Exploration of Disruption from Digital Transformation through the ARIES Framework Enterprise Element Model

by

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Abstract
Never before has disruption arising from digital transformation been more starkly obvious and relevant than amid the ongoing COVID-19 global pandemic with the increasing focus on digitalisation to address the many challenges presented by public health orders that limit human-human interaction.

Whilst a global pandemic is inherently a disruptive event, catalysing and bringing to the fore other disruption, change as a result of digital transformation has been present in business for at least the last decade manifesting in such things as change in business ecosystems and stakeholder landscapes (amongst others). Consequently, such fundamental, transformative change has invited a deeper understanding of emergent trends by many researchers from various domains. Arguably however, a piecemeal rather than holistic approach to exploring different enterprise elements has dominated.

Using a semi-systematic literature review methodology, this thesis purposefully takes a holistic approach to contribute a meta-analytical synthesis of findings and observations to the existing body of knowledge. By anchoring and structuring the research around the ARIES Framework Enterprise Element Model, and leveraging object-process methodology and diagrams from the systems thinking discipline, this thesis explores a cross-section of research domains using the Scopus® database of curated academic literature in addition to other select, reputable sources. Distilling findings across the ten ARIES Framework enterprise elements, this thesis finds that digital transformation is profoundly transformative for enterprises because it is fundamentally about organisational change rather than simply technological adoption. Consequently, enterprises often cited as exemplary and characterised as digital natives: (a) embrace necessary change around organisational elements such as culture, leadership, creativity and knowledge management in support of their digital aspirations; (b) challenge established paradigms of technology integration and digitalise processes at all levels of the enterprise; (c) readily pivot to new business models which capitalise on coopetition, leverage reduction in information asymmetry between the enterprise and its customers, and support monetisation opportunities for information assets; (d) make no distinction between enterprise and digital strategy; (e) are anticipant of the cybersecurity policy landscape; and (f) continuously evaluate the enterprise in light of emerging decentralised and democratised solutions to societal needs.

The culmination of the observations and findings is a single, unified object-process diagram or ‘blueprint’. The blueprint characterises an enterprise-wide response to the disruptive, emergent trends arising from digital transformation synthesised from the research, and provides a holistic birds-eye view and orientation for addressing digital transformation across an enterprise.

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FOR GIA AND SABI.

ACKNOWLEDGEMENTS

There is some irony in undertaking a thesis on the topic of digital transformation when stuck 15,000 km away in the opposite time zone to your thesis supervisor because of a global pandemic. Suffice to say it can be a frustrating and solitary experience. Nevertheless, as the adage goes, 'it is all about perspective', and it has undoubtedly provided a unique opportunity to learn more about myself and discover what fundamentally motivates me both as a scholar and a person in the memorable academic year of 2020-2021. I came to write this thesis not as a first choice but as a second. However, far from being a consolation prize, this thesis has become a labour of love. Perhaps it is because I have always been fascinated by technology and am old enough to remember life before the internet and mobile phones. That 'old-school' perspective has made exploring the topic of digital transformation an inspired endeavour and an incredibly rewarding experience. Most importantly, I have come to learn this about myself – that irrespective of a first or second choice of thesis topic, I enjoy thinking about the bigger picture, and I am driven to explore uncertainty in emergent trends that ultimately define what the future holds.

First and foremost, I have to thank my employer Chevron. Their sponsorship and support of this masters program and enabling me to step away from the office for a year of full-time study is a privilege not lost on me. It is a life-changing opportunity. A special thanks to the commercial leadership team of the Australian business unit, whose support and readiness to assist in every way possible has made this challenging experience a little bit easier. An extra special thanks to my manager David Kagi. His always being ready to encourage, support and offer good advice made a world of difference. A heartfelt 'thank you' David, it meant a lot every time. I also need to thank the digital scholar program team at Chevron for their support throughout. Especially Shana Bolen and Chevron fellow Margery Connor who were always in my corner providing encouragement and support. A heartfelt 'thank you' to you both. I could not have done it without you.

If I have got nothing else right in this thesis, then at least I selected the right supervisor in Dr Donna Rhodes. I cannot thank her enough. She has been instrumental in my getting to the end of this experience. Without her patience, wisdom, good advice and self-less sharing of her time, I would not have made it this far. I was absolutely lacking clarity in both the questions I wanted to ask and the answers I was hoping to find, but she helped me get there nonetheless. 'Thank you' Donna. Also, a thank you to Professor John Sterman and the teaching staff at the Sloan Sustainability Initiative for their good guidance and support early in my thesis journey. Then like Google Scholar says in its tagline below the search bar … 'Stand on the shoulders of giants'. I have certainly done this throughout my entire MIT experience. I would not have made it this far without the guidance and support of the 'giants' that are my fellow cohort (especially the Chevron crew and TA Elizabeth Baker). You all kept me sane, and I definitely would not have gotten this far without you.

Of course, a big thanks goes to my family. My parents, Salvatore and Emilia Lucioli, who have made endless sacrifices to afford me every opportunity to study so that I may have a better life. Your example and the tremendous work ethic and resilience you instilled in me has always served me well. Thanks also to my brother Luca Lucioli for being an inspiring sounding board over the years for so many ideas in the technology space.

Last but certainly not least, a heartfelt thank you to my dear wife and children. To my wife, Melissa Lucioli, whose name deserves to be on this masters degree as much as mine, I could not have done this without you. Your support in keeping our family unit together whilst I have had my head buried in this year of study is something I hope to one day repay. I love you from the bottom of my heart. And to my children, Gia and Sabatino Lucioli. You are the reason for my existence. Thank you for understanding when I have been absent the past year and missed out on some of our family time. If you read this one day, then know that writing this little thank you is one of the most exciting parts of this whole thesis. Your amazement at the world and the beautiful questions you both ask always inspires me to want to learn and understand more, and your unconditional love is what keeps me going. I hope one day I can provide the same opportunity for you. I love you both more than you will ever know.

Table of Contents

List of Figures

List of Acronyms

AI	Artificial Intelligence
APQC	American Productivity & Quality Center
ARIES	ARchitecting Innovative Enterprise Strategy
BEA	Bureau of Economic Estimates
CD	Compact Disc
CDR	Corporate Digital Responsibility
CeFi	Centralised Finance
CIO	Chief Information Officer
COVID-19	2019 Coronavirus Disease
CSR	Corporate Social Responsibility
DDI	Digital Disruptive Intermediary
DeFi	Decentralised Finance
DNE	Digital Native Enterprise
DSI	Digital Social Innovation
DT	Digital Transformation
DVD	Digital Versatile Disc
EA	Enterprise Architecture
EAF	Enterprise Architecture Framework
EBIT	Earnings Before Interest and Taxes
EC	European Commission
ET	Enterprise Transformation
GDP	Gross Domestic Product

IT	Information Technology
IoT	Internet of Things
KM	Knowledge Management
MIT	Massachusetts Institute of Technology
MP3	Moving Picture Experts Group Audio Layer 3
MP4	Moving Picture Experts Group Audio Layer 4
OPD	Object-Process Diagram
OPM	Object-Process Methodology
SME	Small and Medium Enterprise
SSLR	Semi-Systematic Literature Review
U.S.	United States of America
USD	United States Dollar
WEF	World Economic Forum
ZB	Zettabyte

Chapter 1 – Introduction

"Like air and drinking water, being digital will be noticed only by its absence, not its presence" – Nicholas Negroponte[1] (Wired, December 1998)

Myriad sage quotes from a plethora of disciplines are likely equally fitting to introduce this thesis.

Domains such as enterprise and business disruption, competition, transformation, architectures, frameworks and systems, all have profound truisms relevant to the subject of digital transformation (DT) as addressed herein. For example, one other (arguably equally fitting) prefacing quote considered was: "... 'Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!'" (L. Carroll, 1875)[2]. This often-cited quote refers to 'Red Queen' competition, a concept applied to business by many thought leaders to describe competing enterprises on an accelerated and perpetual quest for relevance. When experiencing such competition, organisations are compelled to respond with out-of-the-box thinking that often impacts leading market incumbents, giving rise to what is ultimately observed as disruption.

Notwithstanding, the selected quote above is arguably more fundamental, alluding to the most critical observation of 'digital', its ubiquitousness. Few would likely dispute this in the modern world, especially in business and enterprise, where its absence is in stark contrast to its presence, now virtually assumed. Moreover, responding effectively to competition and

[1] Nicholas Negroponte is the founder and former director of MIT's Media Lab and the author of the best-selling book, 'Being Digital' (*Nicholas Negroponte*, n.d.) and made the prophetic statement less than a decade after the advent of Web 1.0.

[2] Lewis Carroll's classic tale 'Through the Looking-glass: And what Alice Found There' was referenced by famed biologist Leigh van Valen in 1973 when he coined the term 'Red Queen' competition. He analogised his 'Red Queen' competition concept to the conversation between the Red Queen and Alice in Lewis Carroll's classic in the context of evolutionary and ecological theory. In this way he explained that an entity's evolution is inexplicably linked to their interaction with one another because of the need for continual change amongst the participants of a dynamic system in order to maintain relative fitness (van Valen, 1973).

disruption arguably necessitates an increasingly holistic view to mirror the pervasiveness of DT. In turn, this demands addressing the outward- and inward-facing dimensions of an enterprise such as the ecosystem it operates in, external stakeholders, company strategy, organisational structure and infrastructure it utilises (amongst others).

Further, never before has DT been more topical or relevant than amid the ongoing COVID-19 global pandemic. Public and private enterprises are experiencing disruption to their core. They face the challenges of ensuring critical institutions and services continue to function effectively when public health orders require limiting movement and contact. Suffice to say, the need to physically distance and limit human-human interaction, as the first line of defence against the coronavirus, has accelerated the digitisation and digitalisation of almost every aspect of modern society. Furthermore, this acceleration has led to enterprises increasingly aiming to have the virtual world mimic the real one in response to ever-escalating demands from stakeholders.

This chapter introduces and provides a brief grounding in some of the domains and concepts above. It also elaborates on the motivation behind this thesis, the questions it aims to address, and the methodology utilized. Finally, it provides a brief outline of the thesis organisation.

1.1 Background and Motivations

The birth of 'ones' and 'zeroes' in 1940 (and conceivably perhaps their first application to business)[3] predates the internet. However, despite the development of the first electronic computer in 1946, the invention of the transistor in 1948[4] and the modern computing industry growing and developing for the next four decades thereafter (Copeland, 2000), the current digital era is often thought about synonymously with the advent and widespread adoption of the internet in the 1990s as a result of companies such as Microsoft, Amazon, Yahoo and eBay and technologies such as web browsers and Java (Jefferson Online, 2016). These companies

[3] In 1940, MIT Professor Claude E. Shannon published his landmark master's thesis "A Symbolic Analysis of Relay and Switching Circuits" where he described how Boolean algebra could be used to simplify telephone electromechanical relay arrangements. In doing so he proved they could conversely be used to solve Boolean algebra problems (C. E. Shannon, 1940), establishing the notion of using electromechanical switching to implement logic.

[4] In 1946, Eckert and Mauchly at the Moore School of Engineering (University of Pennsylvania), developed the 'Electrical Numerical Integrator and Calculator' (ENIAC), the world's first electronic computer. Then in 1948, Bordeen, Brattain and Shockly invented the transistor whilst working at Bell Labs, enabling 2nd generation transistor circuit based computers to be developed and replacing 1st generation (mechanical) vacuum tube ones (Coleman, 2016).

and technologies forever changed the business landscape, incontestably leaving no enterprise dimension untouched.

Two salient observations made of DT (amongst many relevant to this thesis) that are plausibly at the heart of explaining the uniqueness of the paradigm shift it catalyses are its (1) diffuse and (2) self-referential nature. These are succinctly characterised by Koch and Windsperger (2017), citing others [including Yoo et al. (2010a), Yoo et al. (2010b), Bharadwaj et al. (2013), Zammuto et al. (2007) and Iansiti and Lakhani (2014)] who note that the diffuse nature of digital lowers potential barriers to entry for new players who can contribute to the digital innovation process. Moreover, because the process depends on itself, it creates a reinforcing and accelerating network effect, resulting in further innovation (Koch & Windsperger, 2017).

These observations possibly explain why there appears to be an impact on all enterprise elements as DT takes hold.

1.1.1 Digitisation, Digitalisation & the Digital Transformation (DT) Space

A surfeit of definitions for digitisation, digitalisation and DT exist from the extant literature. Saarikko et al. (2020) present a helpful summary and note that understanding the relative scale and scope is crucial beyond the importance of differentiating between definitions. Further, they also suggest subsumption occurs. Essentially, digitisation is nested within digitalisation, which is nested within DT, as depicted in Figure 1 (Saarikko et al., 2020).

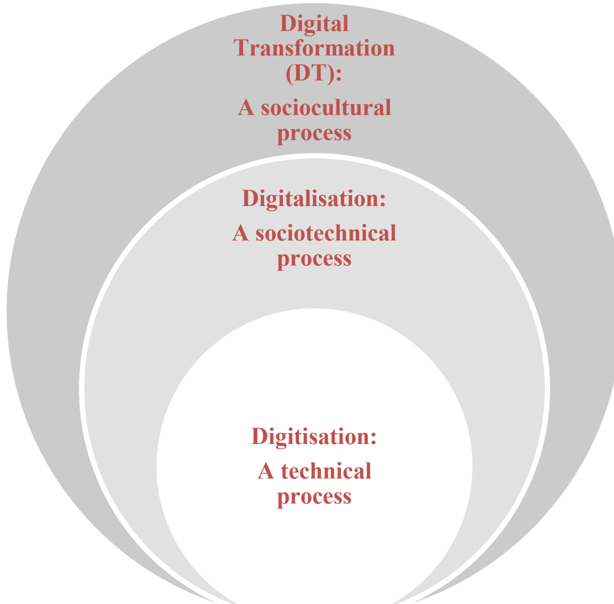

Figure 1 - Nesting of Concepts of Digitisation, Digitalisation and DT

Beyond providing a helpful summary, Saarikko et al.'s notion of these concepts being nested within one another is adopted in this thesis to highlight that:

- An understanding of DT requires an understanding of digitalisation, which in turn requires an understanding of digitisation;
- There is often an inconsistent interchange between the use of the terms 'digitisation' and 'digitalisation' that results in loss of critical conceptual differences between them, and
- The primary concern of the exploration herein is the outermost circle in Figure 1, that is, DT.

Also, as Saarikko et al. insightfully note, hidden layers of complexity exist with respect to what each term means relative to the elements of an enterprise and how organisations understand and perceive them (Saarikko et al., 2020). Thus, it is useful to briefly describe and juxtapose each term to ensure clarity and avoid confusion.

[NB: The definitions below are from mostly paraphrasing Saarikko et al. (2020) citing several other authors[5] except where otherwise noted or not referenced]

- Digitisation is the process of converting analog information to digital (a technical process). It describes the form and function[6] (in terms of capabilities) of a system of technologies, and hence, it is the innermost circle (and precondition) in the nested relationship shown in Figure 1. By digitising, the coupling between form and function of data (and information) is 'loosened'. The example cited by Saarikko et al. is the digitisation of music. There is a tight coupling of analog data (music on a vinyl record) with its form (the vinyl record). However, once digitised, the same data becomes less attached to the form (computers, smartphones and other devices can use the same MP3 file formats). Further, assuming there is an available sensor, the scope for capturing digital data is virtually limitless, resulting in the many 'smart' devices available today. Further integration of digital data enables software algorithms that give rise to the advanced technologies now commonplace (Saarikko et al., 2020). Arguably then, digitisation is now almost assumed and expected for all data and, by corollary, information in the modern world.

- Digitalisation is a higher-level abstraction. Compared to digitisation, which is concerned with form and function, digitalisation is a socio-technical process that affects all elements of the enterprise. It subsumes digitisation to create a new value proposition. In doing so, it addresses the reason for digitisation being necessary in the first place (for example, in the form of new organisational structures and business models). In essence, it answers the 'what', 'why' and 'how' questions of digitisation's relevance to an enterprise. Saarikko et al. (2020) revisit the example of music to exemplify that greater form agnosticism has changed access and consumption of music. This fact is relevant to the music industry's stakeholders and ecosystem[7], for example, how performers and

[5] Other authors include Tilson, Lyytinen, & Sørensen, Porter & Hepplemann, Brynjolfsson & McAfee, Kathan et al., Benjamin & Levinson, Grover et al., Vial, Kane et al., Kohli & Grover, Kaplan & Haenlein, McAfee & Brynjolfsson, Prince et al., Westergren et al., Jacobides et al., Rong et al. and Saarikko et al. (from separate research).
[6] Section 1.1.4 below describes the ideas of form and function in greater detail as they are relevant to systems thinking.
[7] The terms 'ecosystem' and 'stakeholders' are specifically relevant to the ARchitecting Innovative Enterprise Strategy (ARIES) Framework further described Section 2.2 below.

producers monetise their work and how distribution channels operate. Therefore, it is undeniably relevant and impactful to enterprises concerned with that industry (for example, the streaming business model adopted by platforms like Spotify, which has disrupted the compact disc industry). Digitalisation can therefore affect the use of products and the nature of business. In the music industry example, it shifts monetisation of offerings to a model that favours service access and use instead of discrete product sales (Saarikko et al., 2020). In doing so, digitalisation results in wide-reaching impacts on all enterprise elements.

- Digital Transformation (DT) as distinguished from the digitization and digitalization described by Saarikko et al. (2020) is a term from the 'recent past' (only a decade or so old) and is a comparatively more nascent research area in contrast to digitisation and digitalisation. Although the term appears prior to the last decade, it was more liberally interchanged with digitisation and digitalisation. Credit for first coining the term, as intended by Saarikko et al. (2020), generally goes to the authors of the landmark publication entitled "Digital Transformation: A Road-Map for Billion-Dollar Organizations"[8] (Westerman et al., 2011). Like digitalisation, where focus shifts from a technical process to a sociotechnical process, it follows the same subsumption pattern and envelopes the sociotechnical process to shift concern to broader sociocultural processes. It is also concerned with the entanglement[9] of digitalised enterprise elements, which ultimately speak to societal aspects (for example, impact on the workforce from advancements in automation). The DT space is the landscape that results from this complex entanglement, often because of the intersection of physical and virtual. Combined with the diffusion and self-referencing nature alluded to in 1.1 above, the intersection of physical and virtual has wide-reaching implications for society (Saarikko et al., 2020) and, therefore, enterprises and business. Consequently, this invites and aligns with a more profound, holistic understanding of the impacts resulting from disruption arising from DT (a central tenet of this thesis).

1.1.2 Enterprise Transformation (ET) & Business Disruption

[8] The publication is a joint study conducted by the MIT Center for Digital Business and Capgemini Consulting and widely considered to be one of the top thought-leadership publications of the last few decades.
[9] The concept of entanglement is further explored in the context of the ARIES Framework in section 2.3 below.

From an elementary transformation theory perspective, enterprise transformation (ET) is concerned with either experienced or perceived value deficiencies. Such value deficiencies generally result in one of three outcomes with a broadly increasing degree of transformative impact: (1) an improvement in how an enterprise delivers on its existing value proposition; (2) a change in the way the enterprise delivers on its existing value proposition; or (3) a change in the value proposition an enterprise delivers (Rouse & Baba, 2006). Moreover, value deficiencies arise due to disruption, whose source is internal or external to the enterprise. Such disruption fundamentally affects one or more enterprise elements (especially strategy). It therefore impacts how business is done, how value is delivered, and how the enterprise relates to the environment it operates in (Assar & Hafsi, 2019).

Revisiting the definition of DT in 1.1.1 in light of how ET is defined, arguably, a case exists that the DT space is a domain that is a type of ET space. It is often referred to as disruptive because it can touch all elements of an enterprise and profoundly impact its value proposition and how it competes in an ecosystem (Assar & Hafsi, 2019). That is, DT is an instance of ET that gives rise to business disruption. Further, to understand the outcomes of the disruption, an understanding of both the fundamental change taking place and the enabler of that change is necessary (Rouse & Baba, 2006).

Traditionally, to address DT, a traditional enterprise architecture (EA) management approach is adopted to focus on the technological aspects of the change. However, there is recognition in the literature that this approach is inadequate to deal with the broader scope of DT and address the non-technological elements of change (for example, organisational elements). Other domains like change management often deal with such elements (Assar & Hafsi, 2019), and consequently, this suggests exploring DT may benefit from integrated, holistic approaches. One such approach is enterprise architecture frameworks (EAFs) described below.

1.1.3 Enterprise Architecture (EA) & Frameworks

The concept of architecture frameworks stems from the systems and software engineering discipline. In this domain, the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) define architecture as *"fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the* *principles of its design and evolution"* and architecture framework as *"conventions, principles and practices for the description of architectures established within a specific domain of application and/or community of stakeholders"* (ISO/IEC/IEEE, 2012).

It is little coincidence that the history of EA links to the Information Technology (IT) space. The traditional focus of EA has been on addressing IT capabilities and business process elements to assist organisations in effectively responding to business imperatives and disruption as part of ET (Mittal, n.d.). Credit for early EA work often goes to Professor Dewey Walker and his work on IBM's Business Systems Planning (BSP[10]) approach while at IBM in the 1960s when IBM was motivated to integrate business and technology to steer investment and technology decisions (Zachman, 1982). BSP subsequently evolved in the 1970s and 1980s to ultimately become the 'Zachman Framework™'[11] (Sowa & Zachman, 1992), and often-cited foundational (and arguably more ontological) enterprise architecture framework (EAF). Other commonly cited EAFs include: FEAF – the (U.S.) Federal Enterprise Architecture Framework (The Chief Information Officers Council, 1999); DoDAF – the Department of Defense Architecture Framework (U.S. Department of Defense Chief Information Officer, 2010); and TOGAF™ – The Open Group Architecture Framework (The Open Group, 2018).

The various EAFs described above illustrate that (1) there are choices in EAFs to classify and organise elements that define and describe an enterprise, and (2) most EAFs derive from EA management of IT systems and possibly lack a holistic view. This thesis selects the ARIES Framework (specifically, the Enterprise Element Model) as further described 2.2.

1.1.4 Systems Thinking & Object-Process Diagrams (OPD)

Connected to the ideas and concepts covered in 1.1.3 (which leads to EAFs and the selected ARIES Framework Enterprise Element Model) is the notion of a system and the domain of system thinking. The International Council on Systems Engineering defines a system as *"... an arrangement of parts or elements that together exhibit behaviour or meaning that the*

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[10] BSP – Developed internally at IBM (and later commercialised) as a strategy-oriented enterprise analysis tool to describe an enterprise in terms of its information characteristics (Zachman, 1982).

[11] John A Zachman was Professor Walker's successor at IBM, and in collaboration with Dr. John F. Sowa, the computer scientist best known for inventing conceptual graphs (*JFS Biography*, n.d.), expanded his original EAF to produce the 'Zachman Framework™' more commonly seen today.

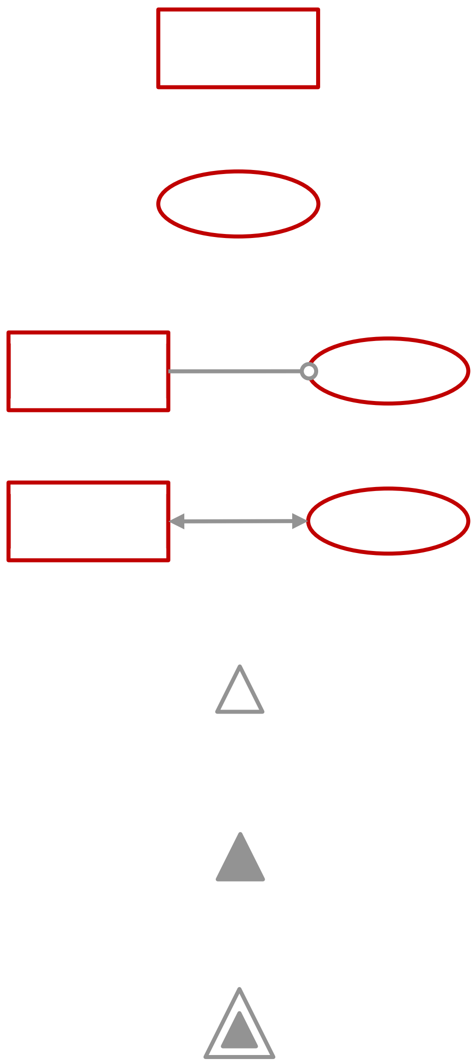
individual constituents do not" (INCOSE, n.d.). Crawley et al. (2016) cite three key aspects (1) the notion of elements of the system having a functionality, (2) a relationship existing between the elements, and (3) the adage 'the whole is greater than the sum of the parts', also referred to as 'emergence' (Crawley et al., 2016).

Returning to the concept of architecture discussed in 1.1.3, the 'system architect' uses architecture to describe and depict a system in terms of its constituent elements and their relationships in an abstract way (Crawley et al., 2016). Systems thinking, therefore, becomes another way to reason and think, and can be thought of as sitting alongside other modes of reasoning, such as critical, analytical or creative thinking. It enables the complexity of a challenge (i.e. a question, circumstance or problem) to be decomposed in terms of a system as previously defined. That is, elements that have a function and relationships to one another and, when considered together, exhibit behaviour and meaning that is greater than the individual elements in isolation (Crawley et al., 2016). In doing so, the system architect can ideate and analyse those decisions that define the system at a level of abstraction matching the complexity of the challenge of concern by depicting them in an 'architecture'. Therefore, the architect arrives at an architecture that defines the system's 'form and function'[12] and the constituent element's form and function, as well as their relationships, amongst other requirements (Crawley et al., 2016).

Ultimately, this thesis takes an accretive approach to develop an overall system architecture for the problem space (further elaborated on in 1.2.3). It models several simplified architectures characterising the themes that precipitate exploring the ARIES Framework Enterprise Element Model elements. This thesis uses Object-Process Methodology (OPM)[13] to describe emergent themes in terms of form and function and provide visual representations using Object-Process

[12] In the systems domain 'form' and 'function' are defined terms used to describe what a system *is* and what a system *does* respectively (Crawley et al., 2016).
[13] OPM stems from object-process analysis (OPA) methodology which in turn is a combination of ideas from the software domain including object-oriented analysis (OOA) and data flow diagrams (DFDs) used to integrate system structure and procedure into a single frame of reference (Dori, 1995). OPM is selected for its simplicity in incorporating system function, structure and behaviour in a single model that represents objects and processes and is commonly represented using the object-process diagram (OPD) visualisation approach. The OPD therefore becomes an efficient and effective way to visualise a system at a desired level of complexity (Dori, 2001).

Diagrams (OPDs) with standard notation as shown in Figure 2[14] (Dori, 2011).



Object – Something physical/tangible (for example, a paintbrush)

Process (or processing) – Something that requires an instrument (see below), consumes an input and produces an output (for example, 'painting' requires a 'paint-brush', uses 'paint' and produces a 'painted' surface)

Instrument Link – The object is an instrument of the process (for example, a 'paint-brush' is an instrument of 'painting')

Effect Link – Denotes a directional effect between objects and processes which can be either unidirectional or bidirectional (for example, 'stirring' will affect 'paint')

Generalisation-specialisation relation – Denotes a 'type-of' or 'instance-of' relationship (for example, 'to paint' is specialisation of 'to change' [because by painting something we change its surface])

Aggregation-participation relation – Denotes a 'whole' to 'part-of' relationship (for example, paint tin 'handle', paint tin 'lid' and paint tin 'can' are parts of a whole paint tin)

Exhibition-characterisation relationship – Denotes a 'feature' or 'characteristic' of an object or process (for example, paint can have the characteristic of being glossy or matte)

Figure 2 - OPD Symbols and Definitions[15] (adapted from Dori, 2011)

OPM stems from object-process analysis (OPA) methodology, which in turn is a combination of ideas from the software domain, including object-oriented analysis (OOA) and data flow diagrams (DFDs) used to integrate system structure and procedure into a single frame of

[14] This thesis focuses on high-level concept of form, function and relationships in support of an enterprise-wide view at an appropriate level of complexity. Consequently, Figure 2 does not show the full OPD symbol set and only includes those symbols used in this thesis in the interest of simplicity.
[15] NB: Examples cited in Figure 2 are not from Dori (2011) but have been included to illustrate the definitions presented by Dori in his paper.

reference (Dori, 1995). OPM is selected for its simplicity in incorporating system function, structure and behaviour in a single model that represents objects and processes. It is commonly represented using the object-process diagram (OPD) visualisation approach. The OPD therefore becomes an efficient and effective way to visualise a system at a desired level of complexity (Dori, 2001).

As this thesis moves through each of the ARIES Framework Enterprise Element Model elements, it presents OPDs for each element. It culminates in a final integrated OPD (a 'system of systems' – as shown in Appendix 1: Object-Process Diagram (OPD) – 'Blueprint' for Holistic Enterprise Response to Emergent Disruptive Themes from DT).

1.1.5 Personal Motivations

I am fascinated by the ubiquitousness of digital technology. Most stark is how it is seemingly both the cause and solution to many problems. It has capacity for disruption at the most fundamental levels; yet it has also undoubtedly revolutionised connectivity and knowledge dissemination, arguably improving understanding and awareness of many of society's issues.

Working for a large multinational with a rich history of business success in the pre-digital economy, I am curious about the transformative change it catalyses. I am interested in how enterprises can ensure relevance and innovate as profit pools shift and established companies and mature industries are reinvented.

I derive the most satisfaction from enterprise-wide thinking, particularly related to business strategy and development and anticipate a need for future leaders to understand better the cross-over space of DT and crucial societal needs like climate change and pandemics.

1.2 Research Objective and Questions

Establishing in 1.1 that the pervasiveness of digital causes DT and ET efforts to become increasingly indistinguishable and necessarily intertwined, this thesis explores and characterises the disruptive trends that emerge. Ultimately, it modestly aims to contribute to the body of knowledge by producing a single unified blueprint representing a holistic enterprise response, the artefact in Appendix 1.

1.2.1 Problem Space Description & Definition

The value of seeing an enterprise as a system and knowledge of that system being the lever to altering its behaviour is a noteworthy observation by pre-eminent MIT Professor Jay W. Forrester[16] (Church, 2016). Professor Forrester noted the value of a structured, systematic and holistic approach to assessing an enterprise. He also noted that combinations of mismatched enterprise elements, due to organisational management by committee, intuition and 'historical happenstance', predetermine failure (Forrester, 1991).

Distilling the ideas (and interconnections between them) presented in 1.1 and having established the value in a systemic approach to developing a holistic view of an enterprise suggests that a problem space exists that warrants further exploration that is precisely in this realm. The problem space is thus defined by limited attempts to holistically (and systematically) assess the impact of disruption from DT across an enterprise. The extant literature is rich in observations and findings, but these require a guided synthesis to 'draw' a holistic picture of the disruptive, emergent themes.

Employing the helpful 'system thinking' technique of formulating a system problem statement (SPS)[17], the personal motivations in 1.1.5, the research objective and questions established in 1.2.2 and the problem space defined above can be effectively combined. An SPS has a distinct canonical TO-BY-USING form and enables the succinct articulation of this research's objective, motivation, and approach (Crawley et al., 2016). Adopting this TO-BY-USING approach, we can state the SPS as shown in Figure 3 and depict its associated OPD as shown in Figure 4.

[16] Professor Jay W. Forrester is known as the founder of the systems dynamics discipline (amongst many other achievements) and his noteworthy observation of seeing an enterprise as a system is captured in his observation that the human assets of an enterprise are ultimately participants in a system. They act within it subject to what the system dictates rather than being able to dictate the system's behaviour (although the uninitiated in systems may believe this to be the case). Consequently, only knowledge and understanding of the system can empower those human actors to alter the systems behavior (Church, 2016).
[17] The System Problem Statement (SPS) technique employs a basic "TO-BY-USING" canonical form and uses a similar approach to formulating a mission statement. That is, a mission statement aims to articulate what an enterprise aims to accomplish, and therefore how it defines success (Crawley et al., 2016).

System Problem Statement (SPS)	
TO	systemically *explore* digital transformation (DT) of an enterprise
BY	holistically *characterising* disruption respective to the ARIES Framework Enterprise Element Model
USING	a semi-systematic literature review (SSLR) [described in 3.2]

Figure 3 – System Problem Statement (SPS) for Thesis

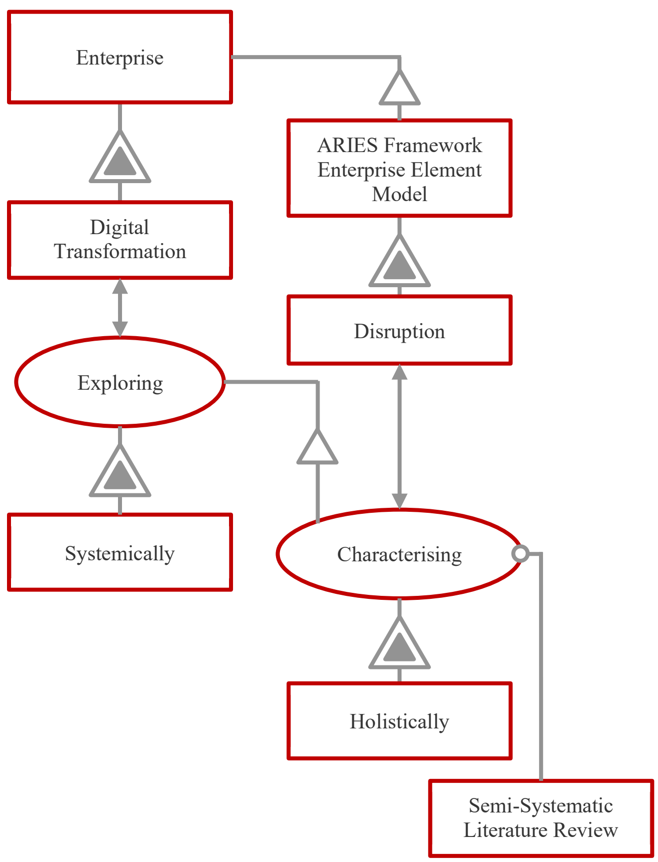


Figure 4 – Object-Process Diagram (OPD) for defined Thesis SPS

1.2.2 Research Questions

This thesis explores the research topic guided by two overarching questions:

- What are the emergent disruptive trends impacting enterprise elements as a result of DT?
- What does an enterprise-wide 'blueprint' look like for actively anticipating likely disruption?

Moreover, it aims to address the following specific questions (aligned to the ARIES Framework Enterprise Element Model elements described in 2.2):

- What ecosystem changes are being precipitated by DT?
- How does DT impact the stakeholder landscape?
- How does DT affect the approach to business models and values?
- How does DT shift the information dimension for enterprises?
- What infrastructure considerations does DT precipitate?
- What distinguishing characteristics in products and services does DT catalyse?
- How does DT affect business processes?
- What organisational characteristics does DT precipitate?
- How does DT impact the knowledge paradigm?

1.3 Thesis Outline & Structure

This thesis is composed of five chapters:

- Chapter 1 – Introduction.

  This chapter provides relevant background information. It includes a brief grounding on key concepts and definitions relied upon in this thesis, relevant to enterprise architecture and frameworks, digital and enterprise transformation and business disruption. This chapter also establishes the motivations for this thesis, questions of interest and articulates the problem space by borrowing an SPS format from the systems thinking domain to develop an initial OPD that aids in focusing the research.

- Chapter 2 – Fundamentals of the ARIES Framework.

  This chapter introduces the ARIES Framework and provides a short primer on the 'Enterprise Element Model' that is part of the framework. The model guides the semi-systematic literature review approach and is the basis for exploring disruption across the enterprise.

- Chapter 3 – Research Methodology & Design: Meta-Analytical Approach to Literature Review.

  This chapter describes the meta-analytical approach used in this thesis, including explaining the semi-systematic literature review methodology and other supplementary data sources leveraged throughout this thesis.

- Chapter 4 – Exploring Disruption across Enterprise Elements.

  This chapter presents the findings and insights resulting from independent exploration of each of the ARIES Framework Enterprise Element Model elements, constructing a basic OPD for each element.

- Chapter 5 – Conclusions.

  This chapter synthesises the findings of the detailed exploration, focussing on key insights drawn. It combines the initial OPD and the OPDs constructed in Chapter 4 into a single unified OPD (the 'blueprint'). It also notes the limitations of this thesis and recommends future work to pursue to mature this research area.

In short, this thesis begins by establishing certain fundamental knowledge that the thesis relies upon in exploring disruption to enterprises as a result of DT. It then addresses emergent disruptive themes for each ARIES Framework Enterprise Element Model element (including the construction of basic OPDs). Finally, it collates key insights and presents them as part of concluding remarks on the overall state of disruption to enterprises due to DT. Ultimately the insights are integrated into a single output artefact (blueprint) that characterises a holistic enterprise response to emergent disruptive themes stemming from DT.

Chapter 2 – Fundamentals of the ARIES Framework

Whilst EA theory and the EAFs briefly outlined in 1.1.3 provide relevant background, context and utility in their area of application, as previously established, many have typically focused on IT. They are therefore less adequate for addressing other enterprise elements stemming from historically more complementary domains. For example, organisational culture is likely to be traditionally explored in strategic management and organisational behaviour domains rather than through existing IT-grounded EAFs where it less likely to fit readily.

This observation is also made by Nightingale and Rhodes (2015), who look beyond IT to draw on broader domains (such as strategic management) to inform their work. They also posit that, in addition to the preoccupation with IT, a lack of holistic focus may also contribute to certain distinct failure types observed in their course of study and research, for example, forgetting specific stakeholders or overly focusing on technology as the solution. Ultimately, this apparent framework gap motivated them to develop the ARchitecting Innovative Enterprise Strategy (ARIES) Framework (Nightingale & Rhodes, 2015).

2.1 Intent and Relevance of the ARIES Framework to this Research

Owing to the three key reasons cited by Nightingale & Rhodes (2015) below, the ARIES framework is instrumental in guiding this research because:

- Its intended applicability is in the exploration phase of transformation
- It adopts a holistic approach
- Its intended use is early in the transformation lifecycle (to explore future state alternatives)

Further, enterprises are complex systems and thus, a methodical approach aids in reducing the complexity associated with understanding them as a whole (Nightingale & Rhodes, 2015).

The complete ARIES framework consists of three components; (1) the enterprise element model, (2) an architecting process model consisting of eight activities, and (3) selected techniques and templates to support the architecting process (Nightingale & Rhodes, 2015). For this thesis, the sole focus is on the first component, the enterprise element model.

2.2 The ARIES Framework Enterprise Element Model

Figure 5 depicts the ARIES Framework Enterprise Element Model. It typifies a complete enterprise in terms of ten ontological elements derived from the empirical research of Nightingale and Rhodes (Nightingale & Rhodes, 2015):

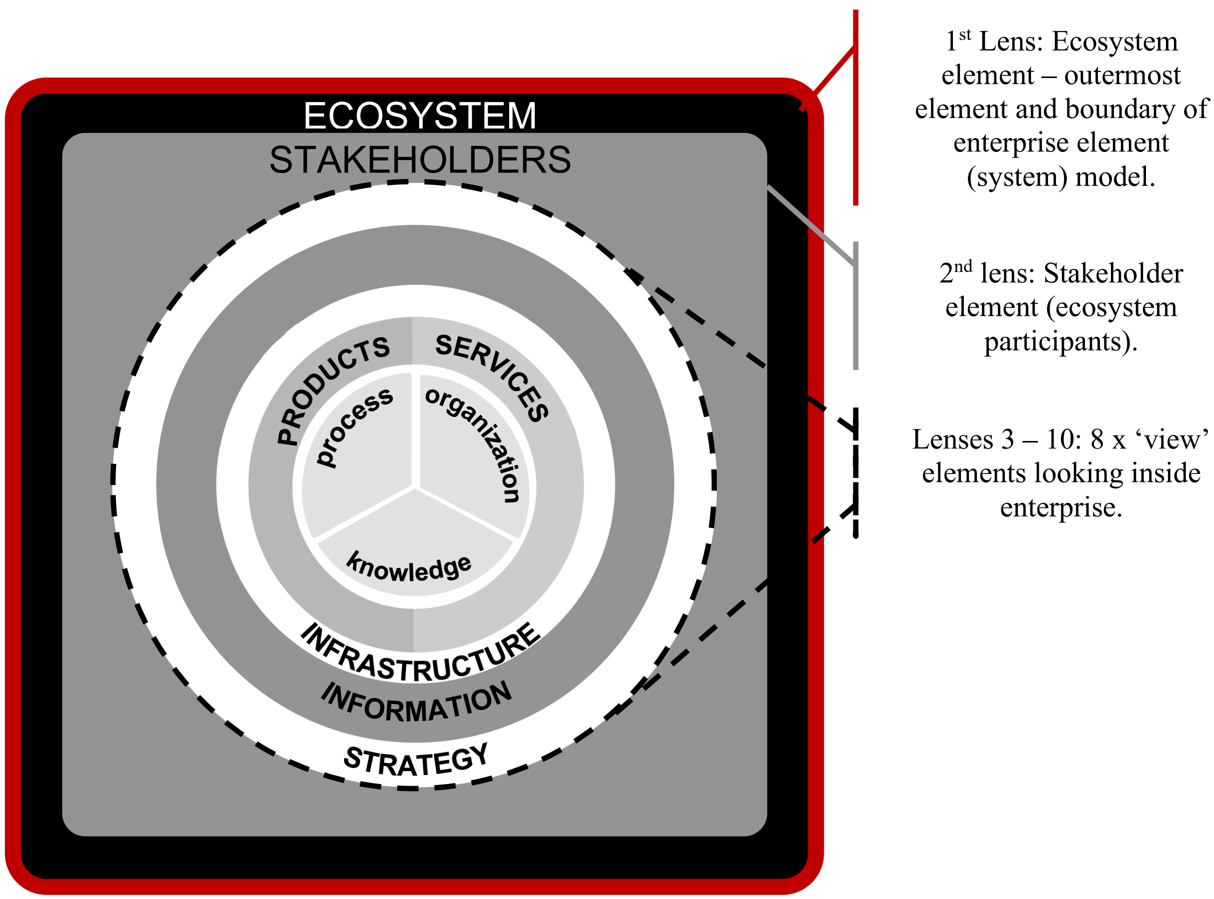


Figure 5 - ARIES Framework Enterprise Element Model (Rhodes, 2021)[18]

[18] Image reproduced with minor adaptations with permission of Dr. Donna H Rhodes (from 'Lecture 1 - Systems Architecting Applied to Enterprises: Fundamental Concepts and Architectural Thinking' delivered by Dr. Donna H. Rhodes on 6 February 2021). Used with express permission of Dr. Donna H. Rhodes limited to use in this thesis only.

Each element is a ‘lens’ (as termed by Nightingale and Rhodes). Looking through each lens or zooming in, we reduce complexity, which aids in a deeper understanding of a specific element and provides a unique perspective on the enterprise. Zooming out again, we gain multiple perspectives from various elements and a better understanding of the enterprise as a whole. Using lenses is distinctly different from adopting a single viewpoint from which to examine an enterprise that arguably provides a deeper understanding of that specific element but likely at the expense of more holistic insights, which may have otherwise revealed novel needs of other stakeholders (Nightingale & Rhodes, 2015).

As shown in Figure 5 above, the first (outermost) element is the ecosystem element. The ecosystem element delineates the boundary for the model system within which both the enterprise and a subsystem of ecosystem participants exists. Thus, the second element, the stakeholder element, is defined by a grey space within the ecosystem. Moving inward beyond these first two elements, we enter the enterprise entity proper characterised by eight ‘view’ elements (as coined by Nightingale and Rhodes), including strategy, information, infrastructure, products, services, process, organization, and knowledge elements. Each of these elements (or lenses) provides a different perspective within the enterprise system boundary. Noteworthy is (1) the enterprise is placed within the grey space of the stakeholder element because stakeholders can be internal or external to the enterprise, (2) there is a coupling between products and services, and (3) process, organization, and knowledge are interrelated, and at the center of the enterprise (Nightingale & Rhodes, 2015).

To support the explanation of Figure 5 above and provide necessary context for the research and exploration in this thesis, brief, paraphrased descriptions of each element (from Nightingale and Rhodes) are provided below.

- Ecosystem Element – This is the exogenous space relevant to where an enterprise operates. It broadly includes the political, regulatory, economic, market, and societal environment where competition and cooperation with other enterprises in the ecosystem occurs.

- Stakeholder Element – This element defines any entity (individual or group) that contributes, benefits or is otherwise affected by the enterprise. As previously noted, stakeholders may be external or internal to the enterprise. And, depending on the nature of their business, enterprises may differ on how they characterise and perceive stakeholders.

- Strategy – The strategy element reflects the enterprise's vision, values, objectives, and business model. Hence, the outermost element that bounds the enterprise proper as a system and defines the remaining seven enterprise ‘view’ elements.

- Information – The information element reflects all information required and relating to the enterprise from strategy through to operations (for example, organisational information, financial information, etc.). Hence, it is depicted inside the strategic element boundary, tightly coupled with it, as information flow supports the six elements within.

- Infrastructure – This reflects the real-world physical and virtual building blocks that enable and support the enterprise in operating effectively and executing its mission statement. It can constitute a range of building blocks from tangible hardware to less tangible cloud-based virtual enterprise platforms and advanced algorithmic software.

- Products – The product element includes items the enterprise develops, manufactures, or otherwise acquires, and in turn markets and distributes to stakeholders relevant to it.

- Services – Like products, the services element delivers value to enterprise stakeholders (sometimes in support of products). Services reflect offerings (of various tangibility) that derive from the enterprise's skill, competency, knowledge, and expertise.

- Process – The process element constitutes all enabling processes (for example, lifecycle processes) the enterprise leverages to execute its mission statement and ultimately create and deliver value for stakeholders.

- Organization – The organization element includes the structural (groups and hierarchies) and behavioural and cultural aspects (social dimension) of the relational network that defines the enterprise.

- Knowledge – The knowledge element includes implied and express knowledge. It is concerned with all knowledge the enterprise generates, holds and manifests, including resident intellectual property.

Notably, Nightingale and Rhodes suggest all elements should be considered. Acknowledging that differences in relevance and importance may exist from one enterprise to the next, especially as enterprises move through evolutionary stages of their lifecycle, they note that failing to consider any single element may cause system issues to remain hidden. Consequently, the design of the ARIES framework enterprise element model deliberately guides holistic thought. It acknowledges that elements are inextricably linked, and therefore due cognisance should also be given to their 'entanglement' as briefly described in the next section (Nightingale & Rhodes, 2015).

2.3 Entanglement of Elements in the Model

It is essential to acknowledge that examining the 'entanglement' of the elements described in 2.2 above is also necessary to understand, appreciate and reveal the underlying dynamics of enterprise behaviour (Nightingale & Rhodes, 2015).

While zooming in and out through each of Nightingale and Rhodes's ten elements provides a holistic survey view, those elements are necessarily related and connected. They interact, drive, influence and affect one another, ergo are 'entangled'. The degree of entanglement and directionality of effects will differ between enterprises and the ecosystems and stakeholders relevant to them. Entanglement may be limited to a boundary interaction in one enterprise versus a more pervasive interaction in another for the same elements. Irrespective of the degree of entanglement however, enterprise performance is implicated and thus an in-depth exploration is warranted for each specific enterprise (Nightingale & Rhodes, 2015).

While understanding entanglement is an integral part of gaining a holistic view, it is a more bespoke exploration unto itself and thus beyond the scope of this thesis. However, 5.2.2 provides ideas for future exploration.

Chapter 3 – Research Methodology & Design: Meta-Analytical Approach to Literature Review

It is perhaps especially fitting in a thesis concerned with DT to adopt a research methodology that is cognisant of the 49ZB ($1{,}000^7$ bytes) of data generated every day by humans (Vopson, 2021). Although somewhat sensational, this statistic exemplifies that humans have become adept at producing an increasing amount of fragmented information with the advent of mass storage systems, increasing data transfer speeds and decreasing data costs associated with the generation, transmission, and storage.

The academic space is, by its peer-reviewed nature, only a tiny fraction of this fragmented information. However, academic publications have nonetheless grown approximately 4% annually over the decade 2008 through 2018[19]. Thus, it is perhaps more difficult than ever to be accretive when adding to the body of interdisciplinary knowledge that contributes to the human record. Consequently, the ability to build on predecessors' work in any field of research increasingly demands the ability to distil, select and synthesise existing work effectively.

3.1 Meta-Analytical Approach

A typical starting point for many researchers in synthesising knowledge is to conduct literature reviews, an essential component of any research effort that aims to contribute meaningfully to a field or discipline. Literature reviews provide a foundational basis for educating (by disseminating old ideas) and ideating (present new ideas, concepts and insights).

The approach to literature reviews varies. Supposing empirical research is the pursuit, then the focus might be seminal or other supporting papers in the specific field of study to support the methodology and analytical approach of the research. Alternatively, a literature review can also, in itself, be an effective 'method' to use when conducting research. This approach is more generically referred to as meta-analysis and is combinatorial in nature.

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[19] As measured by the National Science Board of the (American) National Science Foundation using data from the Scopus® database (*Publications Output: U.S. Trends and International Comparisons | NSF - National Science Foundation*, n.d.)

The meta-analytical approach is an efficient way of addressing the necessary literature 'curation' effort. Interestingly, the need for such an approach pre-dates the 'big data' digital revolution. In coining the term 'meta-analysis' in 1976, Glass identified and addressed the very need to efficiently organise and manage growing bodies of academic work in many fields (Glass, 1976).

3.2 Semi-Systematic Literature Review (SSLR) Methodology

Researchers in various academic fields and disciplines, from psychology to marketing, have explored and adopted many approaches (narrative, integrative, systematic, semi-systematic) to meta-analysis and structured literature review (Snyder, 2019).

This thesis adopts a Semi-Systematic Literature Review (SSLR) methodology. An SSLR approach is flexible and typically broader, either qualitative or quantitative (or some combination of both) and not necessarily limited to being wholly systematic or strictly rooted in only academic research papers concerning the selection of research material. Such an approach is beneficial for interdisciplinary research topics. It is, therefore, more likely to be characterised by a diversity of mental models (owing to the various fields they may draw from) and where the research question is less narrow and the research areas have greater breadth. Moreover, SSLRs are notably helpful in (1) overviewing research areas, (2) framing the state of knowledge (especially where it is emergent), (3) enabling thematic analysis and pattern identification, (4) providing historical overview, (5) tracking development of research over time, and (6) mapping fields of research to illuminate opportunities for further research (Snyder, 2019).

From various standards and guidelines, Snyder, synthesising the research of others, suggests four (4) phases to assure sufficient rigour and reproducibility in results obtained from a systematic SSLR approach:

1. Designing the review
2. Conducting the review
3. Analysis, and
4. Writing up the review.

This thesis closely aligns with the four phases mentioned above in its use of the SSLR approach. However, arguably in SSLR, the boundaries of the first phase (design) are perhaps less well-defined as the research itself may iteratively inform this phase and introduce additional material.

3.3 Design of the SSLR

In designing the SSLR, a central objective is to ensure a representative sample of literature that effectively investigates the research questions of interest. To facilitate this, (1) the researcher identifies an appropriate database(s) and (2) selects search criteria that are intentional in their generation of a results dataset.

3.3.1 Scopus® Database Search Criteria Selection

This thesis selects the Elsevier[20] Scopus®[21] database (Scopus) as the preferred database to search. Scopus is a comprehensive peer-reviewed, source-neutral database updated daily with over 75 million abstract and citation records across books, journals, trade publications, conference papers and articles in press from established publishers (e.g., Cambridge University Press, IEEE, etc.). The Scopus Content Selection & Advisory Board protects the integrity of scholarly endeavour by providing independent, subject matter expert curation of data from the social sciences (~32% of active titles), physical sciences (~27% of active titles), health sciences (~25% of active titles) and life sciences (~16% of active titles) disciplines three times per year.

Scopus's advanced search features enable selective, refined searching using Boolean operators (AND, OR, etc.) across several fields (document, author, year, etc.).

Concerning this thesis, a search in Scopus for the exact phrase ‘digital transformation’, in the absence of any other search limiters, yields ~7,000 records spanning 1968 to date. Of all records, 98% have a publication date post-2011 (consistent with coining of the term in that year as previously noted in 1.1.1). The remaining 2% of records are therefore assumed to use the phrase in a different context. Further, 93% have a publication date post-2016, indicative of the

[20] “Elsevier is a global information analytics business that helps institutions and professionals advance healthcare, open science and improve performance for the benefit of humanity” (*About Elsevier*, n.d.)
[21] “Expertly curated abstract & citation database” (Elsevier, n.d.)

emergent nature of the research space (most research occurs in the last five years).

Thus, establishing the following search criteria ensures collation of a valuable, representative cross-section of literature:

1. Search for all records associated with the exact phrase ‘digital transformation’ and keywords reflecting the particular question of interest within each ARIES Framework Enterprise Element Model element, irrespective of source (journal, conference paper, etc.) or discipline (social, physical, health or life sciences). This method is consistent with the SSLR approach of being careful not to unintentionally limit search results by using overly prescriptive search criteria for specific search terms.
2. Limit the period of relevance to those articles published after 2011 and sort results by most cited and most recent. This approach ensures (1) the inclusion of only the most impactful records using the phrase ‘digital transformation’ (as intended in this thesis), and (2) the appropriate reflection of the emergent nature of the field (by giving greater focus to articles published post-2016).

The search criteria above results in a generalised Scopus query string composed as follows:

- TITLE-ABS-KEY ({digital transformation}) AND TITLE-ABS-KEY (*<INSERT SEARCH WORD>** W/n *<INSERT SEARCH WORD>**) AND PUBYEAR > 2011

Where:

A. TITLE-ABS-KEY searches for the keywords within the title, abstract and keyword list of a record.

B. PUBYEAR > 2011 limits the search results to only those records published after 2016.

C. Braces ({}) find an exact phrase

D. An asterisk (*) behaves as a wildcard character and finds all affixes of the keyword (e.g., *covid** finds records with keyword *covid* or the suffix *covid-19*).

E. W/n is a proximity operator that finds the first search term within ‘n’ words of the second search term[22].

[22] Where ‘n’ is selected on a case-by-case basis depending on the question formulated to address each of the ARIES Framework Enterprise Element Model elements.

Executing the query above processes the Scopus search according to Scopus' order of precedence rules for Boolean operators. The OR operator is processed first, followed by proximity operators, the AND operator, and finally, the date limitation. That is, Scopus:

1. Searches for documents containing the exact phrase 'digital transformation' within the title, abstract or keyword lists, THEN
2. Separately searches for documents containing all suffixes of the first search word inserted within 'n' words of suffixes of the second search word inserted within the title, abstract or keyword lists, THEN
3. Searches for documents belonging to all search result 'sets' in steps (1) and (2) above, limiting results to those articles published after 2011.

A sort occurs on the resultant set of records for each discrete search, as outlined in 3.3.2 below.

3.3.2 Refining SSLR Results

Natively within Scopus, the corpus of resultant records retrieved for each discrete search (i.e., per ARIES Framework Enterprise Element Model element) is firstly sorted by the number of citations (revealing the most popularly referenced and likely the most impactful literature), then by date (revealing the most recent and likely the most emergent literature). This ordering facilitates a more systematic review of abstracts for each record deemed relevant to the specific questions noted in 1.2.2, with a heuristic approach employed to determine relevance.

Following a review of abstracts, an assessment is made of relevant records in terms of their findings and conclusions. Similarly, if those signal ongoing relevance, the complete document is explored, with an in-depth review of the article, conference paper, etc., including a cited literature review to enrich the exploration effort.

If a record's abstract signals relevance but its conclusions and findings are less compelling to the question of interest, the record is relegated to a 'parking lot' in the event the exploration process prompts revisiting it. The SSLR process and refinement approach are summarised in Figure 6:

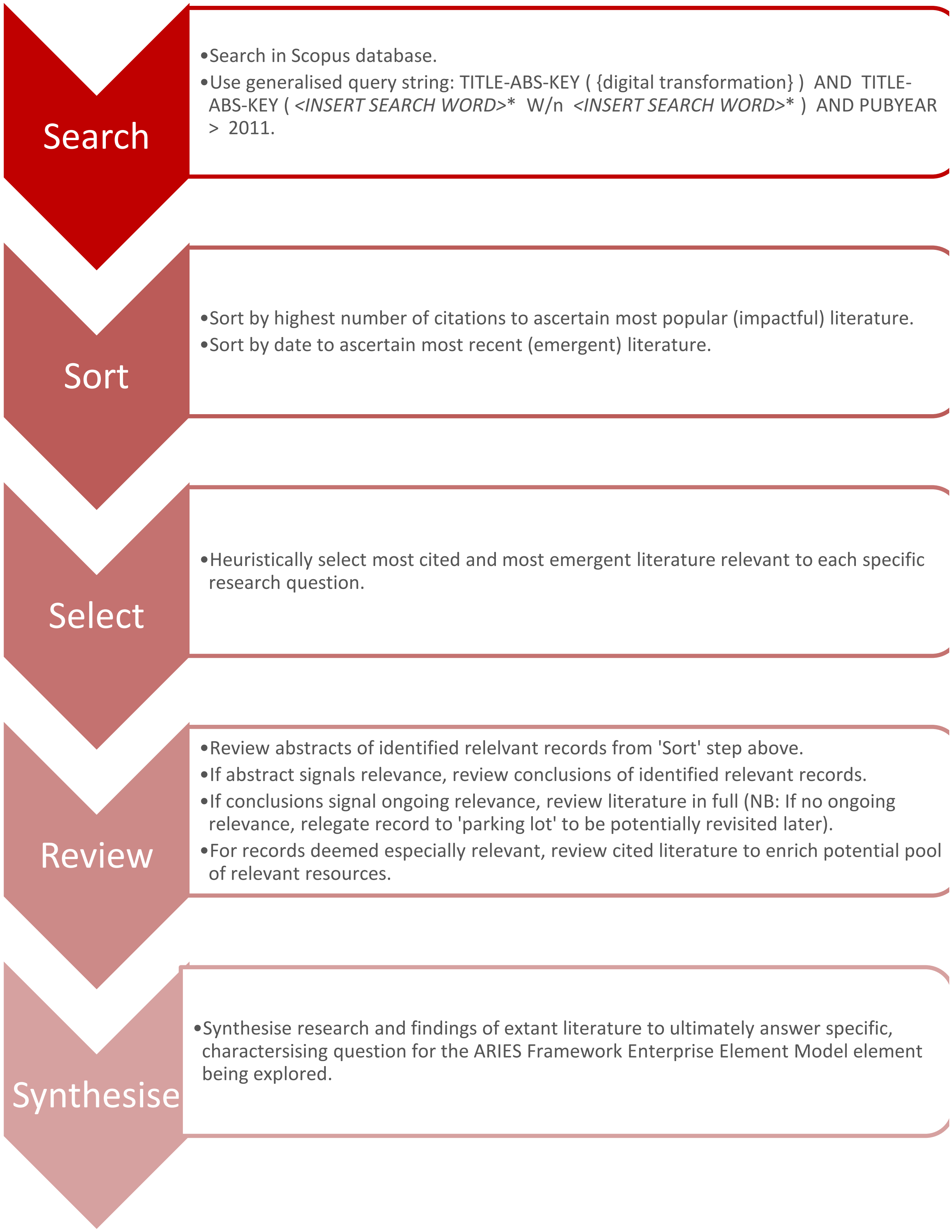


Figure 6 - SSLR Process and Refinement Approach

3.4 Supplementary Data Sources

Consistent with the SSLR approach, in addition to the Scopus database, this thesis also draws on other supplementary data sources beyond the body of extant literature generated by the peer-reviewed journals and papers extracted from Scopus. Supplementary data may include reports and information from reputable consultants and recognised expert bodies with subject matter expertise in the areas of interest to this research, especially those credited with significant and substantial contributions, such as MIT, the World Economic Forum (WEF), Capgemini Consulting, Gartner (and others). Consequently, this thesis also utilises publicly available surveys, studies, research, and reports from the aforementioned supplementary data sources.

It should be noted that certain supplementary data sources arise from reviewing literature citations of the material found using Scopus, whilst basic heuristics results in others.

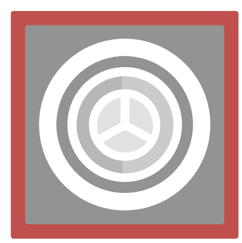
Chapter 4 – Exploring Disruption across Enterprise Elements

Chapters 1 through 3 establish the usefulness and relevance of exploring disruption from DT holistically through the ARIES Framework Enterprise Element Model. This chapter presents the synthesis of applying the meta-analytical research methodology (described in Chapter 3 – Research Methodology & Design: Meta-Analytical Approach to Literature Review) to each of the ARIES Framework Enterprise Element Model elements (described in 2.2) to address the questions outlined in 1.2.2.

Except for products and services, each section deals with a single ARIES Framework Enterprise Element Model element and concludes with an OPD characterising the outcome of the exploration for that element (in the case of products and services, 4.6 details the reasoning behind combining them).

Integration of the various OPDs from this chapter (4.1 through 4.9) with the OPD established in 1.2.1 results in a 'system of systems' representation for the totality of this thesis, presented in 5.1.2 and shown in Appendix 1: Object-Process Diagram (OPD) – 'Blueprint' for Holistic Enterprise Response to Emergent Disruptive Themes from DT.

4.1 Ecosystem Element: What ecosystem changes are being precipitated by DT?



The ecosystem within which we define the enterprise delineates the outermost boundary for the ARIES Framework Enterprise Element Model representation as previously described in 2.2. It is an exogenous space where the enterprise operates and competes, characterised by multiple dimensions including political, regulatory, economic, market and societal environment (amongst others). These combined define the ecosystem element.

In this thesis, there is an assumption that the entanglement between the political and regulatory dimensions is sufficiently entrenched to warrant exploring them as a single dimension. Similarly, economic and market entanglement makes those dimensions challenging to separate, resulting in due consideration as a single dimension.

4.1.1 Regulatory & Political.

As the fabric of society has become digitalised and virtual, the digital agenda for politicians has become increasingly relevant. In the context of the political and regulatory dimensions of the ecosystem element in the ARIES Framework Enterprise Element Model, their deliberate grouping is not without logic. Since the advent of the internet in the 1990s, political discourse has inevitably linked the two as policy conversations have sparked debate around necessary regulation to nascent challenges arising from digital technology. This link is especially evident amid the current COVID-19 global pandemic when governments face challenges such as ensuring critical institutions and services (for example, education, healthcare, social security, taxation and the democratic right to vote) continue to function effectively when public health orders necessitate limiting movement and contact. A recent forward-looking report by PwC (March 2021) supports this view, describing the six (6) 'big' challenges facing governments as (1) economy, (2) healthcare, (3) education, (4) national safety and security, (5) climate and (6) trust in government, noting 'digital' as both an enabler and accelerator in addressing each (J. Shannon & Burrowes, 2021).

Whilst the challenges noted by PwC are hardly revelations, in the current frame of a global pandemic and the context of the ubiquitousness of DT, policy changes as a result of DT are now present in almost all aspects of government debate. The use of DT as a positive equalising tool to deliver the critical services described by PwC's six challenges suggests the presence of such discourse is not surprising (J. Shannon & Burrowes, 2021). However, whilst this aspect is encouraging, it also introduces opportunities for malicious behaviour and cybercrime. And with the ramifications from cybercrime being serious, increasingly, lawmakers are making less distinction between addressing digital and physical risks (for example, sovereign border control versus government firewall incursions), deeming them equally critical (J. Shannon & Burrowes, 2021). Governments face new uncertainties as they grapple with balancing the provision of equitable services whilst preserving and protecting the rights of their citizens as economic, regulatory, legal and social dimensions become increasingly intertwined (Artemenko & Benchabane, 2020) with cybersecurity risk.

Unfortunately, even in some of the most mature jurisdictions like the U.S., there remains a lack of systemic use of national policies across government and sub-national government agencies

(Chatfield & Reddick, 2019). This disparate approach to cybersecurity policy inevitably makes assuring security for the generation, storage, and use of data more challenging and likely hinders technological advancement (Litvinenko, 2020). It is not unreasonable for enterprises to assume an increased likelihood that mature jurisdictions will seek to accelerate the enhancement of their cybersecurity frameworks. Consequently, government policymakers, regulators, and industry will likely increasingly view cybersecurity as a joint responsibility as more gaps and uncertainties are exposed.

The Australian example of the federal government's recent call for views (13 July 2021) on cybersecurity strategy (as an initiative of Australia's Cyber Security Strategy 2020) exemplifies the assertion made above. The call from the Australian government seeks to engage the private sector in a focussed discussion on the availability, integrity and confidentiality of digital information. It provides a valuable benchmark into likely focus areas for mature jurisdictions, namely: (1) governance standards for larger enterprises, (2) government support for small and medium enterprises (SMEs) to adequately mitigate cybersecurity threats, (3) personal information standards, (4) smart device labelling requirements and standards, (5) information disclosure requirements, and (6) clarity in legal remedies for consumers (*Strengthening Australia's Cyber Security Regulations and Incentives - A Call for Views*, 2021).

From the private sector's standpoint, other helpful data points are evident when enterprises look outward to the ecosystem they need to operate in. Expert studies conducted by the insurance sector, whose core business is to identify, characterise and quantify risk (and by corollary uncertainty), provide a useful data source. The Allianz Global Corporate & Speciality (AGCS) entity (part of the Allianz Group) conducts one such study. Every year for the past decade, AGCS has conducted a forward-looking survey canvassing over 3,000 respondents, across geographic regions and risk domains, stemming from Allianz's global business customers, insurance brokers and trade organisations, for their perception of the top corporate risks in the next 12 month period and beyond (*Allianz Risk Barometer | AGCS*, 2021). This comprehensive survey reveals that cyber incidents rank third after business interruption and pandemic outbreak, making up the 'COVID trio' (as dubbed by Allianz).

The Global Risks Perception Survey (GPRS) provides another datapoint with a similar conclusion. This survey, conducted by the World Economic Forum (WEF) in conjunction with insurance companies (including Marsh McLennan, SK Group, Zurich Insurance Group) and respected academics (Wharton Risk Management and Decision Process Center at the University of Pennsylvania), canvasses both the public and private sector. The results from surveying 650 business, government, civil society and thought leaders from the WEF's membership place cybersecurity failure fourth behind infectious diseases, livelihood crises and extreme weather events in the most proximal, short-term (0-2 year) timeframe and persisting in ranking eighth in the medium term (3-5 year) timeframe (Franco et al., 2021).

ECOSYSTEM ELEMENT INSIGHT 1 (Political & Regulatory) – Across the political and regulatory dimensions of the ecosystem element, enterprises should anticipate a strong focus from the political establishment, working in conjunction with the private sector, to enhance and strengthen rules and laws around cybersecurity.

Figure 7 depicts the OPD for the regulatory and political dimensions of the ecosystem element subsystem.

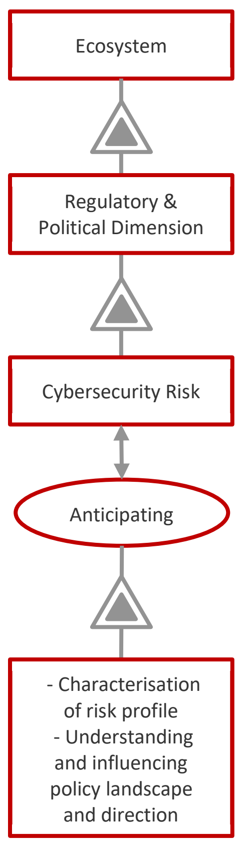


Figure 7 - Ecosystem Element Regulatory and Political Dimension OPD

4.1.2 Economic & Market.

The economic impact of DT is significant and represents an increasingly influential component of Gross Domestic Product (GDP) for many nations. Using U.S. Census Bureau economic data, the U.S. Bureau of Economic Analysis (BEA), within the U.S. Department of Commerce, began publishing digital economy satellite account[23] estimates in March 2018 to capture all goods and services associated with digital business and enterprise. The BEA has refined their estimates annually (in April 2019 and again in August 2020) with their most recent report published in June 2021 containing updated data spanning 2005 through 2019.

This latest BEA data shows the digital economy consistently growing at between 2 to 5 times the rate of the total U.S. economy (the world's largest) and representing almost 10% (9.6%) of GDP or just over $2 trillion U.S. dollars (USD 2,051.6 billion) in 2019 (compared to circa 8% in 2005). In the top 10 sectors of the U.S. economy, which represent over 85% of U.S. GDP, the digital economy now ranks fourth behind real estate (including rental and leasing), government and manufacturing sectors. The digital sector is now ahead of finance (and insurance), professional (including scientific and technical) services, health care (including social assistance), wholesale, retail and information sectors (*Digital Economy | U.S. Bureau of Economic Analysis (BEA)*, n.d.). At a global level, the Brookings Institution[24], citing research conducted jointly by Huawei Technologies Co. Ltd. and Oxford Economics, reports a global value for the digital economy of approximately $11.5 trillion U.S. dollars and 15.5% of global GDP. It also reports growth of the digital economy at circa 2.5 times faster than global GDP (Henry-Nickie et al., 2019) over a similar timeframe to that analysed by the BEA. This macro view highlights the increasing importance of digital to economic prosperity.

From a market perspective, DT incites and catalyses 'coopetition'[25] ('The Dynamics of Competition in This Digital Age', 2020) and blurs, redraws or removes boundaries in traditional markets. Underlying connectivity in market infrastructure fundamentally reshapes markets

[23] Satellite account data is supplementary to, but consistent with, core economic account data of an economy (*Digital Economy | U.S. Bureau of Economic Analysis (BEA)*, n.d.)
[24] The Brookings Institution is a not for profit organisation that conducts research in the public policy space ('About Us', 2016)
[25] Coopetition – A term coined by Adam Brandenburger (Harvard Business School) and Barry Nalebuff (Yale School of Management) in 1996, with the publication of their book of the same name (*Co-Opetition by Adam M. Brandenburger, Barry J. Nalebuff*, n.d.), to describe cooperation and competition coexisting

since organisations can grow markets by sharing technology investment costs and expanding networks while competing within and between them (Weill & Woerner, 2015).

Empirical research by McKinsey in 2017 anticipates shifting (and skewed) profit opportunities as these new markets emerge (Bughin et al., 2017). On average, DT depresses revenue growth and EBIT[26] for enterprises whereby an approximate tripling of digital penetration will double the current contraction in average revenue growth and average EBIT growth. This doubling of contraction for every tripling of digital penetration results from DT precipitating a reduction in economic friction and increased competition (Bughin et al., 2017).

However, McKinsey also reports that whilst averages show a decline, revenue and profits are highly inequitably distributed amongst enterprises relative to their DT performance (Bughin et al., 2017). From a strategic perspective, top-quartile performers in DT will see a disproportionate growth in revenue and profits compared to bottom quartile DT performers, who are likely to sustain negative impacts (with the overall average being a depression in growth rates as described above). This disproportionality suggests that DT may exacerbate the digital capability gaps between companies as market reshaping occurs. The result is significant financial gains most likely coming from companies who go beyond 'well executed DT' and create disruption (Bughin et al., 2017).

ECOSYSTEM ELEMENT INSIGHT 2 (Economic & Market) – The economic impact of DT is increasingly significant, representing material portions of GDP and anticipated to continue to grow. DT is redefining markets, and companies that can execute DT well are those most likely to precipitate profitability increases and capitalise on a burgeoning sector.

Figure 8 depicts the OPD for the economic and market dimensions of the ecosystem element subsystem.

[26] EBIT – Earnings before interest and taxes

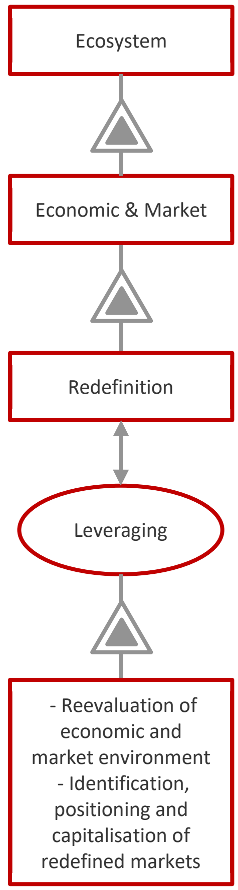


Figure 8 - Ecosystem Element Economic and Market Dimension OPD

4.1.3 Societal Environment.

The term Corporate Social Responsibility (CSR) has arguably now become part of the fabric of every modern enterprise. It signals a shift away from 'amoral' and 'immoral' business conduct (A. B. Carroll, 1991) and toward one that places 'people' and the 'planet' on equal footing with profits, otherwise known as the 'triple bottom line' ('Triple Bottom Line', 2009). Whilst enterprises across the globe have embraced (to different extents) societal pressure to be good corporate citizens; they risk disruption from a coalescing of DT and CSR in the guise of Digital Social Innovation (DSI).

In 2015, the European Commission (EC), Directorate-General of Communications Networks, Content & Technology published a study entitled 'Growing a Digital Social Innovation Ecosystem for Europe', arguably first coining the term DSI to describe the nascent space. The report's principal author (Dr. Francesca Bria) defines DSI as 'a type of social and collaborative innovation in which innovators, users and communities collaborate using digital technologies to co-create knowledge and solutions for a wide range of social needs and at a scale and speed that was unimaginable before the rise of the Internet'. In its purest form, DSI is technology (hardware, networks and data) and knowledge that is open, accessible and decentralised, operating in the interest of social good (Bria, 2015). Business borne of DSI is therefore inherently addressing CSR because it aims toward addressing outcomes that more closely align with societal needs (in contrast to most capitalist enterprises that aim fundamentally for profits). Since the EC published their study, many DSI-inspired ideas have now come to the fore.

As the ultimate expression of the disruptive potential found at the nexus of DT and CSR, blockchain and 'smart contract' technology are open-source, distributed, decentralised and immutable by design with privacy at their core, making many DSI ideas viable and competitive. To put the potential into perspective, the WEF, in a study conducted in collaboration with PwC and Stanford Woods Institute for the Environment, estimates that blockchains will store 10% of global GDP (over USD 100 trillion) by 2027 (*Building Block(Chain)s for a Better Planet*, 2018). Similarly, Gartner estimates that the additional business value added by blockchain will increase almost twenty-fold in under five years, from just over USD 176 billion in 2025 to more than USD 3.1 trillion by 2030 (Costello, 2019).

One stark example of a likely viable and competitive idea forged in the DSI space is Decentralised Finance, otherwise known as 'DeFi' (where traditional centralised finance, is now labelled as 'CeFi' to distinguish the two). DeFi grew almost eight-fold during 2020, from just under USD 1 billion in January 2020 to an estimated USD 8 billion in September 2020 (Sandner et al., 2021). Established, legacy financial institutions, who traditionally provide transaction banking services, are now faced with significant disruption. At its core, DeFi offers a model that is, through its simplicity, disintermediating[27] and thus inclusionary for SMEs. DeFi represents a market opportunity worth an estimated USD 5 trillion and requires little more than access to a smartphone to remove onerous, traditional barriers and the reliance on

[27] Disintermediation – This term originates from the finance domain and was first used in the 1980s to originally describe the impact of new technology on brokerage firms in the stock market. In modern usage, it refers to the process by which intermediaries are removed from any value chain, including supply chains, transactions, or social, economic, and political relationships (Chadwick, 2016).

established relationships with finance partners. Removing long-standing barriers levels the playing field with larger competitors who have typically been in an advantageous position, with the capability and resources to secure favourable financial terms to support their business (Liao, 2021).

Perhaps the most significant level of disruption likely to stem from DeFi is the ability to provide ready access to finance to the many considered 'unbanked' (Downey, 2020) in the developing world. To appreciate the scale of such disruption, at time of writing of this thesis (August 2021), according to DappRadar.com (a site that analyses on-chain data directly from underlying blockchains), the value of DeFi is currently sitting at approximately $130 billion, a sixteen-fold increase from September 2020 (*Decentralized Finance - Rankings, Analysis and News*, n.d.).

Disruption and disintermediation are not limited to established and legacy sectors. Even arguably more immature markets, like carbon credits, are being disrupted. Projects like Moss Earth[28], a decentralised blockchain-based project is creating certified tokenised carbon credits reflecting carbon sequestered via afforestation and reforestation projects around the globe. Similarly, Greenheart CBD[29] aims to provide decentralised financing to underserved cannabidiol farmers who find it difficult to secure business finance from mainstream banks through a DeFi lending protocol, in addition to AI and drone technology support.

Disruption is also evident in the most advanced and emergent technology layers. Artificial intelligence (AI) algorithms are being decentralised and monetised by projects like Singularity.net[30], a marketplace for AI services. Similarly, projects like Iagon[31] implement decentralisation and democratisation of control in data processing and storage in the cloud computing space. Noteworthy in both cases is the intentional shift away from the influence and centralisation of the largest companies like Google and Amazon.

Motivated by the dynamic monetisation of the assets in an Internet of Things (IoT) paradigm, it is not difficult to imagine a future cohort of companies that leverage blockchain and smart contracts in radically disruptive ways (Hill, 2017). Many projects are already gaining

[28] https://moss.earth/
[29] https://www.greenheartcbd.io/
[30] https://singularitynet.io/aboutus/
[31] https://www.iagon.com/about.html

momentum and will aim to directly compete with other 'big tech' companies like Facebook, Twitter, and YouTube. Their point of difference will be deliberate decentralisation of ownership, democratisation of service, and a prevailing focus on users' privacy.

Alongside the growing activity in the DSI space, there is also growing cognisance of Corporate Digital Responsibility (CDR). CDR is linked to CSR but defined separately to account for digital technology being exponential in growth, highly flexible by nature and deeply penetrative in reach, potentially creating ethical issues for organisations delivering digital products and services (Lobschat et al., 2021). Such adverse outcomes may not always be immediately apparent. They may arise from unintended externalities of DT due to the asymmetry between the speed at which DT enables societal progress and the rate at which we're able to appreciate the effect DT has on society (Saarikko et al., 2020). For example, the disinformation resulting from the hyperconnectivity and diffusion enabled by social media platforms feeds conspiracy theories around COVID-19 vaccines. Other adverse outcomes may be more obvious, like the broad diffusion of AI displacing human labour and potentially exacerbating unemployment.

A key observation here is the competitive advantage that DSI-inspired models may hold. Corporate incumbents may need to consciously shift, change and potentially invest to address CDR issues arising from their core business or delivery of digital offerings. Comparatively, DSI-inspired models may already have such considerations at their core and may hold an immediate competitive advantage. For example, where monetisation of personal data is viewed negatively from a societal perspective, a privacy-focused, decentralised social media platform may be designed to explicitly ensure the selling of its user base data does not occur.

ECOSYSTEM ELEMENT INSIGHT 3 (Societal Environment) – Industries, enterprises and technology will see increasing disruption from DSI models that are more congruent with societal expectations and operate in the digital-societal overlap space where DT and CSR merge and converge. In this space, the capacity to disintermediate is material and readily available via blockchain and smart contract technologies. Such technologies will decentralise, democratise, reorganise and reinvent traditional business, particularly where CDR considerations are a fundamental component of the use case.

Figure 9 depicts the OPD for the societal environment dimension of the ecosystem element subsystem.

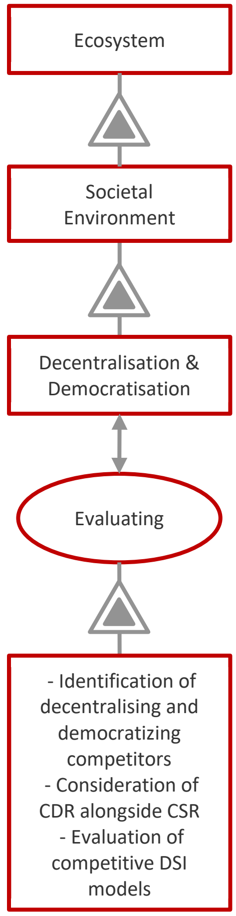


Figure 9 - Ecosystem Element Societal Dimension OPD

Combining the OPDs in Figure 7, Figure 8 and Figure 9, the complete ecosystem element subsystem can be generated as shown in Figure 10.

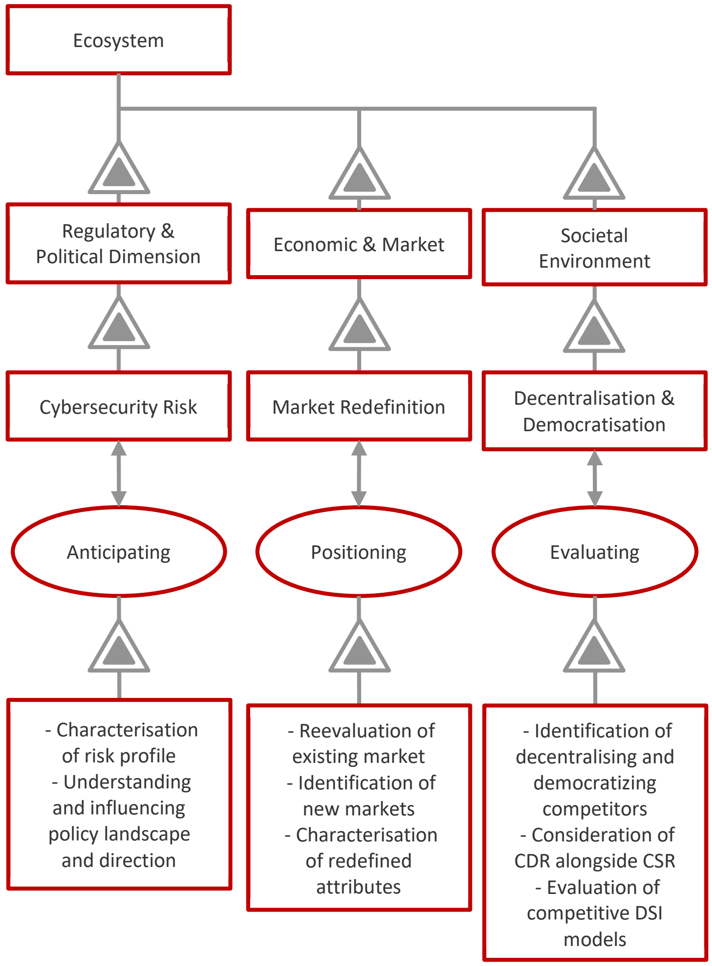


Figure 10 - Ecosystem Element OPD

4.2 Stakeholder Element: How does DT impact the stakeholder landscape?

Understanding stakeholders in many different domains (engineering, humanities, business, etc.) ultimately equates to considering the value exchanges between them. Since enterprises exist with the purposeful intent of creating and delivering value, stakeholders constitute many actors who are directly or indirectly affected because they create, transfer or receive some form of value (Nightingale & Rhodes, 2015). Since transformative undertakings like DT will impact or change how an enterprise creates and delivers value, there must necessarily be some impact to stakeholders of that enterprise. Consequently, without proper consideration, the ability of the enterprise to continue to create or deliver value may be adversely affected (Nightingale & Rhodes, 2015).

While DT can fundamentally impact stakeholders internal and external to the enterprise, one of the most disruptive changes from a stakeholder's perspective is likely to be disintermediation. The logic in doing so usually aligns with the fact that removing actors in a value chain either reduces cost, increases speed or improves efficiency (or all or any combination of these).

When technology successfully combines within an organisation, stakeholders may be removed from the value chain and replaced by software, systems, networks, and platforms. For example, IoT, cloud computing and AI can create a digital view of a physical system. The digital picture created allows an enterprise to monitor and manage the system in real-time by aggregating the data in the cloud efficiently (and cost-effectively) and enabling autonomous optimisation and decision making to occur via AI (IBM iX and University of Cambridge, 2019). When looking beyond an organisation to the ecosystem of stakeholders, similar observations concerning disintermediation are also evident. In their thematic analysis of research by others in the same field, Nadkarni & Prugl conclude that multi-sided digital platforms and networks disintermediate by matching sellers and buyers (Nadkarni & Prügl, 2021).

Disintermediation can also be deliberate and 'managed' at an industry level due to competitors acting in concert. Consortiums like VAKT[32] aim to leverage permissioned blockchain technology and smart contracts to deliberately impact the stakeholder landscape of the post-trade lifecycle in the energy sector by reducing reliance on financial institutions, brokers and other agents in the value chain for trade financing, settlement and payment. VAKT demonstrates the possibilities for sector-wide collaborative efforts between stakeholders who acknowledge market inefficiencies and archaic business models in the stakeholder landscape of suppliers, terminal operators, surveyors, agents, ship owners, brokers and banks (*VAKT Global - Commodities Post Trade Management Platform*, n.d.). The VAKT example highlights an important point around trust intermediation. Despite smart contracts and a focus on disintermediation and disruption, VAKT's use of a permissioned blockchain, as opposed to a permissionless one, highlights that aspects of stakeholder relationships traditionally reliant on trust intermediation are more difficult to disintermediate (Ritzer-Angerer, 2018).

[32] VAKT – A consortium of companies including BP, Royal Dutch Shell, Saudi Aramco Energy Ventures, Chevron Corporation, Total Energies, Reliance Industries Limited, Equinor, Gunvor, Koch Industries Inc., Mercuria Energy Group Ltd., ABN-AMRO, ING and Societe Generale

Disintermediation is arguably an ‘anticipated’ outcome of pursuing cost, speed and efficiency improvements by substitution via technology. However, the ‘other face’ to the same coin is when DT results in (digital) intermediation that disrupts the value chain. Established industries can see new third party entrants disrupting the stakeholder landscape with digital offerings that challenge ways of creating and distributing value. Researchers from Capgemini Digital Innovation Practice (Australia) and the University of Sydney Business School coined the term Digital Disruptive Intermediaries (DDIs) in 2015 to describe these new entrants (Riemer et al., 2015). DDIs are some of the biggest success stories in the DT space and include companies such as Amazon, Netflix and Uber and platforms such as iTunes (Riemer et al., 2015).

It is especially relevant to address DDIs in the context of the stakeholder element of the ARIES Framework Enterprise Element Model because although their modus operandi is digital, their differentiating feature is, in fact, their focus on the value pathway and the stakeholder landscape. They achieve this by leveraging information resources rather than traditional resources to synthesise novel service offerings and generate network effects that capitalise on market inefficiencies (Riemer et al., 2015).

Through their network effect models, companies like Uber and Airbnb exemplify the impact DDIs can have on value pathways and the stakeholders involved. By focussing on creating and owning new information streams rather than ownership of vehicles or properties, they successfully match supply and demand for transit and accommodation. Paired with a reciprocal feedback rating system, Uber and Airbnb have disrupted the traditional value pathway of the established taxi and hotel industries, respectively. Similarly, iTunes and Netflix have impacted the value pathway and stakeholders in the personal and home entertainment industry by focussing on transforming a physical product (CDs and DVDs) into a digital product (audio and video streams) and driving entire sectors in the CD and DVD market (manufacturers, retailers, rental stores, etc.) to obsolescence (Riemer et al., 2015).

STAKEHOLDER ELEMENT INSIGHT – DT can result in disintermediation from technology as a substitute or catalyse the entry of DDIs that focus on information streams in business models. In either outcome, the result will affect the value pathway, creating or destroying stakeholder relationships and thus altering the stakeholder landscape.

Figure 11 depicts the OPD for the stakeholder element subsystem.

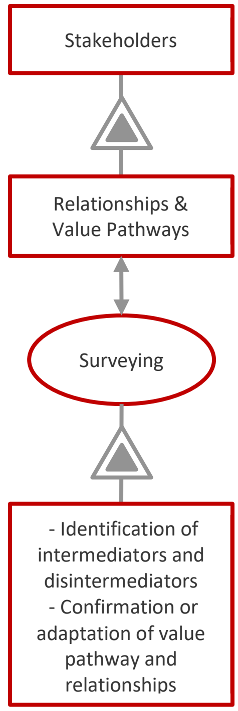
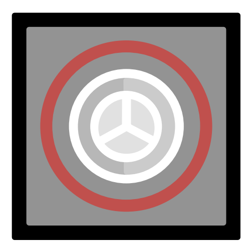


Figure 11 - Stakeholder Element OPD

4.3 Strategy Element: How does DT affect the approach to business models and values?



Traditionally, the interaction between enterprise strategy and digital strategy has been in the form of a subordinated relationship. The connection between the two has been at the functional level, where digital has been supportive of, aligned with, and directed by, overall enterprise strategy (Bharadwaj et al., 2013). However, this view has seemingly evolved as DT has taken hold. Arguably, DT causes enterprise elements, their interconnections and their relationships to become increasingly digitalised (or reliant on other increasingly digitalised elements).

Contestably, 'digital' is now a superfluous clarification when describing enterprise strategy for a modern company, such is its fundamental and inherent nature. Enterprise strategy and digital strategy are virtually indistinguishable, and there is only digital enterprise strategy with four defining attributes: scope, scale, speed, and source of value creation and capture (Bharadwaj et al., 2013). Moreover, since 'strategy' is a formula for how, what and where a company competes (Porter, 1998), the ever-escalating impact from DT on enterprise values, objectives and business models, which collectively form its strategy (Nightingale & Rhodes, 2015), has led to fundamental disruption for many incumbents.

In 2018, the WEF, in collaboration with Bain, published a comprehensive report exploring the digital enterprise. The research observed that technology and new business models change and shift notions about the business ecosystem and competition. Traditional competitive advantage, derived from being the incumbent enterprise in a business sector, can be fundamentally disrupted by DT and even turn assets into liabilities (World Economic Forum, 2018). For example, advances in internet speeds and internet-enabled televisions allowed Netflix to introduce high-quality video streaming to serve content directly to customers at home. This new digitalised offering resulted in Blockbuster's legacy business model, with physical DVDs on shelves in a brick and mortar store, unable to compete. An effective strategy in the context of DT may also demand dissolving traditional boundaries and fostering more progressive 'coopetitive' behaviour (as discussed in 4.1.2). For example, sharing data and customer information allows two enterprises to anticipate better customer needs (Casalino et al., 2019).

Ross et al. (2017) note two overarching choices in selecting a strategy: (1) customer engagement or (2) digitised solutions. Enterprises that engage customers use various digital channels to create feedback loops that connect the customer to the enterprise in meaningful ways. In doing so, they enable a more bespoke offering that fosters loyalty and trust. Alternatively, enterprises that focus on digitised solutions aim to create a feedback loop that adds incremental value to existing products and services, transforming them into solutions (Ross et al., 2017). These strategies then manifest in one or more of three salient business models (described below) that (a) revisit flows and pools of profits, (b) are often linked synergistically by data, (c) exploit network effects and (d) go beyond being an overlay to a legacy business model (World Economic Forum, 2018):

- The Platform Model – This is one of the most successful models exemplified by the fact that eight of the world's ten most valuable companies by market capitalisation (as of 31 March 2021) have adopted it (PricewaterhouseCoopers, 2021). It exploits network effects from platform usage to create exponential value for incremental unit cost, or put another way; economic activity is more efficient because transaction costs are lowered

(Artemenko & Benchabane, 2020). In doing so, the opportunities to create new (and often substantial) profit pools materialise where the majority of profit flows to the platform owner.

- The 'as a Service' Model – This model is experientially-focussed and typically technologically combinatorial. It leverages big data, cloud computing and sometimes AI in real-time to provide a rich feedback experience for customers. The goal of the model is to nurture a curated customer relationship and ensure a highly engaged customer.

- The 'Freemium' model – This model is one of the most disruptive because it adversely affects profit pools for incumbents. Value in one market is offered freely to customers (by either giving something away or as an upsell), typically in exchange for data useful to the freemium provider in a different market.

The aforementioned models result in reframing at scale of scope and value exchange with stakeholders (or creation and capture as described by Bharadwaj et al., 2013). Further, adopting new models that emerge from existing ones converging is correlated with positive financial performance (Abou-foul et al., 2021). Companies like Netflix and Amazon are exemplary in this regard.

Netflix has shifted from being a DVD distributor to an online streaming provider and now to a content creator competing and winning against established incumbents in the film and television industry. Amazon has shifted from an online bookstore to an online retailer and now to technology (and even logistics provider), competing and winning against established incumbents in retail and other sectors. Both companies have behaved as DDIs, using their rich customer data sets to inform new value creation and capture by leveraging various Platform and 'as a Service' approaches.

Thus, if reframing at scale of scope and value are the common denominators between successful DT strategy execution, then the remaining differentiating element from Bharadwaj et al. is speed, characterised in the extant literature as:

- DT enabling an increasing pace of innovation (Vey et al., 2017);
- DT necessitating both decision making and product and service offerings to be delivered more quickly (Bharadwaj et al., 2013), and
- DT resulting in the best ideas spreading quickly (World Economic Forum, 2018).

Despite a sense of urgency suggested by the above, a critical insight from the WEF report is that in the absence of a distinct first-mover network effect advantage, a company is more likely to be successful as a fast-follower. In the context of strategy, fast-followers understand that speed is valuable in DT but are cautious to learn from failures of first-movers, adopting an improvement mindset, testing, experimenting and iterating quickly (World Economic Forum, 2018).

STRATEGY ELEMENT INSIGHT – DT fundamentally redefines markets resulting in digital strategy collapsing into enterprise strategy. This redefinition necessitates enterprises revisiting their value exchange, scope and scale of offering. It also results in enterprises generally selecting either a customer engagement or digitised solution strategy and deciding whether to be a first mover or fast follower. Consequently, traditional business models give way to 'platform', 'as a service' and 'freemium' models, and competition increasingly presents as coopetition.

Figure 12 depicts the OPD for the strategy element subsystem.

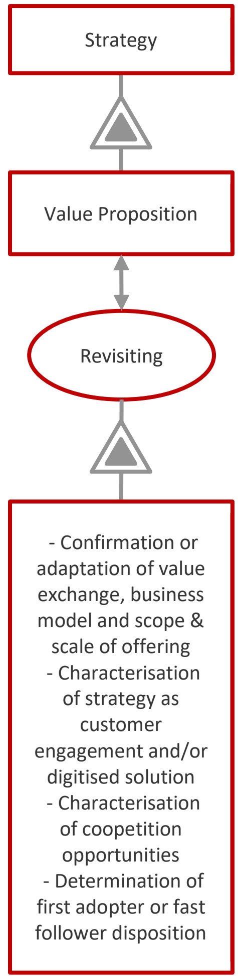


Figure 12 - Strategy Element OPD

4.4 Information Element: How does DT shift the information dimension for enterprises?

Seminal work by researchers at the University of Southern California in 2011 estimated that by 2007 the world already had 94% of its information in digital format, and this trend would only continue to accelerate (Hilbert & López, 2011). It is arguably an expected outcome that DT has led to digitalised information becoming undeniably pervasive in modern business (Vey et al., 2017). This pervasiveness is because the effective operation of an enterprise aligned with the strategic element discussed in 4.3 necessitates appropriate information (Nightingale & Rhodes, 2015) and quality information supports and enables competition (Hemmatfar et al., 2010).

External to the enterprise, through the accuracy of information sharing within the business ecosystem, DT enables improved resource allocation and quality (Abou-foul et al., 2021). It fundamentally changes the enterprise-customer relationship by reducing information asymmetry between parties (Granados & Gupta, 2013) and alters engagement strategies (Ross et al., 2017) through the various delivery modes available. For example, social media, customer reviews, blogs, rich media content and increasingly through augmented reality (AR). This fundamental change in the enterprise-customer relationship results in customers having escalating expectations about being well-informed and enterprises needing to revisit customer-side operations and strategies (Setia et al., 2013). In short, information flows are far more easily created and more dynamic in nature due to DT.

The 2019 WEF briefing paper on the topic of 'Shaping the Future of Digital Economy' notes the generation of information can be either explicit or implicit. The WEF paper notes explicit generation occurs by a product or service user, and implicit generation occurs by software algorithms while a product or service is in use. It also notes that information has a certain 'intensity' associated with it that dictates network effects and the ease of value exchange (*Platforms and Ecosystems: Enabling the Digital Economy*, 2019), and through feedback loops, influences behaviours (*Gartner Top Strategic Technology Trends for 2021*, 2020). For example, a supply chain can increase responsiveness by adjusting planning, production, transport, and even creating bespoke goods. Doing so results in information models shifting from being historically closed and vertical to increasingly open and horizontal across the enterprise (*Assessment of Information and Communication Support of Production Systems in Conditions of Digital Transformation of National Economy*, 2020). A novel observation here is that as information flow and exchange becomes more open and diffuse, it creates a virtuous loop. Thus DT leads to further technology development (*Assessment of Information and Communication Support of Production Systems in Conditions of Digital Transformation of National Economy*, 2020), which in turn leads to an increased likelihood of DT being successful (de la Boutetière et al., 2018).

Beyond the specific content of information, DT also changes the structure of information (*Assessment of Information and Communication Support of Production Systems in Conditions of Digital Transformation of National Economy*, 2020). Characteristics that might typically be associated with how impactful information is (like source, accuracy, quality, speed, etc.) combine with other attributes like pervasiveness, connectedness and symmetrisation (amongst others). This ultimately results in information being integrated across the enterprise (Westerman et al., 2011) and impacting operations and strategy. Winning in a modern business landscape becomes necessarily contingent on completeness and effective use of information (*Assessment of Information and Communication Support of Production Systems in Conditions of Digital Transformation of National Economy*, 2020).

Monetisation considerations surrounding information are also increasingly relevant to modern enterprises. Technology such as IoT, cloud computing, AI and ML enable the ready collection, storage, processing, optimisation and analysis of significant data sources. Thus, enterprises can readily support the increasing demand for information, and the importance of intra- and inter-enterprise information flows in the modern business landscape (Dzhulii et al., 2020). This ultimately has given rise to new forms of economic activity between enterprises and across sectors. Market participants are now part of an 'information economy' borne out of the conversion of information as a good for mass production, consumption and ultimately monetisation. Further, because the costs of transmitting information are negligible, SMEs can readily compete with larger ones (Dzhulii et al., 2020).

INFORMATION ELEMENT INSIGHT – DT reduces information asymmetry in the enterprise-customer relationship, shifting information models from closed vertical ones to open horizontal ones. This change in model orientation translates to changes in expectations surrounding information and stakeholder engagement strategies, and in turn, information becomes more integrated across an enterprise. More sophisticated information attributes (such as pervasiveness and connectedness) become increasingly relevant in support of the flows and exchanges demanded by modern business to and capitalise on monetisation opportunities.

Figure 13 depicts the OPD for the information element subsystem.

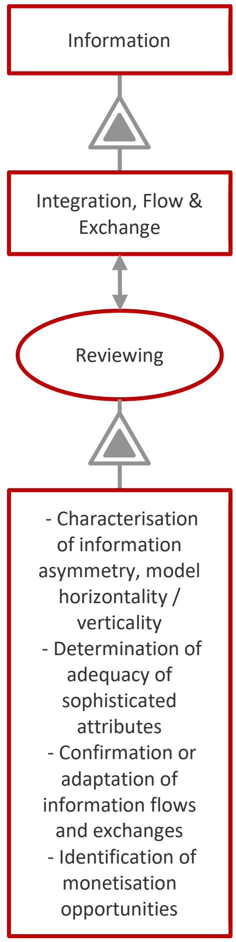
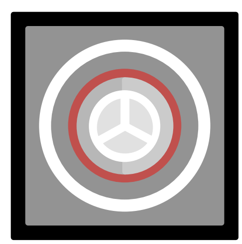


Figure 13 - Information Element OPD

4.5 Infrastructure Element: What infrastructure considerations does DT precipitate?



Since Gordon Moore famously first described exponential growth in transistor density on integrated circuits in 1965 (Moore, 1965), the growth in almost every facet of both physical and virtual digital infrastructure has been similarly rapid and exponentially accretive (Roser & Ritchie, 2013).

In the context of DT, infrastructure has arguably evolved beyond software and hardware building blocks to integrated technologies necessary throughout the enterprise and within the broader ecosystem. Research by Dr. Ina M. Sebastian, Dr. Jeanne W. Ross and others from MIT Sloan's Center for Information Systems Research (CISR) suggests that a necessary integration of technology and enterprise business functions must occur. If a modern enterprise seeks to succeed in the digital economy, decision-makers cannot view technology and business functions separately (Sebastian et al., 2020).

The concept of Industry 4.0 or the fourth industrial revolution (4IR) often exemplifies this integration. Conceived and named almost a decade ago by the German 'Industrie 4.0' working group, 4IR describes the next evolution of industrialisation brought about by DT. This next evolution sees emergent and convergent technological infrastructure digitising and digitalising manufacturing and production (often prefixed with 'smart'), enabling value to be added across the lifecycle of a product (Kagermann et al., 2013). Smart products and services are cyber-physical systems (Wang et al., 2015) that can provide rich (potentially real-time) feedback for iterative product and service development and delivery (Tao et al., 2018).

An observation of 4IR is that it tends to create a synergistic feedback loop for further innovation with unprecedented speed, depth and breadth of impact from production and manufacturing to management and governance (Schwab, 2016). Productivity, flexibility and sustainability opportunities are created whilst at the same time also without sacrificing bespoke product offerings when customers demand them (Dalenogare et al., 2018). Thus, viewed from a 4IR perspective, infrastructure in the context of DT is increasingly a coalescence of real and virtual technologies that must be intelligent and adaptable to support business models in readily responding to change at scale (Kagermann et al., 2013). Further, they must also meet the demands of an increasingly socio-technical and sustainability-focused value chain (Stock et al., 2018).

The extant literature notes numerous and varied taxonomies for identifying and categorising DT infrastructure at the enterprise level. McKinsey's October 2018 report (publishing results from a wide-reaching survey for technologies in actual use at organisations[33]) includes: traditional web technologies, cloud computing, mobile internet technologies, big data, IoT, AI, robotics, ML, augmented reality (AR) and additive manufacturing (de la Boutetière et al., 2018). The WEF also includes frontier technologies such as quantum computing in their interactive mind-map (*Fourth Industrial Revolution Curation: World Economic Forum*, n.d.).

[33] McKinsey's online survey was conducted between January 16, 2018 and January 26, 2018 and canvassed 1,793 participants representing a full range of regions, industries, company sizes, domain expertise and tenure. McKinsey also note that 1,521 respondents were part of at least one digital transformation in the preceding five years.

Sebastian et al. offer five, arguably more ontological, dominant categories as social, mobile, analytics, cloud and internet of things (which they coin as 'SMACIT') as shown in Figure 14 (Sebastian et al., 2020):

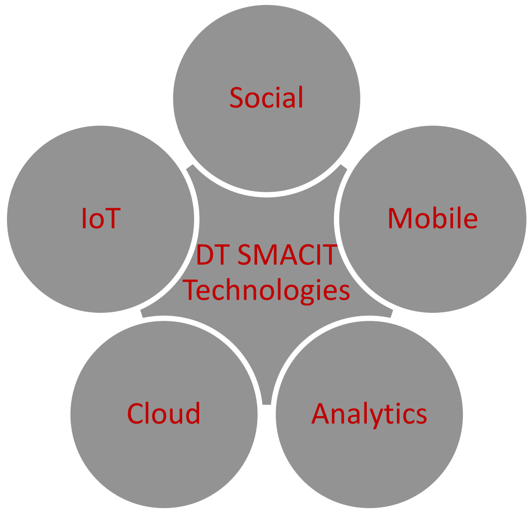


Figure 14 - DT SMACIT Technologies

Insofar as infrastructure in the context of DT goes, industry incumbents focusing on SMACIT technologies are most likely to ensure that new entrants do not erode their value proposition. Incumbents with a SMACIT focus exhibit a robust operational backbone and a platform encouraging innovation and rapid response to market changes (Sebastian et al., 2020). General Motors Co. provides a salient example of this, focusing on SMACIT technologies that underpin the fundamental shift in their value proposition from vehicle manufacturer to mobility services provider (Lienert et al., 2021). Successful integration of digital infrastructure throughout the enterprise becomes indistinguishable from enterprise infrastructure (Sebastian et al., 2020).

Research conducted by the Brookings Institution in 2019 also suggests a strong shift toward SMACIT technologies. The most emergent technologies enterprises are pivoting toward include AI, IoT and blockchain with spending on legacy technologies, likely giving way to cloud computing, big data and analytics, social and mobile platforms (Henry-Nickie et al., 2019). Future emergent technologies and investments are likely to continue to develop along a dynamic trajectory that innovates on prior technologies to unlock new value. Gartner defines this as 'combinatorial digital innovation', an approach that brings different technologies together to find either new or incremental value (Kandaswamy, 2019).

In separate research on technology trends, Gartner forecast that DT will cause infrastructure to evolve to support a necessarily more 'plastic' enterprise. They note this is especially evident as a result of the impacts of COVID-19, citing such future technology trends as the Internet of Behaviours (IoB), privacy-enhancing computation[34] distributed cloud[35] and cybersecurity mesh[36] (*Gartner Top Strategic Technology Trends for 2021*, 2020), amongst others. IoB is especially salient. As Gartner describes, IoB will combine many existing technologies (e.g. big data, AI, ML, geolocation, facial recognition, etc.) and sources of information (e.g. public, private, social media, etc.) to map behavioural events. Those events in turn will both inform technology development and influence and change undesirable human behaviours. Metaverses[37] is another frontier concept and technology that exemplifies the disruption likely to be experienced at the enterprise infrastructure level. Companies like Facebook are heavily investing in technology to support metaverses, anticipating they will succeed the internet by creating a unified, immersive reality experience where users will have the ability to perform work and conduct business in a virtual environment via avatars (Lei & Ratan, 2021).

INFRASTRUCTURE ELEMENT INSIGHT – DT increasingly challenges established paradigms of technology integration as digital and enterprise infrastructure become increasingly indistinguishable. Pervasive technology becomes more advanced, interconnected and interdependent, catalysing accretive and combinatorial value addition across the enterprise and spawning further innovation in the process. The result is a highly sophisticated enterprise infrastructure able to meet the demands of an increasingly socio-technical, interconnected and collaborative value chain.

[34] Privacy-enhancing computation – Gartner note that the need to enhance privacy and security of data and analytics and expect that this will be achieved by combining secure environments with a decentralised and encrypted approach to computation. The aim of such technology is to ensure confidentiality and security of information is maintained without limiting the ability to collaborate within and between enterprises.
[35] Distributed cloud – Gartner anticipates that enterprises will need to distribute existing public cloud services to specific locations whilst keeping operation and governance with the centralised cloud provider to both manage data costs and meet likely legal data export requirements.
[36] Cybersecurity mesh – Gartner forecasts the need for a more modular and architecturally distributed approach to cybersecurity to enable scalability and flexibility in defining a security perimeter around a discrete real or virtual object rather than the traditional zonal approach to cybersecurity.
[37] Metaverse – A concept borrowed from science fiction to describe an 'always-on', interactive virtual online environment (Lei & Ratan, 2021)

Figure 13 depicts the OPD for the infrastructure element subsystem.

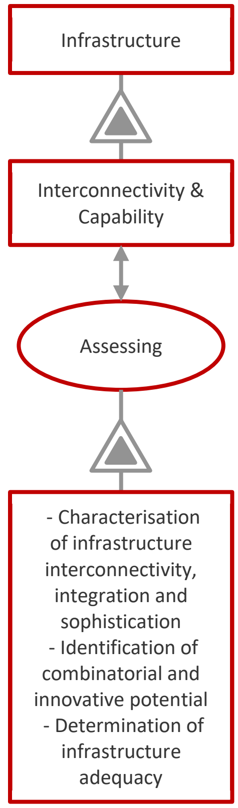


Figure 15 - Infrastructure Element OPD

4.6 Products and Services Element: What distinguishing characteristics in products and services does DT catalyse?

Because of the large variability in products and services across industries, sectors and enterprises, a valid argument exists that it is challenging to take a holistic and more generalised view in exploring an enterprise's scope of offering (Bharadwaj et al., 2013). However, specific characteristics nonetheless appear to prevail as a result of disruption from DT.

With due cognisance given to the definition of products and services provided in 2.2, for this exploration (and as further elaborated below), there is an intentional grouping of products and services as the 'container' by which value transfers to stakeholders. The observation made by Nightingale and Rhodes that products and services are a 'coupled set' that may be useful exploring as a cluster also supports grouping them (Nightingale & Rhodes, 2015).

The usefulness of clustering products and services and a compelling reason to do so (beyond convenience) is apparent when considering them in the context of DT. Citing Yoo et al. (2010a) and Schilling (2000), Koch and Windsperger (2017) note that once digitalised, the nature of objects is changed such that previous functional limitations and intent are no longer relevant (or can be overcome). This change occurs because objects become loosely coupled elements due to DT (Koch & Windsperger, 2017). For example, the entertainment industry and associated CDs and DVDs noted in 1.1.1 and 4.2 sees digitalisation resulting in streams of data (for example, MP3 or MP4 file formats) accessible on various platforms replacing digitised products (music or video) residing on a physical object (CD or DVD product). Consequently, the limitation of needing a specific device of a particular design and form factor to utilise the product (CD or DVD player) is no longer relevant.

In 1.1.1, there was an introduction to the notion of transcendence of the physical layer (physical object), resulting in a product becoming unconstrained in terms of opportunities to conceive, manipulate and monetise value in new ways. The example above highlights how digitalisation results in fluidity in defining a ‘product’ or ‘service’. This fluidity arises because digitalisation influences an enterprise’s approach to products and services, and impacts the value exchange with stakeholders. In short, at the digitalisation junction, the boundary between each is blurred. An enterprise’s scope may remain the same (to provide entertainment) but as a result of digitalisation, the value transferred or transmitted to stakeholders is arguably better described as an ‘offering’, dependent on an enterprise’s strategy and preferred business model. Spotify and Netflix are two enterprises exemplifying support of monetisation strategies that adopt ‘service access’ models rather than ‘product sale’ models. Therefore, the salient observation is that DT disrupts by enabling boundary dissolution and, in doing so, gives rise to entanglement (as intended in 2.3) of products and services.

As a result of such dissolution, DT also inherently changes the value-adding mechanism. Citing Porter & Millar (1985), Bowman & Ambrosini (2000) and Vargo et al. (2008), Koch and Windsperger (2017) note disruption to the traditional, ‘linear’ and sequential value-adding chain. Further, where the product (or service) features and quality were previously the focus when value-adding, multiple stakeholders now more readily contribute to and integrate offerings (Koch & Windsperger, 2017). There is thus an observation that value is increasingly co-created due to DT enabling collaboration between stakeholders (Ng & Wakenshaw, 2016). Consequently, there is the establishment of value networks that leverage partnerships to co-create and capture value (Evens, 2015).

Distinctly then, DT results in greater independence of function (information and services) from form (physical goods) and a need to re-evaluate offering architectures (Koch & Windsperger, 2017). Building on the entertainment example above, a car manufacturer who may have previously focussed on adding features or improving the quality of their in-car entertainment system can instead partner with a technology company such as Apple to integrate the Apple CarPlay™[38] offering into their vehicle offering. A re-evaluation of the resulting in-vehicle entertainment system, in terms of its architecture, occurs. It becomes a co-creation effort between two enterprises, with the ultimate result of a richer overall offering for the vehicle owner. Thus, there is a value network between the car manufacturer and Apple that leverages the partnership between the two enterprises. There is a link between this idea and the exploration of strategy in 4.3. Notably, enterprises focusing on transforming products and services into solutions tend to create feedback loops that add incremental value to existing offerings. Citing Selander et al. (2013), Tiwana et al. (2010), Yoo et al. (2010a) and Yoo et al. (2012), Koch and Windsperger (2017) also observe that as enterprises combine capabilities across industries, traditionally segregated by physical product boundaries, greater innovation results (Koch & Windsperger, 2017).

The discussion above reveals certain characteristics that present as a result of DT that are common to the notion of offerings (as opposed to separate products or services), including:

- fluidity in definition;
- boundary dissolution;
- entanglement;
- non-linear value-adding;

[38] Apple CarPlay – An Apple standard that enables communication and control between an in-car entertainment system and a device running Apple iOS operating system (*IOS - CarPlay*, n.d.)

- co-creation; and
- output from innovating value networks.

From their research of DDIs (see also 4.2), Riemer et al. (2015) suggest the importance of control (exploitation and redirection) of essential information streams as a critical characteristic of enterprises that place information at the core of their offering. Further, Riemer et al. observe eleven prevailing core functions from enterprises embracing an 'information-first' approach: (1) cataloguing; (2) bundling; (3) reordering and filtering; (4) ranking and recommending; (5) delivering; (6) hosting; (7) sharing; (8) intent casting (providing features that enable needs to be communicated); (9) channelling actors (providing routing channels for stakeholders); (10) pricing functions; and (11) matching actors (Riemer et al., 2015). As a result of an information focus and the leveraging of core functions enabled by DT, customer behaviour, knowledge and preferences (particularly due to social media) consequently influence what information-sensitive enterprises offer (Berman, 2012). The result is that increasingly buyers rather than sellers tend to establish the value dimensions of enterprise offerings (Keen & Williams, 2013).

PRODUCTS AND SERVICES ELEMENTS INSIGHT – DT changes the nature of products and services, dissolving the boundary between them. It entangles them and causes their definition to remain fluid, stemming more from an enterprise's strategy, business model, and monetisation approach than physical product boundary. As a result, the notion of an enterprise offering (rather than a product or service) results. Non-linear value-adding tends to occur via value networks that co-create and innovate, with information typically at the core of the offering. Enterprises that exploit and redirect this information characteristic to their benefit through various core functions are likely to capture and respond to customer sentiment most effectively. Consequently, the sentiment feedback loop increasingly appears to define the value dimensions of the modern enterprise's offerings.

Figure 16 depicts the OPD for the products and services elements subsystem.

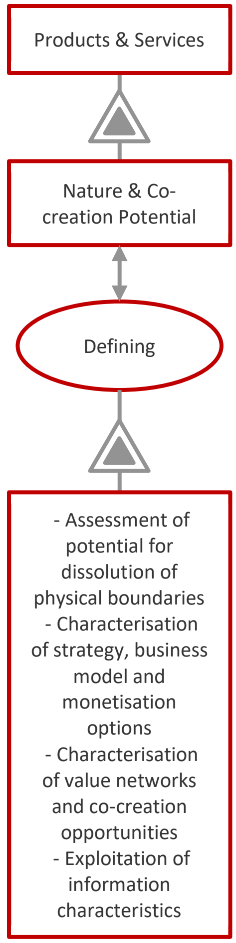


Figure 16 - Products and Services Elements OPD

4.7 Process Element: How does DT affect business processes?

In the context of the ARIES Framework Enterprise Element Model, processes have a broad definition. They are not limited to enabling processes (i.e. operational payroll process in a finance department or a managerial approval process for decisions), but can also include leadership and lifecycle processes of an enterprise (Nightingale & Rhodes, 2015).

Further, there is often entanglement of processes with other (often less tangible) elements. This entanglement can result from enterprise policies driving processes, instantiation of processes to support strategy, or establishing processes to disseminate knowledge (Nightingale & Rhodes, 2015). In addition, how those elements manifest, are implemented or are likely to be experienced internal and external to the enterprise inevitably entangles processes with the stakeholder element. For example, an employee experiences an enterprise's recycling policy by using the different coloured bins around the office floor that separate recyclables from landfill.

In their process-oriented research of organisational design (specifically, systematic exploitation of digitalisation potential of business processes), Denner et al. (2018) citing Allen (2015) and Matt et al. (2015) note that DT disrupts work practices and compels enterprises to revisit business processes (Denner et al., 2018). Arguably, one of the most direct, widespread and potentially disruptive impacts to an enterprise due to DT is digitisation and digitalisation of its processes. The result is enterprises needing to contend with the extensive choice and uncertainty associated with digital technologies, often with limited knowledge (Denner et al., 2018).

An extreme example from 4.5 is the metaverse, where enterprise personnel will perform work in an entirely new virtual paradigm in the new (virtual) reality it offers. New possibilities for corporealisation and reification of intangible aspects of current interactions with data and information will materialise. These in turn will likely disrupt enterprise processes in ways not yet fully considered. For example, keystrokes and mouse clicks typically used to manipulate data in a spreadsheet, generate a visualisation, and share the output with a colleague could be readily obsolete. In the metaverse, the same spreadsheet might be life-size and manipulated with hand gestures. It is not difficult to imagine 'grabbing' rows and columns, 'throwing' data onto a desired virtual visualisation board and 'flicking' the resultant output across a virtual room to a nearby colleague's avatar. Hence, there is potential for significant disruption to enterprise processes pivoting into the metaverse.

In their 2014 McKinsey Digital article, Markovitch and Willmott note that the key to leveraging widespread disruption imposed on enterprise processes from DT is recognising that digitisation and automation are insufficient, and digitalisation must occur. Each process must be revisited holistically, including both tactical aspects like the number of steps and documents involved to strategic aspects such as decision-making, operational models, organisational structure and learning and development of personnel (Markovitch & Willmott, 2014).

Markovitch and Willmott (2014) also note that successful digitalisation of enterprise processes catalyses direct material enterprise benefits such as cost reductions (up to 90%) and turnaround time improvements (by several orders of magnitude). Indirectly, rich data sets are generated that can be mined for insights to inform future strategy and further enhance process digitalisation (Markovitch & Willmott, 2014). Botha quoting Rosen et al., notes that enterprises typically held up as 'model' and epitomising enterprise process digitalisation are often referred to as Digital Native Enterprises (DNEs)[39] (Botha, 2019). DNEs are fundamentally different and distinguished by the commoditisation of data. They place it at the core of DT efforts and use it as a catalyst for all processes within the enterprise to underpin:

- Data enhancement, management and manipulation;
- Digital access, sharing storage, retrieval and dissemination of information and ideas;
- Technical/digital/operational productivity, optimisation and enhanced decision-making;
- Novel generation and delivery of value;
- Customer-centricity and connection to enterprise value;
- The notion of employees as assets;
- Scaling of offerings;
- Enterprise agility and innovation at speed; and
- Platform models and collaborative relationships in synergistic ecosystems.

(Botha, 2019).

However, DNEs have also precipitated heightened expectations from stakeholders in how they interact and engage with an enterprise. It is now customary for stakeholders to experience

[39] Digital Native Enterprise (DNE) is a term coined by Rosen et al. in 2017 in their report entitled "How the digital-native enterprise is winning the future, now" (Rosen et al., 2017). It is an extension of the term 'Digital Native' coined by Marc Prensky in 2001 in his article entitled "Digital Natives, Digital Immigrants". The article contrasted students familiar with computers, gaming and the internet as "native speakers" of the underlying digital 'language' with essentially everyone else for whom it is not the mother-tongue (Prensky, 2001).

intuitive, always-available, instantaneous, and seamless experiences as a result of DNEs like Apple and Amazon digitalising processes en masse. This 'default' experiential level now presents a challenge for non-DNEs who must revisit normal business processes and accelerate their re-engineering in response to demand for increasing reinvention and digitalisation (Markovitch & Willmott, 2014).

PROCESS ELEMENT INSIGHT – Disruption to enterprise processes results in broad impact. Leveraging disruption for favourable outcomes compels non-DNEs to accelerate re-engineering and digitalisation of business processes to meet changing stakeholder expectations set by DNEs. Further, inherent entanglement of the process element with other elements necessitates a revisit of enterprise-wide processes. Consequently, employing a holistic approach mimicking the successful behaviours of DNEs is helpful to ensure adequate consideration of both tactical and strategic aspects of process digitalisation. Such an approach focuses on data commoditisation underpinning enterprise-wide processes.

Figure 17 depicts the OPD for the process element subsystem.

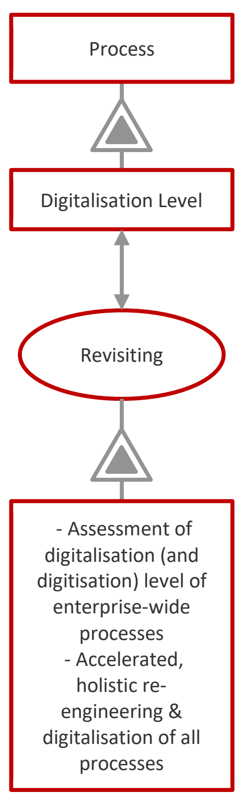


Figure 17 - Process Element OPD

4.8 Organization Element: What organizational characteristics does DT precipitate?

In the ARIES Framework Enterprise Element Model, the organization element encompasses structure, leadership, culture and networks (Nightingale & Rhodes, 2015). In the context of DT, the extant literature provides numerous examples of the importance of these attributes. For instance, Sebastian et al. (2020) note the importance of embracing organisational structures that empower stakeholders to experiment collaboratively (Sebastian et al., 2020). Similarly, Botha (2019) notes the importance of social networks and the empowerment of global employees (Botha, 2019). And, in investigating how DT affects organisations in the key themes of work design and leadership, Schwarzmüller et al. (2018) note organisational hierarchies, work-life and health and talent management amongst four central themes[40] with high relevance in preparing to respond to disruption arising from DT (Schwarzmüller et al., 2018).

Interestingly, many researchers also suggest that these attributes (and thus the organisation element) are likely of greater importance than the technological aspects of disruption arising from DT. Tabrizi et al. (2019), in their Harvard Business Review article entitled "Digital Transformation Is Not About Technology", suggest five lessons for enterprises. The lessons offered are all heavily rooted in the organisational element attributes of leadership, culture and networks (amongst other non-technological focus areas such as vision, strategy and knowledge). For example, avoidance of external consultants and leveraging talent and networks within the organisation, leadership cognisance of employee fears of being replaced by technology, and introducing and fostering a creative and innovative 'start-up' culture inside the enterprise (Tabrizi et al., 2019). Similarly, earlier Gartner research from 2015 suggests a centrality and paramount importance of cognitive ability and social practice exhibited by employees that successfully adopt, leverage and utilise all forms of digital technology in novel and innovative ways, referring to this as 'digital dexterity'(Ingelbrecht et al., 2015).

The notion of digital dexterity appears to be both an emergent and persistent one. A joint study by Soule et al. from the MIT Sloan School of Management and Capgemini Consulting also

[40] The fourth theme in the Schwarzmüller et al. research is the use of information and communication technology.

introduces digital dexterity (Soule et al., 2016), seemingly independent of the research conducted by Ingelbrecht et al. (Gartner) above[41]. Soule et al. synthesise interview and survey data from 150 organisations to describe a concept not dissimilar to the Gartner notion. They characterise digital dexterity as the 'hallmark' of digital enterprises defining it as 'the sustained organizational ability to rapidly adapt and self-organize to take advantage of emerging digital possibilities' (Soule et al., 2016). Interestingly, revisiting their research in 2017, Gartner subsequently refined their meaning of digital dexterity to include the aspect of it being a learned ability and expanded the construct to include similar notions to those of Soule et al., i.e. adaptability, analytical thinking, creativity, and fluency in collaboration (Waller et al., 2017).

Sitting alongside digital dexterity is the related concept of digital capability, which Soule et al. (2016) identify as manifesting in three dominant clusters: (1) customer experience (including communication and interaction); (2) operations efficiency (optimising, automating and streamlining); and (3) workforce enablement and engagement (developing and promoting skills, knowledge and collaboration). Soule et al. demonstrate that digital capability clusters are associated with digital dexterity and underpinned by mindsets, practices and resources, all attributes of the organizational element of enterprises. Whilst many enterprises might exhibit digital capabilities to some extent, members of the 'digital organisation' cohort have a mindset framed around confidence in digitisation and digitalisation solutions. They ultimately believe in practices, workforce characteristics and resources that realise digital possibilities[42] (Soule et al., 2016). Like digital dexterity, digital capability also appears to be an emergent and persistent theme insofar as the organisation element goes. In a separate study, the World Bank defines digital capability in terms of three key attributes: (1) digital leadership, (2) digital culture and (3) digital skills, with all three being necessary prerequisites for success in responding to disruption arising from DT (Melhem & Jacobsen, 2021).

Digital dexterity (and capability) give rise to the notion of a digitally dextrous enterprise, which ultimately has an advantaged position and experiences success in digital business due to its

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[41] A review of cross-references was inconclusive with respect to whether the Ingelbrecht et al. research (Gartner) inspired the Soule et al. research (MIT / Capgemini) or whether common use of the term 'digital dexterity' was coincidental. However, from a purely chronological point of view, Ingelbrecht et al. appear to be first in using the term.

[42] Soule et al coin the acronym M-PWR to bundle the four 'essential qualities' of the organisational element of enterprises – <u>M</u>indset, <u>P</u>ractices, <u>W</u>orkforce (characteristics) and <u>R</u>esources.

ability to capitalise on technology (Ingelbrecht et al., 2015). Digitally dextrous enterprises can readily pivot as ecosystem, stakeholder and strategy elements change and shift. They reinforce flexibility, fluidity, and dynamicism in roles, responsibilities, relationships, and ways of improving stakeholder engagement and experience (Soule et al., 2016). In a related report to the Soule et al. research, Capgemini notes that a 'digital-first' mindset distinguishes digitally dextrous organisations. This mindset results in defaulting to a digital solution across the enterprise at scale. As a result, digitally dextrous organisations evolve to a self-reinforcing state of digital dexterity and capability that can address disruption and seize business opportunities more readily than competitors, typically outperforming them on critical metrics such as innovation (Bonnet et al., 2015).

Amongst the coalescing and entangled definitions of digital dexterity, digital capability, and the digitally dextrous enterprise, an arguably salient and recurring attribute is one of leadership. Enterprise leadership is foundational in workforce skills development and digital culture promotion throughout enterprises (Melhem & Jacobsen, 2021). Chief Information Officers (CIOs) are central to ensuring digital dexterity is an enterprise-wide competency and are key to addressing processes, procedures, policies, and practices to encourage digitally dextrous behaviours. Further, CIOs should focus on solutions that reflect generational, gender, racial and cultural workforce diversity (Prentice, 2015) whilst championing, inspiring and fostering digital dexterity throughout the enterprise (Waller et al., 2017). Research from MIT's Center for Information Systems Research using interviews, surveys and machine learning techniques empirically demonstrated the importance of these attributes and the resulting positive outcomes. Enterprises with digital-savvy leadership focus on learning, automated decision making, open, agile and modular systems and shifting culture toward coaching and communicating (and away from traditional 'command and control'). These attributes are closely related to the various notions of digital dexterity and result in superior financial performance across multiple metrics, including market valuations, revenue growth and profit (High, 2020). Further, the notion of digital-savvy leadership also extends to company boards. When three or more board members are digital-savvy, meaningful conversation tends to precipitate that juxtaposes risk in project evaluation with business model risk of foregoing innovation (High, 2020).

ORGANIZATION ELEMENT INSIGHT – DT is profoundly organizational change and thus fundamentally disruptive to the organization element of the enterprise. Consequently, a focus on dimensions of the organization element is arguably more important than a focus on underlying technology dimensions. Pervasive notions of digital dexterity and digital capability collectively encompass the key attributes of a digitally dextrous enterprise that characterise success in navigating disruption arising from DT. Such attributes include leadership, skills, culture, adaptability, self-organisation and creativity (amongst others). To inspire digital dexterity, digital capability and ultimately a digital-first mindset, enterprises should have strong digital-savvy leadership from the board down.

Figure 18 depicts the OPD for the organization element subsystem.

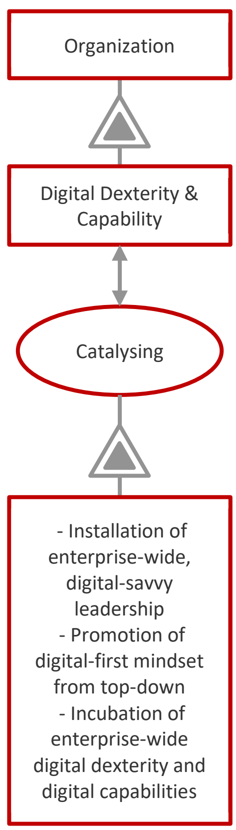

Figure 18 - Organization Element OPD

4.9 Knowledge Element: How does DT impact the knowledge paradigm?

An organisation acquiring, creating and disseminating knowledge, and responding accordingly with a behaviour change, is an organisation that learns and develops (Senge, 2010). In the ARIES Framework Enterprise Element Model, the knowledge element describes express and implied enterprise knowledge. This includes competencies, expertise and intellectual property inherent in the enterprise and created by it (Nightingale & Rhodes, 2015).

As DT increasingly digitalises information (Hilbert & López, 2011) and data generation exponentially increases (Desjardins, 2019), the task of effective acquisition, creation and dissemination of knowledge also grows at a commensurable rate, making knowledge management (KM) a vital issue for enterprises. Researching the innovation network space, Lyytinen et al. (2016) note that technology supports identification, sharing and assimilation of knowledge by enabling more sophisticated properties such as traceability in time and space, semantic coherence and coordination. They argue that digital technologies (1) increase connectivity by increasing the scope and reach of connections and reducing costs of communications, and (2) increase knowledge heterogeneity and the requirement for knowledge integration due to faster and broader digital convergence (Lyytinen et al., 2016).

Readiness to address KM challenges is also observed to be a challenge in itself and entangled with the organisational element of enterprises. Deloitte's '2020 Global Human Capital Trends' survey notes that the gap between the perceived importance of knowledge creation and preservation and the readiness to address it is material, with 75% of organisations surveyed perceiving it as important but only 9% indicating they are ready to address it (Volini et al., 2020). Although many organisations cite lack of technological infrastructure as a barrier to success, Deloitte's research found that most barriers impeding success were noted as human ones by survey respondents. They include organisational silos (55%), lack of incentives (37%), lack of organisational mandate (35%), and frequent shifting of personnel (35%). A primitive understanding of KM was also observed, with 55% of respondents indicating a limited definition of KM, defining it as documentation and sharing of knowledge, with little acknowledgement of its acquisition, creation or strategic link to driving and creating new value (Volini et al., 2020).

Deloitte's findings suggest a consistent theme with earlier academic work by Ihrig and MacMillan from the Wharton School at the University of Pennsylvania. They contend that when addressing KM in the context of DT, the initial focus of most enterprises is on eliciting insights from data rather than focussing on knowledge drivers (Ihrig & MacMillan, 2015). Enterprises tend to start with the approach that they should look to combine varying degrees of data management and analytics. In doing so, they hope to capture, interpret and share knowledge across the multitude of technical and non-technical information assets the enterprise owns. However, in the process, the management of knowledge assets (the ones noted by Nightingale and Rhodes) is sometimes neglected, resulting in an inability to fully elicit the insights sought by the deployment of technology in the first place (Ihrig & MacMillan, 2015).

Instead, Ihrig and MacMillan (2015) suggest a more effective approach is to begin with establishing a mandate to understand the critical knowledge that drives value, competitiveness and underpins business success. They recommend looking across enterprise silos and engaging enterprise-wide subject matter experts. They then propose mapping knowledge on the continuums of tacit versus explicit (in one dimension) and proprietary versus widespread (in a second dimension) to understand where additional value can be created. For example, some knowledge may be critical to success but is 'embedded' in the expertise of a few key employees, and therefore can benefit from being more codified and widely diffused throughout the enterprise. Thus, by first mapping knowledge, technology-driven efforts become more targeted and more likely to reveal novel insights and new knowledge (Ihrig & MacMillan, 2015).

The focus toward strategy, mapping (of knowledge assets, flows and needs), prioritisation and the trend toward non-technological solutions in the first instance is also found in the American Productivity & Quality Center (APQC) 2019 survey. Of the 401 KM professionals surveyed:

- More than one-third (37%) cited developing or improving strategy and identifying, mapping and prioritising critical knowledge as a priority focus in 2019. APQC also note that there is greater recognition that sharing, collaboration, engagement and deployment of KM tools will likely result in greater success if there is an overarching strategy.

- In terms of future trends, almost one-third (30%) anticipate a focus toward work management methodologies (i.e. agile), and nearly one-third (29%) expect a trend toward solution design methodologies (design thinking / human-centred design) as the two dominant trends. APQC note that there is a ready embrace of solution design methodologies such as design thinking because they are driven by customer-centricity and creativity, resulting in the acquisition and creation of knowledge that is more novel and bespoke in terms of its ability to solve problems facing an enterprise

Overall the APQC survey suggests a shift in thinking toward knowledge as enabling enterprise outcomes rather than supporting them (American Productivity & Quality Center, 2019). Citing Venkitachalam and Willmot (2017), Botha (2019) notes that strategic approaches to KM that enable such enterprise outcomes are characterised by codifying and personalising knowledge. In doing so, enterprises inspire innovation and enable workforce productivity improvements, as exemplified by the deliberate, seamless technology integration approaches employed by DNEs (Botha, 2019). Technological evolution will thus depend on new ways of organising knowledge and supporting its generation, testing, and modification.

Whilst DNEs are exemplary of strategic KM, citing Timperley (2018), Botha (2019) also notes that enterprises will likely require a workforce that can integrate with machines that can learn and increasingly perform a greater degree of decision-making and cognitive tasks that have been the historical domain of humans. Thus, even in DNEs, enduring and sustainable KM will demand a workforce with an evolved degree of skillfulness and mindfulness (Botha, 2019).

KNOWLEDGE ELEMENT INSIGHT – In the absence of an adequate understanding of KM and the human barriers to success rooted in the organizational element of the enterprise, DT will likely result in an inefficient deployment of time, capital and other resources as a result of attempts to elicit novel insights for competitive advantage. To successfully respond to disruption arising from DT in the knowledge element of the enterprise, a shift away from technology and toward strategy is necessary. First and foremost, focalising on mapping, prioritising and cultivating a workforce with an evolved degree of skillfulness and mindfulness is paramount.

Figure 19 depicts the OPD for the knowledge element subsystem.

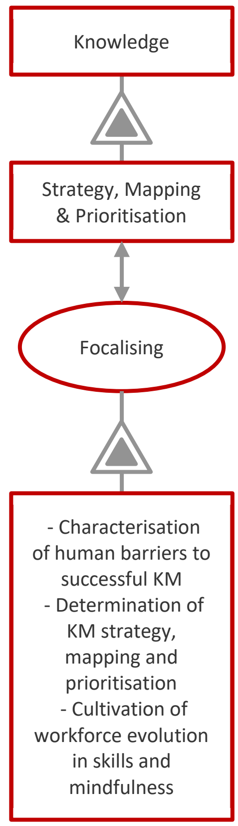

Figure 19 – Knowledge Element OPD

Chapter 5 – Conclusions

Fundamental, transformative disruption unsurprisingly invites a deeper understanding of emergent trends and themes by researchers from various domains. Arguably, however, a piecemeal rather than holistic approach to exploring change typically dominates. In contrast, this thesis deliberately takes a holistic approach to advance the discussion on disruption arising from digital transformation as it affects various enterprise elements defined by the ARIES Framework Enterprise Element Model developed by Nightingale and Rhodes (2015).

Consequently, the system problem statement in 1.2.1 describes the objective of this research:

TO systemically explore digital transformation (DT) of an enterprise BY holistically characterising disruption to the ARIES Framework Enterprise Element Model USING a semi-systematic literature review (SSLR)

Thus, using the Scopus® database of curated academic literature in addition to other select, reputable sources, a meta-analytical synthesis of findings and observations from a cross-section of research domains has been conducted. This exploration has crystallised insights informing a deeper understanding of how organisations can pivot toward successful digital transformation.

By leveraging object-process methodology and diagrams from the systems thinking domain, findings have been distilled across the ten ARIES Framework Enterprise Element Model elements outlined in 5.1 below.

5.1 Insights & Findings

As a result, of the systematic exploration employed, this thesis answers the guiding and specific questions in 1.2.2 as summarised in 5.1.1 below and generates the accretive blueprint artefact shown in 5.1.2 below.

5.1.1 What are the emergent disruptive trends impacting enterprise elements as a result of DT?

- What ecosystem changes are being precipitated by DT?

The ecosystem an enterprise operates and competes in can expect to see an increased perceived risk around cybersecurity for both the public and private sectors. This risk will likely result in policy requirements attracting greater focus in the political and regulatory dimensions.

In terms of the economic and market dimensions of the ecosystem, the redefinition of traditional markets persists as digital continues to represent an increasing portion of most economies. This growing economic share results in a direct correlation between profitability and success in DT.

On the societal front, supported by emergent decentralising technologies like blockchain, goods and services are likely to continue to change due to pressure to decentralise and democratise society. This pressure will see DT and CSR increasingly merge, and CDR become more relevant as DSI becomes more diffuse. As a result, the real potential exists for disruption and disintermediation of incumbents' traditional business and business models.

- How does DT impact the stakeholder landscape?

DT catalyses both the entry of DDIs that focus on information streams in business models and disintermediation from actors focussing on technology as a substitute. In both intermediating and disintermediating outcomes, there is a disruption to the stakeholder landscape as value pathways are altered, necessitating both the creation and destruction of relationships.

- How does DT affect the approach to business models and values?

It is becoming increasingly difficult to distinguish between digital and enterprise strategies because technology is no longer a simple overlay to an organisation. Just as DT has fundamentally disrupted markets, it has also fundamentally disrupted enterprise strategy in response to shifting and, in some cases, drained profit pools. The most successful companies now reflect those cognisant of network effects who adopt disruptive behaviours such as coopetition. These enterprises demonstrate that effective strategy comes from revisiting value exchange, scope and scale. They select either a customer engagement or digitised solution strategy and adopt one or more of ‘platform’, ‘as a service’ or ‘freemium’ business models by merging or evolving their existing business model. In doing so, they typically behave as 'fast followers rather than 'first-movers' unless there is distinct opportunity to capitalise on network effects.

- How does DT shift the information dimension for enterprises?

Flows, exchanges and asymmetry of information between stakeholders are evolving as enterprise information becomes more integrated and sophisticated in terms of genesis, collection, storage and manipulation due to DT. Attributes such as connectedness become increasingly relevant in information models shifting toward more open and horizontal structures that inform strategy and operations. Network effects maximise value exchange and, combined with the negligible costs of transmitting information, can also create monetisation opportunities.

- What infrastructure considerations does DT precipitate?

DT challenges established paradigms of technology integration. Enterprise infrastructure becomes indistinguishable from digital infrastructure in response to an increasingly socio-technical value chain that demands greater interconnection and collaboration between stakeholders to add incremental value and unlock new value. Discrete hardware and software building blocks become antiquated notions of what constitutes infrastructure as a host of advanced SMACIT technologies combine to yield even greater sophistication across the enterprise. Pervasive technology becomes more advanced, interconnected and interdependent. This pervasiveness causes accretive and combinatorial value addition and spawns further innovation in the process.

- What distinguishing features in products and services does DT catalyse?

DT changes the nature of products and services and dissolves the boundary between them. It also entangles them and causes their definition to remain fluid, stemming from an enterprise's strategy, business model, and monetisation approach rather than the physical product boundary. This fluidity and entanglement of elements result in the notion of an offering instead of a product or service. Value networks with information typically at the core of their offerings and with the aim of co-creating and innovating provide opportunities for non-linear value-adding by respective enterprises. Further, enterprises that can exploit and redirect the information at the core of the offering to their benefit, through various core functions, are likely to capture and respond to customer sentiment most effectively. This sentiment feedback loop consequently increasingly defines the value dimensions of an enterprise's offerings.

- How does DT affect business processes?

Inherent entanglement of the process element with other elements necessitates a revisit of enterprise-wide processes. Disruption to processes results in broad impact, and leveraging it for favourable outcomes compels non-DNEs to accelerate re-engineering and digitalisation of business processes to meet changing stakeholder expectations set by DNEs, who readily commoditise data to underpin business processes. Employing a holistic approach mimicking the successful behaviours of DNEs is useful to ensure adequate consideration of both tactical and strategic aspects of process digitalisation.

- What organizational characteristics does DT precipitate?

A focus on dimensions of the organization element is arguably more important than a focus on underlying technology dimensions. This refocusing is necessary because DT is fundamentally disruptive to the organization element of the enterprise, given it is profoundly organizational change. Pervasive notions of digital dexterity and digital capability characterise success in navigating disruption arising from DT and encompass the critical attributes of a digitally dextrous enterprise. Such attributes include leadership, skills, culture, adaptability, self-organization and creativity (amongst others). Digital-savvy leadership from the board down is necessary to inspire such digitally dexterous enterprises and the digital-first mindset exhibited by DNEs.

- How does DT impact the knowledge paradigm?

DT will likely result in an inefficient deployment of time, capital and other resources as a result of attempts to elicit novel insights for competitive advantage in the absence of an adequate understanding of KM and the human barriers to success rooted in the organizational element of the enterprise. A shift away from technology and toward strategy is necessary to successfully respond to disruption arising from DT in the knowledge element of the enterprise. Paramount to this shift is focalising on mapping, prioritising and cultivating a workforce with an evolved degree of skillfulness and mindfulness.

5.1.2 What does an enterprise-wide 'blueprint' for actively anticipating likely disruption look like?

The starting point for generating a holistic blueprint is the object-process diagram reflecting the system problem statement for this thesis (Figure 4). The blueprint is then 'built' by progressively connecting the object-process diagrams that precipitate from sections 4.1 through 4.9. Following this methodical approach yields the single 'blueprint' OPD shown in Figure 20 below (see Appendix 1: Object-Process Diagram (OPD) – 'Blueprint' for Holistic Enterprise Response to Emergent Disruptive Themes from DT for an exploded view).

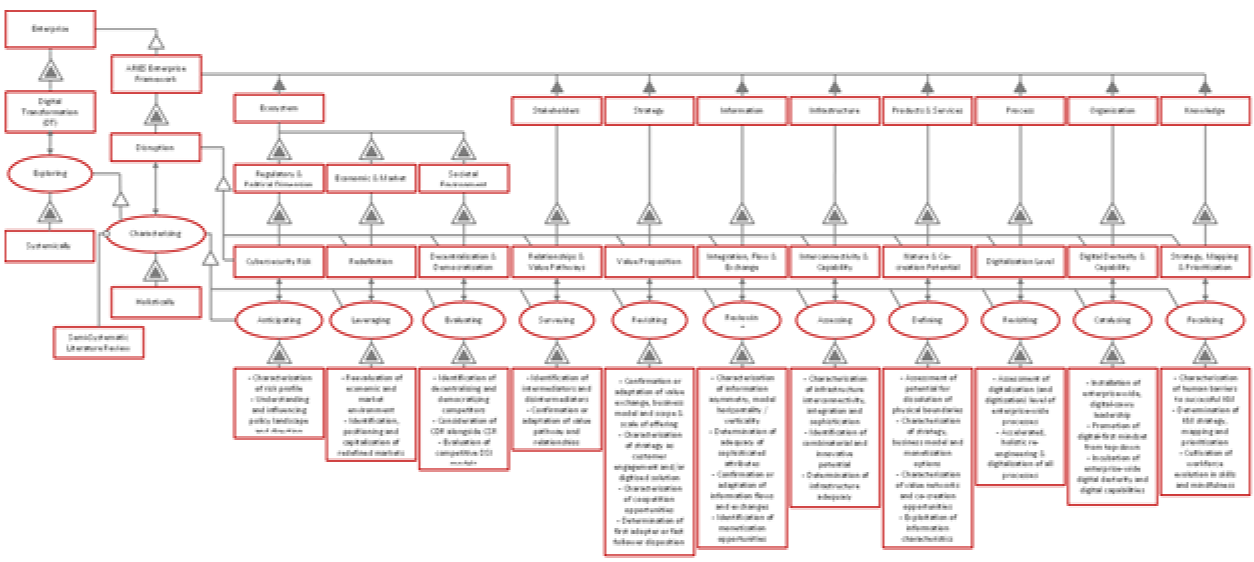

Figure 20 – ARIES Framework Enterprise Element Model 'Blueprint' OPD

Two noteworthy points regarding Figure 20:

- The additional level of decomposition in the ecosystem element (defining the regulatory and political dimension, economic and market dimension and societal environment dimension) reduces complexity and facilitates exploration. Alternatively, the omission of this additional level of decomposition is also valid, although arguably, it reintroduces a degree of complexity.

- The process, organization and knowledge elements exhibit a strong interrelationship and centrality in the enterprise (Nightingale & Rhodes, 2015), hence their depiction in Figure 5. Consequently, grouping their exploration similar to how the products and services elements in 4.6 have been treated in this thesis would have been equally valid. However, greater complexity owing to their entanglement was anticipated. Thus, to facilitate simplification of the exploration, each element was addressed separately (notwithstanding a theme of DNE versus non-DNE appears to materialise).

Ultimately, the blueprint in Figure 20 provides a useful unified view across the enterprise. It illustrates that a systems approach can facilitate both a holistic and sufficiently sophisticated understanding of constituent ARIES Framework Enterprise Element Model elements. It can also serve as a starting point for a deeper discussion on individual elements. For the level of decomposition adopted in this thesis, several conclusions can be made, namely that:

- Digital transformation is profoundly transformative for enterprises because it is fundamentally about organisational change rather than technology. Enterprises often cited as model and characterised as digital natives embrace necessary change around organisational elements such as culture, leadership, creativity and knowledge management to support their digital aspirations.

- Digital native enterprises also importantly challenge established paradigms of technology integration and digitalise processes at all levels of the enterprise. In doing so, they can readily pivot to new business models that capitalise on coopetition, leverage reduction in information asymmetry between the enterprise and its customers, and support monetisation opportunities for information assets.

- Digital native enterprises are inherently digitally dextrous organisations and exhibit rapid, innovative responses and novel approaches to transmitting value to stakeholders. By doing so, they assure their relevance in a dynamic business environment. Such organisations actively pursue a collapse of their enterprise strategy into digital strategy, making no distinction between them, and embrace markets and business models becoming fundamentally redefined.

5.2 Limitations, Recommendations & Future Work

As with all research, limitations are present in the methodology employed and the resulting analysis as outlined in 5.2.1 below. In addition, a brief description of recommendations and future work (that may address certain identified limitations) is in 5.2.2 below.

5.2.1 Limitations

Given that this thesis is a single researcher's solitary endeavour, there is material subjectivity in the SSLR concerning what constitutes relevant literature for inclusion. Although this research has primarily used the Scopus database, cross-referenced citations (from articles found via Scopus), and other select recognised and reputable sources (for example, WEF), other potentially valuable sources likely exist and have been omitted. Similarly, search and sort criteria may also have unintentionally omitted useful literature connected to the research topic.

Further, employing heuristics in the exploration process relies on interpretation and can lead to skewed outcomes in observations and findings as a result of the researcher's subjectivity and unconscious bias in what constitutes a salient and emergent theme. There is also a practical limitation on the exhaustiveness of observations owing to how many articles can reasonably be cited in support of an observation or finding. For example, enterprise attributes (such as pervasiveness and connectedness in the information element, culture, adaptability, self-organisation and creativity in the organisation element, or skillfulness and mindfulness in the knowledge element) are supported by the cited literature but may not be an exhaustive list.

In addition, there is limited analytical depth in this thesis due to the practical limitations of a master's thesis. However, within the defined scope of the research, it is posited that the thematic exploration nonetheless adds to the body of knowledge. Consequently, the level of abstraction of the OPDs in this thesis aligns with the level of exploration of each enterprise element and supports a holistic view. More detailed OPDs are possible, each leading to its own detailed 'blueprint' for a specific enterprise element; however, certain holistic insights may be lost.

Finally, this thesis has been limited to a preliminary exploration of each ARIES Framework Enterprise Element Model element. A more detailed investigation of each element is necessary to validate the insights presented in this thesis.

5.2.2 Recommendations & Future Work

In pursuing a deeper, holistic understanding of the enterprise elements explored in this thesis, four specific recommendations and areas for further research are identified:

1. The traditionally causal relationship between a product or service giving rise to a particular strategy and business model (owing to considerations such as production and supply chain requirements) appears to become inverted due to DT. Owing to the flexibility offered by digitalising technology, enterprises seem to be more likely to establish a strategy and business model and then determine whether they will sell a product or service. This readily enabled transition between products and services due to the dissolution of physical boundaries suggests a simplification to the ARIES Framework Enterprise Element Model may be possible by combining products and services and resolving them in the model to a single 'Offering' element instead. To validate this recommendation, future work might include a more extensive exploration of products and services including an exploration of their entanglement.

2. As alluded to in 5.1.2 (and anticipated by the ARIES Framework), there appears to be material entanglement in the process, organisation and knowledge elements that merits further exploration to characterise differences between how virtuous feedback loops between processes may be operating in DNEs versus non-DNEs. For example, a deeper exploration of concepts such as digital dexterity and capability may inform a novel measurement of the 'degree of entanglement' of elements, which in turn may more insightfully inform DT efforts. More generally, entanglement of any one or more elements could also be explored with other approaches such as stock and flow models from the systems dynamics domain. This is likely to provide greater insights into causality of relationships and feedback effects from one element on another as each changes.

3. The concept of metaverses is briefly introduced in this thesis by way of examples. The new paradigm they present for enterprises is fascinating and suggests any number of separate detailed explorations for the various elements of an enterprise. Especially valuable is likely to be an exploration of the impact on the ecosystem and

stakeholder elements. There is an anticipation of this impact given how radically each is likely to change how boundaries for enterprises, and their ecosystem participants, are delineated. For example, a possible approach may be a comparative exploration of a real-world enterprise versus one existing in the metaverse in terms of likely similarities and differences in ecosystem dimensions. The regulatory and political, economic and market and societal environment could be compared and contrasted to identify where the most impactful change is likely to originate from. A comparison of the real-world and metaverse stakeholder landscapes could be undertaken in a similar way

4. The OPDs in this thesis are presented as 'static' in that they represent generalised observations and insights. For each OPD, however, it may be useful to construct other connected OPDs at various levels of abstraction and decomposition to represent evolution of any single element throughout the lifecycle of the enterprise to gain further insights. For example, the stakeholder element OPD (Figure 11) indicates surveying the stakeholder landscape as the salient 'function' to be performed however this could be further decomposed into separate functions of identifying stakeholders and characterising value pathways. Similarly, each of these functions could be further decomposed into other subordinate functions to provide an increasing level of detail to the objective being pursued (ultimately to enterprise-specific, task-level granularity if so desired).

5.3 Final Thoughts

Never before has disruption arising from digital transformation been more starkly obvious and relevant than amid the ongoing COVID-19 global pandemic with the increasing focus on digitalisation to address the many challenges presented by public health orders that limit human-human interaction.

Whilst a global pandemic is inherently a disruptive event, catalysing and bringing to the fore other disruption, over the last decade, digital transformation has been finding its way into every aspect of business, arguably and paradoxically often generating more problems than solutions. Digital transformation and the disruption it gives rise to is no longer simply about information technology infrastructure and business process support. The notion of ‘digital’ permeates every element of an enterprise and creates new constructs through which to view it.

Digital now goes well beyond the enterprise itself, fundamentally redefining the ecosystem it operates in and the stakeholders relevant to it.

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Appendix 1: Object-Process Diagram (OPD) – ‘Blueprint’ for Holistic Enterprise Response to Emergent Disruptive Themes from DT

Figure 21 – ARIES Framework Enterprise Element Model ‘Blueprint’ OPD (Exploded View)

[Shown below in 3 parts]

Figure 21 – Part 1/3.

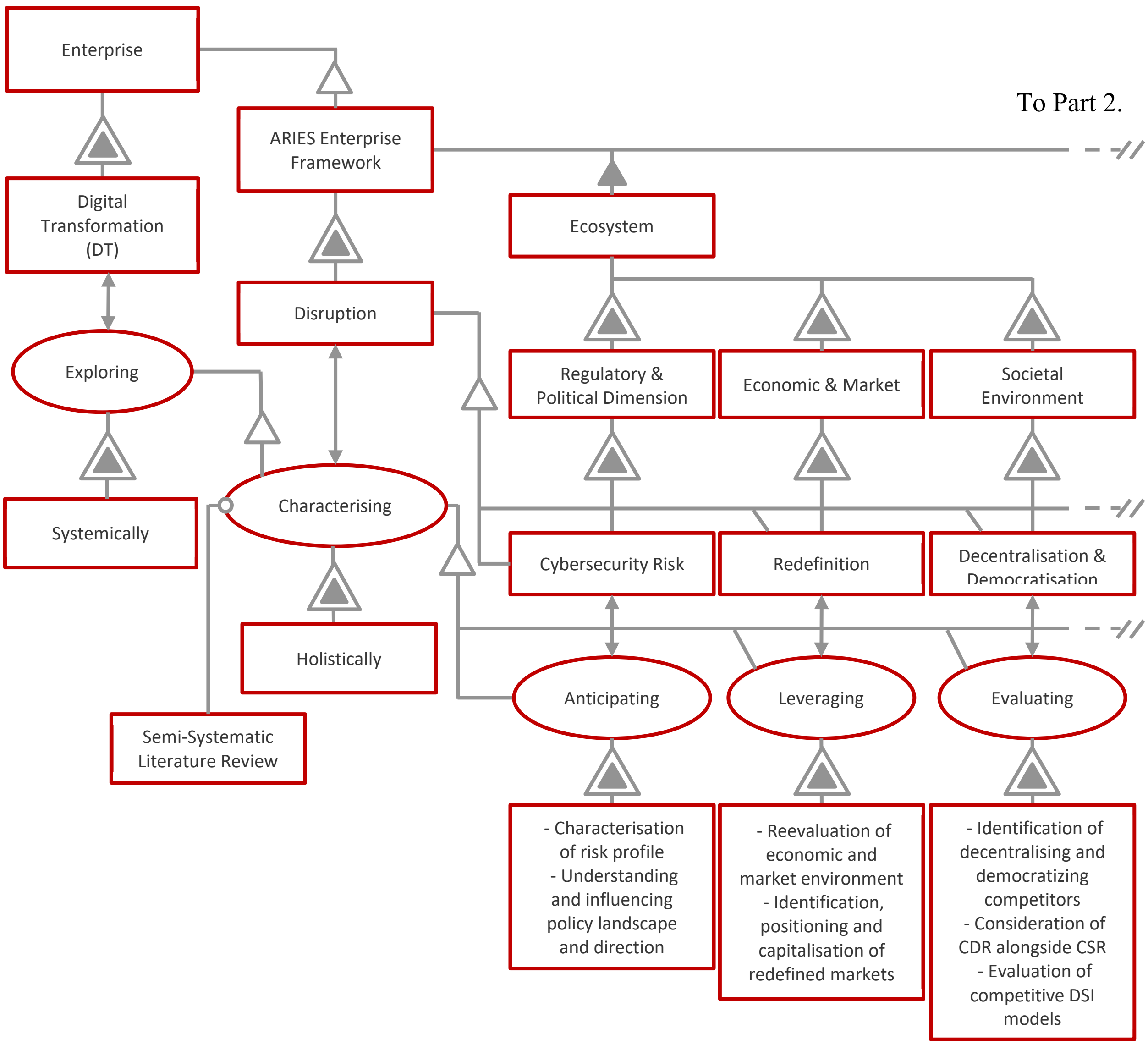

Figure 21 – Part 2/3.

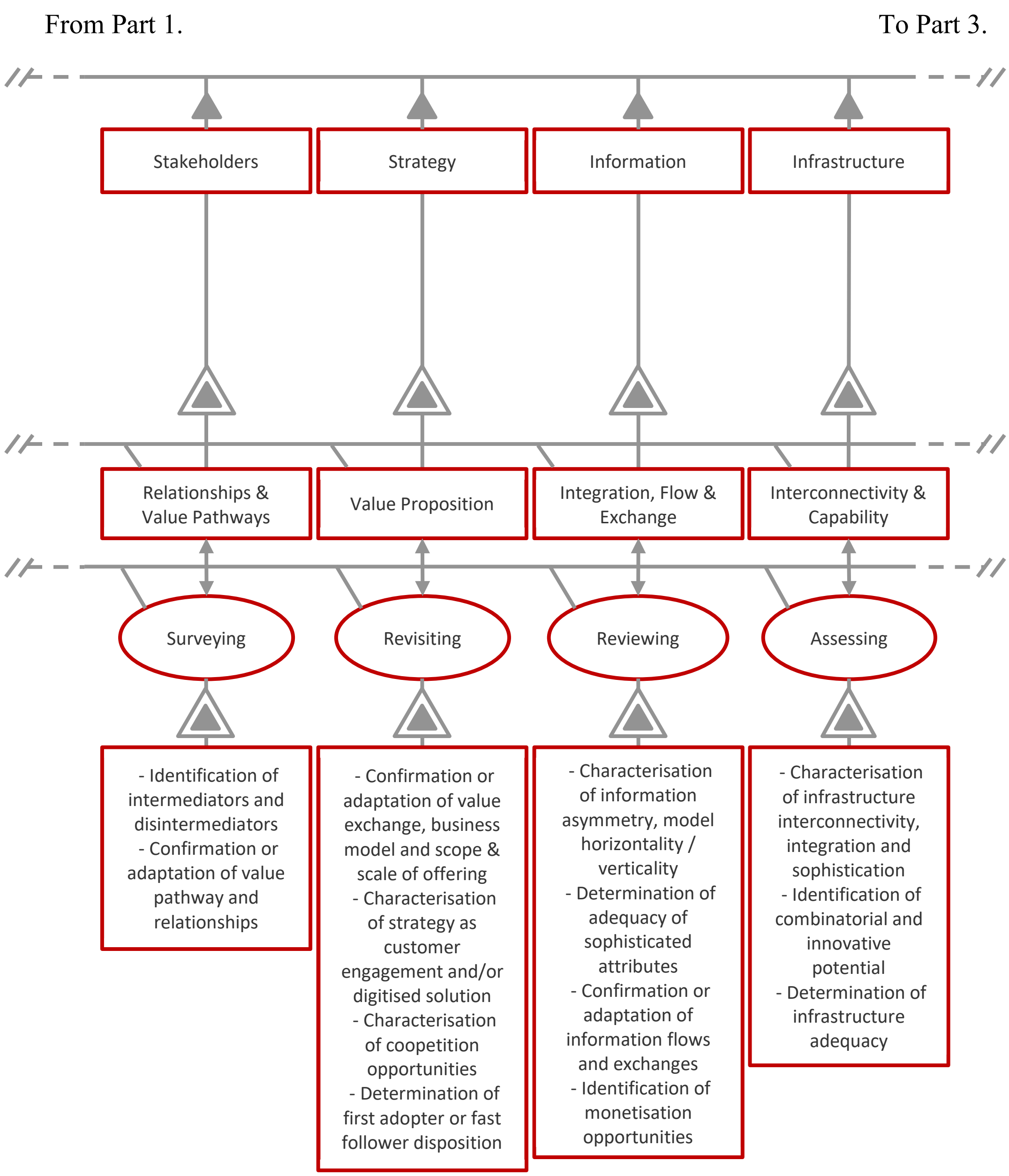

Figure 21 – Part 3/3.