Faculty of Design

2022

Technological governance: Opportunities for systemic design

Wong, Desmond

Relating Systems Thinking and Design
2022 Symposium
University of Brighton, Brighton, UK,
October 13-16, 2022

Technological Governance

Opportunities for systemic design

Desmond Wong

Independent Scholar[1]

Historically, systemic design (SD) has drawn on methodological aspects of system thinking. However, this is challenged by technology – which is simultaneously today's milieu and methodology. Given this, we need a new composite of foundations and practices before SD can provide effective technological or design governance. I also discuss a modern update to boundary framing and microservices as a bridge to enriched practice alongside key movements like Penrosean rents and Wintelism.

KEYWORDS: boundary framing, critique, dynamic governance, microservices, systemic design

RSD TOPIC(S): Policy & Governance

[1] 1desmondwong@gmail.com

Introduction

> It is worth considering the role of the state, as well as … [the] distribution of agents' capabilities, instrumentation, and legitimacy related to the pace of change, [and] consequences for the social groups left behind … [This means a] more embedded approach, one that looks into the diversity …. of governing … change. (Borras & Edler, 2020, pp.21-22)

Institutions and technology are the rules of society that incent exchange and interaction and determine its transaction and transformation costs. Yet, digital economies upend these rules. The world has entered a new long wave as the nature of production has definitively shifted to a network economy and its knowledge base (Phillipson, 2022; 2020).

In this paper, I explore the potential of systemic design (SD) in technological governance. In Dream, I outline governance challenges in digital economies alongside the potential and shortfalls of SD; in Design, boundary framing and microservices as inroads into complexity and enriched SD practice; in Deliver, three practice takeaways for the reader.

Dream

Big shifts are accompanied by disrupted industries like finance and more uncertainty. The market capitalisation of 'Big Tech' rivals the top two hundred banks (Dietz et al., 2020), as a key feature of network economy has been the dispersion of production functions. New complex (ex-)changes require we recast our vision of what policy making should be.

Technological governance

Governance is the provision of rules, institutions, and networks for policy making (Howlett et al., 2022). It is both structure and dynamic relationship between government and citizens to create value, reduce market failure, and enable new strategies to emerge. These cannot be achieved by policy mixes alone, which mostly lag behind the real world.

To remain relevant, policymakers have shifted their focus to networks that complement the pivotal role of (formal) institutions in economic change. They are made up of actors or coalitions that cross boundaries, evolve over time, organise locally, and have different intentions and/or incentives (Bussu et al., 2022; Ingold et al., 2021; Kapucu & Hu, 2020).

These governance challenges are compounded by technological emergence, where similar knowledge-based networks are disrupting industries and making jobs obsolete (Burmaoglu et al., 2019). In today's economics, 'Big Tech' accounts for 90% of goods and services and 50% of American equity growth over the last two decades (Petit & Teece, 2022).

Technology is a rule of society that complements institutions. Broadly, technology is the methodology of doing things (Nelson et al., 2018). More narrowly, technologies "focus … on the design of the artefacts produced and services rendered, and … [tacit] processes involved in … production and implementation" (p.36). In turn, there are four key insights.

First, the ecosystems are dynamic. On the one hand, markets cross boundaries, definitions, and tensions reinforced by digitization[2] (Lobato, 2020). On the other, firms compete for future profits through cyclic innovation (Schumpeterian) than superior production or resources (Ricardian or monopoly rents). No policymaking can anticipate such dynamism.

Second, supply and demand are entwined. Firms innovate by orchestrating resources within and without (Petit & Teece, 2022), undergirded by a tacit knowledge base (Penrosean rent) (Niemczyk & Trzaska, 2020). Consumers also produce data that shapes demand (network externalities) amid more co-production, modularity, and open source.

[2] In antitrust, the debate is no longer about meaningfully applying principles like '*Brown Shoe factors*'. Rather, it is about how legal doctrine needs a refresh to keep up with the real world (E.g., Bhadra, 2022; Rogers III, 2018). The power to define markets has definitely shifted from legislators and regulators to firms with asymmetric resource bundles. This is compounded by changes in the nature of production and rents, below.

Third, the government is the sponsor and guarantor, then the regulator. Technology firms often have superior resources or the motivation and means to work around as-is policy and governance. Recent examples include Starlink's satellite deployment and Ant's 'nationwide banking' over its merchant platforms (Oxford Analytica, 2022; Prasad, 2021).

Fourth, there are novel issues. They include re-casted roles for government and citizens, definitions of sovereignty and competition or markets, asymmetry by big data and artificial intelligence (AI), and sources of tensions that may be unilaterally and perpetually enforced via digitisation (Ulnicane et al., 2021; Craglia et al., 2020; Susana & Jacob, 2020).

Today's policymakers need "a more embedded approach to unveil the complexity and mixes of roles of the state … [and] the underlying properties … before defining specific policy instruments … [It is] a more explicit, conscious approach to understand governance conditions … [for] contextual … policy-making" (Borras & Edler, 2020, p.20).

While technological governance is a large topic that cannot be covered in short form, a key idea is its embrace of 'public policy as governance'. This has gained traction from different perspectives (E.g., Howlett et al., 2022; Peters, 2019), including SD applications in real government settings (Kaur, 2021; Wong & Tan, 2021a; Malcolm, 2017; Rava, 2016).

Systemic design

SD is the transdisciplinary application of systems thinking to design under high complexity (Jones, 2021). What it is: An emerging field with its principles (grammar) and methodologies (vocabulary) for a shared language to change. What it is not: Systems design, or where 'systems' are things we model than milieus of purposes to act (with-)in.

While extending foundational competencies, SD has also followed definitive shifts from

- Technical to social complexity, or complex adaptive to soft systems (Hossain et al., 2020; Smith et al., 2019)
- Analysis to abduction, or static frameworks to boundary framing (Baker & Mouhkliss, 2020; Micheli et al., 2018)

There is also a growing shift from working with many voices to many tensions or from a dialogic to dialectic approach (Nelson, 2021; Ozkaramanli, 2021; Wong & Tan, 2021a; Rava, 2016). Although grounded in SD's principles, this also reflects Peter Checkland's (2019) near dominance of systems practice today (Hossain et al., 2020; Smith et al., 2019).

More policymakers are turning to SD to improve the effectiveness of policy and governance (Blomkamp, 2022; Nohra et al., 2022). Yet, most examples are still confined to local community, social, or sustainability domains. The feedback also ranges from impracticality to a poor fit with culture and setting (Blomkamp, 2022; Haynes et al., 2022).

Impracticality can be the result of SD drawing on methodological aspects of systems thinking in navigating complexity, which also lags behind the real world. For example, the viable system model still retains a cult-like following in Chile circa 1971, even as it had led to hyperinflation and 350% price hikes before the coup (Caputo & Saravia, 2019).

Conversely, systems design is converging with SD. Palantir uses abduction and boundary framing with network models to integrate $897 million in big data for policymakers each year (Udekwu, 2017), as the neural network in OpenAI's GPT-3 executes complexity with meaning-laden content that is not differentiable from a real person's (Brown et al., 2020).

These equally transdisciplinary developments create new inroads into complexity that should enrich SD practice and bring it up to date. They are also from a network economy and microcosms of novel issues in technological governance. A better understanding could nudge more policymakers to SD, especially those in the global technology domain.

While technology is both today's milieu and methodology, "the value of a broad theoretical perspective … should [moreover,] be judged in terms of the strength and quality of the understanding of empirical phenomena and the illumination of policy questions … by that perspective" (Nelson et al., 2018, p.2). It is a timely challenge for SD.

Contra methodological aspects of systems thinking, SD is characterised by constructive experiments that embody policy hypotheses. This makes it a fit for the cyclic innovation and tacit processes in technology. It is also predisposed to boundary framing, which discards methodology for ongoing critique and a form of design governance (Wong, 2022).

Borras and Edler's (2020) paper is the first call for SD in technological governance. Their paper mirrors the dynamic capabilities strategy (Teece, 2018) and involves orchestrating tangible (like policy mixes and institutional capabilities) and intangible resources (like new narratives) for change. Nevertheless, it is boundary framing that comes to the forefront.

Design

In SD, the term 'design' is used to refer to problem structuring in systems thinking. Yet, all design is partial. On the one hand, we tend to assume that our ideas and technologies are thought through than 'ready-to-hand'. On the other, they are influenced by and influence our milieus of purposes (Krakauer, 2022). This entwinement is very significant.

Boundary framing

In an earlier paper, I revisited the differentiation of design from maps and critique (Wong & Tan, 2021a). Maps are close to reality and the as-is (correspond), design leans to values and the to-be (cohere), while a critique embodies milieus of purposes (disclose).[3] When the milieus changes, so do the maps and designs that are then 'ready-to-hand' (Figure 1).

This differentiation comes from Werner Ulrich (2021). He reminds us that

> … not unlike a good map, a good process of decision-making should make transparent the boundary judgments on which claims to be decided rely, and … how different these claims may [thus,] look in light of alternative boundary judgments. (Ulrich & Reynolds, 2020, p.263)

In gist, boundary critique is a framework that helps us surface tensions between

- Critique and maps, or our 'reference systems' versus an abstraction of reality
- Why and who, or our purposes versus identities with(-in) reference systems
- Claims and means, or our justifications versus what we do with(-in) systems
- Conflicts and cost, or scarce mutual understandings versus scarce resources

In turn, 'critical systems heuristics' (CSH; Figure 2) help us surface the boundaries around

- Motivation, or where the sense of purpose(-fulness) and value come from
- Power, or who controls resources and what we need to achieve our goal(s)
- Knowledge, or what experience or expertise supports our claims or means
- Legitimacy, or the who, how, and why to be considered and also, reconciled

To date, boundary critique is singularly unique for using (explicit and implicit) heuristics than methodology (Reynolds & Wilding, 2020). It also pioneers surfacing options through critique and antinomy (dialectic) across tensions and boundaries (Wong & Tan, 2021a), a development from European schools (W. Ulrich, personal communication, 24 Nov 2021).

---

[3] In philosophy, "critique is an active surfacing and challenging (*dialectic*) of irresolvable tensions (*antinomies*) that we *live out and embody* – not *'critically'* think about. In turn, *boundary critique* is its real-world counterpart" (Wong, 2022, p.2). It is often misrepresented as *'being critical*' about boundaries in the colloquial sense, scoping, or a focus on specific tensions. Ulrich (2022) and Wong and Tan (2021a) are short form clarifications.

The transdisciplinary use cases cross five continents (Wong, 2022), where there is a need to discern “underlying conflicting issues of ethics and politics” in situations (Ulrich & Reynolds, 2020, p.301). Evaluators are strong adopters (Schwandt, 2018; Gates, 2018), with technologists in catch-up (Wong, 2022; Ivanova & Elsawah, 2021; Raza et al., 2019).

To recapitulate, boundary framing in technological governance includes re-casted roles for government and citizens and definitions of sovereignty, competition, and markets. These tensions and boundaries are wide and deep. In real terms, any meaningful intervention must flesh out and mobilise networks and narratives in the public interest.

Furthermore, technology’s entwinement with institutions and (cross-)purposes presents much embodiment and embeddedness to unpack – ones that are invisible and in situ. It is conveniently where a heuristic-based framework shines, which perhaps explains striking similarities between Ulrich's (2021) and Borras and Edler’s (2020) ideas and oeuvre.

While critique can inform design, it must ultimately drill down to the level of resources for real-world change (Ivanova & Elsawah, 2021). In turn, a systems view of dynamic capabilities could change this. One way to work with entwinement is to situate critique and maps between the other so new designs emerge (Figures 3 & 4), i.e., design governance.

Of the four tensions in boundary critique, a refreshed tension between critique and maps will be key to effective technological governance. Thus far, I have covered a modern update of policy as governance in technology, boundary framing for design governance, and microeconomic foundations. This helps us to segue into microservices.

Microservices

What if our technologies and milieus are now closer than we think? In a simulacrum: What if abstraction has shortened the distance between technical and social complexity, maps and critique? Could digital maps embed a critique and framework, even heuristics? Positive answers to either question hold insights that would potentially enrich practice.

In an earlier paper, I explored technical and social complexity through boundary framing and networks (Wong & Tan, 2021b). Networks have been implicit in this paper until now. They embody complexity, are de facto tools (Nair & Reed-Tsochas, 2019; De Bacco et al., 2017; Ubekwu, 2017), and powered your Google Search until 2019 (Page, 2006/2019).

Neural networks are an AI advancement that embodies how we learn (neuronal signals). Today, it drives 40% of all value from analytics (Chui et al., 2018), powers Netflix and Youtube addictions worldwide, and beats Go champions (Geron, 2019). A key idea is a unique approach to architecting structures, as translated to use cases in microservices.

First, they have closed the gap between our technologies and milieu, mobilising narratives. Recent examples include OpenAI's GPT-3, Meta's OPT-X, and Microsoft's XiaoIce. Not only does XiaoIce sustain 10 billion conversations with 660 million people worldwide (Zhou et al., 2020), it had to be 'dumbed down' after learning to criticise the Chinese government.

Second, such structures shorten the distance between technical and social complexity. In fact, each digital map is a self-contained critique, framework, and heuristics that wrestles with irresolvable tensions and boundaries in our lives. More interestingly, the interpretations behind heuristics have now become more explicit (Agarwal et al., 2021).[4]

Third, these structures operationalise fitness in microservices. Like network economy, Netflix disperses production functions (modules). Technologies abstract organisation, so production can reset and run only on critical ones (Greeven et al., 2021; Evans, 2016), i.e., deliberately architecting multi-layered/-capital structure enables emergent design (Figure 5).

In addition, scaling by the module is a form of local boundary framing – stretching the boundaries of complex (ex-)changes and the nature of transaction costs (Sun et al.,

[4] In economics, "there has been hardly any evolutionary writing concerned with factors affecting demand … One fundamental question is how are preferences formed? What is the role of advertising? Or the influence of … one's peers … or own experience? … economic actors … often … make decisions in contexts with which they have … no experience" (Nelson et al., pp.215-216). A microservices inroad already holds some answers.

2020; see also Camacho et al., 2018). Microservices are live examples of emergent design from appropriating critique and maps and orchestrating rents and resources in the process.

To date, the trade-offs have been between structure and demand (including exception handling), granularity, and security (Waseem et al., 2021; Soldani et al., 2018) – the proverbial 'devil in the details'. In a nod to earlier schools of strategy, the key is to intermediate through structure and co-specialization(s) (Mintzberg, 2019; Teece, 2018).

Here, a refreshed tension between structure and dispersion in orchestrating resources will be key to effective technological governance. This is made up of three elements: Dynamic strategic intent (polycentricity), archetypal approaches to production functions, and technologies that might abstract managerial tasks of organisation and sensemaking.

Microservices are an inroad into complexity less for technique than for enactment of revitalised governance, boundary framing, microeconomic foundations, and network strategy (Philipson, 2022; Philipson, 2020; Niemczyk & Trzaska, 2020). In turn, a fuller synthesis would enable SD to become a mainstay in policy and governance applications.

Deliver

The constraint of short-form writing has meant covering a lay of the land, occasionally glossing over topics explored by the textbook. In the hard sense, technological governance involves big shifts in the nature of competition, costs, complexity, and consensus. In a softer one, a latent embodiment, embeddedness, and/or entwinement.

Three takeaways

In this paper, I explored the potential of SD in technological governance. I have also tried to recast a vision for policy as governance or design governance. To achieve this, we will need a new composite of foundations and practices. As such, I discussed a modern update to boundary framing and microservices as a practical bridge to implementation.

Methodological aspects of systems thinking have contributed to SD and are helpful (Jones, 2021). However, they also work off a false tension between thinking and practice, often closing in on self-referential calls for a more 'flexible' (meta-)methodology. Yet where technology is today's milieu and methodology, we cannot really meet it with yesterday's.

First, we must learn and build on core microeconomic foundations. This is a longstanding gap in SD that has kept it mostly contained in local domains. Broadly, a general understanding is needed to work with the rules of society. More narrowly, the focus should be on the movements in Penrosean rents in strategy research (e.g., Gomas-Casseres, 2022).

In this regard, design governance remains the missing link between firms as organisations (whose nature is changed by AI) and bundles (where resources are decoupled and granular) (Wintelism).[5] Novel reference systems, rent co-specialization, and knowledge transfers (Figure 6) are critical topics for amalgamation in light of tacit processes that drive change.[6]

Second, we must work with refreshed tensions between critique and maps. This means working through conditions than 'designing' policy mixes. Design is not a choice. Instead, it is "a diverse set of types of inquiry … linking analysis to action … sophia … [and] enabling judgments that give … new purpose" (Nelson, 2021, p.3; Figure 6). Such inquiries are fluid.

They are also an emergent design from situating critique and maps between the other, which is not just ideālis. It is to concretely weigh resources against the eternal boundary

[5] Philipson (2022) is a short form treatment of key issues, including the tension between structure and dispersion enacted in microservices: "The firm [of today] … need not '*design*' (innovate, product develop … [only build] architecture at a high level of the product structure … [with] radically new solutions" (pp.6-7). In comparison, Gomes-Casseres (2022) is a recent discussion on Penrosean rents and strategy making today.

[6] In strategy, the key issues also relate to dynamic ecosystems (*hyper-competition*), entwined supply and demand (*endogenous* technological emergence), and novel issues (I.e., how rents and resources actually emerge from complex capital and privileged negotiations). Resource tensions – in the way they are applied, constrained, created, orchestrated, and searched for – remain unresolved. It is a gap that SD might well fill.

of dialectics and makability or fitness and feasibility (Figure 4). Technologies like microservices are already enacting these inquiries in ways that should inform/enrich SD practice today.

Third, we must work with refreshed tensions between structure and dispersion in orchestration. Technologies abstract managerial tasks but are categorically different. They are meant to help us discover knowledge and paths that cannot be thought through in the first place. A new age of strategy has made it easier to 'grow weeds in the garden'.

While this is also about working through conditions, such an approach to architecting multi-layered/-capital structures involves exploring resource tensions in equally creative combinations and detail (Figures 2-3;6; 8); since new narratives and orchestrations cannot really be anticipated or 'future-proofed' (Lin et al., 2022; Bundgaard & Borras, 2021).

Conclusion

> Truth cannot therefore be considered as a thing, or an object. A conversation … [is] an example, in which truth is at one and the same time that towards the speakers are conscious of moving, and that which spurs them towards this goal … Reflection occurs …. to recover … the unity which had been lost … [outside the] decomposing or analytic. (Marcel, 2001, p.x)

I am ending this paper with a more unconventional 'recipe' and quote, with the hope that it serves as a call to action and reflection. While I have introduced big shifts in this paper, it is not an advocacy for technocracy nor a negation of SD. Behind the rules of society are always people and lives full of meaning, which must similarly remain our truest concern(s).

The recipe

1. Apply the first refreshed tension until the critique and map converge on resources (Figures 2; 3).
2. Apply the second to orchestrating resources in your map (Figure 8).

3. Break resources and demand down to different tensions and granularities.
4. Use technologies and dilemma-driven design (Ozkaramanli et al., 2020).
5. Be present, intuit, and iterate.

Author notes

While I have drawn on five-year references, I am indebted to earlier critical readings in critique (Ulrich, 2003; 1983), economic rents (Penrose, 2009; Spender, 1994), governance (Neo & Chen, 2007; Schonberger & Lazer, 2007), technology (Foss & Robertson, 2005; Nelson & Winters, 1985) and also, phenomenological study (Marcel, 2001; Stiegler, 1998).

I thank Profs Werner Ulrich, Neo Boon Siong, and Amanda Gregory for pointing me to a deeper appreciation of systems and strategy practice; Dr Cheryl May for her kind invitation; RSD11 reviewers for their insights; colleagues at Infocomm and Media Development Authority for inspiration over the course of work. To Elizabeth. – A.M.D.G.

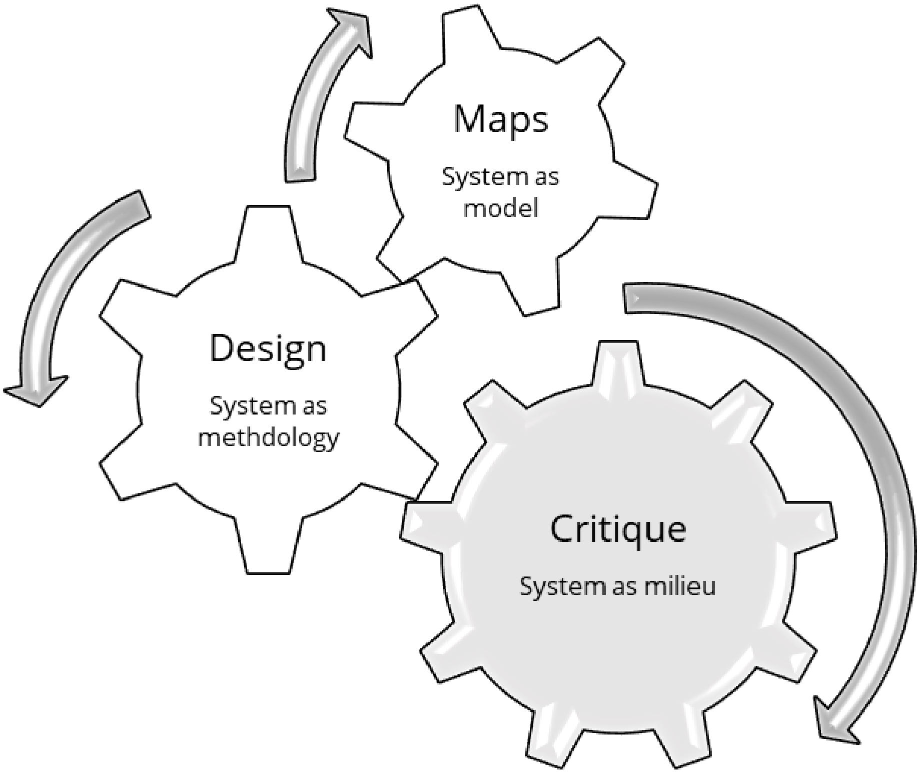

Figure 1. Entwinement in design. Adapted from Ulrich (2021).

<table>
<tr><th>Sources</th><th>Stakeholders</th><th>Stakes</th><th>Stakeholdering</th><td rowspan="4">People involved</td></tr>
<tr><td>Motivation</td><td>2.
Beneficiary?</td><td>1.
Purpose?</td><td>3.
Measure of improvement?</td></tr>
<tr><td>Control</td><td>5.
Decision maker?</td><td>4.
Resources?</td><td>6.
Decision environment?</td></tr>
<tr><td>Knowledge</td><td>8.
Expert?</td><td>7.
Expertise?</td><td>9.
Guarantor?</td></tr>
<tr><td>Legitimacy</td><td>11.
Witness?</td><td>10.
Emancipator?</td><td>12.
Worldview?</td><td>People affected</td></tr>
</table>

Figure 2. Boundary framing, adapted from Ulrich and Reynolds (2020).

These numbers reflect the authors' recommended order for unfolding tensions, which is done tacitly. In my experience, being able to walk through a congruent narrative for each stakeholder (e.g., putting post-its along each number etc.) quickly gets you up to speed with the capabilities and asymmetries. When this is done at the multistakeholder level, scarcity and trade-offs come to the forefront. This is where the real insights and options are. The source material covers the sensemaking and facilitation process in more detail.

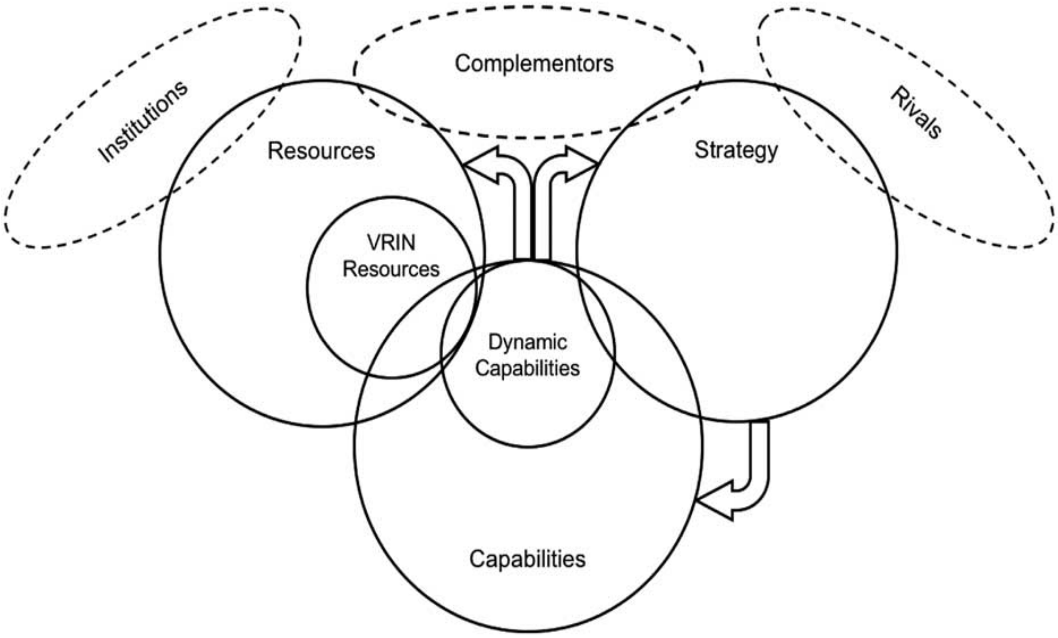

Figure 3. Dynamic capabilities, from Teece (2018).

This abstraction reflects the author's map for unfolding trade-offs between resources and capabilities and fitness principles. In my experience, being able to creatively flesh out resources that can be combined, stretched, and orchestrated quickly gets you up to speed with what you are dealing with. Resources are where it converges with boundary framing (Figure 1). When fitness is enriched by critique, fresh strategies come to the forefront. Real design is what emerges between the critique and map than (meta-)methodology.

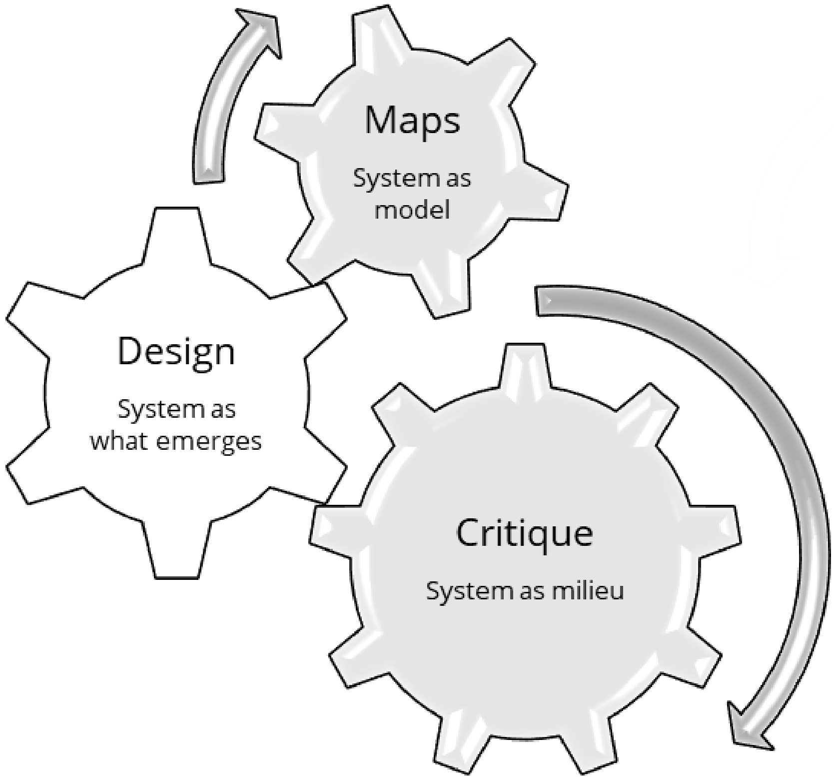

Figure 4. Working with entwinement in design.

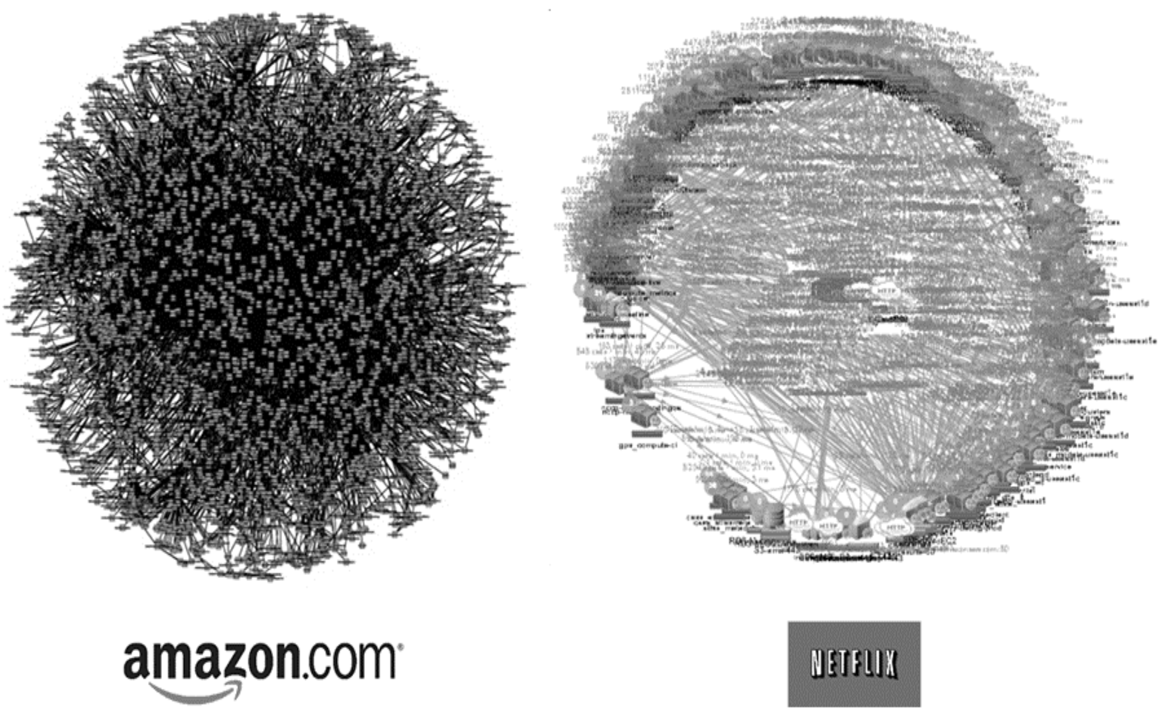

Figure 5. Emergent design in microservices, from Khazin (2022).

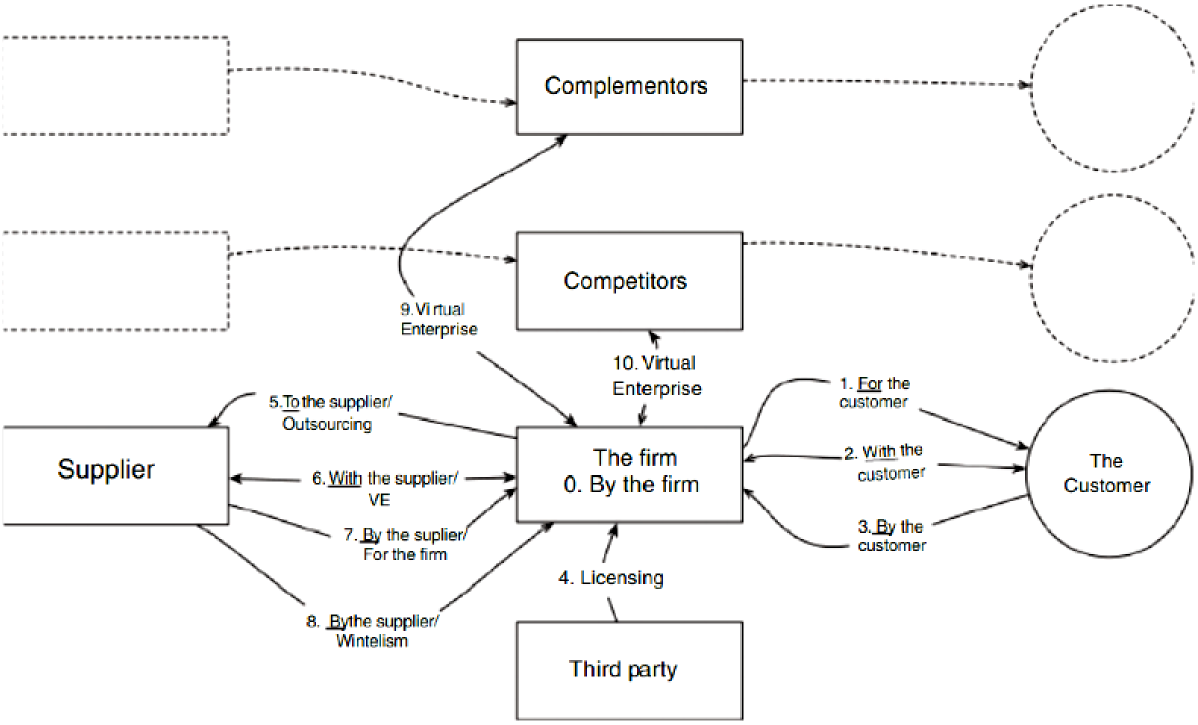

Figure 6. Sources of innovation today, from Philipson (2020).

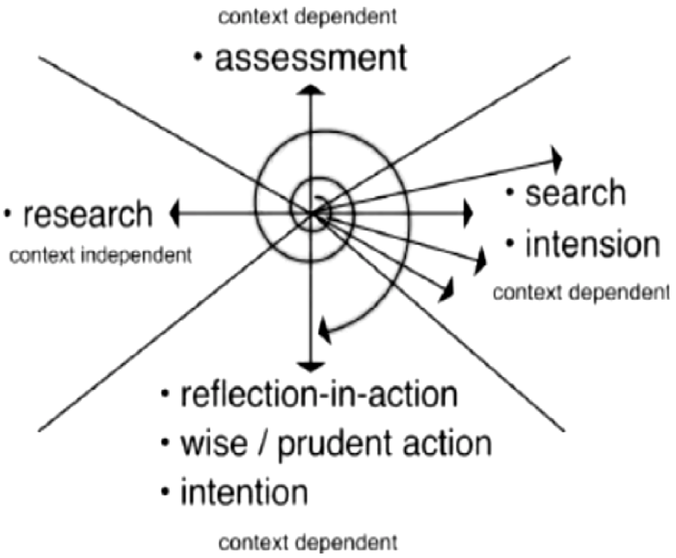

Figure 7. Emergent design in systems thinking, from Nelson (2021).

Evolutionary and demand fitness	
Compete on cyclic innovation	**Collaborate** through alliances and open source
Concentrate structure and knowledge management	**Disperse** knowledge discovery, networks, resources
Coordinate capabilities against demand	**Decentralize** scalability against security

Figure 8. Structure versus dispersion, adapted from Wong and Hiew (2019).

Conventionally, the rows in Figure 8 are used to surface tensions and trade-offs in strategy. This is especially the case for strategies that involve clusters and place-based benefits. In my experience, being able to articulate what and why you are parsing into the box categories quickly gets you up to speed with your domain. Microservices upend these tensions. Technology abstracts coordination, decentralisation, and dispersion. It also complements concentration and collaboration, executing intent and orchestrations at speed and scale.

References

1. Agarwal, R., Melnick, L., Frosst, N., … Hinton, G. (2021). Neural additive models: Interpretable machine learning with neural nets, Proceedings of the 35th Conference on Neural Information Processing Systems. https://doi.org/10.48550/arXiv.2004.13912
2. Baker, F., & Moukhliss, S. (2020). Concretising design thinking: A content analysis of systematic and extended literature reviews on design thinking and human-centred design, Review of Education, 8(1), 305-333.
3. Bhadra, R. (2022). LinkedIn: A case study into how tech giants like Microsoft abuse their dominant market position to create unlawful monopolies in emerging industries, Hastings Science and Technology Law Journal, 13(1), 3-20.
4. Blomkamp, E. (2022). Systemic design practice for participatory policymaking, Policy Design and Practice, 5(1), 12-31.
5. Borras, S., & Edler, J. (2020). The Roles of the State in the Governance of Socio-technical Systems' Transformation (Fraunhofer ISI Discussion Papers – Innovation Systems and Policy Analysis, No.65). Fraunhofer Institute for Systems and Innovation Research.
6. Brown, T., Mann, B., Ryder, N., … Amodei, D. (2020). Language models are few-shot learners, OpenAI. https://doi.org/10.48550/arXiv.2005.14165
7. Burmaoglu, S., Sartenaer, O., & Porter, A. (2019). Conceptual definition of technological emergence: A long journey from philosophy of science to science policy, Technology in Society, 59, 101126.
8. Bundgaard, L., & Borras, S. (2021). City-wide scale of smart city pilot projects: Governance conditions, Technological Forecasting and Social Change, 172, 121014.
9. Bussu, S., Bua, A., Dean, R., & Smith, G. (2022). Embedding participatory governance, Critical Policy Studies. https://doi.org/10.1080/19460171.2022.2053179
10. Camacho, D., Merelo-Guervos, J., Cotta, C., … Fernandez, F. (2018). From ephemeral computing to deep biosinspired algorithms: New trends and applications, Future Generation Computer Systems, 88, 735-746.

11. Caputo, R., & Saravia, D. (2019). The Case of Chile: The Monetary and Fiscal History of Chile, 1960 – 2016 (Macro Finance Research Program Working Paper). Becker Friedman Institute.
12. Checkland, P. (2019). Reflections on 40 years in the management field: A Parthian shot (friendly), Journal of the Operational Research Society, 70(8), 1219-1223.
13. Chui, M., Manyika, J., Miremadi, M., … Malhotra, S. (2018). Notes from the AI Frontier: Insights from Hundreds of Cases. McKinsey Global Institute.
14. Craglia, M., Scholten, H., Micheli, M., Hradec, J., Calzada, I., Luitjens, S., Ponti, M., & Boter, J. (2020). DigiTranScope: The Governance of Digitally-Transformed Society (JRC Science for Policy Report). European Commission.
15. De Bacco, C., Power, E., Larremore, D., & Moore, C. (2017). Community detection, link prediction, and layer interdependence in multilayer networks, Physical Review E, 95, 042317.
16. Dietz, M., Kincses, A., Rab, I., & Andrade, B. (2020). Big Techs versus Big Banks: Battle for the Customer. McKinsey & Company.
17. Evans, G. (2016, 7 December). Mastering Chaos: A Netflix Guide to Microservices. Youtube. https://www.youtube.com/watch?v=CZ3wIuvmHeM&list=PLf_PaUKZeu5ND3vIOvn8BiVhSkFYF0qx9&index=4
18. Foss, N., & Robertson, P. (Eds.) (2005). Resources, Technology and Strategy: Explorations in the Resource-based Perspective. Routledge.
19. Gates, E. (2018). Toward valuing with critical systems heuristics, American Journal of Evaluation, 39(2), 201-220.
20. Geron, A. (2019). Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems. O'Reilly.
21. Gomes-Casseres, B. (2022). Penrose in the new economy, Strategic Management Review (in-publication). https://alliancestrategy.com/wp-content/uploads/BGC-Penrose-New-Economy-v7.pdf
22. Greveen, M., Yu, H., & Shan, J. (2021). Why companies must embrace microservices and modular thinking, MIT Sloan Management Review, 62(4), 1-6.

23. Haynes, A., Garvey, K., Davidson, S., & Milat, A. (2020). What can policy-makers get out of systems thinking? Policy partners' experiences of a systems-focused research collaboration in preventive health, International Journal of Health Policy Management, 9(2), 65-76.
24. Hossain, N., Dayarathna, V., Nagahi, M., & Jaradat, R. (2020). Systems thinking: A review and bibliometric analysis, Systems, 8, 23.
25. Howlett, M., Capano, G., & Ramesh, M. (2022). Governance styles: Re-thinking governance and public policy. In M. Howlett and J. Tosun (Eds.), The Routledge Handbook of Policy Styles (ch.16). Routledge.
26. Ingold, K., Fischer, M., & Christopoulos, D. (2021). The roles actors play in policy networks: Central positions in strongly institutionalized fields, Network Science, 9(2), 213-235.
27. Ivanova, K., & Elsawah, S. (2021). Iterative refinement of multi-method OR workshop designs through boundary critique: An analytical framework and case studies in technology utilisation, Systemic Practice and Action Research, 35, 345-372.
28. Jin, Z., Zeng, S., Chen, H., & Shi, J. (2022). Explaining the expansion performance in technological capability of participants in megaprojects: A configurational approach, Technological Forecasting and Social Change, 181, 121747.
29. Jones, P. (2021). Systemic design: Design for complex, social, and sociotechnical systems. In G. Metcalf et al. (Eds.), Handbook of Systems Sciences (pp.787-811). Springer.
30. Kapucu, N., & Hu, Q. (2020). The development of network governance and its relevance for public affairs education, Journal of Public Affairs Education. http://doi.org/10.1080/15236803.2020.1839851
31. Kaur, M. (2021). Systemic design in the Australian Taxation Office: Current practice and opportunities, Australian Journal of Public Administration, 80(4), 1017-1031.
32. Khazin, E. (2022). Transition from monolith to microservices: Advantages, disadvantages & use cases, Prime TSR Insights. https://primetsr.com/insights/advantages-of-microservices/

33. Krakauer, D. (2022). The mind made matter: Analog tools are collaborators in cognition, not mere mechanical servants, RETURN. https://return.life/2022/03/07/the-mind-made-matter/
34. Lobato, R. (2020). On the boundaries of digital markets. In P. Szczepanik et al. (Eds.), Digital Peripheries (pp.51-62). Springer.
35. Malcolm, B. (2017). Introducing systemic design to support an Australian Government regulatory agency address complex problems, Proceedings of the Relating Systems Thinking and Design (RSD6) Symposium, Oslo School of Architecture and Design, Oslo, Norway. https://rsdsymposium.org/introducing-systemic-design/
36. Marcel, G. (2001). The Mystery of Being, Volume I: Reflection and Mystery (Gifford Lectures, 1949-1950). St Augustine's Press.
37. Micheli, P., Wilner, S., Bhatti, S., Mura, M., & Beverland, M. (2018). Doing design thinking: Conceptual review, synthesis, and research agenda, Journal of Product Innovation Management, 0(0), 1-25.
38. Mintzberg, H. (2019). Bedtime Stories for Managers: Farewell, Lofty Leadership ... Welcome, Engaging Management. Berrett-Koehler Publishers.
39. Nair, A., & Reed-Tsochas, F. (2019). Revisiting the complex adaptive systems paradigm: Leading perspectives for research operations and supply chain management issues, Journal of Operations Management, 65(2), 80-92.
40. Nelson, H. (2021). Systemic design inquiry: The reconstitution of Sophia – the wise hand, Academia Letters, 503. https://doi.org/10.20935/AL503
41. Nelson, R., Dosi, G., Helfat, C., ... Winter, S. (2018). Modern Evolutionary Economics: An Overview. Cambridge University Press.
42. Nelson, R., & Winters, S. (1985). An Evolutionary Theory of Economic Change. Belknapp Press.
43. Neo, B., & Chen, G. (2007). Dynamic Governance: Embedding Culture, Capabilities and Change in Singapore. World Scientific.
44. Niemcyzk, J., & Trzaska, R. (2020). Towards a network strategy: Economic rent perspectives, Proceedings of the 32nd International Business Information Management Association Conference (IBIMA). https://www.wir.ue.wroc.pl/docstore/download/UEWR90cf117dc8114d0ebac5827d2d62fb87/Niemczyk_Trzaska_Towards_a_Network_Strategy.pdf

45. Nohra, C., Pereno, A., & Barbero, S. (2022). Systemic design for policy-making: Towards the next circular regions, Sustainability, 12, 4494.
46. Oxford Analytica (2022). Ukraine war showcases private space companies, Expert Briefings. https://doi.org/10.1108/OXAN-ES267833
47. Ozkaramanli, D. (2021). Dilemmas and conflicts in systemic design: Towards a theoretical framework for individual-system dialectic. In J. Diehl et al. (Eds.), Playing with Tensions: Embracing New Complexity Collaboration and Contexts in Systemic Design (pp.364-371). Systemic Design Association.
48. Ozkaramanli, D., Desmet, P., Ozcan, E. (2020). From discovery to application: What to expect when designing with dilemmas, Disena, 17, 58-83. https://doi.org/10.7764/disena.17.58-83
49. Page, L. (2006/2019). Method for node ranking in a linked database (US Patent No. 7,058,628 B1). US Patent and Trademark Office.
50. Penrose, E. (2009). The Theory of the Firm (4^{th} Ed.). Oxford University Press.
51. Peters, B. (2019). Governing in the shadows, Journal of Chinese Governance, 4(2), 108-122.
52. Petit, N., & Teece, D. (2022). Innovating Big Tech firms and competition policy: Favoring dynamic over static competition, Industrial and Corporate Change, 30, 1168-1198.
53. Philipson, S. (2022). The end of the present mode of production – A new Kondratieff wave? New directions for research?, International Journal of Innovation and Technology Management, Online Ready. https://doi.org/10.1142/S0219877022400028
54. Philipson, S. (2020). Sources of innovation: Consequences for knowledge production and transfer, Journal of Innovation & Knowledge, 5(1), 50-58.
55. Prasad, E. (2021). The Future of Money: How the Digital Revolution is Transforming Currencies and Finance. Harvard University Press.
56. Rava, N. (2016). Designing for policy and institutional change in governance, Proceedings of the Relating Systems Thinking and Design (RSD5) Symposium, OCAD University, Toronto, Ontario. https://www.torontomu.ca/content/dam/cpipe/documents/Why/RSD5%20-%20Advanced%20Policy%20Design%20-%20Nenad%20Rava.pdf

57. Raza, S., Siddiqui, A., Standing, C. (2019). Exploring systemic problems in IS adoption using critical systems heuristics, Systemic Practice and Action Research, 32, 125-153.
58. Reynolds, M., & Wilding, H. (2020). Boundary critique: An approach for framing methodological design. In D. de Savginy et al. (Eds.), Applied Systems Thinking for Health Systems Research: A Methodological Handbook (pp.38-56). Open University Press.
59. Rogers III, C. (2018). Why do bad antitrust decisions sometimes make good law? The Alcoa and Brown Shoe examples, SMU Law Review, 71(1), 97-126.
60. Schwandt, T. (2018). Evaluative thinking as collaborative social practice: The case of boundary judgment making, New Directions for Evaluation, 158, 125-137.
61. Schonberger, V., & Lazer, D. (2007). Governance and Information Technology: From Electronic Government to Information Government. The MIT Press.
62. Smith, C., & Shaw, D. (2019). The characteristics of problem structuring methods: A literature review, European Journal of Operational Research, 274(2), 403-416.
63. Soldani, J., Tamburri, D., Van Den Heuvel, W. (2018). The pains and gains of microservices: A systematic grey literature review, Journal of Systems and Software, 146, 215-232.
64. Spender, J. (1994). Organizational knowledge, collective practice and Penrose rents, International Business Review, 3(4), 353-367.
65. Stiegler, B. (1998). Technics and Time, 1: The Faults of Epimetheus (R. Beardsworth & G. Collins, Trans.). Stanford University Press.
66. Sun, R., Garimella, A., Han, W., ... & Shaw, M. (2020). Transformation of the transaction cost and agency cost in an organization and the applicability of blockchain: A case study of peer-to-peer insurance, Frontiers in Blockchain, 3. https://doi.org/10.3389/fbloc.2020.00024
67. Teece, D. (2018). Dynamic capabilities as (workable) management systems theory, Journal of Management and Organization, 24(3), 359-368.
68. Udekwu, O. (2017). Programming Insight: Human and Machine Intelligence in the Petabyte Age (Doctoral Dissertation). University of California, Berkeley.
69. Ulnicane, I., Knight, W., Leach, T., Stahl, B., & Wanjiku, G. (2021). Framing governance for a contested emerging technology: Insights from AI policy, Policy and Society, 40(2), 158-177.

70. Ulrich, W. (2022). Assessing assumptions about boundaries with critical systems heuristics, Integration and Implementation Insights. https://i2insights.org/2022/05/24/critical-systems-heuristics/comment-page-1/
71. Ulrich, W. (2021). Can we discipline 'alternative facts'? Towards a new critical competence, Academia Letters, 332, 1-9.
72. Ulrich, W., & Reynolds, M. (2020). Critical systems heuristics. In M. Reynolds and S. Holwell (Eds.), Systems Approaches to Managing Change (pp.243-292). Springer.
73. Ulrich, W., (2003). Beyond methodology choice: Critical systems thinking as critically systemic discourse, Journal of the Operational Research Society, 54(4), 325-342.
74. Ulrich, W. (1983). Critical Heuristics of Social Planning: A New Approach to Practical Philosophy. Wiley.
75. Vukovic, J. (2021). You are not Netflix. In A. Bucchiarone et al. (Eds.), Microservices: Science and Engineering (pp.333-348). Springer.
76. Waseem, M., Liang, P., Shahin, M., Di Salle, A., & Marquez, G. (2021). Design, monitoring, and testing of microservices systems: The practitioners' perspective, Journal of Systems and Software, 182, 111061.
77. Wong, D. (2022). Boundary critique: The work of Werner Ulrich. In J. Diehl et al. (Eds.), Possibiltiies and Practices of Systemic Design: Proceedings of the Relating Systems Thinking and Design (RSD11) Symposium (In-publication). Systemic Design Association.
78. Wong, D., & Tan, S. (2021a). Antinomies in systemic design: Dilemmas, paradoxical tensions, and Werner Ulrich. In J. Diehl et al. (Eds.), Playing with Tensions: Embracing New Complexity Collaboration and Contexts in Systemic Design (pp.37-44). Systemic Design Association.
79. Wong, D., & Tan, S. (2021b). Using network analysis to evaluate dynamic capabilities: A new concept of method, Proceedings of the IEEE International Conference on Industrial Engineering and Engineering Management (pp.338-343), IEEE, Singapore.
80. Li, Z., Gao, J., Di, L., & Shum, H. (2020). The design and implementation of XiaoIce, an empathetic social chatbot, Computational Linguistics, 46(1), 63-93.