In Pursuit of Design-led Transitions

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In Pursuit of Design-led Transitions

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This paper contributes to the growing maturity of transition design. A Dutch transition design project with the Dutch Government and food sector is presented and reveals the challenges of designing at a system level. Reflection on the project reveals two insights that were not factored within the project but in retrospect require the attention of transition designers; (1) the timing of the transition relative to the surrounding environment and; (2) the velocity or speed at which a transition can be fully enacted. The paper shifts to investigating change theories to identify possible directions to address these challenges. Theoretical implications are concluded from this investigation. This paper deals with politics, power, democracy, leadership, and enablers and inhibitors of change.

Keywords: power, policy, leadership, ecosystem, pluralism

Introduction

It is a time of unrest described in various strong rhetorical forms as a *time of many problems* (Margolin, 2015), an *increasingly complex world* (Buchanan, 2015), a time of *rapid changes* (Bucolo, 2015), and *transience* (McGrath, 2013). The successful processing of this subject matter has elevated design (and designers) to areas of organisational reform, system[1] design, policy reform and technology related transformations (Muratovski, 2015). The witnessed rise in the statue of the design discipline is eloquently described by Richard Buchanan as the *design movement* (2015). In short, it has been a busy period for designers.

One particular growth area in the design movement is the increasing popularity of design-led innovation. Design-led innovation provides organisations with the means to negotiate uncertainties and innovate to create and capture value. Design becomes a source of new thinking and action and informs the strategic direction of an organisation. Yet focus is shifting again. Design is now being explored beyond the scale of individual organisations. Questions such as 'how might design assist national economies to thrive during uncertainty', and; 'how will international carbon emission be lowered while maintaining social and economic stability' are now open to designers (Irwin, 2018). Such an increase in scope has led to methodological developments within the discipline. *Transition design* is one such emerging methodological development (Irwin, Kossof & Tonkinwise, 2015). In particular, guidance on how to apply transition design given the inherent scaling challenges and political implications associated with working at a system-level remain an area for further attention.

The aim of this paper is to contribute toward the methodological emergence of transition design. The paper reveals how the urgency for transition design can be arrived at from an alternative path to social innovation -

[1] The terms system and ecosystem will be used interchangeably from herein

via design-led innovation. Design-led innovation is acknowledged as a means to drive organisational transformations.[2] Transitions do require the collective transformation of public and private organisations together (Geels, 2002) which acts as an interaction point for design-led innovation. This logic is explored through a review of literature before the paper shifts to describing a Dutch case of transition design in effort to explore the current state of the methodology. Literature on policy making (e.g., Bason, 2013), technology forecasting (e.g., Adner & Kapoor, 2017), innovation (e.g. Christensen, 1997), management (e.g., McGrath, 2013) and ecological economics (e.g., de Jesus & Mendonça, 2018) is consulted in order to draw upon multidisciplinary perspectives that reflect the complexity of transitions literature. Based on these insights, theoretical implications for designing transitions are presented.

The Design Movement

Central to design, is the notion of design being capable of addressing wicked problems (Buchanan, 1992; Rittel & Webber, 1973). Designerly strategies (such as problem-framing) are particularly, if not uniquely suited to dealing with ill-defined or wicked problems (Cross, 2007; Forlizzi, Stolterman, & Zimmerman, 2009; Gaver, 2012; Stolterman, 2008). Buchanan presents the four orders theory of design in which wicked problem-solving are encountered (1992; 2015), see Figure 1. Buchanan's *four orders* deconstructs the nature of design problems, relating activities required to prescribed solutions. As Buchanan states of the four orders, "the *evolution* of the design professions from graphic and industrial design to interaction design and, then, to the design of systems, environments and organisations is the hallmark of the current design movement" (2015, p. 11). Since the turn of the century, a series of new approaches to design have evolved from human-centred foundations. From transformation design to service design, design-led innovation and strategic design (see e.g., Calabretta, Gemser & Karpen, 2016; Jones, 2017; Bucolo et al. 2012). This diversification away from a heritage of industrial design is an indication of the discipline's increasing maturity, a journey supported by the positive reception of the designers within newfound contexts of organisational reform (Elsbach & Stigliani, 2018) and policy arenas (Yee & White, 2016).

Fields of Design Problems

		Communication Symbols	Construction Things	Interaction Action	Integration Thought
Arts of Design Thinking	Inventing Symbols	Symbols: Words & Images			
	Judging Things		Physical Objects		
	Connecting Action			Activities, Services, Processes	
	Integrating Thought				Systems, Organizations, Environments

Figure 1: Four Orders of Design - Buchanan, 2015

Design-led Innovation to Design-led Transitions

Design-led innovation as a concerted approach was realised in response to growing pressure on the Australian manufacturing sector from nearby high-productivity and low-wage competitors based in Asia. A design-led approach to innovation encapsulates the methods, skills and culture of design throughout the entire process of creating and capturing value within an organisation. The approach conceptualised by Bucolo, Matthews and Wrigley (2012) assists an organisation to diversify by gathering and acting upon novel insights from customers

[2] I choose to make a distinction here for clarity. *Transformation*s are changes at an organisational-level, and *transitions* are changes at the system-level.

and stakeholders. Novel insights become a basis for differentiating innovation and a vital source of top line growth for firms experiencing the pressures of market competition. Cases reveal that design-led innovation can positively contributes to, and can even drive organisational transformations (Doherty, Wrigley, Matthews & Bucolo, 2015; Townson, Matthews & Wrigley, 2016; Krabye, Wrigley, Matthews, & Bucolo, 2013).

While design-led innovation began with a motive to support the Australian manufacturing sector, interest quickly grew from the broader business community. Of note is the mobility sector (Garret, Straker & Wrigley, 2017; Price & Wrigley, 2016). General findings from these initial years of research are contained in the work of Wrigley (2016) and Price, Wrigley and Straker (2015). Design-led innovation has also transferred successfully to the European context, involving partnerships with an automotive company (Bryant & Wrigley, 2014) and software developer (Bastiaansen, Price, Govers & Machielsen, 2018). Parallel efforts to bring design-led innovation into the public sector have also been positive (Bason, 2013; Camacho, 2016).

Focus has turned progressively from the scale of individual organisation and impact of design, toward a macro perspective of the potential impact of design across networks of organisations. This shift entails scaling design-led innovation, and more broadly design as a source of improved competitiveness for single organisations, to the resilience of a network of organisations – an entire sector, industry or indeed a national economy. Fraser (2012) raises the potential of design to be a source of an economic prosperity, describing an *innovation economy* where enterprises compete with and through design. Similarly, Bucolo (2015) extends the design ladder (Figure 2) to describe *design as national competitive strategy* (step 6) whereby a government designs and implements macro-economic strategies that promote national resilience. The Australian paradigm prevails in the work Peppou, Thurgood and Bucolo (2017). Yet there are also parallel international efforts to elevate design to source of system-level impact. Of note are methodology developments that address:

- The socio-technical → thing-centred design (Giaccardi, Speed, Cila and Caldwell, 2016), DesignX (Norman & Stappers, 2015);
- The socio-cultural → infrastructuring design (Hillgren, Seravalli & Emilson, 2011), and;
- The socio-economic → Design-led innovation (Bucolo, Matthews & Wrigley, 2012), design driven innovation (Verganti, 2009).

Another emergent methodology is transition design. Transitions are more prominent within fields such as policy development and technology forecasting. Journals such as *Futures, World Development, Research Policy* and *Technological Forecasting and Ecological Economics* contain work that is topical to the transitions of developing nations and adoption of new technology innovation systems. Transitions represent the collective shift of multiple levels of a system (Geels, 2002). Geels describes three levels that must be aligned for a transition to take place. These levels are

1. The ‘niche’ level where innovation occurs;
2. The ‘regime’ level where policy frameworks operate, and;
3. The ‘landscape’ level where megatrends and collective motivations reside.

As Geels, (2011, np) writes:

> *Although each transition is unique, the general dynamic pattern is characterised by transitions resulting from the interaction between processes at different levels: (a) niche-innovations build up internal momentum, (b) changes at the landscape level create pressure on the regime, and (c) destabilisation of the regime creates windows of opportunity for niche-innovations.*

As an example, the sustainable energy transition requires innovation to develop renewable energy products and services that are attractive to citizens (niche). The organisations that are responsible for that innovation must also undergo a transformation. New policy frameworks (regime) that promote renewable energy sources are required too so that the existing finite energy system is phased out. Finally a collective movement toward acceptance of the need to act on climate change (landscape) creates a sense of urgency (Kivimaa & Kern, 2016). A window of opportunity is opened and a transition can take place. When these layers realign and stabilise to a new state, a transition is said to have been enacted. For this reason, transitions require overcoming ‘lock-ins’ or entrenched ways of operating, thinking and being at each level (Lachman, 2013). Hence, transitions also require a build-up of forces for change that move dynamically between citizens, industries and political division (Frantzeskaki & de Haan, 2009). This build-up takes time and inherently involves tension (Jorgensen, 2012). Overtime the existing system is creatively destroyed and replaced with a new system and accompanying paradigm (Kivimaa & Kern, 2016).

The strength of transition theory is in the comprehensive way retrospective cases are described. However, Lachman (2013) also describes this as a ‘catch 22’, as literature offers limited practical guidance for designing and enacting transitions. Further transition literature points generally to the collaborative effort and engagement between niche and regime actors. However, actual description of practices required to facilitate this interaction are vague (Kemp & Rotmans, 2009). Martens and Rotman (2005) do point toward anticipatory approaches that are reflexive, test assumptions and drive innovation. An opportunity for design is apparent.

From a design perspective, transitions theory shifts rhetoric from commercial principles such as viability and competitiveness associated with *design x innovation* (Dong, 2015) to a holistic perspective – an ‘interconnectedness’ of social, economic, political and natural systems to address present and future wicked problems (Irwin et al. 2015). Wicked problems such as climate change, loss of biodiversity, and increasing wealth disparity require the design and implementation of new products, services and systems. Such change in rhetoric elevates design to new urgency. Irwin et al (2015) view transition design as a natural extension of existing design approaches, view visualised in Figure 3.

As Irwin (2018) describes, designing transitions involves three repeating phases; (1) reframing present and future; (2) designing interventions, and; (3) waiting and observing. The methodology places emphasis on envisioning long-term futures that are desirable for a holistic range of stakeholders, then backcasting toward feasible realisation steps. The present context is also reframed, for example how Leitao (2018) reframes the narrative of western modernity to explore new notions of past and present . These new perspectives inform envisioning that is intended to break away from conventional ‘lock ins’ described by Lachman (2013) that reinforce the present ecosystem. Interventions are then built and enacted at various system-levels that are informed by Geels’ multi-layered perspective (MLP) (2002). These interventions are intended to create pressure for change between and across levels of a system. Waiting and observing as evaluative activities then determine the status of the interventions before a series of reframing occurs again.

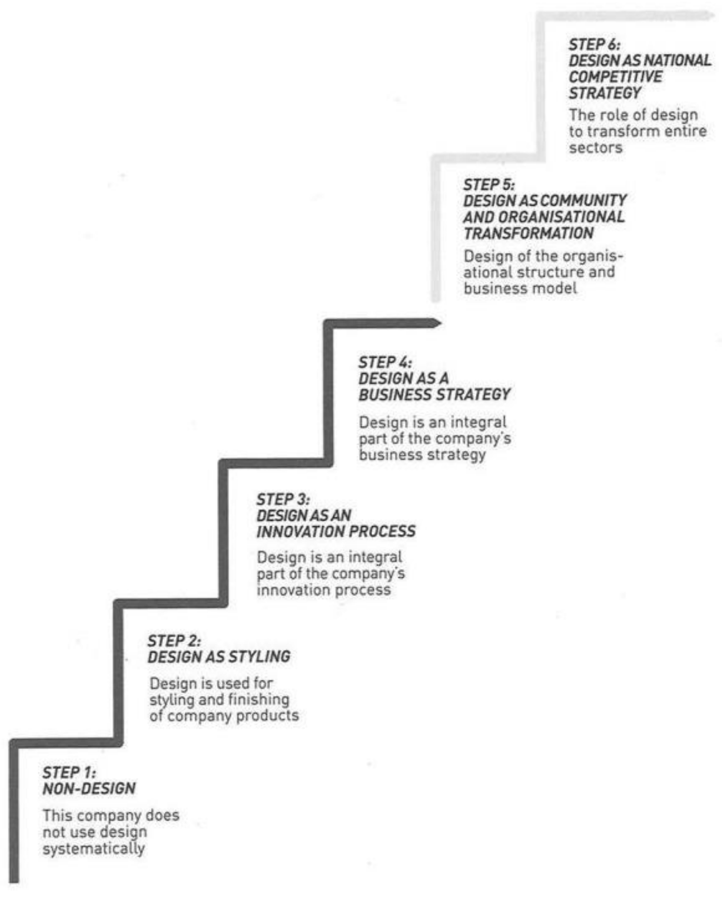

Figure 2: Design Ladder Extended – Bucolo 2015. Reaching national transitions

Figure 3: Emerging Discipline of Transition Design – Irwin et al. 2015

RtD: Dutch Transition Design Case

Presenting a practical example of transition design provides insight into the nuances and emergent state of the methodology. As part of a collaboration with the Dutch Government's *X-Lab*, Youngsil Lee (2018) lead a design team to create a *kitchen-code service* to promote healthy and sustainable daily cooking habits for Dutch citizens. The design team was multidisciplinary; including designers, ecologists, industrial engineers and policy makers. The project, *From things to systems, and back: a thing-centric approach to protein transition in the Netherlands* explored socio-cultural and socio-economic circumstances of food purchase, preparation and consumption. This construction by Lee involved the integration of *commons* theory (Ostrom, 2015) as mechanism to create tension between new daily individual actions and the food industry. This approach is consistent with Geels' multi-levelled perspective (2002).

Lee designed a service to encourage changes in how food is produced, regulated and consumed. The strength of the project lies not only in the outcome – a new service proposition - but in the conceptual construction of a spatiotemporal axis of the kitchen to which the problem of unhealthy and unsustainable societal eating habits reinforced by current agricultural and food processing is confronted. Lee establishes a vertical axis from individual consumer, to family, community and society and uses each level as an interlinked design context (Figure 4). The kitchen context is reframed as a decision making space and becomes the vertical axis. Kitchen tools that afford certain cooking techniques and practices are identified as amplifying effects for the diffusion of change at each horizontal rung of the axis. The home kitchen, the commercial kitchen, the restaurant kitchen, the farmer's kitchen all act as decision making spaces that determine supply and demand within the greater food system.

Lee and her team designed a service intervention that would support policy efforts to reduce meat-based protein consumption in the Netherlands. Overtime, the home cook would be encouraged to use green protein (as opposed to animal-based protein) sources in purchasing and cooking decisions. When buying new green food products, the *kitchen-code service* would assist individuals and groups to learn new recipes based on what cooking utensils were available in their own kitchen context. Should the entire Dutch population cease to purchase and consume meat overnight, a supply-chain induced disaster would occur with waste accumulating toward crisis point. Under the kitchen code service, policies would need to be devised that would support farmers to shift their production over time to ensure they were producing food relative to demand and substituting meat based farming with green alternatives.

The case of protein transition within the Dutch context is an example of the emerging state of transition design. The project reveals that the task of building conceptual and theoretical integrity within the methodology must take place in situ while experimenting via *research through design*. An observation throughout the project was that the ecosystem was 'not ready' to embrace such thinking about the reduction of meat-based protein sources. More insight about the state of the ecosystem was required to determine when the transition could be enacted. The production of meat-based protein, especially in the dairy industry, in the Netherlands is considered part of the socio-cultural identity of the country. The Dutch are proud of their cheese, milk and dairy products which are exported globally. In this sense, the project felt political resistance. While the kitchen-code service has not been implemented, the principles underpinning the protein transition and kitchen code are now informing policy making.

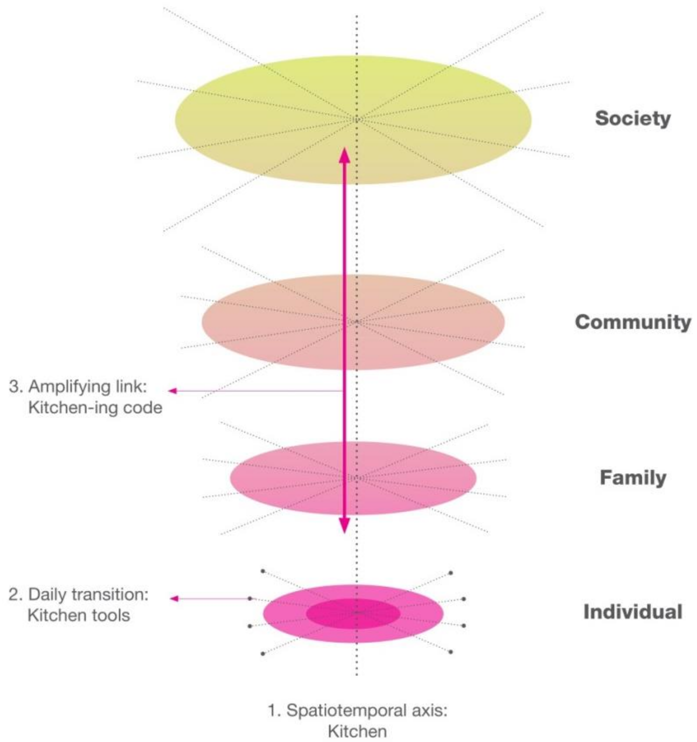

Figure 4: System diagram of the Kitchen Concept developed by Lee (2018) and inspired by Geels (2002).

A second key insight gained by the researchers was a sense that how quickly a protein transition could be fully enacted across an ecosystem. The scale of changes within the agricultural industry in particular would take many years to stabilise. The protein transition designed by Lee and colleagues provided an idealistic vision of steps required to move toward a new food-system. Necessary transformative actions and the political upheaval within each participating organisation was not factored into the design of this greater transition. In retrospect these two factors of timing and speed were critical. In the next passage of this paper, I look to theories associated with change and growth to learn more about how timing and speed are addressed in transitions literature.

Looking to Change Theories for Guidance

Transitions requires daily changes at the scale of the individual. In daily life there are many transitions already underway. Transitions can manifest in adoption of new products and services; for example from combustion to electric vehicles or from non-recyclable plastics to organic alternatives such as alginate based materials. These two transitions can be considered part of the general sustainable transition. This transition involves an unwinding from an industrialised carbon-intensive economy toward notions of renewable energy, reuse, repair, repurpose and recycle (de Jesus & Mendonça, 2018). The challenge of this transition is not to change one individual, but to scale change viably across the entire value chain associated with production to consumption of goods and services.

Innovation can be an enabler here, as Schot and Kanger (2016, pg 76) note; 'As Innovation enabled the development of an industrial, carbon-intensive economy, it is plausible that ("transformative") innovation may now be the vehicle for triggering a new, "green" transition'. However, the same approach to innovation prioritising efficiency and productivity that hailed in the industrial era cannot be repeated. With the power of retrospect and with the presence of an information economy, it is clear that an approach that integrates ecological and social factors into an economic and technical 'transition' must be championed. Here transition design as source of innovation that integrates socio-cultural, ecological, economic and technology developments is of significant relevance.

It is important to note, that I view technology as a scaffold for new types of actions that collectively build pressure for change. This viewpoint is consistent with technology innovation system theory (TIS) that forms one direction within transition literature (Hekkert, Suurs, Negro, Kuhlman, Smits, 2007). TIS involves viewing the co-evolution of technical systems with social and economic institutions. This viewpoint has synergies to the theoretical underpinnings of design-led innovation. Notably how design as an alternative approach to innovation can stimulate cultural and organisational transformations that benefit society. TIS theory is closely related to strategic niche management (SNM) which offers another nuanced direction within transitions literature (Kemp, Schot & Hoogma, 1998).

The S-Curve

The seminal work of Christensen (1992; 1997) provides valuable starting point to explore innovation and system-level change. The s-curve is a theoretical model that fundamentally describes the phenomena of growth in relation to time (Christensen, 1991; 1997). The s-curve, named for its approximate shape of an 'S', has been applied to study population growth (with the advent of the *pearl function*), adoption of products and services, and the efficiency of technologies during operation (see Figure 5). Growth begins slowly. When the tipping point or critical mass is achieved, growth accelerates and can even be exponential. Eventually growth plateaus due to maturity or stabilisation of the phenomena. Martens and Rotmans (2005) contextualise the s-curve within transition studies, following a similar route to stabilisation. Martens and Rotmans place greater emphasis on describing the acceleration phase where growth occurs and visible structural changes take place between interactions of various levels; socio-cultural, ecological, economic and intuitional.

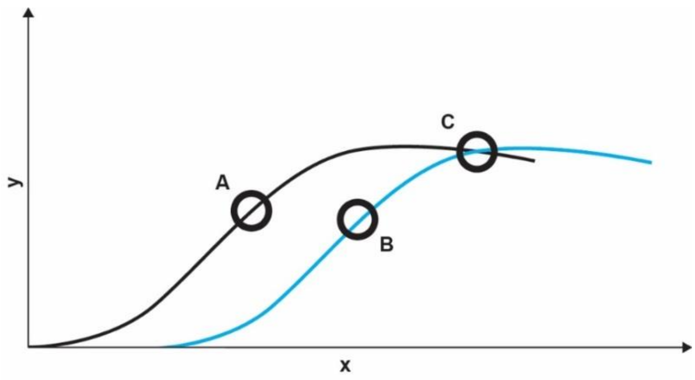

Figure 5: S-curve model; A) growth of product 1 sales; B) growth of product 2 sales and C) inflection point where growth curves intersect.

Depending on the nature of a growth trajectory (Dosi, 1982) and competitive forces at play (Porter, 2008), a technology or firm represented by an s-curve will be displaced by another firm or technology of superior performance. The existing firm or technology is unable to match the performance and capabilities of the newcomer. The newcomer enjoys market success until its own position is disrupted by a new alternate product or service of superior performance. A series of *creative destructions* take place. When observed from distance, this process is akin to general progress.

The notion of *disruptive technologies* pioneered in the work of Christensen (1997) has deeply influenced the direction and shape of management and technology disciplines. For example the positive economic influence of competitive forces (particularly the threat of the entrant) has been identified as a stimulant for investment in research and design (R&D). R&D investment has historically been a key metric underpinning prosperous economies (Foster, 1986). Design is already known to assist organisations to flourish under the associated innovation challenges of the competitive arena. This position is acknowledged in practice and academic alike (Rae, 2016; Sheppard, Kouyoumjian, Sarrazin, & Dore, 2018).

The Dynamics of an S-Curve Jump

When the vertical parameter (y axis) is extended and two or more s-curves are represented, discontinuities can be identified. The transition from one growth curve to another is termed by Asthana (1995) as the *s-curve jump* (see Figure 6). The notion of 'jump' describes a moment of increased activity associated with springing into a new mode. Usually this jump requires significant capital outlay and redistribution of resources to change from one operating system to another. Asthana (1995, p.15) describes, "Properly used, an s-curve analysis helps reduce the risk of premature dismissal of technology." This carries implications for transition design such as when to phase out or replace existing infrastructure, systems and policies associated with the industrial era or predecessor ecosystem. While the term jump carries the denotation of fast speed, often transitions may take many years to enact.

Conditions surrounding the s-curve are inherently uncertain and unstable. In these conditions it is common to find a diffuse range of future visions – note plurality. These visions may also be of varying salience, with some visions of the future already informing decision making. Change becomes difficult as tension builds and disagreements persist. It is common to find power-structures that both enable and inhibit change based on individual agenda. Such conditions are ripe for leadership (Asthana, 1995).

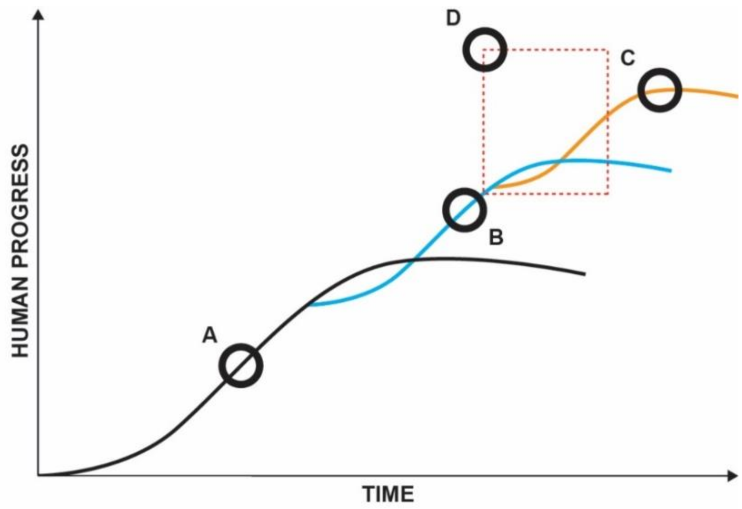

Figure 6: Consecutive s-curve models describing human progress informed by the thought leadership of Harari, (2015); A) growth of the agrarian age; B) growth of the industrial age; C) predicted growth of high-tech age, and; D) scope of current transition period. Note bene: scale is representative only but as Harari notes, each age has approximately halved the time period of the previous age.

Timing of Transition

Identifying the timing of a transition implies a reliable reference point. Here, the theoretical relevance of the s-curve (Christensen, 1991; 1997) returns. Within this article relative the notion of being early, late and a laggard within an adoption or s-curve emerge as a way to describe the *timing* of transition. However the notion of an s-curve 'jump' (or transition to new system) also complicates this perspective as the discontinuities occur across the vertical axis as well as the horizontal axis. The work of Asthana assists in understanding the dynamics of the s-curve jump. The jump from industrialisation to high-tech era (citing Harari, 2015) is perhaps the broadest example to contextualise this theory. The dynamics of this jump are further illustrated in Figure 7. The figure caption describes how each transition involves loss as the s-curve jump takes place.

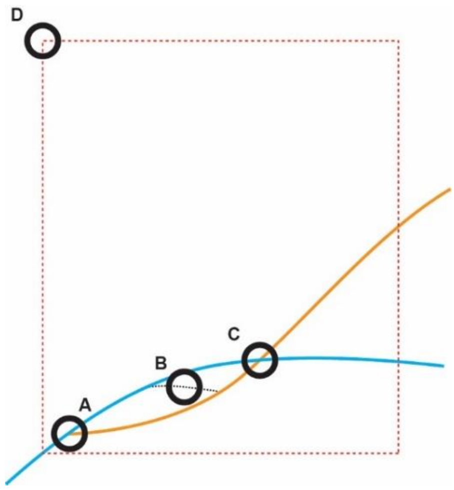

Figure 7: Dynamics of the s-curve jump; A) early mover must make do with an early loss to the performance of the system yet becomes well positioned (intellectually and with necessary infrastructure) for gains when the system begins to perform; B) mid mover must invest considerably in order to transition to the lower trajectory of the new system but can learn from the actions of the early adopter ; C) late mover endures the slowing performance of the older system, and must invest considerably to bridge the gap to now highly performing and mature system, and; D) scope of transition (see Figure 6 for reference point).

Recent work by Adner and Kapoor (2017) builds upon Asthana, using s-curve theory as a way to predict how and when new technologies should replace predecessors. The paper *Right tech, wrong time*, identifies four possible scenarios where technology innovation system transitions occur. These four scenarios are illustrated in Figure 8. Referring to Figure 8, Adner and Kapoor (2018, pg.60) write;

> *Traditional substitution of a new technology for an old one is shown with two S curves. (The solid lines). A more holistic view adds two dynamics. First if the new technology depends on the emergence of a new ecosystem, it becomes dominant more slowly (tightly dashed line intersecting at A and C (sic)). Second, the old technology's competitiveness is extended if it can benefit from performance improvements in its surrounding ecosystems (loosely dotted line intersecting at B and D (sic)).*

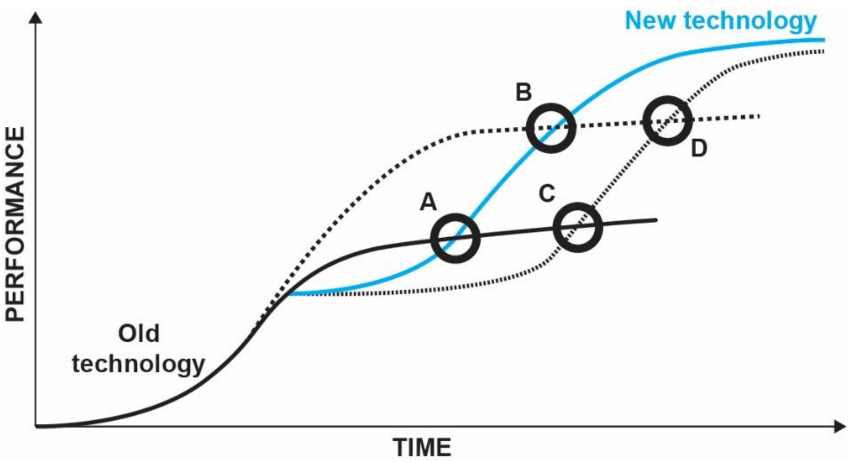

Figure 8: Right tech, wrong time – Adner and Kapoor (2017)

Figure 8 contains two s-curves representing the substitution of an old technology by a new technology. The tightly dashed line (intersecting A and C) represents a delayed arrival of a new technology. The loosely dotted line (intersection B and D) represents the extension of an old technology. Four circled points are annotated as A, B, C and D. These points represent:

- *Point A - Creative destruction.* Described as the classic and fastest substitution of technologies, a new technology is supported by a new and ready ecosystem. The old ecosystem cannot be significantly improved. It is the ideal moment to substitute technologies.
- *Points B - Robust coexistence.* Old technologies have sustained relevance, through improvements to the existing ecosystem. Old and new technologies temporarily coexist. For example the coexistence of combustion and hybrid vehicles, yet the general shift toward an electric vehicle supportive ecosystem is taking place.
- *Point C – Illusion of resilience.* The substitution of an old technology by a new technology occurs with little performance gains as the old ecosystem seems outdated. Yet, the new ecosystem seems to be 'not ready'. It is important to take active steps toward transitioning to a new technology ecosystem.
- *Point D – Robust resilience.* New technologies encounter strong resistance to adoption. The existing ecosystem has great potential to be improved, while the new technology ecosystem requires significant updates before becoming viable. A gradual substitution takes place. Adner and Kapoor provide the example of the barcode to RFID chip. Barcode technology is still relevant, and indeed has been resurgent with QR code scanning allowing the consumer to benefit from simple services and products.

Adner and Kapoor develop a working theory that scales from single technology to implications for the broader technology ecosystem. This logic provides decision makers with a set of clues to analyse a technology in relation to the broader ecosystem. The notion of 'ecosystem' encapsulates technology, consumers, businesses and policies that allow new technologies to be commercialised and part of daily life. Consider how solar technology has been developed, subsidised and adopted, leading to new behaviours and actions that are crucial to a wider energy transition.

Another example of how Adner and Kapoor's work could be harnessed is as follows. A transition designer may identify similar to Iansiti and Lakhani (2017), that Blockchain requires an extensive new ecosystem – most notably total reconfiguration of prevailing financial systems and governance structures to allow peer-to-peer transactions and distributed databases. This process of change may take twenty to thirty years to fully realise. From a societal perspective, the designer might identify that significant deinstitutionalisation is required to shift responsibility and trust to each individual citizen. From this analysis the designer can take reasonable course of action; perhaps plan for gradual improvement of the current ecosystem toward one more supportive of Blockchain's utility – a strategy akin to *robust resilience*.

In sum, the work of Adner and Kapoor offers a strategic approach to consider how and when an old technology can be substituted by a new technologies by analysing the state of the broader technology ecosystem. That ecosystem involves the political, structural, economic and societal elements at play. While technology-focused, an appropriation of this approach can support the efforts of transition designers to realise sustainable futures by analysing the conditions of the prevailing social, cultural, political, economic ecosystem.

Velocity of Transition

One factor implied within the work of Adner and Kapoor, is the velocity to which a transition can be enacted when the timing is 'right'. For lack of suitable terminology here, I will refer to this as the *velocity of transition*. Table 1 contains six transitions drawn from literature used to explore the constructs of timing and velocity. Enablers and inhibitors of change are noted. As previously identified, the timing of a transition may be early, late or somewhere in between. The velocity of a transition can occur gradually or abruptly. I note here that gradual transitions can take more than 10 years. While abrupt transitions occur rapidly below this 10 year time scale. This 10 year demarcation requires much further inquiry to define but for now is a practical reference point. In the next paragraphs I will explore more examples that are summarised in Table 1.

Not all transitions occur quickly. In fact many decades may be required to transition from one operating system to another. These transitions are *gradual*; for example over the last 40 years, the 'Energiewende', or German energy transition from finite to renewable sources has been taking place. This gradual transition has occurred to unwind reliance on the infrastructure associated with the existing energy system. The slow dismantling, reconfiguration or replacement of finite energy infrastructure mitigates social disruption to employment and gross domestic product (GDP). Strong leadership (and even bipartisan unity) was initially required to develop policy that could remain protected overtime, thus allowing implementation beyond electoral cycles.

Similarly, a gradual transition in the Australian energy sector has been occurring for contrasting reasons. During the global financial crisis, Australia was one of the few developed nations to experience growth. Such stability came from the export of minerals (coal, iron ore) to nearby developing trade partners such as China and India. As China's import of Australian coal has slowed in light of its own energy transition, an increase of export to Japan has risen in lieu of closure of the nation's nuclear energy plants following the 2011 earthquake and tsunami. The inhibitors to change associated with the cost of new infrastructure hold such heavy political weight that exploring clean energy alternatives was suppressed for many years. In short, sustained success brought through mineralogy instilled the thinking, 'why change when something is successful'. The country now finds itself on a clean energy precipice. Partnership between the South Australian State Government and Tesla to implement a solar-battery strategy to stablise an unreliable electric grid will be closely followed by many.

An example of an abrupt change is the Chinese Energy Transition. With fast leadership mechanisms enabled by a socialist republic model; President Xi Jingping was able to quickly pass reform and begin capital outlay toward replacing finite energy resources and infrastructure with renewable alternatives. Interestingly, even with the authoritative governmental model of the People's Republic of China, it was vocal protest of citizens living in mega-cities such as Beijing and Shanghai facing serious air quality challenges that encouraged a transition. China still remains one of the largest polluting nations per capita. However, its investment shows how seriously the transition is being pursued. In 2017, China invested more than half of the global renewable energy capita; nearly $280 Billion US dollars (Energiewende Team, 2018). Interestingly, the idea that China's authoritarian model of governance being effective during a system-level transition prompts critique of dialogue-based processes for reform associated with democracy. Such an example does warrant consideration into how to establish a shared vision through democratic processes like that of preceding unity leading to the German energy transition. As Hendriks notes, unfortunately sometimes politics just goes on and on (2009).

Similar abrupt system-level transition occurred in Sweden on 3 September 1967, when driving switched from left side to right side of the road. *Dagen H* (Day H) involved a temporary ban of vehicles driving on roads while intersections were reconfigured. In this case, the existing infrastructure of the road remained a stable factor – allowing a fast transition to take place. This transition was fully enacted within months. Further, an abrupt transition occurred when penicillin was discovered by Dr. Alexander Fleming in 1928. It was not until 1940 that mass production of the drug was achieved. Even today, pharmaceutical development takes many years to achieve[3] given tight regulations around clinical trials and human testing. Once produced *en masse*, penicillin rapidly changed medical practices creating the capability to treat bacterial infections that were otherwise fatal. One of the great inhibitors to the transition to *modern* medicine was the ability to mass produce and distribute penicillin. Once the ecosystem was ready for distribution (timing), the change became widespread and fast (velocity).

Table 1: Timing and Velocity of Transitions

Transition	*Timing of transition*	*Velocity of transition*	*Enablers*	*Inhibitors*
Australian Solar/Wind Energy Drive as a breakaway from previous reliance on coal-fired infrastructure (present);	Late	Gradual	Abundance of natural resources; cost benefits to the consumers with solar in particular; temporary government subsidies; lowering costs of solar panel technology	Entrenchment of finite energy providers lobbying power within the political landscape; immediate trade opportunities for coal/gas in nearby developing nations (for example: India)
Irish Taxi Liberalisation (2000) 20 years after the deregulation and liberalisation trends of the 1970-1980s	Late	Abrupt	Deregulation stemming from new legislation; lower prices passed onto the consumer; population growth; move of inhabitants to urban centres	Labour union protest; backlash from existing industry

[3] Even today with notable technological developments, it still takes about 10-12 years on average to develop and realise new drugs (US Food and Drug Administration FDA).

Singapore Economic Reform (1965) becoming a strong and independent economic hub	Late	Gradual	Strong charismatic leadership and a powerful vision for independence; government incentive for new ventures; geo-political location on intersection of major trade routes	Existing economic instability as an outcome of WWII; lack of capital reserve
Chinese Renewable Energy Policy (2017 – announces 360 billion dollar investment)	Late	Abrupt	Strong (authoritarian) leadership and vast capital reserve; citizen activism regarding the country's air quality; lowering price of solar panel technology	Significant infrastructure dismantling requiring massive job losses and short term instability
German Energy Transition (Energiewende, 1980 to present)	Early	Gradual	Strong leadership and vision; taking responsibility for long term stability	Unravelling of extensive and successful finite energy resources; criticised publically as a 'financial burden'
Integration of penicillin into worldwide medical practices (Between 1928-1929 and 1940)	Early	Abrupt	The ability to survive simple infections (massive performance gains); suitability of penicillin within existing models of care (injection or tablet form)	Disproportionate supply of the drug to massive demand (scaling issues); religious pushback associated with playing 'god'; capital within the US economy post WWII to stimulate mass production

Theoretical Implications

It is necessary to pause now and identify what theoretical implications can be drawn from growth theories that can aid the maturity of transition design. The implications below hold value to transition designers and designers seeking to work across ecosystems. Some implications are:

- A transition can be modelled as an s-curve 'jump';
- A destabilisation or crisis within an ecosystem during the preceding moments before an s-curve jump is an opportune time for design leadership;
- Theoretically, a transition requires loss. Loss occurs either through performance or capital outlay associated with change. The social element of loss is often overlooked in transitions literature;
- A transition begins with the first decisive action toward change, usually policy or legislative reform, but may also be mobilisation of a population toward change;
- Market mechanisms such as deregulation/regulation can drive very fast changes in supply chain reconfiguration and consumer preference;
- Early yet gradual transitions require strong (and united) leadership that extend beyond electoral cycles;
- Some transitions occur rapidly and successfully because a technology, such as penicillin, provides such a radical performance improvement that it sparks the creation of new ecosystem around it;
- Late transitions often come with the challenge of unwinding entrenched lobbying power between for-profit organisations and government parties who are 'locked in' to the old system, e.g. see the Australian energy transition;
- The illusion of resilience of an old technology within an ecosystem only prolongs the responsibility of change to future generations;
- A transition design approach must factor concepts of timing and velocity in order produce robust design interventions.

Regarding the last implication, 'how to' factor timing and velocity of change within a design process remains an area for further research.

Conclusion

As innovation enabled the development of an industrial, carbon-intensive economy; it is plausible too that innovation may now be the vehicle for triggering a new, sustainable transition. With the power of retrospect, it is clear that an approach that integrates ecological and social factors into an economic and technical 'transition' must be championed. Here transition design (as source of innovation) is of significant relevance. While some scholars and practitioners have reached this realisation through the evolution of social innovation, my research has led me to a similar point through expansion of the logic associated with design-led innovation – a human-centred yet economic path.

In this paper I have reflected on a transition design project with the Dutch Government. This project revealed two challenges that were not factored within the design approach; (1) the *timing* of the transition relative to the surrounding environment and; (2) the *velocity* at which a transition could be fully enacted. I inquired into change and growth theories in order to understand how to manage the complexities of leading transitions by design. Theoretical implications act as platform for explorative and reflective practice that continues fostering the maturity of transition design as an emerging methodology.

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