marchant 2011).

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Conflicts of interest: The authors declare that they have no conflicts of interest to report.

Accepted for publication 13 February 2021.

In the next section, we conceptualize what it is that makes disruptive technologies a challenging policy problem. Here we abstract away from specific technologies and focus on the challenges these developments pose to existing arrangements and actors. In the following section we show the asynchronous use of substantive and procedural policy tools used by regulators. Further, effectively deploying an asynchronous mix of tools requires investments in anticipatory policy capacities of regulatory agencies and not just consideration of, for example, the economic consequences of tighter licensing or privacy laws (Howlett *et al.* 2018). We conclude with a summary of the articles that are part of this special issue and briefly highlight their contribution to this analysis and understanding of the challenges to existing regulation and governance caused by specific emerging disruptive technologies.

In advancing these arguments, this introductory article brings together two disparate bodies of scholarship: Bernstein's (1955) life-cycle analogy of regulatory development and the "new" design orientation in the contemporary policy sciences to highlight the specific nature of the different kinds of tools that can be used to address contemporary policy challenges. It argues the regulatory challenge facing disruptive technologies centers on how to develop a portfolio of substantive and procedural tools in an asynchronous fashion initially; correcting past problems while developing anticipatory capacities through the early stages of the regulatory life cycle.

2. Technological disruption as a policy problem

What is it about emerging technologies that makes them a policy "problem" that needs to be tackled? How and why does "disruption" demand a government regulatory response rather than some other? In answering these technological innovations it is important to understand the difficulties they pose to existing arrangements and the unique issues and challenges they raise concerning social and economic relationships in society.

2.1. Asymmetries in information

One problem posed by emerging disruptive technologies which poses problems for their dissemination and control is directly linked to their hi-tech nature and the limited knowledge that most social actors have concerning how it works and why, and what are the possible applications and consequences of its deployment. That is, in policy terms, the policy environment with respect to emerging technologies is characterized by *asymmetries in information* across agents and at multiple levels of society and government. As Becker and Brownson (1964) and others have pointed out, even when knowledge is already available on a technological subject, policymakers may not be aware of it and thus undertake decisionmaking in a situation of uninformed ignorance.

Similar to the situation that exists in other complex sectors such as healthcare, there are gaps in the information possessed by different actors in the sector which advantage some actors over others, making equal exchange problematic (Bali & Ramesh 2015). Just as healthcare providers enjoy innate advantages over users and insurers, technologists and entrepreneurs enjoy knowledge advantage vis-à-vis regulators and consumers. Indeed, technicians enjoy an advantage vis-à-vis their business partners with respect to the potential and limitations of the technology in question.

There are also asymmetries between investors, companies, and consumers and regulators who do not have complete information on what next steps are possible, feasible or likely, or how a given technology can or may be scaled up, or what is the ultimate goal of the agent introducing a "technology." This is relevant as technologies are continually scaled and improved through an iterative process, and are unlike other services that government must regulate which tend to be relatively discrete products or services. All of these problems are exacerbated in the case of new technologies which serve as platforms – such as social media or the internet itself – for additional systems and functionalities often not imagined at the outset of their deployment.

2.2. Policy uncertainty

More fundamentally, policy design and regulatory action in these sectors takes place in an environment of great uncertainty (Walker *et al.* 2013). As Stirling (2010) noted, different kinds of uncertainty exist and not all situations of knowledge and ignorance demand the same policy response. Parameter and associated "fuzzy"

uncertainty are of course common in routine policymaking. Thus, policymakers routinely make decisions on, for example, interest rates without knowing the actual unemployment rate at the time (Schrader *et al*. 1993; Walker *et al*. 2013). Even when causal relationships and future scenarios are relatively well known, there is always some uncertainty with respect to policy predictions due to data and statistical limitations (Morgan & Henrion 1990; Manski 2013).

In the case of emerging disruptive technologies, however, uncertainty is much more profound and pervasive. Governments are typically not entirely aware of the nature of the policy problem they are trying to address and are unsure of what a regulatory solution might look like. Thus, for example, it took some time for bike-share regulators to realize the significant problems caused by bike abandonment and the difficulties in curbing the behavior through regulations. Their experience in regulating abandonment of motor vehicles was of little practical relevance to shared bikes. This lack of awareness, let alone understanding, of the specific challenges of disruptive new technologies pose a major problem for regulators.

Decision makers aware of these gaps may function with an attitude of prudent awareness and deploy procedural policy tools to gather information and continually monitor and learn from experience. However, they may act with a hubristic attitude or overconfidence when they are unaware of their ignorance which may exacerbate existing problems (Becker & Brownson 1964).

2.3. Structural power dynamics

In addition to the challenges posed by uncertainty and information asymmetries, technological disruptions also affect different members of society differently. Some sectors of society may benefit from the deployment of emerging technologies and the disruptions they involve while others lose out. And disputes between winners (such as technology entrepreneurs and venture capitalists) and losers (such as employees of disrupted industries) or those positively or negatively impacted can be deep, widespread, abstruse.

Thus, for example, the proliferation of the sharing economy and IT platforms such as Uber, TaskRabbit, and Amazon Mechanical Turk have brought to the fore regulatory issues such as: whether workers on these platforms are independent contractors or employees, whether maximum work hours per day and minimum pay thus applies to these workers, or whether these platforms can have exclusivity clauses that tie workers to them (Taeihagh 2017). If workers are categorized as employees, they may be subject to regulatory requirements around contributions to social security programs, unemployment insurance, and other statutory requirements that do not apply to self-employed contractors. The Fair Work Commission in Australia recently ruled that Uber drivers were independent contractors and not employees as per the Employment Act in Australia. However, the Unemployment Insurance Appeal Board of the State of New York in a similar case ruled to the contrary and made Uber liable for contributing to unemployment insurance.

2.4. Errors in design of interventions and policy responses

Regulators must negotiate and balance the economic interests of agents that drive these innovations with those of citizens and members of societies that are affected by the outcomes of these innovations. But in approving "new" technologies or regulating a technology, or deciding whether the state should intervene, regulators are often faced with a trade-off between reducing possible type 1 and type 2 errors – that is overregulating benign technologies or under-regulating those that are difficult to regulate (Waring *et al*. 2020).

If we accept the null hypothesis that disruptive technologies are harmful to citizens, two common trajectories may be expected. The first is that the government does not intervene or immediately approves the deployment of a new technology but remains ready to react when inevitable problems emerge. The second is that the government intervenes aggressively, establishes safeguards, but delays the deployment of the technology. Type 1 overreaction errors aim to protect the society at large before all the ramifications of technological deployment are clear or type 2 errors protects the economic interests of the innovators in the first instance, but may cause damage to society at large. Constant monitoring, data collection, and dissemination are vital under both scenarios.

3. Regulatory responses to disruptive technologies

Addressing the challenges that disruptive technologies pose requires application of a range of policy tools to shape policy targets, establish governance relationships and norms within the sector. This involves carefully assembling a combination of "substantive" and "procedural" tools in a policy "mix" or "portfolio" or "package" (Chapman 2003; Hennicke 2004; Taeihagh *et al.* 2013; Howlett *et al.* 2015). Thus, for example, companies that offer ride-sharing are subject to a combination of many substantive regulatory tools such as licenses and standards, as well as procedural tools such as structured market competition and stakeholder consultations (Li *et al.* 2018, 2020).

There is, however, an overarching preference to rely on regulatory tools to contain the risks posed by technologies. Regulation may be usefully defined as "a process or activity in which government requires or proscribes certain activities or behavior on the part of individuals and institutions, mostly private but sometimes public, and does so through a continuing administrative process…" (Reagan 1987, p. 17). In this view, regulation is largely a substantive tool – a requirement or prescription – targeted at specific groups with the intention of changing their behavior to align with the government's objectives. However, the definition also has a procedural component in the sense that the measures need to be administered through continuing administrative processes. In addition, organizational and fiscal tools are often used to reinforce the regulation in question. Thus, regulations are a "mix" of substantive and procedural components rather than a single discrete policy tool (Krebs 2004; Rosenbloom 2007; Leonardi 2010).

These regulatory mixes exist as sectoral "regimes", that is, enabling legislation and standards established over time on a sectoral or issue-by-issue basis such as by industry in the case of automotive fuel standard or by-product or process, such as a ban on toxic chemicals (Hood *et al.* 1999). In either case, according to Eisner (1994), the application of the term "regime" to regulatory activity is intended to convey the same sense that it carries in international relations theory: "implicit or explicit principles, norms, rules, and decisionmaking procedures around which actors' expectations converge in a given area" (Krasner 1982, p. 186). A regulatory regime is thus an institutionalized (though not necessarily codified) instrument mix which contains a set of behaviors and expectations on the part of regulators and regulated in which both sets of actors understand the procedural and substantive rules which affect them and agree to abide by them, albeit often not entirely willingly.

Regulation may come directly from government or its designated government agencies or independent commissions, but may also originate in private trade associations or even international organizations (Lilly & Knepper 1993). Moreover, regulations may take many forms, from command and control regulation to self-regulation (Howlett 2019) which may appear different but share many similarities. There are also voluntary regulatory regimes with no legally binding rules (Whitford & Tucker 2012), regimes with activist government regulators eager to create new rules (Bamberger & Mulligan 2011), and regimes in which the targeted industry benefits from a captured regulator (Croucher 2011). Which if any of these modes is appropriate in the case of emerging disruptive technologies and how they should be implemented remain open questions.

Disruptive technologies, although all "recent", are at various stages of regulatory development and governments have understandably responded to them with different strategies at different speed, from no response to prevention, precaution, traditional control, toleration, and adaptation (Li *et al.* 2018, 2020; Taeihagh & Lim 2019). Although there is considerable variation within and across different sectors, there is also a common trajectory for the evolution of regulatory regimes which is as relevant to emerging technologies as their mature counterparts.

The origin and evolution of regulations entail vital implications for emerging regulation in general and regulation of emerging disruptive technologies in particular. First, for example, it implies that different high-technology sectors can be expected to be at different stages of regime development depending on the length of time since the beginning of the cycle and the nature of the crises and responses which have occurred in each case. Moreover, even in the same sector, there may not be uniformity in progression in regulatory stages and developments if multiple new technologies are deployed simultaneously, as with the case of the IoT or autonomous vehicles. Hence, for example, regulation of autonomous vehicles may be at very different stages concerning aspects related to privacy and cybersecurity and those linked to safety and liability issues (Lim & Taeihagh 2018; Taeihagh & Lim 2019). As a result, when viewing a regulatory regime in a large umbrella category such as "hi-tech", one

should not expect to see a uniform set of practices and processes but rather a pattern of laggards and leaders as each issue area moves through its own standard-setting process.

A second significant characteristic of efforts to regulate emerging technologies is asynchronous application of different types of regulatory tools. That is, regulation involves both substantive and procedural policy tools. The former relative to substantive requirements and prohibitions, backed by rewards and punishment, while latter includes participatory decision processes designed to produce better substantive decisions for the future (Howlett 2000).

While the substantive tools are "in the now", in the sense that the level and type of regulation relates directly to resolving problems which occurred in past phases, the procedural tools are more anticipatory and are typically geared towards the future. The latter are intended to anticipate the next crisis and the kinds of substantive tools that would be needed to deal with it. Thus, for example, current inquiries about the challenges posed by Autonomous Vehicles portend the development of remedial substantive tools to deal with cybersecurity issues prior to need for their adoption (Lim & Taeihagh 2018) while the actual regulations in place deal mainly with health and safety challenges and liabilities which featured prominently in earlier eras. This asynchonicity between procedural and substantive tools remains the case until the regime matures and stabilizes as new problems diminish, allowing both kinds of tools to synchronize.

4. Application of regulatory life cycle theory to disruptive technologies

While regulations have been the subject of intense study for decades, much of the existing research concentrates on answering basic questions such as whether or not regulation should be deployed in the first place (e.g. Demsetz 1968) or examining the mature stages of a regulatory body in which the regulators have been "captured" by the industry they regulate (e.g. Bernauer 2003; Dal Bo 2006; Carpenter 2010). Less attention has been paid to the other stages of a regulatory regime, including the processes through which regulatory standards develop in specific issue area. This has not always been the case, however, as some of the earliest works on regulation did adopt a temporal perspective which can be usefully deployed to examine the case of disruptive technologies. In his pathbreaking 1955 work, *Regulating Business by Independent Commission*, for example, Marver Bernstein noted the significance of time in the process of regulatory development and suggested that regulatory agencies tend to follow a set pattern of evolution or lifecycle, one which roughly parallels a human life (Bernstein 1955).

The history of regulatory activity with respect to new technologies – from food and drug administration to automobile safety standards – reveals a typical life-cycle process through which standards emerge and become institutionalized in a mature regulatory regime (Bernstein 1955; Howlett & Newman 2013). As pointed by Bernstein (1955) over a half century ago, in general, evolution of regulations may be viewed as analogous to a genealogical process through which a regime moves from creation to death, with recognizable stages and punctuations along the way.

In this work, Bernstein postulated that regulatory regimes go through four distinct phases: *gestation*, in which a public problem is first perceived by its relevant stakeholders, and organized advocacy for a solution begins; *youth*, in which an activist, autonomous, regulatory body struggles to define its powers and jurisdiction amid legal opposition from industry groups. Next, regulations reach *maturity*, where a stable regime emerges whose powers and duties are agreed upon by all sides and in which the autonomous regulatory body acts mechanically as a tribunal of the regime. Finally they reach *old age*, when an industry has fully captured the regime and the regulatory body's main role is to fight to retain the status quo. Each stage in this regime life-cycle is linked to the often very slow process of the development of what ultimately emerges as a set of court-supported standards administered by government agencies and maintained over a long period of time. Movement through these stages is not automatic but rather crisis-driven. That is, in general, movement stalls at one stage unless there is some crisis highlighting its inadequacy, ratcheting up the regulatory spiral (Howlett & Newman 2013). Without a crisis, the existing regime is likely to remain in place unaltered.

Over the 65 years since Bernstein's work first appeared, some stages of the regulatory regime lifecycle have been well-explored, while others have remained under-explored. The moment of regulatory birth, for example, has been examined in studies focusing on the question of whose interests were served by the creation of a

particular regime (Stigler 1971, 1975). Similarly, the maturity stage has been examined by scholars of issues such as regulatory capture and by students of administrative law examining the role of the judiciary in regulatory review (e.g. May & Winter 1999; McGarity 2001). The stages of regulatory decline have also been analyzed in works focusing on policy termination (Bardach 1976; DeLeon 1983; Lewis 2002) or de-regulation (Derthick & Quirk 1985; Collier 1998; Lazer & Mayer-Schonberger 2002).

However, the stages between what Bernstein termed "gestation" and "maturity" – or what he called the "youth" phase of regulatory regime development – remain very much underexplored. This is a critical period, however, one in which the agencies and rules which go on to comprise an often very long-lasting mature regime are created and put into place. We argue that understanding regulatory processes for emerging novel technologies require an understanding of the forces and processes at work in these early stages of regime development.

The recent wave of disruptive technologies have been affected by the development of various decision technologies such as Crowdsourcing and Big Data Analytics (Prpić *et al.* 2015; Athey 2017; Taeihagh 2017b) that create both new problems and opportunities for governments. For instance, policy responses to the Covid-19 pandemic have ranged from the use of established technologies such as GPS to improve quarantine enforcement; introducing mobile applications that use Bluetooth to measure propinquity and improve contact-tracing; to more sophisticated technologies that use a combination of mobile-phone-tower data and machine learning to develop social graphs. The latter can measure the propensity and frequency with which people meet or pass through a certain location (The Economist 2020). While these technologies inform and aid policy implementation and the decisionmaking practices, they also give rise to a series of concerns around privacy and civil liberties. Given their disruptive nature, novel technologies inevitably draw government attention and generate pressures to contain their adverse effects. This can already be seen developing in areas such as data protection, privacy, ride-sharing, autonomous vehicles, healthcare and a variety of other sectors (Bygrave 2010; Li *et al.* 2018; Taeihagh & Lim 2019; Tan & Taeihagh, 2020).

5. Papers in this special issue

The challenges of regulating emerging disruptive technologies highlight the need for regulatory regimes which feature not just effective corrections to apparent problems but also anticipatory capacities which allow governments to identify and react appropriately to new challenges. The policy challenges posed by disruptive technologies thus require a range of regulatory policy tools – both procedural and substantive – to address them. It is the question of how this has been managed and how governments have dealt with information and uncertainty challenges in different spheres to which the articles in this special issue are addressed. The articles in the special issue tackles the issue of evolving disruptive technology regulation through case studies and comparative analyses. They do so as illustrated in Figure 1.

The articles are categorized under three themes: (i) challenges of regulating emerging disruptive technologies, (ii) the policy process and disruptive technologies, and (iii) regulatory responses to technological disruptions.

5.1. Theme 1: Challenges of regulating emerging disruptive technologies

This article, "Assessing the Regulatory Challenges of Emerging Disruptive Technologies", examines technological disruption as a policy problem and the development of new regulatory regimes. The article revisits the regulatory life-cycle concept first proposed by Bernstein (1955), and offers insights into the evolution of the regulatory regimes in the context of emerging disruptive technologies. It proposes adaptable responsive regulations as a promising strategy for responding to emerging technological disruptions.

5.1.1. Spillovers and boundary issues

"Emerging Technologies and Problem Definition Uncertainty: The Case of Cybersecurity" by Lewallen (2021) examines how regulatory issues in disruptive technology sectors expand and change as they cross over existing sectoral boundaries. The article focuses on boundary spanning problems using historical data from the US Congress to examine how regulatory authority has been allocated and re-allocated in the cybersecurity area as its impact and challenges have come to be better understood.

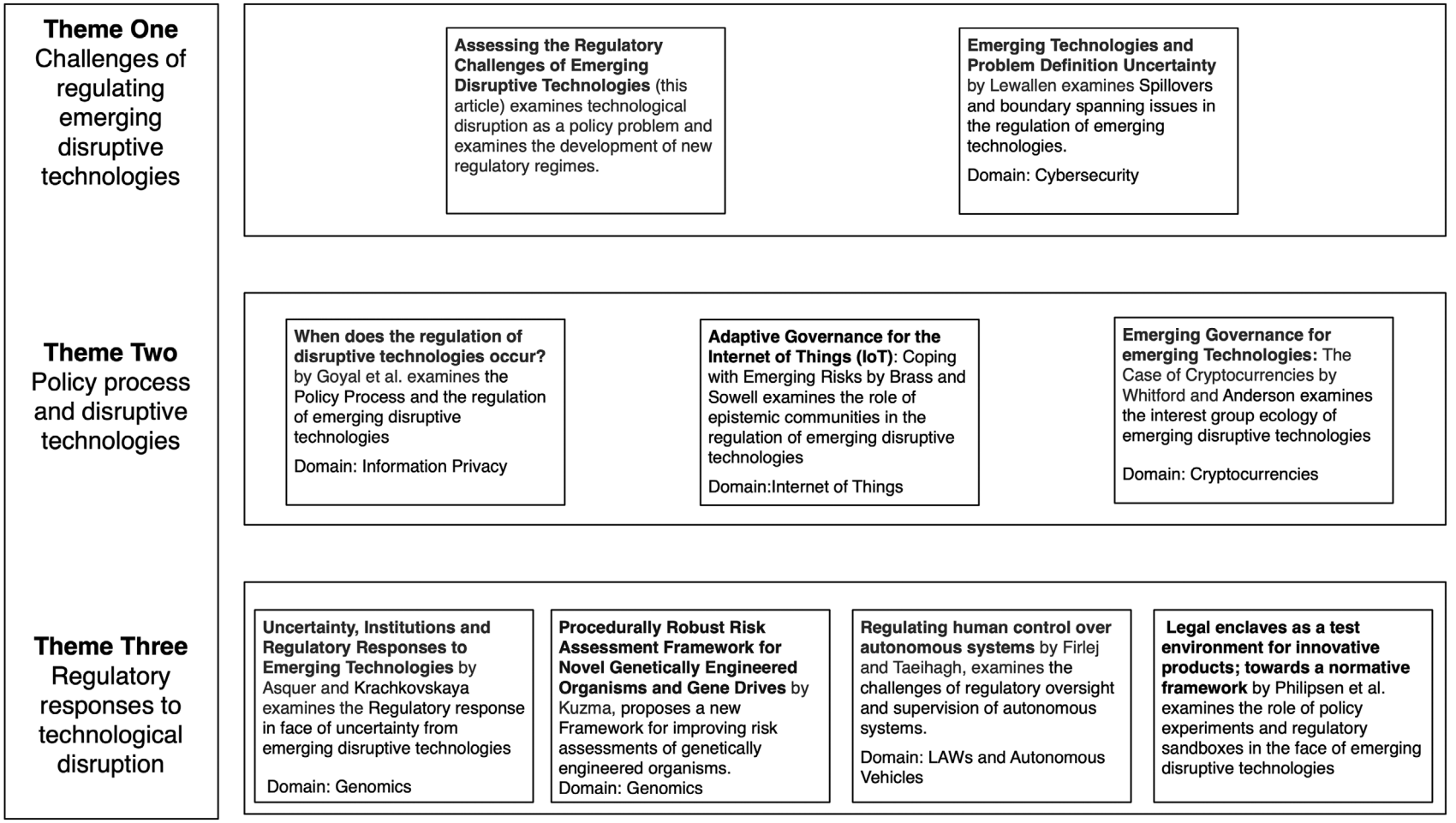

Figure 1 Summary of the articles in this special issue on the governance of emerging disruptive technologies.

5.2. Theme 2. The policy process and disruptive technologies

Following on the discussions about the challenges of regulating emerging disruptive technologies, a set of articles examine aspects of the policy process and actors' behavior in the context of emergence of disruptive technologies.

5.2.1. The policy process and the regulation of emerging disruptive technologies

"An analysis of the creation of the General Data Protection Regulation regime" by Goyal *et al.* (2021) examines how regulation of disruptive technologies occurs and who is involved in the process. It details the emergence and nature of the actors involved in regulating disruptive technologies using the multiple streams framework. Drawing insights from the literature on regulation, science and technology studies, the authors posit that new technology regulations are adopted when a window of opportunity allows actors to push for changes, the exact nature of which depends on the dynamics between actors within and across the streams. The model is illustrated by a case study on the creation of the General Data Protection Regime (GDPR) in the European Union. The findings corroborate the important roles played by various governmental and non-governmental actors in the adoption of GDPR, and how crises helped overcome strong resistance from information technology firms.

5.2.2. The role of epistemic communities

How regulators and policy actors frame regulatory challenges is also the theme and focus of the next article, "Adaptive Governance for the Internet of Things (IoT): Coping with Emerging Risks" by Brass and Sowell (2021). The article provides an overview of IoT risks and critically examines the existing regulations in the sector in terms of their (in)effectiveness as policy responses to the risks of the new technology. The article provides a framework to assist the framing and regulation of IoT.

5.2.3. The interest group ecology of emerging disruptive technologies

"Emerging Governance for Emerging Technologies: The Case of Cryptocurrencies" by Whitford and Anderson (2021) examines integrative regulation and governance logics in the case of cryptocurrencies and explores the landscape of actors present in the cryptocurrency regulatory space. The article examines the current state of the regulation for cryptocurrencies and examines the regulatory environment around it, highlighting how self-governance is a common operating modality in the early stages of regulation of an emerging technology and why this is the case.

5.3. Theme 3. Regulatory responses to technological disruptions

5.3.1. Regulatory response in face of uncertainty from emerging disruptive technologies

"Uncertainty, Institutions and Regulatory Responses to Emerging Technologies: CRISPR Gene Editing in the US and the EU (2012–2019)" by Asquer and Krachkovskaya (2021) examines the development of regulatory responses to the CRISPR gene-editing technology in the EU and USA. It uses the comparison between the two case studies to demonstrate how path dependencies quickly develop in these sectors but also how they are undermined by future development of the technology. It engages the life-cycle theory of regulation to explain the general pattern of the regulatory trajectories identified in these two cases.

"Procedurally-Robust Risk Assessment Framework for novel genetically engineered organisms and gene drives" by Kuzma (2021) proposes a new Procedurally Robust Risk Assessment Framework (PRRAF) for improving risk assessments of novel genetically engineered organisms (GEOs) in a variety of institutional, regulatory and governance contexts. The framework enhances risk assessment protocols for GEOs under high degree of uncertainty and is applied to the case of a genetically engineered mosquito designed for decreasing disease transmission through killing its wild population. The case study demonstrates that the regulatory approval of this genetically engineered insect fall short under PPRAF criteria. The article highlights the importance of bolstering risk analysis methods used by regulatory agencies and technology developers prior to field testing.

5.3.2. The challenges of regulatory oversight and supervision

"Regulating human control over autonomous systems" by Firlej and Taeihagh (2021) examines how challenges of regulatory oversight and supervision can be handled by regulators as technologies change and develop. It examines the growth and emergence of regulatory frame around the continuing need for "human control" in the context of the increased use of automated and quasi-autonomous systems in these two critical policy domains:

warfare and transportation. The study highlights relevant regulatory gaps and issues in the governance of autonomous systems and how retaining human control over them has been identified as a solution to them. It examines the conceptualization and operationalization of "human control" and offers a typology of direct and indirect control using a comparative policy perspective.

5.3.3. The role of policy experiments and regulatory sandboxes

In their article, Philipsen *et al.* (2021) discuss the use of procedural tools in emerging technology regulation, notably the use of legal enclaves to test innovative products and the regulatory issues they raise. This procedural tool aids in the development of regulation by fostering regulatory innovation. The article examines regulatory sandboxes from legality, equality, accountability and certainty perspectives and provides guidelines for opening, granting and post permission phases in their deployment: contributing to the understanding of how regulators and entrepreneurs can mutually benefit from their interactions.

Acknowledgments

The special issue editors acknowledge the support provided by the Lee Kuan Yew School of Public Policy, National University of Singapore through the TRC grant scheme. The special issue editors would like to thank the editors of Regulation & Governance and all the anonymous reviewers for their constructive feedback and support for this and other articles in the special issue on Regulating Emerging Disruptive Technologies.

Data availability statement

Not applicable.

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