Co-evolution: Applications and Implications for Governance Research in Communication Studies

Johannes M. Bauer[1] and Michael Latzer[2]

[1] Professor, Department of Media and Information,
Director, Quello Center for Media and Information Policy
Michigan State University, East Lansing, Michigan, USA
Email: bauerj@msu.edu
Internet: https://quello.msu.edu

[2] Professor, Department of Communication and Media Studies
Head of the Media Change and Innovation Division
University of Zurich, Switzerland
Email: m.latzer@ikmz.uzh.ch
Internet: https://www.mediachange.ch

Submission to
M. Puppis, H. van den Bulck, & R. Mansell (Eds.),
Handbook of Media and Communication Governance.
Cheltanham, UK; Northampton, MA: Edward Elgar (forthcoming 2024)

PENULTIMATE VERSION
February 26, 2023

Abstract

A co-evolutionary theoretical framework offers new concepts and methods for communication governance researchers. These concepts and methods are particularly well suited to study problems with strong interdependencies between actors. Such problems often develop in a dynamic, open-ended way and are associated with high levels of uncertainty. Many important, pressing governance tasks in convergent communication sectors, such as efforts to regulate digital platforms, could benefit from integrating insights from co-evolutionary models. For some problems, such as global internet governance, co-evolutionary models may be the only way to develop a robust understanding of the available governance options. This chapter introduces the co-evolution concept, points to applications in communication governance research, and presents models and tools that could enrich future research. It also highlights the implications of its applications for communications governance, summarizes the strengths and limitations of the approach, and gives a brief outlook of further developments.

Keywords: Co-evolution, complexity, governance, media, communication, policy

JEL Codes: O31, O33, L86

INTRODUCTION

The concept co-evolution originated in biology but is increasingly applied in other scientific disciplines, including the social sciences. It offers an analytical approach and empirical methods that can enhance communication research to better understand fast-paced social, economic, political, cultural, and technological changes. Co-evolutionary approaches are well suited to analyse how interdependencies and interactions among actors and systems influence the development of communication systems over time. This in turn opens additional insights into the roles, effects, and limitations of communication governance that are not as clearly visible in theories and models that abstract from these characteristics.

In this chapter, governance is broadly construed to encompass social and technical mechanisms that shape the working and outcomes of the communication system. Traditional forms of government by law, regulation, and other instruments constitute important methods of governance. But the notion of governance is wider to include coordination by private actors (a horizontal extension of government) and by players at multiple levels of the socio-technical system (a vertical extension of government). Moreover, technology, both as actor and structure, is also considered as a form of governance. This inclusive view of communication governance encompasses intentional and unintentional influences on the socio-technical system in which all forms of societal communication via old and new media, telecommunications and the internet are embedded. Governance efforts may be motivated by a range of goals, from the pursuit of a shared public interest to the narrow special interests of one or more players.

Communication policy research across the social sciences often treats government as a privileged actor, capable of steering the societal communication system in desirable directions. Political economic approaches critically interrogated this assumption and examined the role of

power and interest in communication policy. Early notions of governance added non-government actors and forms of networked coordination to the research toolkit. These approaches necessarily paid more attention to interdependencies and contingencies of effective governance. However, they often assumed the existence of relatively stable social and economic structures and interests, such as class, that could be identified and changed with appropriate political will.

Co-evolutionary theoretical frameworks go one step further and fully endogenize governance and its effects. They are theorized as part of an interlocking process that unfolds over time (Pierson, 2004; Choucri & Clark, 2019). Power, interests, and the ability to govern are no longer structural, but rather reflexive and are co-constituted by ongoing interactions among the actors in a system. In the emerging contributions to the field of communication governance, co-evolutionary perspectives are used metaphorically, analytically as a conceptual framework, and to develop specific models and tools. All three perspectives contribute to addressing puzzles with which other theories struggle. Co-evolutionary approaches are particularly useful to explain dynamic change that involves many interdependent actors over time.

This chapter introduces co-evolutionary theory to communication researchers. It outlines the basic features of the approach, points to applications in communication research, and presents models and tools of co-evolutionary research. From these building blocks, the chapter discusses the implications of co-evolutionary approaches to communication governance, summarizes its strengths and limitations for governance research, and gives a brief outlook to further developments. Although much work remains to be done, co-evolutionary approaches offer promising avenues to tackle some of the most vexing problems of communication governance research and practice.

FEATURES

In their review of the literature about the uses of the co-evolution concept in the social sciences, Mitleton-Kelly and Davy (2013) identify several, broadly consistent features and commonalities. Co-evolution describes the mutual, causal influence of the elements of a system on each other's development over time. Whereas evolution is a process in which variation, selection, and replication lead to gradual changes and differentiation, the notion of co-evolution expands this idea to interdependent processes. Used as a metaphor or interpretive frame, the concept is particularly useful to study evolving, complex phenomena, such as the intertwined development of multiple actors or of multiple systems, such as media, technology, economy, and politics. Reciprocity and reflexivity represent central building blocks to explore mutual influences and how they change the behaviour of actors in social or socio-technical ecosystems.

The authors identify four main clusters in which concepts of co-evolution are used in the social sciences: evolutionary economics, socio-technical systems analysis, human culture and cognition, and socio-ecological evolution. Further, they note that some social-scientific uses place stronger emphasis on adaptation and change than on selection and competition. Co-evolution is not interpreted as a normative process, such as a process that results in the survival of the fittest. Rather, it is understood as a value-agnostic, analytical framework that focuses on the specific dynamics of change. In principle, co-evolutionary theories and models can also be used to explore the effects of alternative governance decisions that are contingent on other developments or on likely outcomes. This comparative, stochastic knowledge can be used to clarify the scope for agency and likely consequences of different courses of action.

Communication governance research is a highly interdisciplinary effort. Contributions originate in and often integrate insights from communication, economics, political science,

sociology, science and technology studies (STS), information science, computer science, engineering, and law. Co-evolutionary approaches have made inroads into all these disciplines and are applied also to communication governance issues. They have arguably been adopted most widely in STS (e.g., Geels, 2005; Rip, 2006), economics (e.g., Whitt & Schultze, 2009; Milgrom, 2017), and policy studies (e.g., Room, 2011). Significant uses have also emerged in engineering (e.g., Bustamante et al., 2020), computer and information science (e.g., Easley & Kleinberg, 2010), and sociology (e.g., Lazer, 2001). Beyond these disciplines, they have inspired exploratory work in political science (e.g., Schneider, 2001), communication (e.g., Latzer, 2013; Waldherr, 2014), and law (Cherry, 2007).

Communication governance research can benefit from co-evolutionary approaches in several additional ways. Theories and models inspired by co-evolutionary frameworks are particularly helpful to understand governance problems and processes that involve many interdependent players. Such systems are often multi-layered, with processes at the level of individual actors (e.g., media consumers, content providers) intertwined with developments at the sector level (e.g., legislation and regulation) and at the level of the broader institutional environment. These layers are related in bottom-up and top-down processes. For example, higher order processes typically emerge from lower-level interactions but cannot be reduced to them. At the same time, higher order phenomena enable and constrain lower-level processes.

Multi-level perspectives are widely used in the disciplines that also contribute to communication governance. Co-evolutionary theory provides a framework and methods to analyse these systems in an integrative way. Because multi-actor and multi-layer systems involve social actors that learn and adapt, they often behave as complex adaptive systems. This implies

that aggregate, higher-level outcomes emerge and cannot be explained in a reductionist way from be continuously co-evolving or even chaotic.

Like individual components (e.g., Room, 2011). Complex processes and systems are also characterized by non-linear developments, positive and negative feedback loops, networks, and adaptation (Mitchell, 2009). Such systems may exhibit some stability and regularity (states that are referred to as 'stable attractors') or they may other areas afflicted with uncertainty, the history of the communication sector is characterized by mispredictions as well as desirable and unwanted, unanticipated consequences. For example, the development of the internet ecosystem is considered the result of an interplay of multiple agents with varying levels of information and rationality, market-, and non-market forces (Post, 2009; Whitt & Schultze, 2009). It is the product of the co-evolution of technologies, markets, and politics, with positive and negative outcomes that often were neither intended nor predicted (Latzer, 2014; Choucri & Clark, 2019).

These observations are consistent with insights from co-evolutionary theory that the specific direction of co-evolutionary processes is difficult or impossible to control. Governance can, of course, prohibit some types of actions by individual actors and incentivize others. It can intervene by setting rules at higher levels of the system, such as laws and regulation. Whether such measures can effectively influence the system is contingent on the degree of freedom available to actors to bypass such measures. Because digital technology is highly plastic and develops on a global scale, it offers many opportunities to undermine and evade local and national forms of governance.

Co-evolutionary processes may generate new patterns and the emergence of new rules (Nelson & Winter, 1977). Digital innovation, therefore, can also be understood as co-evolutionary processes (Frenken, 2006). Techno-economic innovations and communication

governance innovations are interconnected. Driven by human agency, existing technologies continuously spawn new technologies (e.g., Arthur, 2009). In that generalized sense, they evolve and co-evolve with other systems and actors.

It is important to distinguish co-evolutionary approaches that are applied to socio-technical systems from applications in other sciences. Biological evolution is 'blind', and emerges from random variation and mutation, selection, and replication. In contrast, co-evolutionary processes in socio-technical systems involve deliberate design efforts and human agency. For example, the technical system and its components are shaped by deliberate design, as are mechanisms of governance. Socio-economic factors (e.g., markets and competition) and policy choices replace natural selection. And reproduction does not happen via genes but in a process that involves institutions, routines, and socio-cultural learning (Laland, 2017; Ziman, 2000). Because governance is forward-looking, anticipation and imaginaries of better futures affect decisions and outcomes (Voss & Bauknecht, 2007; Rip, 2006; Mansell, 2012).

METAPHORS AND CONCEPTUAL FRAMEWORKS

Work on United States (U.S.) telecommunications policy as a co-evolving, complex adaptive system (Cherry, 2007) and the application of an emergent economics perspective to communications policy (Whitt & Schultze, 2009) are two early examples of co-evolutionary analyses in communications governance. Latzer (2013, 2014) proposed to analyse media change as an innovation-driven, co-evolutionary process in an environment marked by complexity. Innovations are understood as co-evolutionary processes and convergence in communications as driven by mutual, selective pressure, adaptation, and coincidences.

Referred to by some authors as co-construction, confluence (Benkler, 2006), and co-dependence (Fransman, 2010), the notion of co-evolution helps to understand processes of change. It offers a framework to analyse the continuous need of actors to adapt to actions by others and to the overall emergent changes in the system. Evolution has been conceptualized as metatheory of change (Schneider, 2012), of emergent design without a central designer. In contrast, co-evolution allows the exploration of the scope for agency ('design') and how it is contingent on actions by others ('being designed'). The resulting co-evolutionary path is neither precisely predictable nor purely coincidental. These insights challenge theories of governance that assume the simple controllability of the outcomes of a system (Schneider & Bauer, 2007; Bauer, 2022a, 2022b).

A combined co-evolution and complexity perspective (Garnsey & McGlade, 2006) of communication governance has various advantages over traditional approaches. It explicitly examines interdependences and overcomes the dichotomy and antagonism of technological determinism (stating that technology shapes social change) and social determinism (stating that social forces shape technology). Latzer (2014) demonstrated this for the example of convergence in the electronic communications sector. However, the framework can also be applied to an understanding of other phenomena related to media change, such as the increasing differentiation of the sector and the interaction of technology and society. For decades, communication scholars debated media change as technologically determined or socially shaped. A co-evolutionary perspective theorizes media change as an outcome of the interaction of both forces.

A co-evolutionary approach also helps to understand the recent phase of digitalization, which began around the turn of the millennium and follows the digitalization of telecommunications and broadcasting in the twentieth century. Latzer (2022) refers to this

process as the ‘Digital Trinity’ of datafication, algorithmization, and platformization. He emphasizes the associated convergence of technology and religion, which results in an implicit, digital everyday religion that subsequently shapes the social order. The co-evolutionary perspective of such a threefold digitalization reveals that it takes over some traditional functions of religions in societies, such as complexity reduction, transcendence experience, and social cohesion. The reciprocal, co-evolutionary interplay of the three transformation processes of the ‘Digital Trinity’ and their effects can be modelled, and the design of appropriate governance strategies can be guided. Traditional, centralized instruments and approaches can control these processes to only a limited extent (see section on implications below).

In this phase of digitalization, the human-machine relationship is moving into the centre of interest. It is fuelled by trans- and post-humanist thought combined with developments towards nano-bio-info-cogno convergence (NBIC), brain-computer interfaces, etc. (Latzer, 2022; Roco & Bainbridge, 2002). Lee (2020) proposes a co-evolutionary perspective on the relationship between technology and human culture as opposed to the deterministic perspective of a "digital creationism" characterized by a top-down, intelligent design process. In this context, co-evolution focuses on symbioses and co-dependence (Fransman, 2010) rather than on fusion and annihilation, which is often the case in transhumanist narratives, such as that of technical singularity (Kurzweil, 2005). This choice between conceptual perspectives also leads to significant differences concerning the choice of public policies and governance strategies. Whereas digital creationism focuses primarily on top-down regulations that constrain individuals, a co-evolutionary approach, according to Lee (2020), favours ‘nudging’ socio-technical processes of change.

Choucri and Clark (2019) demonstrate that internet governance is another field, which can benefit from the application of a co-evolutionary framework. The authors apply a co-evolutionary approach to explain how the interdependencies between international relations and the internet have become irreversible. They show how the many actors in this system exert mutual competitive selection processes on each other (also referred to as the 'Red Queen Effect', that is, the need to continuously adapt and innovate in response to changes by others even to stay in place and not lose ground). This framing reveals 'digital co-evolutionary dilemmas' as well as new leverage points of internet governance (Choucri & Clark, 2019).

MODELS, TOOLS, AND PRACTICES

During the past two decades, social scientists and policy researchers have developed formal models and tools that use elements of co-evolutionary approaches (Easley & Kleinberg, 2010; Room, 2011, 2016; Sherry, 2015). One insight from this research is that not all governance problems benefit equally from the application of co-evolutionary perspectives (Bauer, 2022b). Therefore, a first methodological question is whether theoretical and empirical models that reduce interdependencies to simple, linear causation are justifiable abstractions of the problems to be analysed. Such theories and models can be considered as special cases of more general, dynamic, co-evolutionary theories and models.

However, the pervasive and ubiquitous role of media and communication technologies in modern society suggests that interdependencies among local, national, and transnational actors, are increasingly relevant (e.g., Beck, 2016). Consequently, the realms in which co-evolutionary approaches will likely have methodological advantages and a great potential to add explanatory power are expanding. Researchers have begun to embed interdependencies in simpler models,

most often in the form of moderation effects or in models that examine causation over time. For example, Dutton (1992) proposed the conceptualization of communications policy as an ecology of games. Research on media effects increasingly recognizes the need to model dynamic processes over time. Slater (2007; 2015) used a dynamic systems approach to study the bi-directional (reciprocal) causation process that links exposure to media sources and outcomes over time. These approaches offer first steps but do not capture the full power of co-evolutionary modelling.

The multifaceted nature of interdependencies within the societal communications system and with social, technical, and political developments creates a dense fabric of tightly connected processes. In such systems, governance measures that are initiated by government or non-government players typically have direct, indirect, and systemic effects. Direct and indirect effects are recognized in parts of policy research (e.g., Bourreau et al., 2010). Yet they continue to be abstracted away in most practical approaches, including in recent efforts to regulate the digital economy. A third type of interdependencies - endogeneities among players - has yet to be integrated more fully into communication governance research and practice.

Endogeneities exist if the actions of one player affect not only the environment of other players but the foundations upon which decisions are based. This could be an actor's perception (mental model) of the world, preferences, moral dispositions, values, or the effects of conformity bias. Moreover, in social and networked systems, individual actors typically take others into consideration, as epitomized by other-regarding preferences and conformity bias. If this is the case, the assumption of stability that undergirds many theories and models used in communication governance cannot be maintained. It is in this area that co-evolutionary models have begun to make innovative contributions.

Communication governance research has long used scenario building and simulation exercises. Advances in computational analysis tools greatly enhance these approaches with more powerful models and tools. For example, Waldherr (2014) used an agent-based model to examine news waves, linking them to the adaptive behaviour of journalists. Koning (2017) developed a computational model of network neutrality governance, using genetic algorithms to integrate learning into an agent-based model. Milgrom (2017) explains the development and deployment of large computational models to inform U.S. spectrum auctions. Moreover, laboratory experiments permit the understanding of the behaviour of individuals and the emergent properties of differently architected, computer-mediated, communication environments (Bail, 2021).

Concepts and insights from co-evolutionary models are beginning to influence the practice of communication governance. An example is the growing interest in adaptive and agile forms of governance, such as experimental regulation, regulatory sandboxes, and data-driven regulation (OECD Council, 2021). These new governance tools were developed in response to the co-evolutionary challenges of technology governance. Reliance on feedback loops and policy learning is one important common characteristic of these new governance approaches. Moreover, systematic monitoring of the effects of interventions and limited-scale policy experiments are used to fine-tune and improve policies (see the examples in World Economic Forum, 2020).

IMPLICATIONS AND EMERGENT RESPONSES

The consequences of applying insights from co-evolutionary theory to media and communication governance are manifold. Latzer (2013) argued that it recasts the internet and emerging communication technologies as digital construction kits and innovation machines. Among the influential consequences for communication governance research are the acceptance

of the limited predictability and controllability of developments in communications policy. Others include a reframing of adequate government interventions in communication markets and modified guidelines for how policy can influence co-evolutionary and complex processes. When a co-evolutionary perspective is applied, both the perceived framework conditions for policymaking and its strategic guidelines are changing (Latzer, 2014).

An important change in the framework conditions for policy is that developments can, at best, be pushed in a certain direction, because there is no linear, additive development. The new conditions to consider also include the importance of anticipation, which is often overlooked in governance research. There are no all-knowing agents in complex, co-evolutionary systems, and no single agent can pick winners or losers, because it is a design without a central designer. Socio-technological systems are not only the output of governance, but they themselves also have governance effects.

These changing framework conditions revealed by a co-evolutionary perspective imply different strategic guidelines for communications policy. Many of these new strategic guidelines are already visible in current communications policy on the national and supranational levels (Latzer, 2014). It can be assumed that they will continue to become more relevant. Collaboration and exchange between politics and the industry are driven by forms of co-regulation. Because of very limited predictability, communications policy tries less often to dictate developments than was long common. Politics is more reluctant than in the past to pick winners from technological alternatives and different business models. Nonetheless, players, including private organizations and governments, pursue mission-oriented approaches as seen in areas such as fifth and sixth generation wireless, artificial intelligence, and gigabit networking. However, there is greater

awareness that the success or failure of such projects will be an emergent consequence that becomes known only in hindsight.

Consequently, governance often seeks to enable and foster co-evolutionary processes, which can be accomplished by the creation of a favourable sectoral environment for players. The focus is to support the networking of actors, promote their access to knowledge, support research and development activities, and, in general, enable the feedback mechanisms of co-evolutionary processes. A preferred strategy is to design adaptive policies, for example, by including feedback-loops in the governance process through periodic reviews and revisions of laws. Considerations and proposals are made in the form of scenarios and possible developments, because only broad statements can be made about the future of systems, and policy cannot determine the best path of development. A trial-and-error approach seems appropriate because winners are not apparent at an early stage. The development is toward a portfolio of competing experiments and away from single strategies.

Co-evolving systems may also adapt to overcome forms of governance failure, even though the solution may create additional policy concerns. For example, the decentralized governance model of the Internet complicates the provision of reliable, high service quality and of security. Several responses have emerged. One is technological - illustrated by the massive efforts by the video games industry to design around these shortcomings with sophisticated software solutions (Ball, 2022). A second response is the ascent of globally operating digital platforms that offer differentiated quality of service and security. These private internets co-evolve with the open, public internet (e.g., Stocker et al., 2021), but raise new governance challenges, such as the potential abuse of market power.

The recognition of the increasing interdependencies among players and processes has also contributed to a revived interest in practical, applied ethics (Dignum, 2019; Reich et al., 2021; Vallor, 2016). Traditional, normative criteria that inform governance, such as utilitarian welfare economics or rules-based approaches, such as theories of justice (e.g., Schejter, 2016), face tremendous challenges in providing appropriate guidance, because the outcomes of co-evolutionary processes are difficult to anticipate. A rapidly growing literature proposes to apply virtue ethics, the ethics of care, and frameworks, such as the capabilities approach, to specific technology governance problems (Jasanoff, 2016; Vallor, 2016; Jacobson, 2016). Such principles can be seen as middle-range governance tools that allow the alignment of decisions by individuals and groups with a common, public interest, even in an ever-evolving, co-evolutionary system.

STRENGTHS AND LIMITATIONS

Co-evolutionary approaches help overcome the antagonism of technical and social determinism by emphasizing the reciprocal interaction between these forces over time. They examine emergent properties of a socio-technical system starting from a broad range of behaviours by individual actors that are much closer to observable reality than the highly stylized approach of the rational actor model. Moreover, the analysis of communication governance as part of a dynamic, co-evolving system deepens our understanding of the forces that contribute to the proliferation of forms of governance. It offers an integrating framework to deal with pressing issues, such as the governability of socio-technical systems (Kooiman, 2008). From a meta-governance perspective, it also allows the examination of the most effective coordination and alignment of different forms and modes of governance (Torfing, 2016).

Purposeful, effective, and sustainable governance requires the alignment of three elements: (1) a clear understanding of the working of the system to be influenced, (2) goals that are feasible within the socio-technical conditions of the system, and (3) forms of governance that can achieve these goals (Bauer, 2022b). A co-evolutionary perspective helps address all three issues and their interaction in a general, theoretical framework. This allows the identification of the conditions under which different types of governance are appropriate; it informs the design of the constitution and architecture of transactions and contributes to the design of effective instruments (e.g., Colander & Kupers, 2014).

The openness and plasticity of digital communications suggest that there is more than one constellation of goals and instruments that is compatible with the social and material conditions of the system to be governed. However, alternative governance arrangements will likely correspond to different patterns of outcomes. For example, compared to a more highly regulated system, a less regulated approach may generate more diverse, entrepreneurial risk taking but also a higher level of inequality. Traditional policy frameworks typically seek to find governance instruments that optimize one or more performance metrics. In contrast, from a co-evolutionary vantage point, governance operates more like a ‘tuning’ device that seeks to keep aspects of system performance in a desirable zone.

A co-evolutionary conceptual framework also clarifies that socio-technical systems impose constraints on goals and on the instruments that are available to pursue them. The social and material conditions of the system will likely limit the set of workable governance options. For example, legislative measures need certain majorities to be adopted. Goals need to be technically and economically feasible and must find sufficient political agreement to be implemented. Recent research suggests that consistency between the various forms of governance

that guide an activity and their congruence with the social and material sector conditions is critically important (Finger et al., 2005; Künneke et al., 2010). It is often more important than specific, individual, governance instruments.

If sector conditions, goals, and instruments are poorly aligned, governance will be ineffective and not achieve the envisioned goals, even in the short run. Consequences could be regulatory drift, a sequence of policy interventions, player adaptations, and subsequent policy interventions that have no lasting impact on the performance of the system. If the governance system is designed to adapt, it is possible that a misalignment could be corrected within a reasonable time. In such a case, effective governance approaches may result from trial and error combined with policy learning. For example, Sabel and Zeitlin (2010) describe how experimentalist governance involving member states of the European Union and European institutions may contribute to improved governance over time.

An additional reason why governance may not be effective is associated with the social system in which governance is embedded. Co-evolution implies that players are involved in infinite, open-ended games, in which they mutually influence, but typically do not fully control, the environment and/or outcomes for other players. Every move will initiate other moves, with no clear winners and losers in the medium and long term. Only situations in which all players accept their payoffs, and the moves of other players, will avoid regulatory drift. This is equivalent to a Nash equilibrium, that is, a situation in which no player has an incentive to change the adopted strategy in a dynamic, evolutionary game. This set may be small or even empty, given the high level of interdependencies, the fast pace of innovation, and the multiplicity of stakeholders in digital communications. Consequently, policy will have to resort to continuous adaptation and muddling through, as was already pointed out by Lindblom (1959).

Co-evolutionary approaches also have limitations. Although powerful in reframing developments in media and communication, metaphorical uses remain very generic. They are often more useful in explaining than in prescribing specific, governance solutions. One important conclusion is that governance needs to develop into a learning system in which observation, analysis, and adaptation of governance are in continuous interaction. Such an approach faces tremendous challenges in practice. Dynamic approaches can assist with forward looking, horizon scanning and scenario building, but they may be difficult to translate into specific solutions to policy problems.

One challenge is that dynamic systems are open-ended. They often allow multiple paths forward, but a 'best' path may be difficult to discern, even with co-evolutionary approaches. Adaptive and agile forms of regulation, such as regulatory experiments, can overcome some of these shortcomings by offering middle-range options to respond to dynamic developments that are afflicted with high uncertainty. Recent methodological advancements in computational modelling and in the mathematical analysis of complex adaptive systems (Pastor-Satorras & Vespignani, 2004) may eventually help to discern better from worse paths forward. However, much work needs to be done to develop theoretical models, instruments, and practices that are sufficiently robust to be applied to current policy problems.

OUTLOOK

During the past decades, communication systems have experienced seemingly contradictory developments toward increased differentiation and divergence. Yet, at the same time, they are becoming more integrated in dominant, platform ecosystems. Ever denser networks, from social media to globally connected news cycles in which dynamic, non-linear

processes unfold, cannot be fully understood with traditional models. Co-evolutionary approaches provide a robust and versatile theoretical and empirical approach to understand such processes. Elements of co-evolutionary theories will likely be embraced more widely as communication research grapples with the increasing importance of interdependencies – the reciprocal but often asymmetric processes in which causal forces work in multiple directions over time. One of the promises is that this will allow a better understanding of the role and limitations of communication governance and the development of more appropriate governance approaches.

References

Arthur, W. B. (2009). *The nature of technology: What it is and how it evolves.* Free Press.

Bail, C. (2021). *Breaking the social media prism. How to make our platforms less polarizing*. Princeton University Press.

Ball, M. (2022). *The metaverse: And how it will revolutionize everything.* Liveright Publishing.

Bauer, J. M. (2022a). Agile regulation: Experiments in flexible governance. In F. Birke, G. Brunekreeft, V. Stocker, & H.-J. Weiß (Eds.), *Perspektiven der Netzökonomie – Beiträge zu Ehren von Günter Knieps* (pp. 31-49). Nomos.

Bauer, J. M. (2022b). Toward new guardrails for the information society. *Telecommunications Policy*, *46*(5), 102350.

Beck, U. (2016). *The metamorphosis of the world: How climate change is transforming our concept of the world*. Polity Press.

Benkler, Y. (2006). *The wealth of networks*. Yale University Press.

Bourreau, M., Doğan, P., & Manant, M. (2010). A critical review of the "ladder of investment" approach. *Telecommunications Policy*, *34*(11), 683-696.

Bustamante, P., Gomez, M., Murtazashvili, I., & Weiss, M. (2020). Spectrum anarchy: Why self-governance of the radio spectrum works better than we think. *Journal of Institutional Economics*, *16*(6), 863-882.

Cherry, B. A. (2007). Telecommunications economy and regulation as coevolving complex adaptive systems: Implications for federalism. *Federal Communications Law Journal*, *59*, 369–402.

Choucri, N., & Clark, D. D. (2019). *International relations in the cyber age: The co-evolution dilemma*. MIT Press.

Colander D, & Kupers R. (2014). *Complexity and the art of public policy: Solving society's problems from the bottom up*. Princeton University Press.

Dignum, V. (2019). *Responsible artificial intelligence: How to develop and use AI in a responsible way*. Springer Nature.

Dutton, W. H. (1992). The ecology of games shaping telecommunications policy. *Communication Theory*, *2*(4), 303–328.

Easley, D., & Kleinberg, J. (2010). *Networks, crowds, and markets: Reasoning about a highly connected world*. Cambridge University Press.

Finger, M., Groenewegen, J., & Künneke, R. (2005). The quest for coherence between institutions and technologies in infrastructures. *Journal of Network Industries*, *6*(4), 227–259.

Fransman, M. (2010). *The new ICT ecosystem: Implications for policy and regulation*. Cambridge University Press.

Frenken, K. (2006). *Innovation, evolution and complexity theory*. Edward Elgar.

Garnsey, E., & McGlade, J. (2006). *Complexity and co-evolution: Continuity and change in socio-economic systems*. Edward Elgar.

Geels, F. W. (2005). *Technological transitions and system innovations: A co-evolutionary and socio-technical analysis*. Edward Elgar.

Jacobson, T. L. (2016). Amartya Sen's capabilities approach and communication for development and social change. *Journal of Communication, 66*(5), 789-810.

Jasanoff, S. (2016). *The ethics of invention: Technology and the human future*. W. W. Norton & Company.

Koning, K. J. (2017). An agent model of vertical integration in telecommunications and content. In *Department of Media and Information: Vol. PhD*. Michigan State University.

Kooiman, J. (2008). Exploring the concept of governability. *Journal of Comparative Policy Analysis: Research and Practice*, *10*(2), 171–190.

Künneke, R., Groenewegen, J., & Ménard, C. (2010). Aligning modes of organization with technology: Critical transactions in the reform of infrastructures. *Journal of Economic Behavior & Organization*, *75*(3), 494–505.

Kurzweil, R. (2005). *The singularity is near*. Viking.

Laland, K. N. (2017). *Darwin's unfinished symphony: How culture made the human mind*. Princeton University Press.

Latzer, M. (2013). Towards an innovation-co-evolution-complexity perspective on communications policy. In M. Löblich & S. Pfaff-Rüdiger (Eds.), *Communication and media policy in the era of the internet* (pp. 15–27). Nomos.

Latzer, M. (2014). Convergence, co-evolution and complexity in European communications policy. In K. Donders, C. Pauwels, & J. Loisen (Eds.), *Handbook on European media policy* (pp. 36–53). Palgrave Macmillan.

Latzer, M. (2022). The Digital Trinity—Controllable Human Evolution—Implicit Everyday Religion. Characteristics of the Socio-Technical Transformation of Digitalization. *Kölner Zeitschrift für Soziologie und Sozialpsychologie, 74*(Supplement 1), 331–354.

Lazer, D. (2001). The co-evolution of individual and network. *Journal of Mathematical Sociology*, 25(1), 69-108.

Lee, E. A. (2020). *The coevolution: The entwined futures of humans and machines*. MIT Press.

Lindblom, C. E. (1959). The science of "muddling through". *Public Administration Review*, 19(2), 78-88.

Mansell, R. (2012). *Imagining the Internet: Communication, innovation, and governance*. Oxford University Press.

Milgrom, P. (2017). *Discovering prices: Auction design in markets with complex constraints*. Columbia University Press.

Mitchell, M. (2009). *Complexity: A guided tour*. Oxford University Press.

Mitleton-Kelly, E., & Davy, L. K. (2013). The concept of 'co-evolution' and its application in the social sciences. In E. Mitleton-Kelly (Ed.), *Co-evolution of intelligent socio-technical systems* (pp. 43–57). Springer.

Nelson, R., & Winter, S. G. (1977). Dynamic competition and technical progress. In R. Nelson & B. Balassa (Eds.), *Economic progress, private values and public policy* (pp. 57–101). North-Holland.

OECD Council. (2021). *Recommendation of the Council for Agile Regulatory Governance to Harness Innovation, OECD/LEGAL/0464*.

Pastor-Satorras, R., & Vespignani, A. (2004). *Evolution and Structure of the Internet: A Statistical Physics Approach*. Cambridge University Press.

Pierson, P. (2004). *Politics in time: History, institutions, and social analysis*. Princeton University Press.

Post, D. G. (2009). *In search of Jefferson's moose: Notes on the state of cyberspace*. Oxford University Press.

Reich, R., Sahami, M., & Weinstein, J. M. (2021). *System error: Where big tech went wrong and how we can reboot*. Harper.

Rip, A. (2006). A co-evolutionary approach to reflexive governance – and its ironies. In J.-P. Voss, D. Bauknecht, & R. Kemp (Eds.), *Reflexive governance for sustainable development* (pp. 82–100). Edward Elgar.

Roco, M. C., & Bainbridge, W. S. (2002). *Converging technologies for improving human performance. Nanotechnology, biotechnology, information technology, and cognitive science. NSF/DOC sponsored report*.

Room, G. (2011). *Complexity, institutions and public policy*. Edward Elgar.

Room, G. (2016). *Agile actors on complex terrains: Transformative realism and public policy*. Routledge.

Sabel, C. F., & Zeitlin, J. (Eds.). (2010). *Experimentalist governance in the European Union: Towards a new architecture*. Oxford University Press.

Schejter, A. M., & Tirosh, N. (2016). *A justice-based approach for new media policy: In the paths of righteousness*. Springer.

Schneider, V. (2001). *Die Transformation der Telekommunikation. Vom Staatsmonopol zum globalen Markt (1800-2000)*. Campus.

Schneider, V. (2012). Governance and complexity. In D. Levi-Faur (Ed.), *The Oxford handbook of governance* (pp. 129–142). Oxford University Press.

Schneider, V., & Bauer, J. M. (2007). Prospects of complexity theory in revisiting system theory. *Proceedings of the Annual Meeting of the Midwest Political Science Association*, Chicago, IL.

Sherry, J. L. (2015). The complexity paradigm for studying human communication: A summary and integration of two fields. *Review of Communication Research*, *3*, 22–54.

Slater, M. D. (2007). Reinforcing spirals: The mutual influence of media selectivity and media effects and their impact on individual behavior and social identity. *Communication Theory*, *17*(3), 281–303.

Slater, M. D. (2015). Reinforcing spirals model: Conceptualizing the relationship between media content exposure and the development and maintenance of attitudes. *Media Psychology*, *18*(3), 370–395.

Stocker, V., Knieps, G., & Dietzel, C. (2021). The rise and evolution of clouds and private networks–internet interconnection, ecosystem fragmentation. Available at SSRN: https://ssrn.com/abstract=3910108.

Torfing, J. (2016). Metagovernance. In C. Ansell & J. Torfing (Eds.), *Handbook on theories of governance* (pp. 525–537). Edward Elgar.

Vallor, S. (2016). *Technology and the virtues: A philosophical guide to a future worth wanting*. Oxford University Press.

Voss, J.-P., & Bauknecht, D. (2007). Der Einfluss von Technik auf Governance- Innovationen. In U. Dolata (Ed.), *Gesellschaft und die Macht der Technik* (pp. 109–131). Campus.

Waldherr, A. (2014). Emergence of news waves: A social simulation approach. *Journal of Communication*, *64*(5), 852–873.

Whitt, R. S., & Schultze, S. J. (2009). The new 'emergence economics' of innovation and growth, and what it means for communications policy. *Journal on Telecommunications and High Technology Law*, *7*(2), 217–316.

World Economic Forum. (2020). *Agile regulation for the Fourth Industrial Revolution: A toolkit for regulators*. Davos, Switzerland.

Ziman, J. (2000). Evolutionary models for technological change. In J. Ziman (Ed.), *Technological innovation as an evolutionary process* (pp. 3–11). Cambridge University Press.