Understanding Digital Business Ecosystem Partnerships and Developing a Method for Evaluating the Impact of Interdependencies between Entities in Value Co-creation

A Thesis Submitted in Partial Fulfilment of the Requirements of the
University of Reading for the
Degree of Doctor of Philosophy

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June 2018

Declaration

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

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Prince Kwame Senyo

Dedicated to my parents, Mercy Yeboah and Anthony Senyo. Without your nurturing, support, investments and prayers, I would not have reached this level in life.

Thank you!!!

Acknowledgements

Thank you, God, for it is your Grace and Mercy that has brought me this far!

I am highly indebted to my supervisors Professor Kecheng Liu and Dr John Effah. Without your guidance, support and knowledge you have freely given me, I will not have completed this PhD. Personally, the biggest contribution from this PhD research has been the transformation of my entire life both socially and academically. I owe it all to my supervisors for their unwavering support, encouragement and kindness. Special thanks to Dr Lily Sun for your thought-provoking questions and critical comments on my research. I would like to also thank other staff in the IRC especially Prof. Keiichi Nakata, Prof. Yinshan Tang, Dr Weizi Li, Dr Stephen Gulliver, Dr Ekililu Salifu, Dr Lina Varotsis, Ms Cindy Zhang and Mr Leo Beadman for all the support you gave me throughout my studies. I also thank all doctoral students in the IRC for your assistance and feedback on my research.

Many thanks to Prof. Joshua Abor, the Dean of University of Ghana Business School for your confidence in me and all the encouragement. I also thank the following individuals for their support in my life, Dr Erasmus Addae, Dr Anthony Apekey, Dr Stephen Opoku-Anokye, Mr Dickson Adabla, Mrs. Josephine Kugblenu, Mrs Amegede, Mr Randy Carbonu, Mr Fred Amankwa-Sarfo, Mr Derrick Agyenim-Boateng, Ms Nancy Kuglenu, Mr and Mrs Folikumah, Mr and Mrs Korley, Mr and Mrs Addison and to all persons who contributed to my life and education all these years.

Many thanks to the Commonwealth Scholarship Commission for sponsoring my PhD. I also thank all the respondents for their time and readiness to always talk to me during the data collection period especially to Mr Matey Korley, Customs Sector Commander, Mrs Morley, Customs Head of Systems, Mr Edward Osei, Director of Ports, Ghana Ports and Harbour Authority (GPHA), Mr Boateng, Head of Bond Vehicle Warehouse, and to the importers, freight forwarders, GPHA staff and Customs officers who participated in the data collection.

Last but not least, I thank my wife Sandra Amenyawu Senyo and son Erasmus Dziedzorm Senyo for your understanding, support, encouragement and prayers. I also thank my parents Mercy Yeboah and Anthony Senyo for your investment in my life, support, prayers and encouragements. Finally, I thank all other family members and friends for all the encouragement and support during this PhD journey.

With gratitude

Abstract

New organisational alliances such as digital business ecosystems (DBEs) have emerged in line with technological developments. DBE is a socio-technical network of digital technologies, processes, individuals and organisations that collectively co-create value. At the core of DBEs are interdependencies, which refer to interactions between entities. While some interdependencies make positive contributions to value co-creation in DBEs, others lead to inefficiencies. Thus, it is necessary to understand DBE partnerships and evaluate the impact of various interdependencies. In the extant information systems (IS) literature, there is limited understanding of DBE partnerships while approaches for evaluating the impact of interdependencies are arguably not available due to the paucity of interdependence research. Though some approaches exist, they largely focus on interdependence patterns, modelling and analysis, value exchanges and network structure at the business ecosystem level with little emphasis on measuring the impact of interdependencies. In response, this study investigates DBE partnerships and subsequently develops a method to evaluate the impact of interdependencies in value co-creation. The study conceptualises five components that are interdependence types, classes, behaviour taxonomies, entities and outcome flows as elements needed to understand the formation and behaviour of DBE partnerships. Subsequently, the study develops a Method for Evaluating the Impact of Interdependencies (MEII) in value co-creation. MEII as the main contribution of this study is a methodological solution that provides techniques to articulate DBEs' context, identify, visualise, analyse and measure the impact of interdependencies. For validation, the study employed the case study and the expert review strategies. By explaining the formation and behaviour of DBE partnerships and developing MEII, the study makes several theoretical, methodological and practical contributions. Theoretically, the study contributes by developing MEII as a sound solution to evaluate the impact of DBE interdependencies. Also, this study propounds definitions, a notation and a kernel theory for DBE interdependencies, partnerships, interdependence classes and interdependence evaluation metrics respectively. The study also extends the theory of Organisational Semiotics by adding operational and strategic impact assessment metrics to its social valuation framing technique. Methodologically, the techniques of MEII are valuable artefacts that provide systematic processes for evaluating the impact of DBE interdependencies. Practically, the solutions to understand DBE partnerships and MEII can be useful tools for practitioners to improve value co-creation and resilience in DBEs.

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Senyo, P.K., Addae, E., and Boateng, R. (2018). Cloud Computing Research: A Review of Research Themes, Frameworks, Methods, and Future Research Directions. *International Journal of Information Management*. Vol 38, No 1. pp, 128-139

Senyo P.K., Liu K., Effah J. (2018) A Framework for Assessing the Social Impact of Interdependencies in Digital Business Ecosystems. In: Liu K., Nakata K., Li W., Baranauskas C. (eds) Digitalisation, Innovation, and Transformation. ICISO 2018. IFIP Advances in Information and Communication Technology, Vol 527. Springer, Cham

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Chapter 1

Introduction

1.1 Background and Motivation

Digital innovation has radically changed how organisations collaborate and compete. Coupled with this change are new collaborative value creation webs such as digital business ecosystems (DBEs) which have altered traditional organisational networks (Selander *et al.*, 2013). As such, the current business landscape is witnessing increased interdependence among various organisations (Gartner, 2015). DBE is a socio-technical network of digital technologies, processes, individuals and organisations which collectively co-create value (Nachira *et al.*, 2007; Senyo *et al.*, 2016). The power of DBE lies in its ability to harness resources from diverse partners to co-create value. Value co-creation is where efforts and resources of different individuals and organisations result in an output of value (Prahalad and Ramaswamy, 2004a). Value is defined as benefits derived from interactions between entities, which could be financial or non-financial (Vargo *et al.*, 2008). For many organisations, digital innovation and DBE specifically presents an innovative medium to leverage resources such as technology, knowledge and specialised services to respond to growing customer needs. These and many benefits make participation in DBEs nowadays non-exceptional for some organisations.

DBE has gained popularity in many disciplines such as information systems (IS) (e.g., Senyo, Liu, Sun, & Effah, 2016), general management (e.g., Koch and Windsperger, 2017), tourism (e.g., Del Chiappa & Baggio, 2015) and computer science (e.g., Raza *et al.*, 2010). Aside from the research interest, DBE has also gained increasing attention in practice (Gartner, 2015, 2016) as organisations leverage external resources to co-create value. Example of well-known DBEs are Amazon.com, eBay.com, Alibaba.com and Apple.com. In the extant literature, much focus has been on some of these DBEs, an environment where there are less restrictive membership rules and control over the behaviour of participants (Jansen, 2014). On the other hand, there is limited understanding of other forms of DBEs with stringent membership restrictions.

Recent industry reports (Gartner, 2014, 2015) indicate that most businesses are moving from traditional into digital spaces to leverage opportunities presented by information technology (IT) innovations for growth. These reports also indicate a change in business structure where

there are cross-industry collaborations and competitions. This change presents a challenge to researchers to provide methods that can support organisations during and after this transition. Aside these, there is also a challenge of developing appropriate methods and frameworks to evaluate the effects of interdependencies due to the formation of new organisational networks such as DBEs. Since some relationships in these networks can be beneficial and others detrimental to efficient value co-creation, it is important to have an approach to evaluate the impact of all interdependencies. The key concern is how to effectively diagnose DBEs comprised of several interdependencies. This concern then raises the question of developing appropriate methods, models, guidelines and tools to evaluate DBE interdependencies.

While DBE offers numerous benefits and can be an effective organisational strategy, it is imperative to note that some interdependencies can be detrimental to value co-creation (Fayoumi, 2016). To this end, it is important to understand the contributions of various interdependencies in DBEs so that appropriate steps can be taken to address inefficiencies. Although some studies exist on DBEs in the IS literature, focus has largely been on platform, (e.g., Tiwana, 2015a), capability development (e.g., Selander *et al.*, 2013), DBE conceptualisation (e.g., Stanley and Briscoe, 2010) and system integration (e.g., Korpela *et al.*, 2017). As such, there is less clarity on DBE partnerships and paucity of approaches to holistically evaluate the impact of interdependencies (Pentland *et al.*, 2015; Senyo *et al.*, 2017) with exception of a few which largely focus on interdependence modelling and analysis.

As Peter Drucker once said, “if you can’t measure it, you can’t manage it.” Thus, there is a need to understand DBE partnerships and provide systematic approaches to evaluate the impact of interdependencies. By addressing this need, there will be clarity on the formation and behaviour of DBE partnerships as well as a method to comprehensively evaluate the impact of interdependencies to: (1) foster healthy collaboration between entities to achieve better value co-creation, (2) determine the resilience of DBEs to withstand turbulent periods, (3) distinguish healthy relationships from harmful ones and (4) support strategic planning and decision making. Therefore, the motivation of this study is to explain the formation and behaviour of DBE partnerships and develop a method to evaluate the impact of interdependencies.

1.2 Research Problems

Following the motivation above, the research problems underpinning this study are discussed from three main strands: theoretical, methodological and practical.

Theoretical research problems

In the extant IS literature, DBE and interdependence have been largely investigated separately, although interdependencies are identified as a core element of DBEs. As such, calls have been made for the need to view the two concepts as constitutively entangled (Senyo *et al.*, 2017). In addition, only a few studies in IS research investigate interdependencies. Moreover, these studies largely focus on task (e.g., Bailey *et al.*, 2010), process (e.g., Crowston, 1994), routine (e.g., Spee *et al.*, 2016) and actor (e.g., Gupta and Maltz, 2015) interdependencies. To a large extent, there have been limited studies on interdependencies between a collection of digital technologies, processes and organisations at the DBE level. Given that DBE interdependencies occur between heterogenous entities and not just homogenous ones, there is call for current studies to move beyond the focus in extant literature (Bailey *et al.*, 2010). In the extant DBE literature, much research exists on open private sector DBEs such as Amazon.com, Alibaba.com and Apple.com. Conversely, limited research exists on closed public sector DBEs, creating a lacuna in knowledge. Given that some characteristics such as legal requirements and membership processes differ in the two forms of DBEs, there is a need for research on closed public sector DBEs to bridge the knowledge gap.

Due to the origin and the contemporary nature of DBE, one stream of the extant literature largely focuses on providing understanding of foundational aspects such as definition, characteristics and genesis (e.g., Nachira *et al.*, 2007; Stanley and Briscoe, 2010). In another stream, other studies also focus on lessons from executed DBE projects (e.g., Darking and Whitley, 2007; Herdon *et al.*, 2012). Although these areas of research are important, there is limited theorisation in DBE research. In fact, Tan et al. (2015; 2016) made a call for the development of DBE specific theories to explain some of its aspects due to current limitations. In response, this study undertakes a kernel theorisation on metrics to evaluate the impact of DBE interdependencies in value co-creation.

While there is clarity on the types of interdependencies between entities in DBEs, previous studies (e.g., Pentland *et al.*, 2016; Senyo *et al.*, 2017) have not gone beyond this to explore how the types of interdependencies can be combined with other components such as interdependence classes, outcome flows, behaviour taxonomies and entities to offer a better understanding of DBE partnerships. To articulate these components, there is a need to first understand DBE interdependencies and partnerships. However, there is currently no explicit definition for DBE interdependence and partnership, though they are important foundation for other investigations on DBE interactions, hence, there is a need for clear definitions.

Though design science research enables creation of artefacts to address business problems (Hevner *et al.*, 2004), it is however weak in advancing theoretical development of emerging research areas in terms of formulating definitions and providing understanding of building blocks (Baskerville, 2008). Hence, there is a need to combine design science research with approaches such as Semiotics to advance the development and understanding of fundamental aspect of contemporary research areas like DBE. However, in the IS literature, there is no clear-cut procedure that illustrates how to combine design science research with other approaches.

Within IS research, the theory of Organisational Semiotics has been useful in investigating socio-technical phenomena within organisations. To a large extent, the theory has mainly been used to investigate information (Stamper, 1985), communication (Xu *et al.*, 2016), information systems analysis (Liu *et al.*, 2002), modelling (Liu *et al.*, 2006), design (Pereira and Baranauskas, 2015) and requirement engineering (Liu, 2005). However, there is limited use of Organisational Semiotics in other research areas like DBE. While Organisational Semiotics offers the valuation framing technique to evaluate the impact of innovations, focus is only on social effect whereas operational and strategic impacts are unaccounted for. As interdependencies produce multifaceted impacts, there is a need to extend the valuation framing technique of Organisational Semiotics so that it can holistically evaluate the social, operational and strategic impacts of innovations.

Methodological research problems

Although it has been acknowledged that interdependence evaluation is important (Pentland *et al.*, 2016), there are currently limited methods to carry out this assessment. While the design science research paradigm offers principles to develop artefacts (Hevner *et al.*, 2004), ironically, there is little design-focused research in the DBE field. Thus, to address the methodological challenges in DBE research, there is a need for studies to utilise design-focused approaches to develop artefacts. Currently, some interdependence evaluation approaches exist, however their focus are on value exchanges (Weigand *et al.*, 2007), intangible interdependencies (Allee, 2008), network structure (Battistella *et al.*, 2013) and interdependence patterns (Pentland *et al.*, 2015). In addition, some of these studies largely focus on interdependence modelling and analysis at the business ecosystem level (e.g., Fayoumi, 2016; Tian *et al.*, 2008). Thus, there is a need for a sound methodological solution to evaluate the impact of interdependencies in value co-creation at the DBE level.

Notwithstanding the limited designed-focused artefacts in DBE research, some few approaches exist, however they are largely conceptual without empirical validation. In addition, these approaches mainly focus on technical issues in DBEs such as risks detection (Hussain *et al.*, 2007b), process interoperability (Figay *et al.*, 2012), technology integration (Korpela *et al.*, 2016) and systems architecture (Svirskas *et al.*, 2008). In contrast, there are limited approaches that address business issues in DBEs such as formation and behaviour of DBE partnerships as well as interdependence impact evaluation. As most existing DBE artefacts focus on technical issues, they are largely not underpinned by theory. As a result, their logical development processes are missing in the literature, thus these artefacts are difficult to replicate. Therefore, there is dire need for the development and empirical validation of theoretically sound artefacts that address business issues in DBEs.

Practical research problems

In practice, DBEs are becoming apparent, resulting in increased collaborations and competition between different organisations across industry boundaries. This increased cross-industry collaboration and competition has escalated the complexity of interdependencies between organisations, processes and technologies. However, one key trend in practice is that performance evaluation is largely IT-focused, while less attention is paid to interdependencies. Given that interdependencies occur between IT systems, processes and business actors, they present a generic and a more holistic medium to conduct performance evaluations. Hence, there is a need for performance evaluations to be conducted based on interdependencies instead of IT systems.

Another observation in practice is that evaluation are sometimes undertaken in isolation without considering the effect of interdependent entities as required at the DBE level. For instance, one organisation can evaluate its own performance without necessarily extending the evaluation to others interdependent partners. As a result, the outcome of the evaluation may fall short in providing a holistic view. In the current era of DBEs, it is not prudent for organisations to focus solely on internal performance evaluation. In cases where an organisation is a focal link to others, it will be prudent to consider other interdependent relationships in performing evaluations to determine their impact on the overall performance. In addition, some existing approaches in practice for impact evaluation are not theoretically-driven. As such, they lack required rigour for generalisation in other DBEs. For these reasons, there is a need for a theoretical sound approach to evaluate the impact of interdependencies to avoid performing isolated assessment.

1.3 Research Questions

To address the research problems highlighted above, the overarching research question of this study is:

- How can we analyse DBE partnerships and develop a method to evaluate the impact of interdependencies between entities in value co-creation?

To address the general research question, the study investigates the following sub-questions:

- What are the limitations in the extant DBE literature and interdependence evaluation approaches?
- What are DBE partnerships and how can we explain their formation and behaviour in value co-creation?
- How can a set of metrics be developed to measure the impact of DBE interdependencies?
- How can a method be developed to evaluate the impact of DBE interdependencies?
- How can a method for evaluating the impact of DBE interdependencies be used in practice?

1.4 Aim and Objectives

In line with the research questions above, the aim of this study is to understand DBE partnerships and develop a method to evaluate the impact of interdependencies between entities in value co-creation towards performance improvement. To achieve this aim, the following objectives are formed to guide the study:

- To critically review the extant DBE literature and interdependence evaluation approaches. First, this study systematically synthesised existing studies on DBE and identified limitations. Next, the study reviewed some existing interdependence evaluation approaches to determine their limitations.

- To clearly define DBE partnerships and explain their formation and behaviour in value co-creation. First, the study proposed a definition for DBE interdependencies and partnerships. Next, the study articulated components of DBE partnerships and subsequently explained the underlying relationships of their formation and behaviour to enable understanding.

- To develop a set of metrics to measure the impact of DBE interdependencies in value co-creation. This objective was achieved through the development of a kernel theory on metrics to measure the impact of DBE interdependencies.

- To develop a method for evaluating the impact of DBE interdependencies in value co-creation. This objective led to the development of a method that supports articulation of DBEs' context, identification, visualisation, analysis, measurement and impact assessment of interdependencies in value co-creation.

- To apply and validate the method for evaluating the impact of DBE interdependencies in practice. This objective led to the demonstration of how the developed method can be used to evaluate the impact of DBE interdependencies. In addition, the objective supported articulation of the contributions and limitations of the developed method.

1.5 Research Contributions

This study contributes to research and practice in three-folds: theoretical, methodological and practical.

Theoretically, this study contributes to DBE research, design science and Organisational Semiotics in the following ways. First, this study establishes a kernel theoretical proposition on metrics to measure the impact of DBE interdependencies. Kernel theory is a theoretical foundation for design artefacts that explain and predict phenomena of interest (Goldkuhl, 2004; Kuechler and Vaishnavi, 2008; Walls *et al.*, 1992). Second, the study contributes to DBE research by propounding a definition for DBE interdependencies and partnerships. In addition, the study develops a notation for identifying and classifying DBE interdependencies. Third, the study extends the theory of Organisational Semiotics by adding operational and strategic impact assessment metrics to its valuation framing technique. Fourth, this study extends the Semiotic methodology by proposing suitable tools for its analysis stage. Lastly the study contributed by combining Semiotics with design science to address a dual research aim.

Methodologically, this study contributes to research by developing a method for evaluating the impact of DBE interdependencies. The method and its embedded techniques can be used to evaluate the impact of all classes of DBE interdependencies, hence a valuable solution for interdependence impact evaluation. The generic nature of the method makes it applicable to a wide range of DBEs. Lastly, the method is arguably the first in DBE research, hence a good foundation for future methodological development.

Practically, the method enables evaluation of the impact of DBE interdependencies, thus, can be a useful tool for practitioners. Given that DBEs are now becoming prominent, this study envisages the developed method to contribute to the development of DBEs. In addition, the method can support practitioners in planning and decision making since the results offer directions on how to reorganise interdependencies for optimum impact. It is believed that the result of the interdependence impact evaluation will support better value co-creation between entities and foster growth and overall resilience of DBEs.

1.6 Thesis Outline

This thesis is structured in line with tenets of the Semiotics and the design science research methodologies. Figure 1.1 shows the thesis outline, where the chapters demonstrate the overall flow of activities to address the study's aim. Building on the introduction above, the rest of this thesis is structured as follows:

Chapter 2 presents the literature review. First, the chapter discusses the evolutionary development of DBE from ecology and business ecosystem as well as their differences and similarities. Next, the chapter examines two main forms of ecosystems, namely closed and open and the one this study focuses on. Following this, the chapter critically synthesises the extant DBE literature to determine limitations that warrant the current study. Thereafter, the chapter discusses the literature on interdependence by examining its types and forms as well as highlighting the gaps therein. The chapter also discusses some existing interdependence evaluation approaches and points out their limitations which this study addresses. After this, the chapter discusses the conceptual link between interdependence and value co-creation and how these concepts affect DBEs' performance. Lastly, the chapter discusses Organisational Semiotics and provides the rationale for its choice as the appropriate theoretical lens for this study.

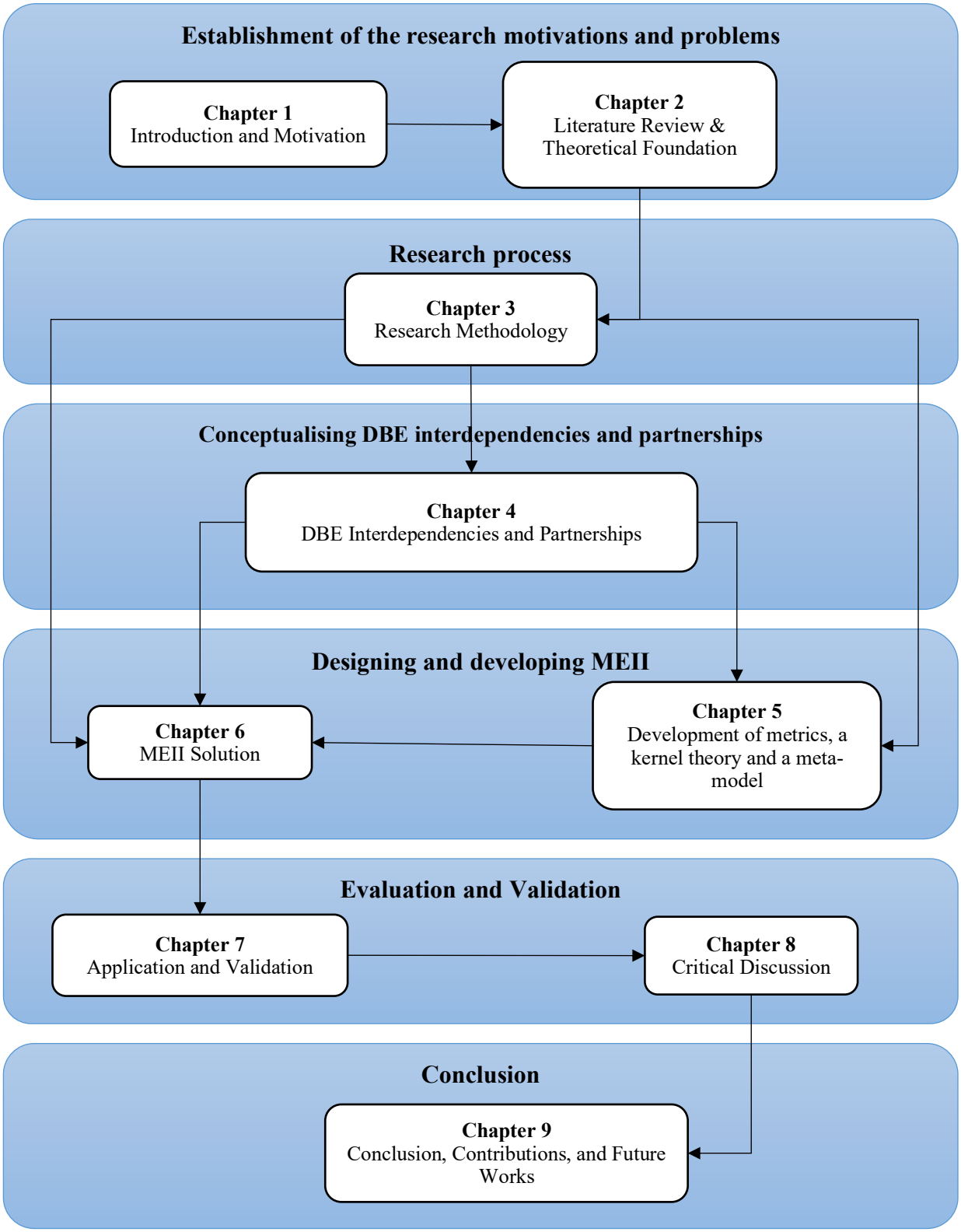

Figure 1.1 Thesis structure

Chapter 3 presents the research methodology. It discusses the philosophical assumptions of the major research paradigms in IS research based on their ontology, epistemology and methodology. Then, the chapter discusses major research methodologies and methods in IS.

Next, the chapter presents the adopted research approaches, methodology and method as well as the rationale for these choices. Following this, the chapter discusses the overall research design by explicating how Semiotics and design science were utilised in this study to address the research aim.

Chapter 4 presents this study's conceptualisation of DBE interdependencies and partnerships. As a first step to understanding DBE partnerships, this chapter discusses DBE interdependencies and proposed a definition. Next the chapter presents a notation for DBE interdependencies to enable easy identification and articulation of interactions. Thereafter, the chapter conceptualises and discusses the components of DBE partnerships to understand their formation and behaviour. With this conceptualisation, it becomes simple to identify, analyse and understand DBE interdependencies and partnerships. Lastly, the chapter provides a visualisation technique to represent underlying relationships on the formation and behaviour of DBE partnerships. Since further investigations into interactions is dependent on a good understanding of the basic concepts such as DBE interdependencies and partnerships, this chapter provides a good foundation for subsequent chapters to define metrics, design a meta-model and develop a method to evaluate the impact of DBE interdependencies.

Chapter 5 discusses mechanisms underpinning the design and development of a method to evaluate the impact of DBE interdependencies. The chapter discusses the development of three metrics, a kernel theory and a meta-model that supports the developed method. First, the chapter discusses operational, social and strategic metrics for evaluating the impact of interdependencies through inspirations from the theory of Organisational Semiotics and the extant management literature. Next, the chapter postulates a kernel theoretical proposition on metrics to measure the impact of DBE interdependencies. Lastly, the chapter develops a meta-model based on the metrics and the kernel theory as the basis for the development of the method in Chapter 6.

Chapter 6 presents the method for evaluating the impact of interdependencies (MEII) between entities in DBEs. The chapter discusses the main stages of MEII and their inherent techniques. The MEII solution comprises three stages: DBE context articulation, interdependence analysis and rationalisation. At the DBE context articulation stage, MEII presents the unit system definition, the interdependence articulation and visualisation techniques. Under the analysis stage, interdependencies articulated from the defined unit system are profiled to derive their outcomes, norms, entities involved and business issues that need resolution. At the last stage,

MEII presents the interdependence measurement, impact assessment and change management techniques. As the main contribution of this thesis, the chapter critically explicates the reasoning behind the development of MEII, and how it draws inspiration from preceding chapters.

Chapter 7 discusses the application and validation processes of MEII. First, the chapter presents an overview of the vehicle clearing domain of Ghana's port DBE. Then, the chapter illustrates the application of MEII with a case study by articulating the DBE's context and interdependencies. Next, the interdependence analysis and rationalisation stages are illustrated to profile, measure and assess the impact of the interdependencies in value co-creation respectively. After the application, the results were used to validate the appropriateness, utility, generality and innovativeness of MEII through expert review interviews. In all, the outcomes of the application and validation processes support MEII as a novel artefact useful for understanding DBE partnerships and evaluating the impact of interdependencies.

Chapter 8 presents a critical discussion of the entire study by analysing the justifications for investigating the research problems, the research design and conceptualisation of DBE interdependencies and partnerships. The chapter also evaluates justifications for the designed meta-model, the kernel theory, the development, application and validation of MEII. These justifications in the chapter lead to articulation of the contributions and limitations of the entire study.

Chapter 9 concludes this study by providing a summary of research activities undertaken in this thesis. First, the chapter provides a summary of how the research questions posited at the beginning of the study were addressed. Next, the chapter presents the research contributions, limitations and avenues for future works. On research contributions, the chapter discusses the accomplishments of this study from the theoretical, methodological and practical strands. Finally, the chapter discusses the limitations of this study and offers recommendations for future research.

Chapter 2

Literature Review

This chapter presents a review of the literature on DBE, interdependence and value co-creation from which the *first research question* of this study is addressed. The chapter begins by providing an evolutionary account of DBE from ecology and business ecosystem. Next, the chapter presents similarities and differences of ecology, business ecosystem and DBE. This is followed by discussions on the forms of ecosystems where distinction is made between open and closed ecosystems. Thereafter, the chapter synthesises the extant literature on DBE to point out gaps that warrant this current study. Following this, the chapter synthesises the literature on the notion of interdependencies, its types and forms. This is followed by a critical review of existing interdependence evaluation approaches. Thereafter, the chapter discusses value co-creation within the context of interdependencies and how it informs DBE partnerships and interdependence impact evaluation. Finally, the chapter discusses Organisational Semiotics as the theoretical lens for this study.

2.1 From Ecology to Business and Digital Business Ecosystems

This section provides a review of three main ecosystems: ecology, business ecosystem and DBE and how they collectively provide support for the current research. Figure 2.1 shows how DBE is conceptualised with support from ecology and business ecosystem.

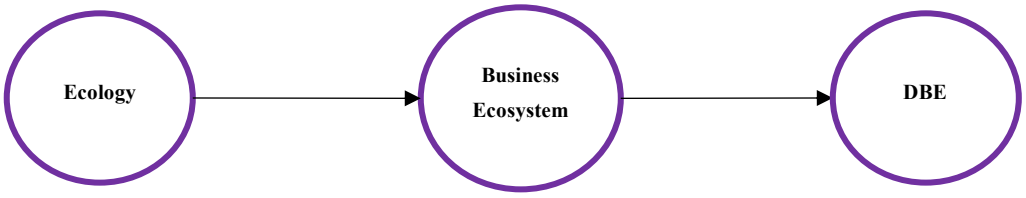

Figure 2.1 Evolution of digital business ecosystems

2.1.1 Ecological Ecosystem

Ecology is a branch of biology that deals with interaction among organisms and their environment (Carroll, 1984; Chauvel *et al.*, 2015). Ecology views interactions among organisms as a network of species called an ecosystem. Ecology is made up of organisms that interdepend on each other to survive. Thus, the fate of an organism is not dependent only on its

characteristics, resources and strategies, but also on other organisms and prevailing conditions in its environment (Hannan and Freeman, 1977). As competition intensifies, some organisms evolve their capabilities and way of life while others go extinct due to changes in the environment. Ecology also shares characteristics of fast evolving, high uncertainty and politically charged environment where organisms' ability to control their fate through adaptation may also be restricted (Carroll and Hannan, 1989).

Despite being deep-rooted in the natural sciences, ecology has been adopted in the social sciences. This development has given rise to new offshoots of the ecological theory such as population, culture, information, organisation and human ecologies (Fedorowicz *et al.*, 2003). Given that DBE has its root in ecology, it is prudent to understand some of its principles regarding structures and relationships. This knowledge is useful in understanding DBE partnerships and the impact of interdependencies in value co-creation. The discussion below presents some principles of ecology such as symbiosis, robustness and self-organisation.

Symbiosis

Symbiosis refers to a relationship between two or more different organisms in an ecosystem (Hannan and Freeman, 1977). The fundamental idea is that an organism in the natural ecosystem must form relationships with others to survive. As a result, there are several interdependencies between organisms in the natural ecosystem. The three main types of symbiosis are mutualism, commensalism and parasitism (Douglas, 1994). Mutualism is a type of symbiosis where organisms within a relationship both benefit without harm to any. A typical example of mutualism is the relationship between dogs and human in some cultures where dogs provide protection to humans against thieves, in return humans provide food and care to dogs. Commensalism is a type of symbiosis where one organism within a relationship benefits greatly while the other does not but is not harmed (Leung and Poulin, 2008). In other words, commensalism is the type of relationship where the benefit is one-sided. An example of commensalism is a relationship between a hermit crab residing in an empty seashell. The hermit crab derives protection from the shell, but the shell does not accrue any benefit and it is also not harmed. Lastly, in parasitic symbiosis, one organism benefits at the detriment of the other (Douglas, 1994). A typical example of parasitism is the relationship between a tick and a dog. The tick benefits from the relationship by socking blood from the dog for its survival while the dog does not derive any benefit and still harmed in the process.

Self-Organising

Self-organising refers to an ecosystem's ability to respond and adapt to changes in its environment without an external force (Fayoumi, 2016). This evolution is largely driven by the emergence of opportunities and threats. In the ecological ecosystem, self-organising can occur in the form of migration or adaptation of organisms (Hubbell, 2001). For instance, a group of organisms may move from one location to another if their source of food in the present location finishes. In the case of adaptation, organisms may self-organise by consuming a new food which they did not previously depend on. A typical example of self-organising is seen in the migration of birds from different locations as the weather changes in their environment. Due to their survival instinct, organisms spontaneously find new ways to live if current conditions are not favourable, thereby resulting in self-organising.

Robustness

Robustness is the ability of an ecosystem to survive turbulent conditions (Hubbell, 2001). In the ecological ecosystem, disasters occur that disrupt the natural balance. As a result, changes may occur in relationships between organisms which could lead to extinction of some species. However, due to the presence of natural robustness characteristics, an ecosystem is able to self-organise to withstand changes. By this, an ecosystem is deemed to have some level of resilience. Robustness in ecology is achieved by strong bonds and multiple layers of relationships and redundancies (Fayoumi, 2016). As such, when an event with negative consequences occur, it takes a long time to affect the core of an ecosystem by which time the process of self-organising might repair the damage. Resulting in the restoration of ecological balance in the ecosystem.

2.1.2 Business Ecosystem

Business ecosystem was coined by Moore (1993) to describe interactions between organisations across traditionally demarcated industry boundaries. Business ecosystem emerged over 20 years ago when the seminal work of Moore (1993) argued for a new dimension of envisaging organisational networks. Since then, several studies have been conducted. Business ecosystem is defined as an economic community supported by a foundation of interacting organisations and individuals where valuable goods and services are produced for customers who themselves are members of the ecosystem (Moore, 1993, 1996). Thus, this study implies that business ecosystems have a diverse group of organisations that interdepend on each other to co-create value. In business ecosystems, partners are empowered by dynamic relationships that can quickly transform static interactions into value co-creation networks. With this support,

organisations in business ecosystems are open to new opportunities and are able to exhaustively explore these new prospects.

Similar to the natural ecosystem, there are different actors within business ecosystems. Most of these roles depend on the influence a firm exerts in a business ecosystem. Iansiti and Levien (2004a) identify three roles of business ecosystem actors – keystones, niche players and dominators. On the other hand, Moore (2006) posits that actors in business ecosystems include governmental institutions, media, customers, lead producers, competitors, suppliers and leadership companies. Similarly, Adner and Kapoor (2010) identify four types of actors in business ecosystems: suppliers, complementors, focal firm and customers. From all perspectives, an overlap can be drawn from the actor roles. Hence, this study identifies the following as business ecosystem partner classifications: keystones, niche-players, dominators and customers.

Keystones

Like the biological ecosystem, business ecosystem has leadership organisations called "keystone species" (Iansiti and Levien, 2004) that have a strong influence over the entire ecosystem. Keystones or focal firms are actors with a leadership position within an ecosystem (Iansiti and Levien, 2004a). They have a strong influence in an ecosystem through ownership of strategic platforms. As such, they are responsible for advancing the growth of an ecosystem through reduction of entry barriers, acquiring and retaining partners as well as filling niche gaps. Keystones strive for the growth of an ecosystem, as such, they usually adopt the win-win approach in dealing with other partners. For instance, keystone partners in the iPhone ecosystem are Apple, application (App) developers, customers and content providers. Apple provides mobile phones while app developers create software for users. Hence, Apple is regarded as a keystone by virtue of owning core platforms (iPhone, developer kits and iTunes) on which others rely for their service innovation. Without Apple's platforms, the developers and customers cannot derive their outcomes.

Niche partners

Niche partners are actors that complement the efforts of keystones. Niche partners are usually small sized organisations and individuals that focus on creating assets and capabilities within specialised domain of a business ecosystem (Zhang and Liang, 2011). The platforms owned by keystones are the source of opportunities for niche partners to develop new products and services. As a result, niche players are always in close relationship with keystone partners.

Similar to the illustration above, App developers are example of niche partners since they rely on Apple and its platforms to create apps for users.

Dominators

Dominators are actors that integrate others vertically or horizontally to own key assets for value extraction (Iansiti and Levien, 2004b; Li, 2009; Peltoniemi, 2006). A dominator within an ecosystem mainly seeks ownership of key assets for value extraction (Iansiti and Levien, 2004a). They gain influence in the ecosystem through value extracted from hubs. The extraction of value may sometimes result in weakness and limited innovation in the entire ecosystem. For instance, Apple can be viewed as a dominator in the iPhone business ecosystem if it acquires a company that produces some parts for its iPhone.

Customers

Customers refer to end-users for whom goods and services are produced in a business ecosystem (Iansiti and Levien, 2004b). Customers represent a vital role in a business ecosystem since all consented efforts are ultimately targeted at them. Due to the nature of business ecosystems, customers play an active role in value co-creation. Using the example above, individuals and organisations that buy iPhone as well as auxiliary product and services such as apps can be classified as customers of the iPhone business ecosystem.

2.1.3 Digital Business Ecosystem

At the root of DBE is Moore's (1993) concept of business ecosystem. As such, DBE can be seen as an extension of a business ecosystem with the introduction of digital technology platforms to facilitate interactions. While business ecosystem portrays generic organisational interdependencies, DBE extends this view to emphasize the centrality of digital technologies in value co-creation. To this effect, the word "digital" was added to business ecosystem to form a new concept of digital business ecosystem (Dini and Nicolai, 2003). The DBE concept emerged out of a project commissioned by the European Union to drive socio-economic development among organisational networks using ICT as a catalyst. Early before the DBE project, Moore (2003) himself used the concept of DBE to refer to ICT development and adoption in Ghana (Moore, 2003). The DBE project had two objectives to fulfil, namely (1) to provide Europe with a recognised advantage in innovative software application development by its small and medium-sized enterprises (SMEs) and (2) to achieve greater ICT adoption by SMEs in general.

DBE is defined as a socio-technical network of technology platforms, processes, individuals and organisations that collectively co-create value (Nachira *et al.*, 2007; Senyo *et al.*, 2016). DBE comprises two main tiers – the digital ecosystem and business ecosystem (Stanley and Briscoe, 2010). Digital ecosystem refers to a virtual environment populated by digital species such as software applications, hardware and processes (Nachira *et al.*, 2007). Digital ecosystem operates as a peer-to-peer distributed technology infrastructure that creates, disseminates and connects digital services over the Internet. On the other hand, business ecosystem refers to an economic community of individuals and organisations operating outside their traditionally define industry boundaries to collectively co-create value for customers (Moore, 1993). Given that participants collectively co-create value, the relationship arrangement in DBE is seen as a partnership. Thus, in a nutshell, a *DBE= (Digital Ecosystem + Business Ecosystem)*. Like business ecosystem, DBE shares some similar characteristics with the ecological ecosystem. The main characteristics of DBEs are platform, symbiosis, co-evolution and self-organising as elaborated below.

Platform

From the DBE perspective, platform refers to a collection of tools that partners in DBEs use to develop their individual innovations (Gawer and Cusumano, 2013; Selander *et al.*, 2013). With platforms, partners can develop new innovations through collaboration with others, thereby shifting concentration from product value to network value co-creation (Prahalad and Ramaswamy, 2004b). Thus, platform owners command great influence in DBEs. Examples of prominent DBE platforms include Apple's iTunes and iOS, as well as Google's Playstore and Android operating system. For instance, the iTunes serves as a platform for app developers, music, book and video sellers to deliver content to customers. The survival of these partners depends largely on the availability of the iTunes platform. The platform characteristic makes DBE a value network instead of the traditional product or service value chain. It is also important to note that there could be more than one platform within a given DBE.

Symbiosis

Symbiosis refers to interdependencies between DBE entities such as partners, processes and technologies that support value co-creation (Senyo *et al.*, 2017). Based on symbiosis, DBE partners become entangled with each other, resulting in a network of relationships where a change may lead to ripple effects. Hence, organisations in DBEs see external competitions as an ecosystem-wide issues instead of a company to company rivalry (Li, 2009). The symbiotic relationship acknowledges the power of synergy to co-create value greater than the sum of value

created individually. According to Adner (2006), no single organisation can produce value to satisfy its customers which supersedes the value from an ecosystem. Thus, it is important for organisations to interdepend on each other to blend their strengths and weaknesses to forge greater value proposition for customers. What distinguishes symbiosis in a DBE from traditional value chain is the fluidity and flexibility to span different industry boundaries. For example, in the iPhone DBE, app developers depend on Apple for the iOS software stack to develop mobile applications. Similarly, Apple also interdependence on Foxconn to manufacture their phones. Merging the capabilities of these interdependent organisations helps to deliver superior value to customers which would be difficult to efficiently accomplish by a single organisation. Therefore, the continuous existence of some key organisations is beneficial to the entire DBE. In DBE, symbiosis exists between both social and technical entities. From the technical perspective, interdependencies occur between digital technologies through resource sharing and systems integration (Adner and Kapoor, 2010). On the other hand, at the business network level, interdependencies occur among partners through business processes (Iansiti and Levien, 2004a).

Co-evolution

Co-evolution refers to a situation where two or more entities reciprocally affect each other's development as a result of their symbiotic relationships (Stanley and Briscoe, 2010). In co-evolution, entities apply selective pressure on their partners through the contribution of complementary capabilities as a result of changes in their environments (Moore, 1993). Co-evolution affects all types of symbiosis including mutualism, parasitism and commensalism. As a dynamic environment, DBEs constantly evolve as new changes emerge. Thus, it is incumbent on DBE participants to have a flexible posture and always scan for new changes. In some cases, the consequences of not co-evolving is extinction as entities may not survive new requirements that underpin evolutions. In a DBE, co-evolution originates between a small number of entities until the entire ecosystem experiences a major evolution. Due to the nature of DBE interdependencies where entities heavily interact to co-create value, it is necessary for keystone partners to evolve in conjunction with other partners for new ecosystem partnership to emerge. For instance, an App developer in iPhone DBE may co-evolve with Apple if new requirements emerge that necessitate a transition to a cloud-based apps platform which will require users to log in to apps in the cloud. As Apple puts in new components in the App platform, developers will have to equally revise their code else they may be left behind, and the ultimate result may be extinction.

Self-organising

Self-organisation is a process where a DBE learns from its context and accordingly evolves to restore its balance whenever there is a disorder (Peltoniemi, 2006). The process of self-organising involves initial interactions between local entities until the entire DBE evolves. Self-organising is often triggered when new requirements, opportunities or threats emerge. As a network of interdependencies, a reaction to changes between two entities may result in ripple effects on an entire DBE. When new changes arise in a particular DBE because of either opportunities or threats, key partners react. Consequently, other interdependent partners also react to take advantage of or mitigate the negative effects of the change respectively. Thus, DBEs do not rely on external agents to regulate self-organising processes as they occur spontaneously. As self-organising occurs in a decentralised manner between several entities, it offers some level of robustness and resilience for self-repair in case of turbulences.

2.2 Similarities and Differences in Ecosystems

As DBE is built on business ecosystem and ecology, they share some similarities. Conversely, DBE possesses some distinct characteristics that set it apart from the other ecosystems. The essence of discussing the similarities and differences is to clearly distinguish DBE from the other ecosystems. Table 2.1 presents a summary of the main ecosystems by highlighting their characteristics, entities, similarities and differences. The key characteristics of the ecological ecosystem are symbiosis, robustness and self-organising (Douglas, 1994; Hannan and Freeman, 1977). In business ecosystem, the key characteristics are productivity, robustness and niche creation (Iansiti and Levien, 2004b). In DBEs, the key characteristics are symbiosis, platform, self-organising and co-evolution (Nachira *et al.*, 2007; Stanley and Briscoe, 2010). In relation to entities, the ecological ecosystem comprises biotic and abiotic organisms which refers to living and non-living things. Conversely, entities in business ecosystem include individuals and organisations while those in DBEs include digital technologies, individuals and organisations.

Table 2.1 Summary of the main ecosystems (Adapted from Stanley and Briscoe, 2010)

Dimensions	Ecological Ecosystem	Business Ecosystem	Digital Business Ecosystem
Definition	A branch of biology that deals with interaction among organisms and their environment	An economic community supported by a foundation of interacting organisations and individuals where valuable goods and services are produced for customers	A socio-technical network of digital platforms, processes, individuals and organisations that collectively co-create value
Characteristics	Symbiosis Robustness Self-organising	Productivity Robustness Niche creation	Symbiosis Platform Co-evolution Self-organising
Entities	Biotic organisms Abiotic organisms	Individuals Organisations	Digital technologies Individuals Organisations
Similarities	1. All ecosystems experience evolution and sometimes extinction of organisms 2. All ecosystems are dynamic in nature 3. All ecosystems comprise numerous diverse participants and relationships 4. All ecosystems experience limited resources		
Differences	1. Ecological ecosystem comprises of natural organisms while business ecosystem consists of individuals and organisations. On the other hand, DBE comprises both technologies, individuals and organisations. 2. Food, water, security and shelters are resources that trigger interdependencies in the ecological ecosystem while resources such as technology, information, skills, finance as well as good and services are the foundation of interdependencies in both business ecosystems and DBEs. 3. DBE relies heavily on ICTs to function while business and ecological ecosystems do not. 4. DBE and business ecosystem compete over membership while ecological ecosystems do not. 5. DBE and business ecosystem have capabilities to develop new products and services while the ecological ecosystem is mainly concerned about survival. 6. Ecological ecosystem is concerned about the exchange of energies while business ecosystem and DBEs are concerned about the exchange of value. 7. Ecological ecosystem is naturally created while business ecosystem and DBE are artificial creations.		

In terms of similarity, all the ecosystems experience evolution and sometimes extinction due to changes in their environment. For instance, evolution occurs in the natural ecosystem when organisms after some time develop resistance mechanisms to certain conditions. In DBEs and business ecosystems, evolution occurs when certain entities become extinct in the environment. A typical example is in the smartphone ecosystem where Nokia who used to be the leader in the mobile ecosystem lost its place and has become insignificant due to its inability to match changes. In addition, all ecosystems are not static but dynamic and constantly evolve as new requirements emerge. The dynamic nature of ecosystems is aided by capabilities of self-organising and co-evolution as opportunities or threats emerge. Due to their nature, all

ecosystems comprise a large number of heterogeneous entities as a result of symbiosis. Lastly, all ecosystems experience some form of scarcity as there are limited resources.

Also, the following differences exists between the ecosystems. First, ecological ecosystem comprised of natural organisms while business ecosystem and DBE comprise digital technologies, individuals and organisations. A key distinguishing feature is the role of ICT in DBEs which has brought digital species that are not evident in the generic business ecosystem such as software applications and components (Graça and Camarinha-Matos, 2017). Second, in ecology, resources on which interdependencies developed include food, water, security and shelter while in both business ecosystem and DBEs, relationships develop around resources such as technology, human skills, information, good and services as well as finance. Third, ecological ecosystems concern exchange of energies between organisms while business ecosystems and DBEs concern exchange of value. Fourth, DBEs rely heavily on ICTs to function efficiently (Briscoe *et al.*, 2011) however, business ecosystems and ecological ecosystems do not. Fifth, entities in business ecosystems and DBEs are capable of forecasting with some degree of accuracy about future events while entities in ecological ecosystems are not. Sixth, business ecosystems and DBEs compete with other ecosystems for membership while ecological ecosystems do not (Iansiti and Levien, 2004b). Lastly, DBE and business ecosystems have capabilities to develop new innovations while the ecological ecosystem mainly focuses on survival (Briscoe *et al.*, 2011; Iansiti and Levien, 2004b; Stanley and Briscoe, 2010).

2.3 Forms of Ecosystems

From the extant literature, ecosystems can be classified into two main forms, namely open and closed ecosystems (Bosch-Sijtsema and Bosch, 2015). Open ecosystem refers to an environment where there are less restrictive membership rules and control over the behaviour of participants (Jansen, 2014). In addition, in open ecosystems there are exchanges between the ecosystem and its surroundings. A typical example of an open ecosystem is the ecological ecosystem. On the other hand, closed ecosystems are environments where there are strict membership rules, with focal partner having some level of control over some key participants (Ceccagnoli *et al.*, 2012). A popular example of a closed ecosystem is Apple's iPhone DBE. Apple as the focal partner regulates membership of certain key partners and controls what they can and cannot do in the DBE. For instance, a mobile App developer who wants to join Apple's DBE will have to pass prerequisite checks before admission. To continue operating in the DBE, the App developer must abide by rules defined in the DBE.

According to Gartner (2017), ecosystem can be classified into three forms: public, private and hybrid. These three forms of ecosystems are defined by their degree of openness (level of restrictions). Public ecosystems refer to ecosystems that are open to a wide range of participant and has less restrictions. Conversely, private ecosystems refer to ecosystems that operate selective memberships and has many restrictions. Lastly, hybrid ecosystems exhibit characteristics of public and private ecosystems. Hence, closed ecosystem can be equated to the private ones while open ecosystems are synonymous with public. In the business environment, the form of a DBE can be identified based on openness of its platforms (West, 2003). In cases where there are restrictive access to platforms, the DBE is likely to be a closed or private and vice versa (Benlian *et al.*, 2015). Restrictions in DBEs become weapons of control for focal partners to set strategic directions. Some of these restrictions cover admission of new members, usage of platforms, interoperability and integration with other DBEs (Sun *et al.*, 2016).

In the business environment, the level of DBE openness varies. While focal partners may have high level of control over all members in some closed DBEs, this is not the case in others. In highly closed DBEs, focal partners determine if some customers should be admitted to the DBE, however, this is not the case in other DBEs. For instance, the port DBE is an example of a highly closed ecosystem. In this DBE, membership is not opened to all customers, only certain importers are accepted as self-declarant importers who are allowed to transact in the port. Other individual importers can only use registered freight forwarders in clearing goods in the port DBE. Apples iPhone DBE is also a closed DBE, however, Apple as a focal partner does not have direct control over customers. As such, customers can easily join and exit the DBE. In this study, the focus is on a highly closed port DBE, dominated by public sector organisations since less is known on this form of ecosystem in the extant literature.

2.4 Digital Business Ecosystem Research

While ecosystem research in the general management field is increasing, DBE research, on the other hand, is dwindling. This is evident in the number of DBE publications over the years. The paucity of DBE research can be attributed to several reasons. First is the difficulty to access data from multiple participants, making DBE research a daunting task. Second is the lack of clear understanding of the DBE concept. In some cases, DBE is literal equated to business ecosystem and digital ecosystem while these concepts are components of DBE. Whereas we acknowledge that DBE research is daunting to undertake, is worth noting that the changes in the traditional value chain place huge responsibilities on researchers to provide guidance, understanding and develop new business models to support organisations that unavoidably find

themselves operating in DBEs. From the extant literature, DBE research can be classified into four main themes, namely business issues, technical issues, DBE conceptualisation and artefacts. These themes were generated through a systematic literature review of 101 peer-review articles published between 2005 to 2017 on DBE research. These articles were sourced from 12 major databases, namely, ABI/INFORM, ACM Digital Library, AISeL, Emerald journals, IEEE Xplore Digital Library, EBSCOhost, SAGE, Science Direct, Scopus, Springer Link, Web of Science and Wiley Online Library as these sources cover a significant range of IS journals and conference publications (Webster and Watson, 2002). The subsections below discuss in detail strands of the extant DBE research and gaps therein that motivates and warrant the current study.

2.4.1 Business Issues Theme

Studies within the business issues theme focus on the commercial implications of DBE. Specifically, these articles examine how DBEs generate business value for participants. The sub-themes under the business issues are *DBE alliances, network analysis, value co-creation, DBE governance and legal issues, trust, risk and security, knowledge development, dissemination and management, as well as DBE strategies, processes and management.* Studies on DBE alliances investigate how relationships are formed between partners and subsequently developed into matured digitally enabled networks. At the core of these studies are issues on stakeholder relationship management (Selander *et al.*, 2010), boundary spanning (Tan *et al.*, 2016), resource sharing (Petrou and Giannoutakis, 2009) and enterprise agility (Tan *et al.*, 2009). Studies on network analysis move a step further to assess the underlying issues of exchanges between entities in DBEs. In these studies, the focus is on analysing physical and virtual ties among entities in DBEs to determine their relationship strength, network stability and robustness (Baggio and Del Chiappa, 2014; Del Chiappa and Baggio, 2015).

Similarly, studies on value co-creation in DBEs focus on how partners collectively generate value. In these studies, issues identified as essential for value co-creation in DBEs include e-readiness (Herdon *et al.*, 2012), capability assessment (Sun *et al.*, 2016), value creation processes (Selander *et al.*, 2010) and inter-network competitions (Tan *et al.*, 2009). Another key sub-theme under the business issues is DBE governance and legal concerns. Given that DBE is self-organising, it is sometimes difficult to define specific governance mechanisms. As such, related studies focus on how flexible governance approaches can be designed and implemented in DBEs (Darking *et al.*, 2006; Tsatsou *et al.*, 2010). In addition, the geographical

independence attribute of DBE creates a lacuna about the applicable law to be enforced in case of legal issues arising from participation in DBEs.

In the same vein, some studies under the business issues theme express concerns over trust, risk and security in DBEs. These concerns are largely fuelled by the virtual nature of DBE transactions where physical contact between transacting parties is limited. As such, issues of trust, risk and security are key concerns for DBE participants (Hussain *et al.*, 2006, 2007a). The constant highlight of these challenges in DBE research has led some studies to provide specific remedy mechanisms in the form of risk and trust detection methodologies (e.g., Hussain *et al.*, 2007b; 2007c). As DBEs are largely dominated by multiple partners, innovation turns to come from different sources. However, how to systematically develop, disseminate and manage these innovative knowledges is challenging. As such, some DBE studies under the business issue theme examine knowledge creation, dissemination and management processes to foster constant innovation. Key recommendations from these studies include the design of platforms to facilitate knowledge transfer (Pappas *et al.*, 2007), and the use of social media to aid stakeholders' involvement in knowledge management activities (Presenza *et al.*, 2014). Lastly, some DBE studies classified under the business issues theme examine DBE strategies and process management. Largely, these studies focus on measures DBE participants can take to leverage and integrate emerging digital technologies into their processes to achieve competitiveness. Also, these studies highlight how DBE platform owners should strategically control their platform (Koch and Windsperger, 2017). For instance, these studies provide insights on which platform layers to open to others in a DBE and how to manage inherent processes during these situations.

2.4.2 Technical Issues Theme

The technical issues theme categorises studies that focus on the technological details of DBE. The sub-themes within the technical issues are *DBE platform design, DBE process and service design, DBE technologies and DBE architecture,* as well as *DBE systems integration and interoperability*. Studies on DBE platform design examine how platforms emerge in DBEs. It is posited that most systems start as supply chain platforms and gradually evolve into DBE platforms due to complementary efforts of other actors (Attour and Peruta, 2014). DBE platform design studies further highlight the need for platforms to create conducive environments that reinforce reciprocate behaviour (Tan *et al.*, 2016). Similarly, the DBE process and service design sub-theme includes articles that target how DBE processes and services are designed in platforms to support value co-creation. Given that DBE services are

sometimes virtual, issues of key consideration include service negotiation processes (De La Rosa *et al.*, 2011), multi-agent system interaction (Wang *et al.*, 2009), as well as service-oriented architecture (Adil *et al.*, 2007).

Studies in the DBE technologies sub-theme examine how technical innovations such as recommender systems, autonomic monitoring, collective intelligence and data mining techniques support DBEs (De La Rosa *et al.*, 2011). In particular, these studies stress the need for standardization of DBE technologies to foster seamless interoperability between systems (Korpela *et al.*, 2017). It is suggested in these studies that DBE technologies should enable partner recommender systems that create virtual organisations as a way for SMEs to join forces with multinational firms to undertake large projects. The DBE architecture sub-theme includes studies that propose new approaches to define the structure of both technical and software components (Cheah, 2007). The key recommendation is the need to develop a DBE oriented architecture instead of relying on existing approaches such as service-oriented technologies since it lacks the capability to deal with some DBE issues (Ferronato and Moore, 2007; Fischer *et al.*, 2010). Lastly, studies in the DBE systems integration and interoperability sub-theme focus on how DBE objects can be seamlessly combined. In particular, these studies stress the need for critical attention to business-related issues since technology integration is not the biggest problem (Korpela *et al.*, 2017). Given that DBEs are composed of numerous partners, some studies also provide approaches to facilitate interoperability. These approaches consider messaging, business processes and collaboration protocol profile as layers to ensure DBE interoperability (Chituc *et al.*, 2007; Corallo *et al.*, 2007; Figay *et al.*, 2012).

2.4.3 DBE Conceptualisation Theme

Studies in this theme examine how the DBE concept has been envisioned. The sub-themes are *DBE development and management, DBE projects, DBE genesis and DBE properties*. The DBE development and management sub-theme includes studies that examine the formation, life cycle, as well as the evolution of DBE. Most of these studies (e.g., Darking and Whitley, 2007; Nachira *et al.*, 2007; Stanley and Briscoe, 2010) are seminal articles that seek to provide general understanding of the DBE concept. Given that DBE emerged from an EU project, some studies under the DBE conceptualisation theme examine key mandates and outcomes of the DBE project as well as the execution of DBE related projects. These studies discuss successes and challenges and how the DBE project could be replicated in other European countries to facilitate socio-economic development (Herdon *et al.*, 2012). The DBE genesis sub-theme includes studies that provide historical accounts of the DBE concept (e.g., Nachira *et al.*, 2007; Stanley

and Briscoe, 2010). These studies discuss the origin and emergence of DBE. Lastly, studies in the DBE properties sub-theme provide an overview and discuss the building blocks and components of DBE. The main issues include discussion on the differences and similarity between DBE and related concepts (Stanley and Briscoe, 2010).

2.4.4 DBE Artefacts Theme

Articles in this theme discuss artefacts in the form of methodologies, frameworks and modelling languages designed to support DBE. The main motivation behind these artefacts is that the unique characteristics of DBE make application of existing artefacts difficult. As such, there is a need for DBE specific artefacts to support its development. The sub-themes under this theme are *DBE methodologies, DBE frameworks, DBE models and DBE modelling languages.* Articles on DBE methodologies provide systematic approaches applicable to certain issues. Some of the DBE methodologies are agent interaction modelling methodology (Hussain *et al.*, 2007c), DBE formation methodology (Nedbal *et al.*, 2013) and trust failure detection methodology (Hussain *et al.*, 2007b; 2007c).

Similarly, articles on DBE frameworks present approaches that explain underlying structural issues in DBE. Examples of DBE frameworks include e-loyalty framework (Faed, 2010), process interoperability framework (Figay *et al.*, 2012), reliability transaction processing framework (Adil *et al.*, 2007), feedback ontology framework (Adil *et al.*, 2008) as well as DBE integration framework (Korpela *et al.*, 2013a). The DBE models sub-theme includes articles that develop models as solutions to DBE issues. These models largely offer similar solutions as the frameworks. Some examples of DBE models include trust model (Isherwood and Coetzee, 2014), coordination model (Razavi *et al.*, 2007) and situation retrieval model (Lu *et al.*, 2013). Lastly, articles under the DBE modelling languages provide a specific set of rules to express the blueprint of DBE objects. Some of the DBE modelling languages are query meta-model language (Kotopoulos *et al.*, 2007) and business modelling language (Corallo *et al.*, 2007).

In conclusion, notwithstanding contributions from the extant DBE studies, it is evident that critical areas like DBE partnerships and interdependence impact evaluation are still open and less researched. Considering the stream of earlier DBE studies, we can argue that only a section of DBE research has been covered. Indeed, the extant literature has acknowledged that only some aspects of DBE have been comprehensively investigated (Lu *et al.*, 2014). Hence, there is a need for further studies into under-researched areas to consolidate understanding. Arguably, limited research exists on DBE partnerships and interdependence impact evaluation. From the

extant DBE research, interdependence has generally been investigated from the relationships and network analysis perspectives. From the relationship perspective, these studies examine how DBEs can be leveraged for enterprise agility (Tan *et al.*, 2009) or how a firm transforms its DBE relationships to achieve an envisioned configuration (Selander *et al.*, 2010). In both cases, the studies provide some antecedents to understand the nature of DBE relationships while the process of evaluating the impact of these relationships remains limited. Similarly, studies that take the network analysis perspective usually engage in analysing the frequency of interactions, robustness, as well as links between partners based on physical and virtual relationships (Baggio and Del Chiappa, 2014; Del Chiappa and Baggio, 2015). Again, these studies also do not provide mechanisms to measure the impact of interdependencies that underpin relationships in DBEs. As interdependence is fundamental to DBEs, its thorough analysis and measurement are important to research and practice. As such, we argue that it is important to investigate DBE partnerships and interdependence impact evaluation. Therefore, this study seeks to fill this gap through the explanation of DBE partnership and development of a DBE interdependence impact evaluation method.

2.5 The Concept of Interdependencies, Types and Forms

Despite manifestation of interdependence in many aspects of life and long decades of research, it is still difficult to identify and define different varieties of interdependencies (Pentland *et al.*, 2015). Thus, it is important to explain the concept of interdependencies, its types and forms. Interdependencies characterise most business activities and relationships but due to their ambiguity, they are sometimes not well acknowledged. Especially when processes are running smoothly, the presence of interdependencies are not quite profound (Pentland *et al.*, 2015). Given the most processes are underpinned by interdependence, it is considered a critical aspect of organisations (Thompson, 1967) and information system (Malone *et al.*, 1999). As organisations and organisational networks are comprised of numerous entities, work is mainly undertaken jointly through some form of division of labour. Consequently, interdependencies are an inseparable phenomenon in organisations and organisational network.

In the general management literature, there have been different conceptualisations of interdependencies. For instance, from Thompson's (1967) view, interdependence refers to the extent of relationship between organisational units. Largely, focus is on how organisational units interact to achieve organisational goals. Building on Thompson's stance, McCann and Ferry (1979) conceptualise interdependence as the exchange of resources between organisational units, but the extent of dependence is based on the frequency, value and amount

of resources exchanged. From the task perspective, interdependence is conceptualised as the "degree to which two or more activities interact to determine an outcome jointly" (Sorenson, 2003). Similarly, from the inter-organisational perspective, Litwak and Hylton (1962) define interdependence as a situation where the accomplishment of individual outcomes depend on reliance on two or more organisations. In a more recent definition, Chakraborty (2016) refers to interdependence as the extent to which actors in a network depend on each other and are unable to easily change these partners during their transactional relationships.

From the different interdependence perspectives, it is apparent that interdependencies involve the following:

1) Interactions, dependencies and relationships between two or more entities,
2) Interdependencies lead to the accomplishment of outcomes,
3) Interdependencies result in some form of exchange of resources between entities.

Based on this premise, this study broadly define interdependencies to involve interactions between two or more entities to accomplish a common outcome through the exchange of resources (McCann and Ferry, 1979; Sorenson, 2003; Thompson, 1967).

2.5.1 Types of Interdependencies

In the general management literature, Thompson's (1967) seminal study clearly distinguishes various interdependencies into three types: pooled, sequential and reciprocal. Given that the basis of these interdependence types is relationship, it is not restrictive to only physical interdependencies, but all forms of interactions be it digital, physical or nested. As a result, these types of interdependencies are still valid. Besides, these types of interdependencies have been used in some recent interdependence studies (e.g., Bailey *et al.*, 2010; Pentland *et al.*, 2016; Sharma and Yetton, 2003). The discussions below explain each interdependence type with individual illustrations while Table 2.2 presents a summary.

Pooled interdependence describes a loosely coupled relationship where different entities produce individual outputs that contribute to an entire system. This implies that for a system to achieve an outcome, all its units must contribute their quota (Thompson, 1967). Pooled interdependence is the basic and commonest type of interdependence. Hence, it requires minimum coordination as individual elements turn to work independently towards an overall goal without the need to directly depend on each other. This scenario of pooled interdependence is presented in Figure 2.2 where E1, E2 and E3 represent entities while O represents the outcome of their interactions. As observed, there is no direct relationship between E1, E2 and

E3, however, they interdependently contribute to O. As such, without consented efforts from all entities, O will not be achieved.

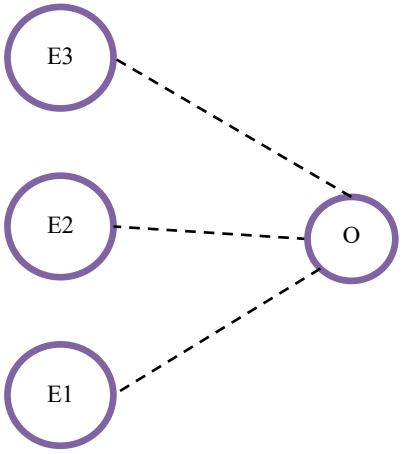

Figure 2.2 Pooled interdependence

The second type of interdependence according to Thompson is sequential interdependence. It describes a situation where outputs from an entity become necessary inputs for the others to perform their tasks. Sequential interdependence depicts a serial relationship between entities. Due to the linear nature of sequential interdependence, it requires high coordination since a problem in one entity directly affect the next entity's ability to perform its operations. A typical example of sequential interdependence is an assembly line. Figure 2.3 depicts sequential interdependence between entities E1, E2 and E3 to produce outcome O.

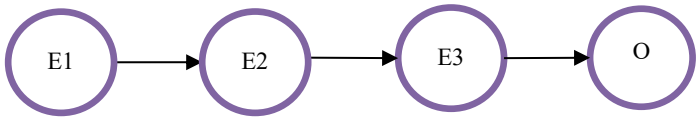

Figure 2.3 Sequential interdependence

The last type of interdependence is reciprocal interdependence (see Figure 2.4). Reciprocal interdependence as the name suggests refers to a cyclical arrangement of mutual flow of inputs and outputs between entities. Reciprocal interdependence operates on a "give and take" assumption where entities concurrently support each other's outcome. According to Thompson, reciprocal interdependence is the most complex type of interactions compared to sequential and pooled respectively. Thus, the presence of reciprocal interdependence is indicative that there is also sequential and pooled. On the contrary, the presence of pooled interdependence does not indicate the existence of sequential and reciprocal interdependence.

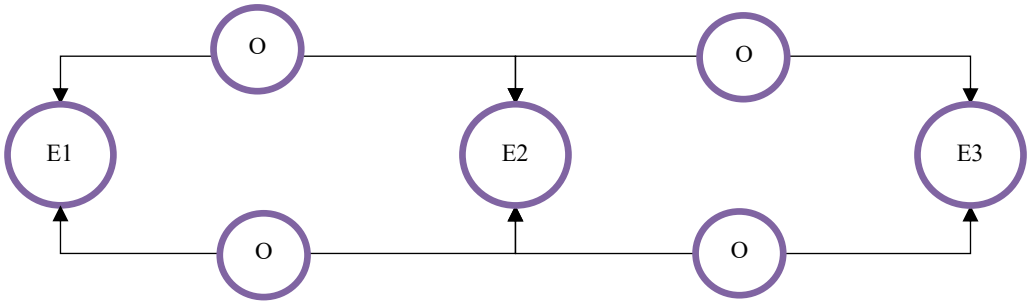

Figure 2.4 Reciprocal interdependence

2.5.2 Forms of Interdependencies

Different forms of interdependencies are evident in the general management literature. While some forms of interdependencies are unique, the majority of others have similar traits. As such, this study classifies the various forms of interdependencies and discuss the pronounced ones in the general management literature. In the subsections, this study discusses task and process, technology, actor and routine interdependence in an attempt to demonstrate limitations in the current literature that warrant this study's conceptualisation of DBE interdependence. Table 2.2 presents a summary of interdependencies.

Task and Process interdependencies

Task and process interdependencies are the dominant forms in the management literature. Even though task, process and activities are distinct concepts, they largely lead to similar outcomes and mostly follow the same patterns. According to Thompson (1967), task interdependence refers to the extent to which work is accomplished through interaction and dependence between group members. Similarly, Malone et al. (1999) define process interdependence as the interaction between processes due to the flow of materials or information. Malone et al further decompose process interdependence into the flow (where inputs of one process becomes outputs of another), shared resources (when two processes require the same inputs) and a common output (occurs when two or more processes produce complementary results). The emergence of task and process interdependence can be attributed to the division of labour (Nuñez *et al.*, 2009). As such, coordination is a consequence of interdependence. As the goal of the work environment is to produce outcomes, task, process and activity interdependencies are regarded as a key component that underpins workflows (Sharma and Yetton, 2003). Task, process and activity are viewed in this study as the larger form of interdependence that sometimes subsumes other interdependencies since they can be found in other entities such as business units, actors and organisations. As the dominant form of interdependence in practice

and the extant management literature, task interdependence transcends all three types of interdependencies. What distinguishes task interdependence in all the three interdependence types is the degree to which a task requires collective action (Wageman, 1995).

Technology interdependencies

According to Bailey et al. (2010), technology interdependence refers to interaction with and dependence between two or more technologies during the course of work. Technology in this interdependence refers to artefacts and technique that provides improved ways to undertake activities (Orlikowski and Scott, 2008). Examples of technologies include software, hardware, devices and specialised techniques. Technology interdependence is now apparent as most organisational activities are now undertaken by technology artefacts. Technology interdependence transcends the three types of interdependencies. As a result, some technologies may contribute directly, indirectly or reciprocally to work. Among various forms of interdependencies in IS research, technology interdependence is the least researched. Although some research exists on technology interdependence (e.g., Adner and Zemsky, 2010; Bailey *et al.*, 2010) focus has been on interdependencies in a single organisation. Thus, there is limited understanding of how technologies interact at the DBE level where multiple technologies feature. On this premise, this study seeks to investigate how technology interdependence is operationalised in DBEs and how these interdependencies contribute to value co-creation.

Actor Interdependencies

Actor interdependencies refer to interaction between two or more individuals or organisations (Gupta and Maltz, 2015). Actor refers to individuals, organisation's members and stakeholders who undertake work (Lyytinen and Newman, 2008). Actors include employees, customers, regulatory agencies and partners. From the literature, actor interdependence can largely occur at the following levels, namely intra and inter-organisational, industry and ecosystem. For instance, at the intra-organisation level, Gupta and Maltz (2015) investigate how actor interdependence influences knowledge diffusion during fuzzy front end innovation. Similarly, Munksgaard (2010), and Solaimani and Bouwman (2012) investigate interdependence at the inter-organisational level using supply chain network and smart living projects respectively. At the industry level, Macaulay (2008) develops an interdependence metric to assess operational risk in the financial sector in United States. Among these strands of actor interdependence literature, limited research has been conducted at the ecosystem level. Except for Kang, Lee, and Tsai (2011) who only provide descriptive understanding of how stakeholder interdependence supports successful deployment of a technology in a mobile communication

ecosystem while limited understanding still exist on DBE partnership and how to evaluate the impact of interdependencies in value co-creation.

Routine interdependencies

Routine interdependencies refer to patterns of repetitive interactions between multiple actors (Spee *et al.*, 2016). In particular, routine interdependence offers a generic umbrella to describe other interdependencies. This is because other forms of interdependencies are visible in routine interdependence. For instance, task interdependence that is repetitive can be referred to as a routine interdependence. While routine interdependencies are repetitive, each interdependence address specific objective (Feldman and Pentland, 2003). Similarly, routine interdependencies occur in the three types of interdependencies. Given that the business environment is dynamic, routine interdependence may change when there is a need to adapt to new requirements (Pentland, 2004). In this case, a routine interdependence temporarily changes from its previous pattern to form a new behaviour. As routine interdependencies are performed repetitively, they minimize conflicts and enable standardisation (Spee *et al.*, 2016). The traditional view of routine interdependence highlights their importance in achieving efficiency as a result of standardisation and stable processes (March and Simon, 1958). On the other hand, contemporary studies view routine interdependence as capable of offering new innovations due to the dynamic nature of the business environment (Dönmez *et al.*, 2016; Feldman and Pentland, 2003).

In conclusion, it is observed that these different forms of interdependencies are suitable for specific context and phenomenon. While this is enlightening, it also reveals that DBE as a new network for business relationships requires conceptualisation of its own interdependence. As one of the contributions of this study, DBE interdependence is proposed as a new form of interaction to account for DBE peculiarities that have not been well established in the extant literature. In proposing DBE interdependence as a novel form of organisational and technology relationship, this study proposes a definition and a notation to represent interdependencies.

Table 2.2 Summary of types and forms of interdependencies

Types and forms of interdependencies	Definition
Types	
Pooled Interdependence	Pooled interdependence describes a loosely coupled relationship where different entities produce individual outputs that contribute to an entire system
Sequential Interdependence	Sequential interdependence describes an interdependence where outputs from an entity become necessary inputs for the others to perform its tasks.
Reciprocal interdependence	Reciprocal interdependence refers to a cyclical arrangement of mutual flow of inputs and outputs between entities
Forms	
Task	Task interdependence refers to the extent to which work is accomplished through interaction and dependence between group members
Process	Process interdependence refers to the interaction between processes due to the flow of materials or information
Actor	Actor interdependence refers to the interaction between two or more individuals or organisations
Technology	Technology interdependence refers to the interaction with and dependence between two or more technologies during the course of work
Routine	Routine interdependence refers to the patterns of repetitive interactions between multiple entities

2.6 Approaches for Ecosystem Interdependence Evaluation

Even though the study of interdependence dates back some decades ago, in IS research, there is a paucity of studies. Moreover, studies on ecosystem interdependence evaluation are more sparse with a few exceptions (e.g., Battistella *et al.*, 2013; Fayoumi, 2016; Pentland *et al.*, 2015; Senyo *et al.*, 2017; Tian *et al.*, 2008). In the IS literature, some approaches have been proposed for ecosystem interdependence evaluation. However, these approaches have some limitations that make them unsuitable for DBE interdependence impact evaluation. Table 2.3 provides a synthesis of the approaches by detailing their focus and main critiques that make them unsuitable for DBE interdependence evaluation.

From the literature, existing approaches for interdependence evaluation can be categorised into three groups: interdependence analysis, modelling and measurement. From the interdependence analysis perspective, these approaches offer mechanisms to explore interdependencies between entities such as actors and activities and how these interdependencies support value exchange (Gordijn *et al.*, 2000). In addition, these approaches are mainly developed for the business ecosystem level. Thus, there is less focus on interdependencies between technologies that support operations in an ecosystem. For instance, Battistella et al. (2013) develop the methodology for business ecosystem network analysis (MOBENA) to analyse, model and forecast business ecosystems with much focus on relational and network structure as well as dynamic foresight analysis. The methodology offers mechanisms to analyse and model business

ecosystem interactions, structure and behaviours. Based on a case study of Telecom Italia Future Centre, MOBENA analysed both tangible and intangible interdependencies by mapping relationships to set the direction for strategic forecasting. Similarly, Allee (2008), Gordijin et al. (2000) and Weigand et al. (2007) propose value network approaches to analyse exchanges in business networks. In case of Allee's approach, the value network method provides technical details with visual elements of how to convert and utilise values from intangible assets in business networks. As a conceptual method, the approach was limited by practical application across a wide range of business issues.

Table 2.3 Ecosystem interdependence evaluation approaches

Approaches	Focus	Critiques
Ecosystem-inspired modelling framework (Fayoumi, 2016)	Interdependence modelling	Focused solely on ecosystem interdependence modelling at the business ecosystem level
MOBENA (Battistella *et al.*, 2013)	Interdependence analysis and modelling	Focuses on relationships and network structure modelling as well as dynamic foresight analysis
BEAM (Tian *et al.*, 2008)	Interdependence analysis and modelling	Difficult to generalise and focuses more on analysing and modelling at business ecosystem level
Interdependence thermometer (Pentland *et al.*, 2015)	Interdependence visualisation and measurement	Developed for routine interdependence and applicable to only objective data.
Agent-based methodology (Marín *et al.*, 2007)	Tangible exchanges in interdependencies	Focuses only on modelling of tangible exchanges
Value network analysis approach (Allee, 2008)	Analysis of intangible assets	Focus solely on intangible aspects of interdependencies in value networks
E3- value modelling (Gordijn *et al.*, 2000)	Interdependencies in value networks	Focused on value exchange between actors in a business ecosystem
C3-value model (Weigand *et al.*, 2007)	Interdependencies in value networks	Developed specifically for business ecosystem and not DBE. Main three constructs are too simplistic to diagnose network of organisations
Partner interdependence modelling methodology (Senyo *et al.*, 2017)	Partners' interdependence modelling	Focus more on partners' interdependence modelling with less attention on processes and technologies

Approaches for interdependence modelling at the ecosystem level provides methodologies to illustrate relationships between entities so that interactions are well understood, aligned and supported. Specifically, some of these approaches provide mechanisms to present interdependence types, structure, substances and participants in an ecosystem. A typical example is the partner's interdependence modelling methodology proposed by Senyo et al. (2017). This approach offers a systematic lens to articulate and represent interdependencies between partners in DBEs. The approach comprises three iterative stages, namely DBE partner identification, interdependence type and substance articulation as well as interdependence

representation. Due to the sequential nature of the approach, it makes interdependence articulation simpler, even in complex DBE environments. Also, the approach emphasises the need to differentiate between interdependence types in DBEs as they may require different coordinating strategies. However, the focus was solely on modelling partners' interdependencies whereas less is known about their impact in value co-creation in the ecosystem. Similarly, Tian et al. (2008) propose the business ecosystem analysis and modelling (BEAM) framework to analyse business models design at the business ecosystem level. BEAM provides a framework that enables evaluation of business model performance under different scenarios to provide understanding into values distribution among entities in a business ecosystem. Similar ecosystem interdependence modelling approaches are evident in the works of Fayoumi (2016) and Marin et al. (2007).

Lastly, approaches for ecosystem interdependence measurement focus on how to quantify patterns of relationships in workflows. For instance, Pentland et al. (2015) present a method conceptualised as "interdependence thermometer" that transforms digital trace data into networks to visualize and measure interdependencies in routines. The study focuses on measuring patterns of sequential interdependence from objective data. The findings reveal that evaluating interdependence using artefacts enables understanding and visualization of relationships that are intuitively difficult to comprehend. However, the measurement covered only interdependence patterns. As a result, less is known about the impact of interdependencies in value co-creation and how these impacts influence overall performance and decision making.

While the insights from existing approaches are important, some limitations still exist. First, extant approaches largely focus on interdependence analysis and modelling. Thus, limited approaches exist on interdependence measurement. In the case where an approach for interdependence measurement is proposed as part of the evaluation, the focus is on visualising and measuring interdependence patterns using objective data (e.g., Pentland *et al.*, 2015). As such, to the best of our knowledge, no approach exists to evaluate the impact of interdependencies in value co-creation in DBEs. Second, existing approaches are not tailored for DBEs but have been developed for business ecosystems. As a result, they are unsuitable for investigations at the DBE level since requirements such as technology interdependencies were not considered. Given the current pace at which multiple webs of value-creation are replacing traditional value chains across organisational boundaries, it is only prudent to develop approaches that align with this new collaborative network. Hence there is a need for DBE specific interdependence evaluation approaches.

Third, existing approaches have not holistically evaluated ecosystem interdependencies in general and DBE relationships specifically. Rather, some studies focus solely on either interdependence analysis, modelling or measurement. As such, there is a need for a comprehensive new method that considers interdependence analysis, modelling and measurement in the evaluation process. Lastly, existing interdependence measurement approaches are designed to use either objective or subjective data. While realistically, in practice, both subjective and objective data are needed to accurately measure interdependencies. As such, there is a need for an approach that accommodates objective and subjective data to complement the limitations of each data format. Based on the pertinent issues in the literature, this study argues for DBE specific approaches, especially for interdependence impact evaluation to address some of these limitations.

2.7 Value Co-creation through Interdependencies

Value co-creation is where the efforts and resources of different individuals and organisations result in an output of value (Prahalad and Ramaswamy, 2004b). Value itself is a complex and subjective concept. Depending on the context, what is considered value might vary, thus, value can mainly be determined by the beneficiary. In this study, value is defined as benefits derived from interactions between entities, which could be financial and non-financial (Vargo *et al.*, 2008). Hence, value could result from the appropriate combination of low cost, quicker duration and high service quality realised from an interaction. Perhaps, an individual can derive value from paying lower cost in an interdependence. In the traditional view, organisations are seen as the sole creators of value (Porter, 1980). However, in the contemporary literature, organisations and their customers are seen as partners in value co-creation (Lusch and Nambisan, 2015; Vargo and Lusch, 2008). For instance, in the technology space, an organisation providing software solution may depend on other companies to host its software. Similarly, the organisation may rely on another company for marketing and promotion. Again, the same organisation may rely on another company to provide customer support. Lastly, customers feedback and complain may become a source of innovation for improvement in the software. As such, there are series of interdependencies between several actors until value is created.

According to Prahalad and Ramaswamy (2004b), value co-creation can be viewed from two perspectives. The first perspective is that interaction is the locus of value co-creation and the second is that co-creation experiences are the basis of value. From these perspectives, it is posited that without interdependencies, value co-creation is not possible. Similarly, the experiences of participants in the value co-creation process define if value is indeed generated.

Building on these premises, it is argued that interdependence therefore forms a core aspect of value co-creation that need constant evaluation. Since value co-creation requires synergy between different entities to collectively generate benefits through resource integration and competence application (Vargo *et al.*, 2008), this study refers to interdependence as a medium for value co-creation.

The DART (dialogue, access, risk assessment and transparency) model (Prahalad and Ramaswamy, 2004a; Taghizadeh *et al.*, 2016) offers a useful frame to understand value co-creation. From the DART model, value co-creation experiences enable an organisation to better understand other parties including their aspiration, behaviour, motivation and desires so as to deliver better value propositions. The DART model comprises four elements, namely dialogue, access, risk assessment and transparency. Dialogue refers to an interactive medium through which an organisation and its partners engage in shared learning and communication to address problems (Prahalad and Ramaswamy, 2004a). Access refers to a situation where an organisation provides tools and information to its partners to contribute to value co-creation processes. Partners are given permission to follow the value co-creation processes so that they become imbued in the overall value generation. Risk assessment refers to a propensity of other parties to be harmed in the value co-creation and how responsibility can be apportioned. Lastly, transparency refers to the degree of information symmetry between partners in value co-creation (Prahalad and Ramaswamy, 2004a). Previously there was huge information asymmetry between organisations and their partners. However, in the current technological era, this phenomenon is fast disappearing as information becomes more accessible. Thus, as organisations engage with other partners through elements of the DART model, better value co-creation can be achieved.

Value co-creation is underpinned by exchanges between different interdependent parties. These exchanges involve the flow of outcomes needed for successful value co-creation. Based on this premise, this study argues that the results of value co-creation through interdependencies can be conceptualised as outcome flows. Generally, different perspectives have been provided for interdependence outcome flows in the literature. For instance, Pfohl and Gomm (2009) identify interdependence outcome flows as information, rights, goods and financial resources. Similarly, Croom et al (2000) posit interdependence outcome flows as goods, financial resources, information and knowledge. Also, Cooper et al. (1997) articulate interdependence outcome flows as funds, materials, goods and information. In a broader discussion Mentzer et al. (2001)

list products, services, information, financial resources and information as values from interdependence outcome flows.

Drawing from these discussions, this study identifies three main outcome flows underpinning interdependencies in value co-creation: finance, goods and information. Information outcome flow refers to the successful transfer of messages between entities (Croom *et al.*, 2000). Goods outcome flow, on the other hand, refers the successful movement of items through various interdependent workflows (Cooper *et al.*, 1997). Lastly, financial outcome flow refers to the monetary reward derived from an interdependence (Pfohl and Gomm, 2009). Though information underpins both goods and finance outcome flows, the focus is on the primary outcomes of interdependencies. By conceptualising these interdependence outcome flows, this study can identify and delineate the outcomes that underpin the formation and behaviour of DBE partnerships to enable a better understanding.

Even though value co-creation research is increasing, the extant literature has been dominated by studies in marketing (e.g., Lambert and Enz, 2012; Lusch and Vargo, 2006; Payne *et al.*, 2008; Vargo and Lusch, 2008; Yi and Gong, 2013) while little is known from the IS domain in exception of a few studies (e.g., Grover and Kohli, 2012; Lempinen and Rajala, 2014; Lusch and Nambisan, 2015). Hence, there is still limited knowledge from technology-driven domain of how value is co-created between socio-technical entities. Arguably, there are limited studies that evaluate the impact of interdependencies between digital technologies, processes and partners in value co-creation. In conclusion, it is observed that value co-creation is enabled by interdependencies and experiences from these interactions. Also, studies on value co-creation are largely limited to marketing management. As a result, limited studies exist on value co-creation from the IS domain. Despite some studies, research on evaluating the impact of interdependencies in value co-creation in general and in DBE specifically is limited. Given the importance of interdependencies in value co-creation and in DBEs, this study argues that there is a need to understand and evaluate the impact of DBE interdependencies in value co-creation.

2.8 Organisational Semiotics for DBE Interdependence Evaluation

The nature of DBE as a socio-technical environment requires the use of theoretical approaches that align with this perspective. To understand the formation and behaviour of DBE partnerships and evaluate the impact of interdependencies, it is therefore required to seek support from sound theoretical approaches. Though Actor Network Theory (ANT) provides a lens to understand networks, it has some limitations that makes its application in this study unsuitable. First, the

ANT focusses more on the infrastructure of actor-networks and how they are formed. Second, the ANT does not provide clear cut medium to understand and measure the underlying partnership between entities in a network. Furthermore, ANT assumes that both human and non-human things are equal in a network without cognisance to imbalances of power (Walsham, 1997). Finally, the ANT does not pay much attention to broader social structure that influences networks. Given that the aim of this study is to understand the behaviour of DBE partnerships, analyse and measure the impact of DBE interdependencies, the ANT is deemed not suitable. On these premises, this study identifies Organisational Semiotics as an appropriate theoretical lens.

In this study, Organisational Semiotics is used as the theoretical foundation because (1) it is firmly grounded in interdependent relationship investigations, (2) it supports the sociotechnical nature of information system by accommodating both social and technical entities (Mingers and Willcocks, 2014), and (3) its provides empirically proven approaches to analyses and evaluate phenomena. Given that DBE is a sociotechnical environment comprising both social and digital agents who undertake different behaviours, the choice of Organisational Semiotics theory is appropriate.

Organisational Semiotics, a branch of Semiotics involves the study of organisational structure and behaviour through the principles of signs. Semiotics itself is the study of signs (Morris, 1946; Stamper *et al.*, 2000). Organisational Semiotics perceives organisations as an information system made up of signs (Liu *et al.*, 2003). Sign refers to something that represents something to someone in a particular capacity and context (Stamper, 1985; Stamper *et al.*, 2000). This implies that a sign carries in-depth meanings of something that is understandable by an individual, group or society.

Organisational Semiotics provides a theoretical lens to analyse, model and understand interactions between social and technical entities in a socio-technical environment. These interactions in Organisational Semiotics can be viewed as norms (see Figure 2.5) categorised by the organisational onion into informal, formal and technical layers (Liu, 2000; Liu and Li, 2015). Norms refer to standards, regulations, rules and laws that underlie behavioural patterns and dictate how members behave, think, make decisions and perceive the world (Liu, 2000; Liu and Li, 2015). Informal layer presents norms related to organisational culture and values that inform meaning and subsequent behaviour. Informal norms are generally unstructured and undocumented. Formal layer presents norms in the form of documented bureaucratic rule or

standards that replace meanings and intentions. Lastly, technical layer represents formal norms that have been automated (Stamper *et al.*, 2000). Since DBE consist of socio-technical entities that form interdependencies mediated by technology platforms based on beliefs, rules and standards, it is argued that organisational onion is appropriate to categorise DBE interdependencies toward understanding of DBE partnerships.

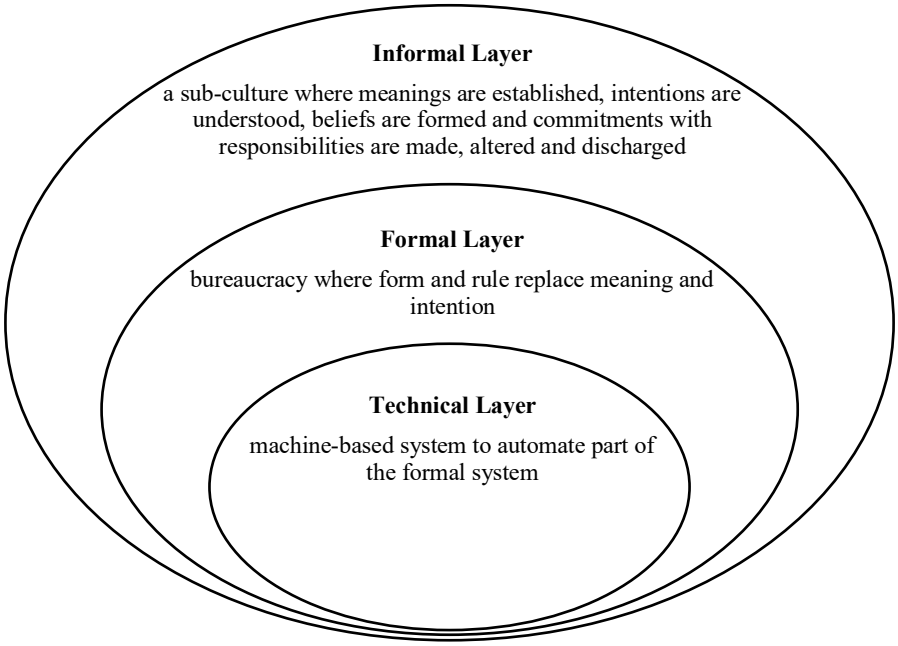

Figure 2.5 Organisational onion (Liu and Li, 2015; Stamper, 1973)

Aside the organisational onion, norms can be classified into behaviour taxonomies under the Organisational Semiotics theory using the organisation morphology. Organisational morphology as presented in Figure 2.6 classifies norms into substantive, communication and control taxonomies (Stamper *et al.*, 2000). First, substantive norms define core activities within socio-technical environments. Second, communication norms concern exchange of information among elements within a socio-technical environment. Third, control norms monitor and regulate substantive and communication norms. As DBE is a socio-technical environment and its interdependencies are undertaken through interactions between entities, the classification of norms by organisational morphology is considered appropriate to understand behaviours in DBE partnerships.

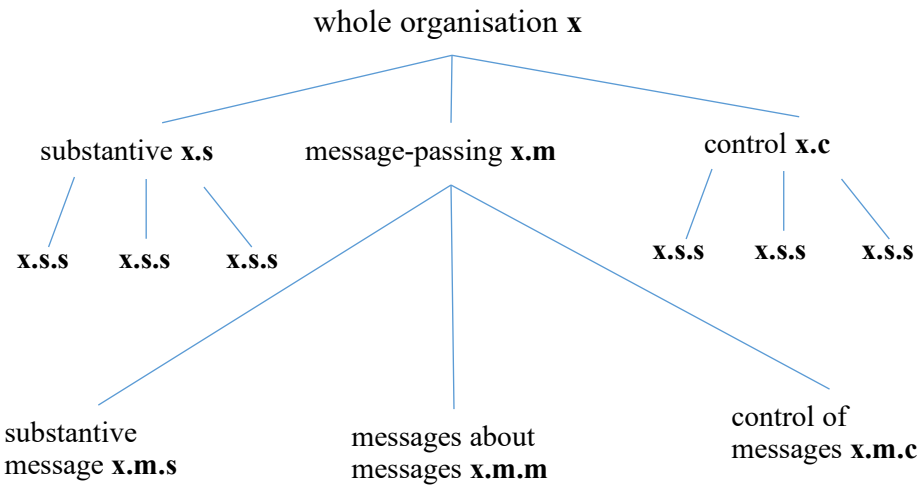

Figure 2.6 Organisational morphology (Stamper *et al.*, 2000)

Another key approach under Organisational Semiotics is the semiotic framework. The organisational semiotic framework provides a handle to deal with both technical and behavioural factors in organisational contexts (Stamper, 1985). The framework consists of six layers: physical, empirics, syntactics, semantics, pragmatics and social. These layers are categorised into two major groups – social and technical. The first group at the base of the framework deals with the structure, organisation and physical properties of a sign while the second category at the upper end deals with how a sign is communicated, its meaning and social consequences. The following discussions explain in detail each of the six layers while Figure 2.7 depicts the Semiotic framework.

Human Perspective (Technical)			Social	Obligations, responsibilities, functions, commitment, contracts, norms, …
			Pragmatic	Intentions, workflow, conversation, negotiation, interaction, …
		Semantics	Meaning, propositions, validity, signification, denotations, ….	
IT Perspective (Social)	Syntactics	Structure, language, logic, data, records, databases, software, files, ….		
	Empirics	Patterns, entropy, channel capacity, redundancy, transmissions, codes, protocols, ….		
Physical	Signals, computer networks, component density, speed, ….			

Figure 2.7 The semiotic framework (Stamper, 1996)

The physical layer deals with the physical properties of a sign and its building blocks in the physical world. The physical properties of a sign are in relation to the size, shape, contrast, intensity, speed of movement, acceleration, source and destination. At the physical layer, a sign is also presented either as static or in motion (Stamper *et al.*, 2000). A sign in static form is referred to as a mark while that in motion is referred to as signal (Stamper, 1996). Based on these properties further investigation as well as specification could be carried on a sign towards a better understanding. For example, a digital document as a sign can be classified under the physical layer in terms of its properties such as size, speed of movement and destination.

Empirics is the second layer which is concerned with the statistical properties of a sign. At the empirics layer, a sign is assessed based on its coding, optimal signal transmission, channel capacity and entropy measurement (Liu *et al.*, 2008). Information at the empirics layer is viewed as a mark or a signal. In the form of a signal, information is deemed appropriate for transmission from one point to the other irrespective of its intended meaning. To enable successful transmission of a message, it needs to be encoded at the sender's end and decoded at the destination. With reference to the example of a digital document, the empirics level will be responsible for transmitting the document to its intended receiver without much emphases on its physical properties or intended meaning.

Syntactics is the third layer which is concerned with the structure of a sign. This layer examines the rules of developing complex signs from a simple one (Stamper *et al.*, 2000). At the syntactic layer, a sign can be expressed either in a mathematical form through a formula, in a sentence through formal language grammar, as a word or combination of these expressions. The syntactic layer is concerned with how information in a form of a sign can be recognised by the sender and the intended receiver. Using the digital document example, the syntactic layer concerns how the digital document is formatted or presented so that it can be recognised by both the sender and the receiver. It could be presented with formal language in text either with or without drawings.

Semantics layer is about the meaning a sign carries. It refers to the relationship that exists between a sign and its intended meaning. Thus, a 'reality' has to be assumed so that signs can then be mapped onto objects in that particular 'reality' (Morris, 1946). Therefore, at the syntactic layer, meaning is posited as a link between a sign behaviour and action. Signs are used as a means of communication. However, for the intended receiver to understand the sign, there must be an already agreed norm or consensus about the use and meaning a particular sign

connotes (Liu, 2000; Liu and Li, 2015). This consensus must also be a shared knowledge among members of a language community. For a simple sign like a 'chair', it represents an object with properties of four legs, a back rest and a flat surface, thus it is easy to get the meaning it carries. However, if a sign becomes complex, different interpretations are given to that sign. Therefore, the semantic layer ensures that a successful communication is achieved by providing same interpretation in the form of a norm to a sign by both a sender and a receiver.

Pragmatics layer deals with how a sign is used based on its intended meaning. Pragmatics is concerned with the relationship between a sign and behaviour of the intended receiver (Stamper *et al.*, 2000). Thus, people will behave in a certain way based on the common knowledge and shared assumptions about a sign in a community. Pragmatics is also concerned with the origin, uses, effects, actualities and prelocutionary effects of a sign (Barron *et al.*, 1999) within the behaviour in which they occur (Morris, 1946). For example, with a digital document, pragmatics will be concerned with characteristics such as the source, how it should be used, and the intended effects of the document on the receiver. Therefore, the pragmatics layer ensures successful communication by making sure the receiver of a sign perceives the intention and purpose of the sender.

The social layer is concerned with how social change is caused whenever there is exchange of signs. The social layer consists of norms such as rules, set of values, ways of behaviour and shared models that shape social reality (Liu, 2000; Stamper, 1996). The social layer also ensures communication of action, obligation or responsibility whenever a sign is received. Considering the digital document example. The document should carry information that can cause a social consequence when it reaches its intended receiver. Therefore, the social layer ensures that communication is successful by making sure the intention of the sender of a sign has resulted in a social consequence to the receiver.

The main methodology of Organisational Semiotics is MEASUR - Method for Eliciting, Analysing and Specifying User Requirements (Stamper *et al.*, 1988). MEASUR comprises sub-methods that support specifying, analysing and modelling of business requirement for IT development. Given that the focus of this study is on understanding DBE partnership and evaluating the impact of interdependencies in value co-creation, two MEASUR methods, namely Problem Articulation Method (PAM) and Norm Analysis Method (NAM) are deemed suitable for this investigation. Specifically, MEASUR methods support the DBE scope definition, interdependence analysis and social impact measurement.

Problem Articulation Method

PAM is a method for understanding complex system context and identification of possible issues that merit attention. This method enables identification of a focal system, which is central to a project at the initial stages so that the project's scope can be determined. Beyond this, PAM also affords decomposing of complex problems so that each unit can be addressed individually. Techniques under PAM are unit system definition, stakeholder identification, collateral structuring and valuation framing (see Figure 2.8).

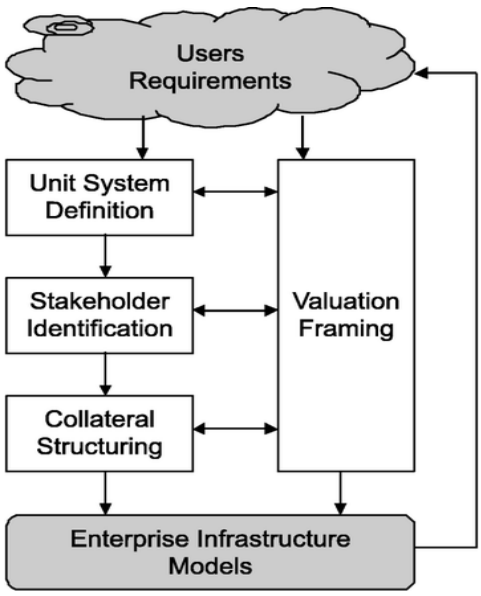

Figure 2.8 Architecture of problem articulation method (Liu *et al.*, 2006)

Unit system definition supports delineation of sub-systems that constitute an environment. Through this technique, a system's scope can be clearly defined for further investigation. Similarly, stakeholder identification technique supports articulation and classification of various actors in an environment based on their roles and responsibilities. Collateral structuring technique supports configuration of a problem domain into a central course of action with corresponding activities. Lastly, valuation framing technique assesses the cultural impact of an innovation on stakeholders with regards to benefits and drawbacks. Valuation framing technique relies on Hall's (1959) ten cultural aspects to assess the social impacts of an innovation in a socio-technical environment. With Hall's classification, stakeholders are able to express their perception of the social impact of an innovation in their environment. Since one key aspect of this study is on interdependence impact evaluation, PAM and its techniques are considered suitable. Table 2.1 presents the 10 cultural aspects and their description. DBE as a socio-technical environment comprises complex interdependencies between several unit systems, stakeholders and problem domains with either positive or negative impact.

Table 2.4 Ten cultural aspects (Hall, 1959; Liu *et al.*, 2006)

Aspects	Description
Association	Grouping, alliances e.g., the formation of teams to evoke competitiveness and sense of belonging to participants
Subsistence	Physical and economic matters related to existences e.g., impact of an interdependence on income or job security
Classification	Differentiation of people by gender, age, level of education e.g. Whether an interdependence improves equal opportunity for all
Territoriality	Accessibility e.g., the impact of an interdependence may lead to an erosion of control, influence, or loss of authority
Temporality	Time division, synchronous, asynchronous e.g. Issues of time zone differences caused by an interdependence
Learning	Sharing knowledge, gaining awareness e.g., de-skill or more opportunity for learning new skills within an interdependence
Recreation	Fulfilment, joy e.g., whether the job becomes more interesting or boring within an interdependence
Protection	Fairness, rights e.g., granting file rights access to the appropriate groups of people and maintain the confidentiality of information
Exploitation	Individual's vs organisation interests e.g., cutbacks on operating costs with salary-cut, retrenchment or longer working hours
Interaction	Interrelations and communications, e.g., fostering collaborative attitudes in the workplace

Norm Analysis Method

NAM is a method that delineates triggers, events and constraints so that dynamics within a business domain can be captured as norms. Thus, with NAM, general patterns of behaviour of agents in a business system can be defined. At the core of NAM are norms that define responsibilities of entities vis-a-vis their roles in an environment. NAM consists of four techniques: 1) responsibility analysis, 2) proto-norm analysis, 3) trigger analysis and 4) norm specification (Liu, 2000; Liu and Li, 2015). Responsibility analysis technique identifies the type of agents/stakeholders responsible for an action. Proto-norm analysis determines conditions under which certain actions are performed by agents. Hence, proto-norm analysis identifies information needed for agents to undertake certain types of behaviour. Trigger analysis determines the sequence of activities that are invoked by pre and post-conditions by specifying which activities to execute as a result of invoking or satisfying previous steps. Norm specification presents a formal representation of norms capture as a reference for agents' decisions and actions within an environment. The norm specification format is as follows:

WHENEVER <*context*>

IF <*condition*>

THEN <*agent*>

IS <*deontic operator*>

TO <*action*>

Context represents the environment in which an agent occupying a role can perform an action. Condition refers to constraints that must be met for an agent to perform an activity. Agent designates a partner or digital entity who performs an activity. On the other hand, deontic operator denotes the expressiveness of norms by establishing whether an agent is permitted, prohibited or obliged to take an action. Lastly, action refers to a series of activity an agent performs to accomplish a goal. DBE as a socio-technical environment comprises agents that exhibits different behaviours during value co-creation. Given that NAM enables holistic analysis of behaviours and interactions between agents in socio-technical environments, it is argued that NAM is appropriate in understanding DBE partnerships and evaluating the impact of interdependencies in value co-creation.

Generally, Organisational Semiotics has been used in two broad domains in IS research: communication and information systems analysis and design. Studies that apply Organisational Semiotics in the communication domain are mostly concern with the transfer of information between actors and objects in organisations (e.g., Li *et al.*, 2010; Stamper *et al.*, 2000). On the other hand, studies that apply Organisational Semiotics in information systems analysis and design focus on requirement engineering (e.g., Liu, 2005; Rambo and Liu, 2011), system architecture and design (e.g., Li *et al.*, 2014; Pereira and Baranauskas, 2015; Valderlei da Silva *et al.*, 2016) and information system modelling (e.g., Effah, 2015; Liu *et al.*, 2003, 2006, 2008). Overall, the IS literature is missing studies that apply Organisational Semiotics theory to investigate DBE partnerships and interdependence impact evaluation. In addition, the use of Organisational Semiotics to investigate phenomena at the ecosystem level is sparse. Hence, this study applies the theory of Organisational Semiotics to DBE research and extend some of its approaches to make theoretical contributions.

2.9 Summary

This chapter critically reviewed DBE, interdependence and value co-creation research and the gaps therein. First, the chapter discussed the notion of DBE and its origin in ecology and business ecosystem. Next, the chapter presented similarities and differences between the main ecosystems. Following this, the chapter discussed open and closed forms of ecosystems and their differences. Thereafter, the chapter discussed the concept of interdependence, its types and forms. Next, the chapter discussed some existing interdependence evaluation approaches. From this discussion, it was revealed that there is a need for a DBE specific approach as current approaches have limitations that make them unsuitable for investigation in DBEs. The chapter then discussed value co-creation and how interdependence as a core element can affect the

performance of DBEs. Finally, given the socio-technical nature of DBE and the aim of this study, the chapter discussed the usefulness of Organisational Semiotics theory as an appropriate theoretical lens. In all, the findings from the literature review reveal the multifaceted nature of DBE and the limitations in the extant literature that warrants the current study.

Chapter 3

Research Methodology

This chapter outlines the research methodology underpinning the study. The chapter begins by discussing research paradigms from the ontological, epistemological and methodological perspectives. Under the research paradigm, the chapter discusses four dominant philosophical stances in IS research, namely positivism, interpretivism, critical and design science research paradigms. Next, the chapter discusses research methodologies, namely quantitative, qualitative and mixed methodologies. The chapter also discusses dominant methods and techniques under the research methodologies. All these preceding discussions are geared towards the selection of appropriate research approaches, methodologies, methods and techniques to address the research aim. Lastly, the chapter discusses the dual research design employed in this study.

3.1 Research Paradigms

Research paradigm refers to principles, tenets and techniques shared by members of a scientific community which acts as a guide by indicating the kinds of problems to be investigated and how they can be studied (Kuhn, 1970; Neuman, 2014). According to Kuhn (1970), a paradigm influences research endeavours in the following ways: (1) what phenomenon to investigate, (2) what questions to ask about the phenomenon, (3) how questions should be asked and (4) how the results of the investigation should be interpreted. Thus, through paradigms, research endeavours are legitimised as an avenue to create acceptable knowledge. Research paradigm is constituted by three main dimensions, namely ontology, epistemology and methodology (Chen and Hirschheim, 2004). Ontology relates to what is reality. Ontology offers two perspectives of realities: objectivity and subjectivity. In the objective reality, there is no human interference while in the subjective aspect, human actions influence reality. Epistemology relates to the nature of knowledge by dictating and explaining the process of acquiring knowledge in research activities while methodology relates to how knowledge is acquired. The subsections below discuss the four dominant paradigms in IS research: positivism, interpretivism, critical and design science research.

3.1.1 Positivist Paradigm

The main purpose of the positivist paradigm is to learn about reality so that general laws can be discovered to describe, predict and control reality (Orlikowski and Baroudi, 1991). The positivists hold that an objective reality exists which is single and concrete (Saunders *et al.*, 2008). In addition, positivists investigate phenomena with predefined instruments since there is the belief of a static a prior relationship. Also, positivist studies seek to test existing theories to obtain a strong predictive understanding through quantification and measurement of variables to achieve greater generalisation (Orlikowski and Baroudi, 1991). As a result, positivists believe that phenomena are autonomous and are not influenced by the researcher. In a nutshell, the positivists' position about ontology is objective reality which is external to human construction or influence. Epistemologically, positivists hold that investigation of independent reality can lead to the attainment of objective knowledge. Lastly, positivists use methodological approaches that are based on tools from the natural science to deduce hypothesis, test and predict phenomena (Chua, 1986).

3.1.2 Interpretivist Paradigm

The interpretivist paradigm holds that there is multiple existence of reality (Walsham, 2006). Researchers aligned with this paradigm go beyond observable actions of people to understand the subjective meanings they assign to their actions to appreciate and interpret the reasons behind those actions. Converse to positivism, the interpretivist paradigm does not base understanding of a phenomenon on a prior knowledge but is open to interpretation ascribed to actions. In addition, interpretive researchers seek a deeper understanding of phenomena instead of generalisation of findings (Orlikowski and Baroudi, 1991). Also, interpretivist do not believe that phenomena are autonomous from researchers and participants but rather intersubjective (Walsham, 2006). Hence, from the ontological perspective, interpretivist paradigm assumes a reality that is supported by human construction. Epistemologically, interpretivists believe that the nature of knowledge is socially constructed through interaction between the researcher and participants. As such, perceptions of both researcher and participants might change during an investigation. Finally, interpretivists favour methodological approaches that allow for the collection of rich data about a phenomenon and its context. As such, interpretivists use social methodological approaches instead of natural science methods under the positivist paradigm.

3.1.3 Critical Paradigm

The critical paradigm bridges the positivist and interpretive philosophies by offering a pluralistic view to commensurate criticisms of both paradigms. Critical realists hold that

perceptions have a certain flexibility and that there are differences between reality and people's perceptions of reality (Mingers, 2004). This paradigm seeks not to predict but to explain social phenomena, through examining the context-mechanism-outcome, such as patterns of associations and possible explanations. The critical paradigm believes some conditions within the environment can constrain people's potentials, hence there is a need to reduce these circumstances to enable positive changes in the lives of the oppressed. Some of these constraints are embedded in cultures, social norms, political ideologies and natural laws (Orlikowski and Baroudi, 1991). From the ontological perspective, critical paradigm assumes that reality is socially constructed as in the case of interpretivism. However, critical paradigm also believes social reality can be constructed through historical characteristics of social, political, cultural, economic, gender and ethnic value (Guba and Lincoln, 1994). Epistemologically, critical paradigm assumes that historical and social practices influence the foundation of knowledge (Chua, 1986). As such, critical paradigm believes the researcher and the phenomenon are interactively linked, hence assumes a value-laden approach to knowledge. Lastly, in terms of methodology, the critical paradigm favours ethnographic and historical approaches that enable critique and analysis of the past and present situations to unearth long-term social constraints that shape a phenomenon (Orlikowski and Baroudi, 1991).

3.1.4 Design Science Research Paradigm

The design science research paradigm provides solutions in the form of artefacts as outcomes of a research process that address specific problems (Gregor and Hevner, 2013; Hevner *et al.*, 2004). As such, design science research paradigm addresses organisational problems by utilising human capabilities to design new artefacts such as methods, models, architectures, frameworks, theories, constructs and instantiations (March and Smith, 1995; Pries-Heje and Baskerville, 2008). The design science paradigm involves two main activities – build and evaluate. The build aspect is the construction phase of an artefact while the evaluation is where the artefact is assessed for performance. During the build and evaluate activities, design science research uses techniques from behavioural sciences to understand, execute and evaluate IS research (Vaishnavi and Kuechler, 2004). Figure 3.1 presents the framework for conducting IS studies through the lens of the design science research paradigm.

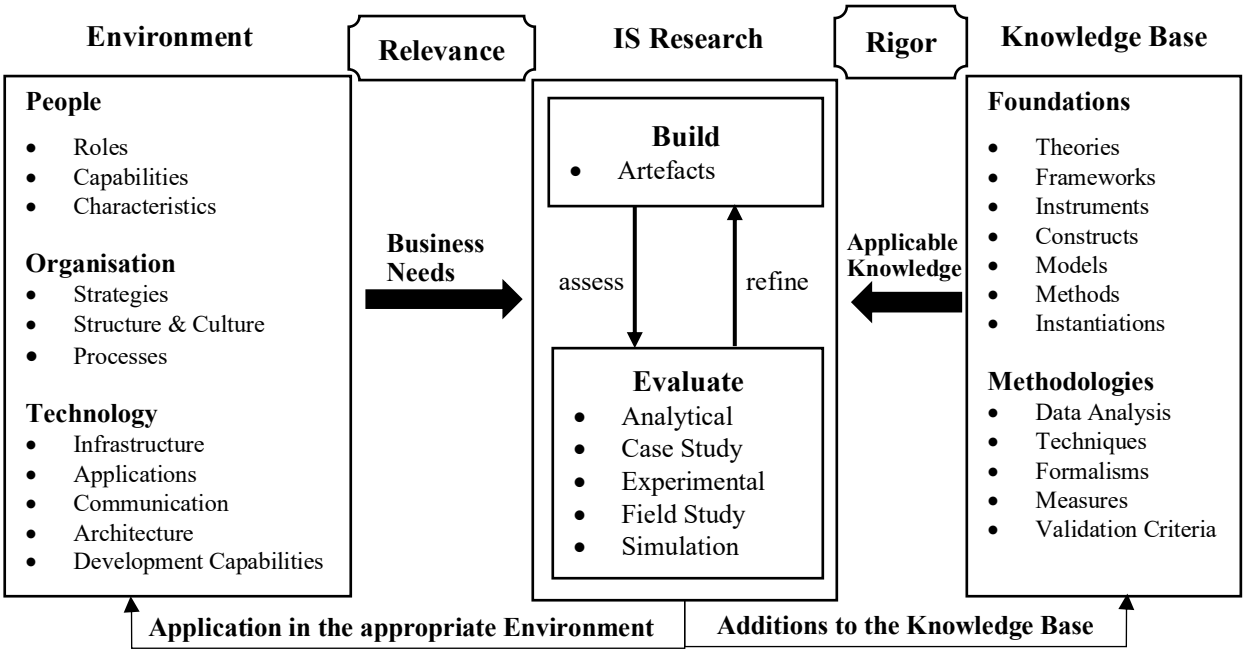

Figure 3.1 Information systems research framework (Hevner *et al.*, 2004)

The framework consists of three main elements, namely environment, IS research and knowledge base. The environment element consists of people, organisations and technologies from which the business need emerges. This need then satisfied the relevance of the research problem worth investigating. The IS research element comprising build and evaluate sections represents the medium through which the identified business need from the environment is addressed. The knowledge base consists of existing foundations and methodologies required as a mechanism to address the business need identified under the IS research element (Hevner *et al.*, 2004). By applying existing theories and methodologies to the IS research element, it is assumed that the needed rigour can be achieved in the artefact design. From the ontological perspective, design science research paradigm supports multiple, context situated alternatives work-states which are socio-technologically enabled (Vaishnavi and Kuechler, 2004). Epistemologically, design science research paradigm believes in knowing through making. As such, meaning is revealed from iterative circumscription and objective construction processes. Methodologically, design science research paradigm believes in the development of artefacts with measurable impacts (Vaishnavi and Kuechler, 2004).

3.2 Research Methodologies

Research methodology describes processes to address a research problem. The three main research methodologies are quantitative, qualitative and mixed methodology. Discussions below explicate each of these methodologies.

Quantitative methodology: This is a positivist-oriented methodology that is based on objective measurement of relationships among variables using numbered data and statistical analysis techniques (Creswell, 2014). Under the quantitative methodology, researchers test existing theories deductively to generalise results by controlling for unexplained variables. The quantitative methodology uses approaches such as survey, laboratory experiments, econometric and mathematical modelling methods. Being an objective aligned procedure, the quantitative methodology is unsuitable for understanding complex social problems with multiple explanations. Survey is the popular research strategy associated with the quantitative methodology.

Qualitative methodology: This methodology seeks to explore and understand the meaning people ascribe to a social problem (Creswell, 2014). The qualitative research methodology is more aligned with the tenets of interpretivism. The qualitative methodology inductively generates insights from data collected in a natural setting as a result of emerging questions during investigation. As such, this methodology utilises research approaches and techniques that support non-rigid research processes such as case study, ethnography, action research and grounded theory.

Mixed methodology: This methodology blends both quantitative and qualitative methodologies in its inquiry (Johnson and Onwuegbuzie, 2004). It involves using assumptions and philosophies from both the quantitative and the qualitative methodologies. Researchers use the mixed methodology when they seek to test an existing theoretical position and to unearth underlying mechanisms of a problem from multiple viewpoints. By using the mixed methodology, researchers can address criticisms of both the quantitative and the qualitative methodologies through a combination of their strengths and weaknesses.

3.3 Research Methods in Information Systems

Research method refers to a strategy that provides directions on how to address a problem (Creswell, 2014). In simple terms, research method offers direction for a research design. IS research uses a wide range of research methods in its investigation. In most cases, the choice of a methodology influences the selection of research methods. Research method is an important aspect of investigating a problem because it dictates what data to be collected, how the data should be collected and from who the data should be collected as well as how the data should be analysed. Given that these requirements of research methods significantly influence the

outcome of a study, it is important to understand some prominent strategies in IS research as discussed below.

Action research

Action research refers to a research method that seeks to resolve a problem to make a change in relation to an organisational issue. In action research, a researcher commences an investigation with a clear purpose and subsequently collaborates with practitioners to devise a set of actions intended to resolve a problem (Middel *et al.*, 2006). During action research, the researcher embeds in the organisation of study and follow through the whole change process rather than more typical research where employees of the organisation become participants or objects of study. Thus, the findings of action research result from collaboration between a researcher and members of an organisation to resolve an important issue of mutual concern (Eden and Huxham, 1996). Due to the nature of investigation, action research involves iterative processes of diagnosis, planning, action and evaluation to determine if intended changes have occurred. Over the years, action research has become prominent in IS research because it offers an opportunity for researchers to gain important practical experiences through research processes (Baskerville, 1999). Similarly, action research bridges the ostensible gap between research and practice through direct application of research knowledge to address real-world problems.

Case study

Case study is a research method for undertaking an empirical investigation of an emerging phenomenon in a natural setting using multiple data collection approaches (Yin, 2003). Through the case study method, a researcher is able to gain valuable insights into a specific context of a phenomenon. Case study is conducted in a context where there is blurred boundary between a phenomenon and the real world as opposed to the other methods undertaken in controlled context (Benbasat *et al.*, 1987). Due to the ability of the case study method to gain valuable insights of a phenomenon, it is mostly used in explanatory and explorative research where there is limited understanding. The case study method utilises different techniques for data collection such as interviews, observation, questionnaire and documentary analysis from multiple sources for triangulation purposes. In IS research, the case study method has been touted as an appropriate strategy since it offers an opportunity to investigate IT phenomena in the natural context (Benbasat *et al.*, 1987).

Ethnography

Ethnography is an inductive aligned method that derived its roots from anthropology (Myers, 1999). Ethnography seeks to describe and explain social construction of a phenomenon through deep understanding by positioning the researcher in a context for a very long period. Ethnography is a time-consuming research strategy since it requires a researcher to immerse him/herself in the social setting of a phenomenon being investigated to gain deep understanding. This research method is flexible and adaptive to change due to the emergence of new patterns of thoughts as the researcher experiences the social construction of a phenomenon being studied. In addition, ethnography does not utilise rigid data collection approaches that oversimplify complexities of the natural setting (Forsythe, 1995). Due to the nature of ethnographic research, a researcher must first find a setting, group or society and then device a way to win their trust prior to commencing the study. Ethnography is not a dominant strategy in IS research due to its time-consuming data collection process as opposed to the volatility of IS phenomena.

Grounded theory

Grounded theory is "an inductive, theory discovery methodology that allows a researcher to develop a theoretical account of the general features of a topic while simultaneously grounding the account in empirical observations or data" (Martin and Turner, 1986, p.141). Grounded theory supports theory building from research findings to predict and explain behaviour (Corbin and Strauss, 1990). Grounded theory research begins without a preconceived theoretical framework, however, a theory emerged from data generated through a series of observations. The insights from the data lead to the generation of propositions that can be further tested (Goulding, 2002). The constant reference to the data and subsequent generation and testing of propositions into theory is the inductive grounded theory process. While most methods base their research processes such as data collection and analysis on existing theories, grounded theory assumes the opposite by detaching from existing theory to uncover all possibilities related to a phenomenon. Grounded theory has gained some attention in IS research lately due to its ability to describe a context-specific aspect of a phenomena.

Survey

Survey is a deductive aligned research strategy that seeks to test existing relationship of a set of variables using structured measurement instruments (Neuman, 2014). Survey is a common strategy in IS research as it is highly economical, less time consuming and support collection of a large amount of data using a questionnaire. Survey method employs statistical techniques

in data analysis to generate quantitative results that can be easily generalised to a population (Saunders *et al.*, 2008). For researchers who utilise the survey method, much effort is required to design and pilot the data collection questionnaire, select an appropriate representative sample and collect responses from participants. Also, the survey method is supported by some computer software for data analysis.

3.4 Adopted Research Approaches

The aim of this study is two-fold: first to understand DBE partnerships and second to develop a method to evaluate the impact of interdependencies. Hence, the study adopted a pluralistic approach in its investigation. Specifically, the study uses Semiotics in conjunction with design science research paradigm to address the dual research aims. Semiotics, the study of sign is a useful lens to understand a phenomenon through norms (Stamper *et al.*, 2000). The choice of Semiotics as a research methodology is to enable a better understanding of DBE partnerships through well-established models and methods. This study uses the Semiotics methodology (Mingers and Willcocks, 2017) to understand DBE partnerships in the first aspect of the research design.

Given that the second aspect of this study's aim is to develop a method to evaluate the impact of DBE interdependencies, the design science research is selected as the additional approach of enquiry. The choice of design science research is motivated by its ability to aid the development of an artefact as a solution to a complex problem (Gregor and Hevner, 2013). The design science research offers researchers a medium to develop a solution as an outcome to a business problem of both practical and research significance (Baskerville *et al.*, 2015). In addition, the design science research ensures systematic development of a solution that consists of both relevance and rigour through the application of the design cycles and processes.

DBE as a contemporary socio-technical phenomenon involves numerous entities and multiplicities of interdependencies, hence it is appropriate to adopt research approaches that aligns with its complexity. Ontologically, Semiotics and design science research support multiple, context situated work-states which are socio-technologically enabled. DBE as an emerging research domain lacks its own research artefact such as theories, models and methods to explain some of its characteristics. Hence, DBE research will accommodate research paradigms that aim to produce some of these artefacts. Semiotics' epistemological orientation focuses on understanding and gaining knowledge through the interpretation of signs and norms (Liu and Li, 2015), a position that aligns with the nature of DBE. Similarly, design science

research's epistemological orientation is knowing through construction processes. Methodologically, Semiotics embraces approach that allow for the collection of rich data about a phenomenon and its context while the design science research believes in the development of artefacts with measurable impacts. As this study's aim is in two folds, the choice of Semiotics and design science research is deemed appropriate.

3.5 Adopted Research Methodology

This study adopts the mixed methodology in the quest to address its aims. The mixed methodology combines principles and techniques of the quantitative and the qualitative methodologies (Creswell, 2014). Principles and techniques of the qualitative methodology supported the identification and conceptualisation of the research problems, exploration of workable solutions, development of the final solution and collection of data for evaluation. For the research problem identification and conceptualisation, the qualitative methodology principles of literature review, observation, document review and interviews were adopted. The quantitative methodology was mainly used during the evaluation phase of the postulated solutions. Quantitative data were collected using questionnaire so that the impact values of interdependencies can be measured to support subsequent evaluation processes. Through the quantitative methodology, this study was able to produce results that support recommendations on the impact of DBE interdependencies in value co-creation. This study deemed the choice of the mixed methodology appropriate since it supported in successfully identifying research problems, developing solutions, collecting data, evaluating and validating the solutions.

3.6 Adopted Research Method

In line with the mixed methodology, this study adopts the case study as its method of inquiry. Case study is an approach that investigates an emerging phenomenon within its natural setting, especially when there is a blurred boundary between the phenomenon and its context (Yin, 2009). The case study method offers researchers opportunity to gain valuable insights into a specific context of a phenomenon using quantitative and qualitative data as well as techniques (Johnson and Onwuegbuzie, 2004). The choice of the case study method in this study is to: (1) gain detailed understanding of DBE partnerships through their formation and behaviour, (2) demonstrate the proof of concepts underlining MEII through validation with empirical data, (3) ascertain the validity, utility and generality of MEII, (4) establish the innovativeness of MEII to ensure contribution to research and practice as well as (5) delineate the contribution and limitations of the study. For these reasons, it is important to select an appropriate case study. During the selection process, possible case study environments were evaluated to determine if

they fit the profile of a DBE. From the definition of DBE, key features were used as baseline in the selection process. These metrics are (1) presence of autonomous partners, (2) availability of a common digital platform (3) interdependence among partners, processes and technologies and (4) capabilities of self–evolution. After careful consideration, Ghana's port DBE was selected as a case since it met all the selection criteria. After seeking approval, the researcher was granted access to the DBE and its key partners.

3.7 Research Design

Research design presents activities undertaken during a research process. These activities include research problem conceptualisation, literature review, data collection and analysis as well as validation. As this study is guided by Semiotics and design science research, the research design was influenced by principles of these two approaches and organised into two main phases. The first section of the research design is influenced by steps in the Semiotics methodology, namely appreciating the research situation, analysing the research materials using Semiotics tools, assessing the validity and plausibility of the potential explanatory mechanisms as well as acting to bring about change if necessary. Figure 3.2 presents the step-by-step Semiotics approach while the operationalisation of the steps is discussed in detailed below:

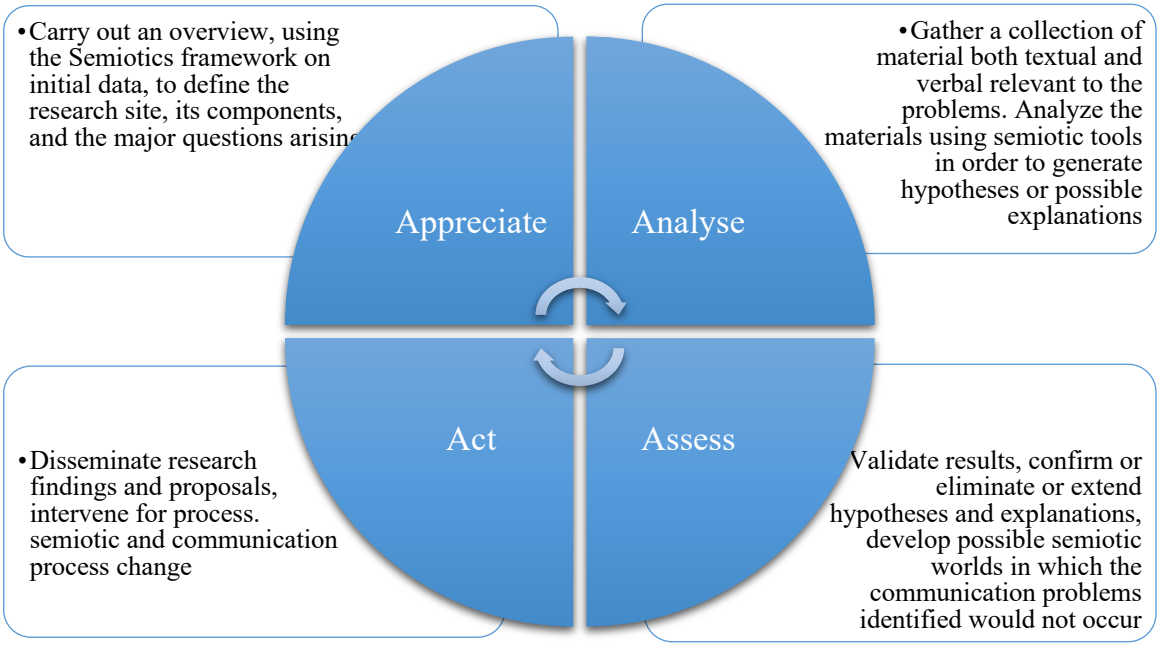

Figure 3.2 First phase of the research design

Step 1: Appreciating the research situation: The aim of this step is to enable identification of research problems and questions. The step involves collection of initial data through review of existing literature, observation and interactions with relevant practitioners to determine

limitations. For instance, through this step, it became clear that DBE partnership has not been defined in the literature and there is no clarity on their formation and behaviour. Using the layers of the Semiotics framework (Stamper *et al.*, 2000), this study explored the initial data on DBE partnerships, their formation and behaviour. At the physical layer, this study explored if there is a conceptualisation of DBE partnerships that offer some level of understanding. However, from the analysis, there is currently no conceptualisation on DBE interdependencies and partnerships. To a large extent, only the types of interdependencies are established in the extant literature.

At the syntactic level, this study explored the availability of knowledge on the formation and behaviour of DBE partnerships. Again, the results from the initial data came back negative, indicating the need for research to understand DBE partnerships. Next, at the semantic level, this study explored the possibility of understanding DBE partnership through the initial data. Again, this was not possible as there is a limitation on DBE partnership and its formation and behaviour. Hence, the need for further investigations to provide a better understanding.

At the pragmatic level, this study explored the usefulness of understanding DBE partnerships. The suggestions in the literature indicate the importance of interdependence and partnerships as drivers of value co-creation in DBEs. Similarly, the literature points that other activities such as interdependence analysis, measurement and impact assessment first require an understanding of DBE interactions. Hence, this study argues that understanding DBE partnerships is a useful endeavour from the pragmatic perspective. Lastly, analysis at the social level confirm that understanding DBE partnerships can effect behavioural change since this knowledge can help in decision making, planning and overall improvements in value co-creation. In the end, this step led to the elicitation of the research problem on the limited understanding of DBE partnerships, their formation and behaviour (see section 1.3).

Step 2: Analysing the research materials using Semiotics tools: The aim of this step is to collect sufficient data to analyse the research problem identified previously. The Semiotics methodology advocates for the use of Semiotics tools to analyse the research problems identified. In this phase of the research design, the focus is on using an appropriate semiotic tool to support definition of DBE partnerships and understanding their formation and behaviour. Thus, two semiotic models, namely organisational onion and morphology are used as tools to analyse and address the research problem. Organisational onion defines three layers of norm taxonomy: informal, formal and technical. Using these taxonomies, interdependencies between

technical entities such as technologies can be clearly elicited. Similarly, informal and formal taxonomies enable articulation of interdependencies between processes, organisations and individuals in value co-creation. In terms of understanding the behaviour of DBE partnerships, this study applies the organisational morphology to support identification and distinction of substantive, communication and control behaviours in value co-creation. With this understanding, the nature of orchestrations in DBE partnerships can be better understood. In the end, it is argued that in defining DBE partnerships, technical, formal and informal components are important considerations. Similarly, the notion of substantive, communication and control norms can foster a better understanding of behaviours in DBE partnerships (see section 4.2, 4.3).

Step 3: Assessing the validity and plausibility of the potential explanatory mechanisms: This step involves validation to verify the rigour of the research process and establish developed solutions for the research problem. Research processes can be validated by the soundness of the results produced. Similarly, solutions professed for a research problem can also be validate through empirical testing. In this study, data for validating the research problem on DBE partnerships were derived from observation, review of standard operating procedures, interviews and validation results are presented in Chapter 7. To justify the research processes used in addressing the first aspect of this study's aim, Chapter 8 presents critical discussions.

Step 4: Acting to bring about change: This last step of the Semiotics methodology concerns dissemination of the research outcomes to contribute to a better understanding of a phenomenon investigated. The step also includes pointing out gaps for future improvements and taking actions to correct problems about a phenomenon if necessary. In this study, Chapter 4 documents the knowledge gained on understanding DBE partnerships while Chapter 9 points to future research avenues. The entire thesis serves as a medium to disseminate the knowledge gained on understanding DBE interdependencies and partnerships.

In the second phase of the research design, the processes of the design science research were applied to conceptualise the research problem, establish key requirements, develop and evaluate solutions. Figure 3.3 presents the second phase of the research design and how the design science research paradigm was operationalised in this study by showing the iterative processes, activities undertaken, data sources and research techniques applied in each instance.

Awareness

The awareness process marks the beginning of operationalising the design science research paradigm. The key activity at this stage is to derive the research problems. Research problems emerge as limitations or puzzles in both practice and literature that if solved could bring significant relief to organisations and contribute to knowledge. This study makes use of problems in practice and limitations in the extant literature as data sources for articulating the research problems. The techniques utilised during the awareness process are critical literature review, observation in practice and interviews with practitioners. The essence of undertaking the awareness process is to establish the relevance of the research problem and determine if some existing efforts have been made to provide solutions. The design science research's principle of *problem relevant* guided the awareness process. That is, the use of design science research should result in the development of a technology-based solution that is important and relevant to address business problems (Hevner *et al.*, 2004). For this study, the number of research calls (e.g., Senyo *et al.*, 2018; Tan *et al.*, 2016) and interest from practice for methods to evaluate the impact of DBE interdependencies in value co-creation testify to the relevance of the research problems. On this premise, the research problems were deemed to be justified for investigation. The outcome of the awareness process is a well-articulated research problem proposal.

Suggestion

To address the research problems, suggestions are sought to find a solution that is theoretical sound from the knowledge base. As such, relevant theories and methodologies are consulted to determine their feasibility to address the articulated research problems. In relation to this study's aim, the main activity undertaken during the suggestion process was establishing key requirements and relevant concepts to evaluate the impact of DBE interdependencies. Thus, an extensive literature review was conducted to select an appropriate theoretical and methodological foundations. In the end, Organisational Semiotics theory and the design science paradigm were adopted for the second aspect of this study's aim. Based on the selected theory and the paradigm, a meta-model was designed after several iterations as a blueprint for the proposed method to the research problem. The suggestion process utilised the design as a search process of the paradigm. This principle entails the use of existing knowledge to effectively design an artefact as a solution to a problem which is accepted within the problem domain (Hevner *et al.*, 2004). In this study, the comprehensive literature review processes and the subsequent design of a meta-model as a blueprint for MEII constituted the *design a search*

process principle. In a nut shell, the outcome of the suggestion process is a tentative solution in form of a meta-model to guide the development of the final solution.

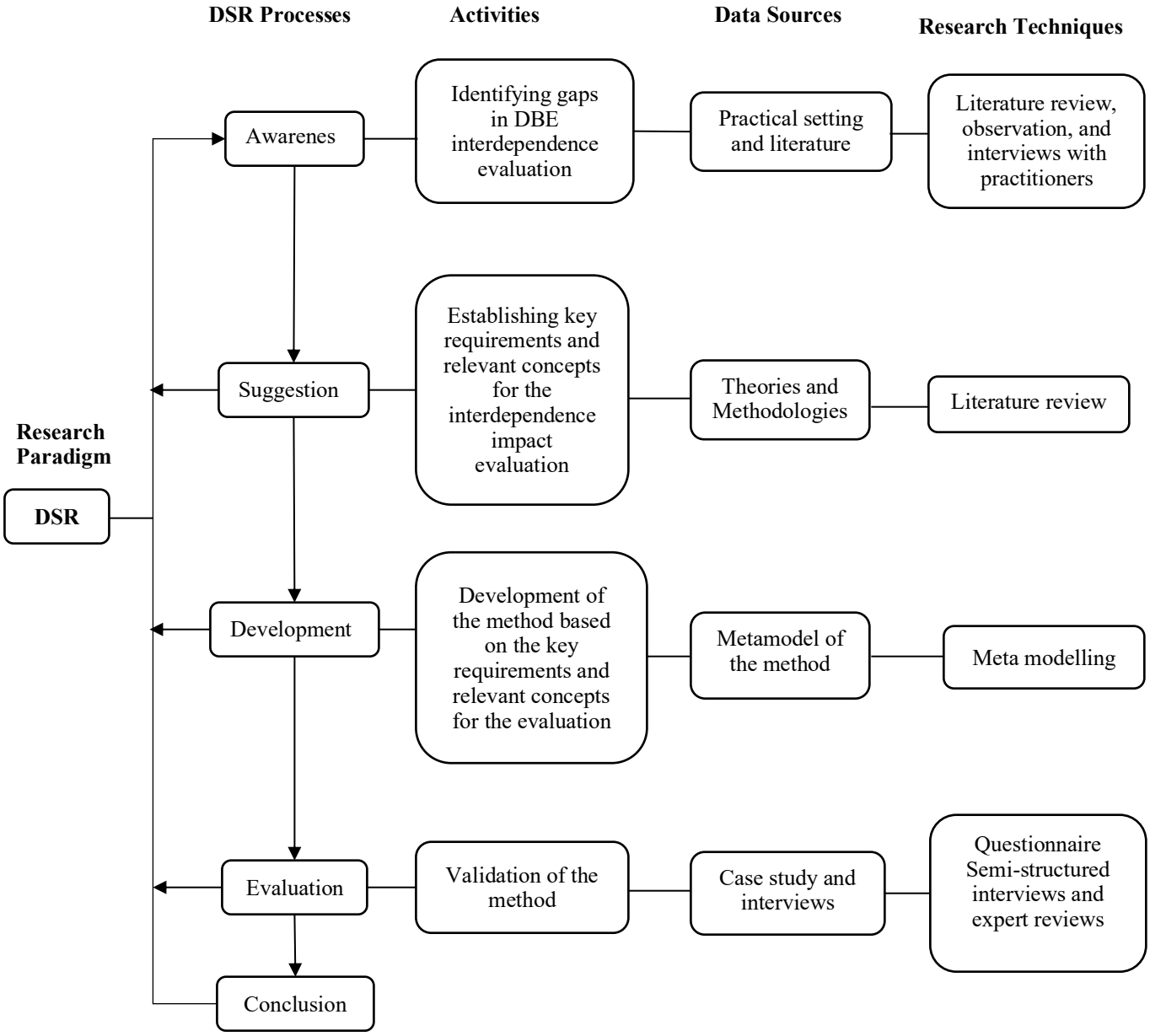

Figure 3.3 Second phase of the research design

Development

The *development* process follows the suggestion procedure by drawing inspiration from the meta-model. This process involves actualising conceptualisations in the meta-model into a viable artefact to address the research problems through several development iterations and micro evaluations until a final version is achieved. The development process was guided by design as an artefact principle of design science research where there is a requirement to

produce a viable object in the form of a construct, model, method or an instantiation (Hevner *et al.*, 2004). In this study, the main activity undertaken during the development process was building a method for evaluating the impact of DBE interdependencies in value co-creation (see Figure 6.1). The developed method is considered as an artefact since it provides a solution to a problem (Hevner *et al.*, 2004; Iivari, 2015). The developed method is considered the main contribution of this study as it fills theoretical, methodological and practical gaps. As such, these three perspectives were considered during the design and development processes. The method draws inspiration from Organisational Semiotics, interdependence, DBE and general management literature. This study argues that combining the strengths of the extant literature, the theory and processes of the design science research ensured the design of a relevant and theoretical sound method as output during the development process.

Evaluation

The *evaluation* process is where a proposed artefact is assessed to determine if it satisfies the requirements of the problem it seeks to solve (Venable *et al.*, 2016). In design science research, evaluation occurs continuously and concurrently in the design process since a large number of micro evaluations take place (Vaishnavi and Kuechler, 2004). The design science research proposes several approaches such as case study, expert review, action research, prototyping and focus group for evaluation (Hevner *et al.*, 2004; Venable *et al.*, 2016). The choice of an approach depends on the desired purpose of evaluation and level of rigour, nature of artefacts, as well as practical constraints, including time, finance, access to research data and objects (Venable *et al.*, 2012). In this study, the case study and expert review approaches are chosen for evaluation based on the criteria above. The case study approach is chosen because it offers the opportunity to conduct an in-depth investigation into the research problems in a practical context, a necessary requirement to complement the immature knowledge based on DBE interdependence impact evaluation. On the other hand, the expert review approach is chosen because it affords the study opportunity to evaluate the developed artefacts from the perspectives of professionals since the outcomes have not been immediately implemented in practice to determine their performance.

This study followed the steps of Venable et al.'s (2016) design science research evaluation processes. Specifically, this study followed these steps: (1) clarification of evaluation goals and (2) determination of artefact properties to assess. As this study sets out to make theoretical, methodological and practical contributions, the artefact evaluation goal is also tailored towards these directions. Specific evaluation goals of this research are to achieve validity, usability,

generality and innovativeness. In line with the evaluation steps, a case study was conducted in addition to expert review interviews to assess the evaluation goals of this study.

For the case study, data was collected in Ghana port DBE. The key activities carried out during the case study data collection include meetings, observations, questionnaire administering and interviews. Series of formal and informal meetings were held during a three-month data collection period with key partners in Ghana's port DBE. The meetings also helped to assess detailed activities undertaken by partners in the port DBE on which interdependencies are formed. Additionally, the meetings enabled identification of technically relevant and experienced participants needed for data collection. The observation activity involved site visits to the Tema Harbour to get first-hand experience of the practical procedure of vehicle clearing. Alongside the observation, there was documentation of interesting revelations.

The aim of the observation activity was to collect self-experienced data to triangulate data from respondents. By undertaking this activity, the researcher is in a better position to understand unobvious issues within the practical setting. In all, a total of 15 observation visits were made to the main harbour, terminals and offices during the data collection period. For the evaluation process, questionnaires were administered to selected participants in the vehicle clearing domain of the port DBE (*see Appendix B*). The aim was to collect empirical data to demonstrate the applicability and validity of the developed solutions. In the end, a total of 18 responses were collected for analysis. The interviews involved face-to-face interaction with relevant partners in the port DBE. Some of these partners were directly involved in the interdependencies at the port while others were responsible for strategic policy decision making. The aim of this activity was to solicit additional responses to complement the survey data. Also, the interview data was to help triangulate data from other sources to ensure validity. The interviews were tape-recorded and later transcribed. In all, a total of 21 interviews lasting between 60 – 80 minutes on average were conducted.

For the expert review, semi-structured interviews were conducted with academics and professionals with over 4 years' experience in business process improvements. The aim of the expert review interviews was to validate MEII through results from its application in the vehicle clearing domain to demonstrate validity, utility, generality and innovativeness. In the end, a total of five expert review interviews were conducted for validation as presented in Chapter 7. By combining the case study and expert review approaches with principles of the design science

research, it is argued that the recommended rigour required in design-focused studies is achieved under the evaluation process.

Conclusion

The final process in the design science research is conclusion. By following these design science research processes, it is deemed that a theoretically sound method is systematically developed as a solution to address the problems associated with evaluating the impact of DBE interdependencies. The conclusion process documents the overall research processes and results. As part of the conclusion process of this study chapter 7 presents result of the application and validation of the developed artefacts through a case study of Ghana's port DBE. Similarly, Chapter 8 presents results of critical discussion of the entire research process while Chapter 9 presents contributions, limitations and future research directions as part of the conclusion processes. Since the results of this study provide useful knowledge that addresses the research problems, and can be repeated in future investigations, the research endeavour is considered successful.

3.8 Summary

This chapter presented the research methodology underpinning the study. The chapter discussed philosophical assumptions in IS research from the ontological, epistemological and methodological perspectives. For research paradigm, the chapter discussed underlying assumptions of the positivist, interpretivist, critical and the design science research. Next, the chapter discussed dominant research methodologies and methods in IS research. These discussions set the stage for adoption of appropriate research paradigm, methodology and method to address the study's aims. Given the aim of this study is to understand DBE partnerships and develop a method to evaluate the impact of interdependencies between entities in value co-creation, the Semiotics methodology and the design science research paradigm were adopted as the methodological lens. Based on these adopted approaches, appropriate research methodology and method were selected to underpin the research design. Finally, the chapter discussed how elements of the adopted research approaches, methodology and methods were combined and utilised in the research design processes.

Chapter 4

Conceptualising DBE Interdependencies and Partnerships

This chapter presents the conceptualisation of DBE interdependencies and partnerships with the aim of addressing the *second research question* of the study: *what are DBE partnerships and how can we explain their formation and behaviour in value co-creation?* First, the chapter presents the conceptualisation of DBE interdependence, from which a definition is proposed. The definition contributes to DBE and interdependence research since there is arguably no clear definition in the literature. Next the chapter develops a notation for DBE interdependencies to help identify and distinguish between different classes of interactions. Following this, the chapter discusses DBE partnerships and their underlying components to explain their formation and behaviour. Finally, the chapter presents a visualisation technique to foster a better understanding of DBE partnerships.

4.1 Defining DBE Interdependence

This study introduces DBE interdependence as a new form of relationship that focuses on interactions between DBE entities. The conceptualisation of DBE interdependence is motivated by limitations in the extant literature to address the emergence of a new form of organisational alliance. As established in Chapter 2 of this study *(see Section 2.5.2)* there are different forms of interdependencies such as routine, process, activity, task and technology interactions. However, these forms of interdependencies focus on a single phenomenon as evident by their naming. For instance, process and technology interdependencies only focus on interactions between processes and technologies respectively. Secondly, these forms of interdependencies are limited to interactions in a single organisation. Conversely, DBEs are comprised of several entities where interactions occur between numerous processes, partners and technologies. Hence, it is argued that there is a need for a new conceptualisation of DBE interdependence.

From the literature and practice, it is evident that DBEs are composed of three main entities: digital technologies (platforms), partners and processes (Senyo *et al.*, 2017). First, digital platforms refer to innovations that other participants rely on to undertake activities (Selander *et al.*, 2013). Examples of digital technology platforms include online payment systems, intelligent scanners, specialised computer application and so on. Technology platforms support

value co-creation activities in DBEs by offering the medium to undertake transactions and interactions (Gawer and Cusumano, 2013). Second, processes refer to a series of steps that transforms inputs into outputs to accomplish an outcome. Processes range for a simple step of entering a password to a complex set of activities such as computing revenue projections. Given the nature of DBEs, there are several processes that support value co-creation. As a component of DBE interdependencies, processes depict interactions between series of activities intended to accomplish an outcome. For instance, the series of steps require to successfully make an electronic payment can be referred to as a process. Lastly, partners refer to individuals and organisations that participate in DBEs. For instance, in value co-creation, an organisation may rely on customers for feedback about their goods and services for improvement. Similarly, a partner may rely on a technology to perform a job. As a complex environment, DBEs comprise several partners sometimes across different traditional industry boundaries. A combination of interactions between these three entities is what creates DBE interdependencies. In addition, these interactions also exhibit different interdependence types, namely pooled, sequential and reciprocal. As a result, DBE interdependencies can be regarded as a network of interactions that underpins value co-creation.

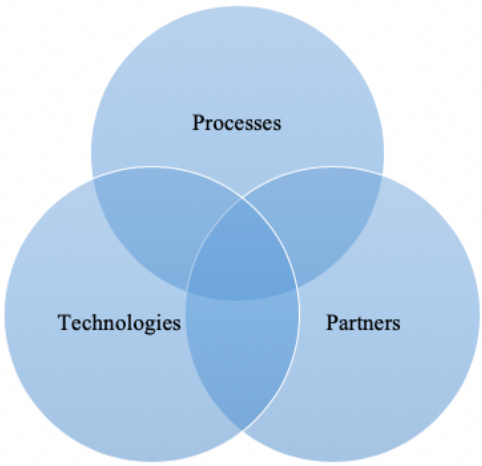

Figure 4.1 Components of DBE interdependencies

As presented in figure 4.1, DBE interdependencies are built on three main components: digital technologies, processes and partners. At the individual level, there are interdependencies between each group of entity. For instance, at the process, technology and partner levels, there are interdependencies between similar entities. In addition, to the individual level interdependencies, there are also interdependencies between the three entities. For instance, there could be an interdependence between a partner and a technology platform or a process. A

combination of these different kinds of interdependencies is what distinguishes DBE interdependence from other forms. In the extant management literature, different forms of interdependencies such as task, process and technology have been conceptualised. However, these forms of interdependencies only focus on one entity at time while DBE combines interdependencies between more than one entity. Thus, this study considers the conceptualisation of DBE interdependence a useful contribution to research.

In line with the semiotic methodology, this study uses the organisational onion as the theoretical lens to formulate a definition for DBE interdependence. Supporting the definition of DBE interdependence with the organisational onion offers a better understanding that reflects interactions between entities. The organisational onion analyses interactions as norms from three layers: informal, formal and technical layers *(see figure 2.5)*. DBE as a socio-technical environment comprises different kinds of entities that interact through interdependencies in value co-creation. These interactions conform to the systems of norms in the form of behaviour, perception and values (Liu and Li, 2015). Even though DBEs are digitalised, they are still characterised by informal interdependencies. Similarities can be drawing between this kind of interaction and the informal layer of the organisational onion. Also, some interdependencies are highly regulated by rules that direct the behaviour of participants. Again, this formalised type of interdependencies can be likened to the formal layers of the organisational onion. Lastly, formal interdependencies that are repetitive can be automated in technology platforms, which can also be likened to the technical layer of Organisational Semiotics.

By explicating the theoretical base of DBE interdependencies using the organisational onion, this study embodies the knowledge and supports the reflection of the structure of DBE interdependencies. From the discussion above, it is evident that DBE interdependence is unique from existing forms and thus needs its own conceptualisation. DBE interdependence exhibits the following:

(1) interactions between heterogenous and homogenous entities, namely digital technologies, processes and partners
(2) characterised by pooled, sequential and reciprocal interdependencies
(3) combines elements from process, actor and technology interdependencies into one main interdependence
(4) comprises informal, formal and technical interdependencies

Based on these premises, this study *defines DBE interdependence as interactions between two or more heterogenous and homogenous entities such as processes, digital technologies and partners in a socio-technical network to co-create value.*

4.2 DBE Interdependence Notation

DBE is a sociotechnical environment comprising individuals, organisations and technologies bounded together by processes to achieve outcomes. As such, interdependencies can occur among individuals and organisations conceptualised as partners as well as digital technologies through the performance of activities embedded in business processes. In addition to the definition of DBE interdependence, this study also proposes a DBE interdependence notation. The notation as a formal representation provides a lower granularity to DBE interdependencies. With this notation, it becomes easier to identify different classes of DBE interdependencies. Also, the notation offers a generic base to categorise all DBE interdependencies to ensure standardisation. With this notation it becomes easier to understand underlying mechanisms of DBE interdependencies.

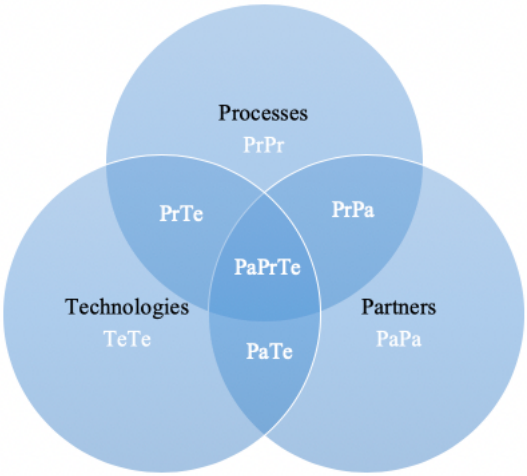

Figure 4.2 DBE interdependence notation

Figure 4.2 shows the DBE interdependence notation comprising three main entities - partners, processes and technologies and 7 distinct interdependence classes. These interdependence classes are PrPr, PaPa, TeTe, PrTe, PaTe, PrPa and PrTePa. PrPr is a process-to-process interaction that portrays an interdependence exclusively between DBE processes. For instance, a process-to-process interdependence occurs when an account balance checking procedure interdepends on user login validation procedure before it provides a feedback to the user. Similarly, PaPa (partner-to-partner) and TeTe (technology-to-technology) represent interdependencies exclusives between DBE partners and technologies respectively. A typical

example of a partner-to-partner interdependence occurs when a customer relies on a credit approval manager to authorise his/her application. Similarly, a technology-to-technology interdependence occurs when an order processing system relies on an electronic payment system to successfully execute an order.

PrTe (process-to-technology) represents an interdependence between a DBE's process and a technology. PrTe occurs when a process depends on a technology to execute its function successfully. The reliance of a payment process on an electronic payment system in a DBE is a typical example of a process-to-technology interdependence. In the same vein, PrPa (process-to-partner) refers to a DBE interdependence between a process and a partner while PaTe (partner-to-technology) represents an interdependence between a DBE technology and a partner. The use of a payment process in DBEs by a customer is a typical example of a process-to-partner interdependence. Also, the use of a point of sale (POS) device by a customer to make payment in a DBE is an example of a partner-to-technology interdependence. Without the POS, the partner might not be able to make payment. Lastly, PaPrTe encapsulate the three main entities in DBE interdependence. This class of interdependence presents interaction between partners, technologies and processes in a single instance. Even though the interdependence classes are specified alphabetically, their relationships are bi-directional. As such, PrPa, PrTe and PaTe is the same as PaPr, TePr and TePa respectively.

The interdependence notation supports understanding of DBE partnerships and the method to evaluate the impact of interdependencies in the following ways. First, to understand DBE partnerships, the notion combines with interdependence types, entities, outcome flows, behaviour taxonomies and entities to explain the formation and behaviour of DBE partnerships. Second, the notation supports the interdependence articulation technique in the method for evaluating the impact of interdependencies to identify and delineate different kinds of interactions between entities. With this exposition, it becomes easy to make a final determination on DBE interdependencies in their reorganisation.

4.3 DBE Partnership

Building on the discussions above, this section specifically addresses the second research question of this study: *what are DBE partnerships and how can we explain their formation and behaviour in value co-creation?* To address this question, this study first defines DBE partnerships and subsequently discusses their formation and behaviour.

This study conceptualises DBE partnership in line with the definition of DBE interdependence above. As such, DBE partnership is defined *as the overall nature and structure of interdependencies in DBEs*. In other words, DBE partnerships provide a complete view of how interdependencies are formed and their underlying structure and behaviour. DBE partnerships arises as a result of an association of two or more entities with an aim to achieve a common outcome. As such, interdependencies are identified as the underlying building block of DBE partnerships. DBE partnerships are underpinned by resource sharing between entities through interdependencies. The components of DBE partnerships are nested in a network of interdependencies to facilitate value co-creation. Thus, this study argues for the identification and analyses of the components of DBE partnerships to understand their formation and behaviour.

In the extant DBE literature, the types of interdependencies have been established as key component of interactions (Senyo *et al.*, 2017). Though there is clarity on the types of interdependencies, previous studies have not gone beyond this to explain how other components can combine with the types of interdependence to explain DBE partnerships. Given that there is limited explanation of DBE partnerships in the literature, there is difficulty in understanding the formation and the nature of relationships that lead to value co-creation. As a contemporary phenomenon, it is hopeful that the understanding explicated in this study will be useful to practitioners after satisfying academic need. To understand DBE partnerships, this study reviews the extant literature to conceptualise additional components, namely *interdependence classes, outcome flows, behaviour taxonomies and entities in addition to the types of interdependencies*. Table 4.1 presents the components of DBE partnerships while detailed discussions on each component are presented below.

Table 4.1 Components of DBE partnerships

Interdependence Types	Interdependence Outcomes	Interdependent Entities	Interdependence Classes	Entities
Pooled Sequential Reciprocal	Finance Information Goods	Processes Technologies Partners	PaPa TeTe PrPr PrTe PrPa PaTe PaPrTe	Partners Processes Technologies

Interdependence Types

Interdependence type as a component of DBE partnership refers to the kind of interaction that underlie interactions. Interdependence types are important building blocks of DBE partnerships

because they help to distinguish between various relationships since each interdependence type invoke different coordination approach. Secondly, interdependence types determine which strategies to adopt when reorganising interdependencies since each kind of interaction brings its own constraints. To clearly identify and compare interdependencies that underpin DBE partnerships, this study adopts Thompson's (1967) interdependence type classification. The interdependence classification suggests three types of interdependencies, namely (1) pooled, (2) sequential and (3) reciprocal interdependencies.

Pooled interdependence is where there are indirect relationships between different entities, but their individual efforts collectively leads to achievement of a common outcome. Sequential interdependence depicts a scenario where output from one entity is needed as input by another entity in succeeding interaction. Lastly reciprocal interdependence is where entities within interdependencies cyclically provide inputs and receive output from each other. To understand how fragile or robust a DBE partnership is, it is important to understand the type of interdependencies that dominate the DBE partnerships. For instance, by examining interdependence types underpinning a DBE partnership, it can be revealed if pooled, sequential or reciprocal interdependencies dominates the DBE. Given that each type of interdependence has its advantages and disadvantages, understanding interdependence types of DBE partnerships is regarded essential.

Interdependence Outcome Flows

Interdependencies are largely triggered by the need for a particular resource to produce specific outcomes (McCann and Ferry, 1979). A combination of these resources during value co-creation lead to outcomes needed to achieve predefined goals. Interdependence outcome flows are results generated from interdependencies during value co-creation. Thus, in understanding DBE partnerships, this study conceptualises interdependence outcome flows as one of the building blocks. This component is considered important to understand DBE partnerships because it highlights outcomes from each interaction in DBEs. With this knowledge, focal partners can determine crucial and less important outcomes so that in reorganising interdependencies, this understanding can support decision making.

From the extant literature, different outcome flows have been highlighted. However, these can be categorise into three main outcomes, namely (1) finance, (2) goods and (3) information (Croom *et al.*, 2000; Gordijn *et al.*, 2000; Pfohl and Gomm, 2009; Pijpers *et al.*, 2012). Reichardt, et al. (2016) assert that one key resource that is always insufficient for organisations

is finance. Financial flow refers to the monetary reward derived from an interdependence (Pfohl and Gomm, 2009). An example of financial flow is an income received from an interdependent customer. The movement of the money from the customer to an organisation due to predefined arrangement is what demonstrate financial flow (Cooper *et al.*, 1997). Goods flow, on the other hand, refers the successful movement of items through various interdependent workflows (Croom *et al.*, 2000). For instance, goods flow occurs when a customer requests for an item and the requested item successfully reaches its intended destination. Lastly, information flow refers to the successful transfer of messages between interdependent entities (Croom *et al.*, 2000). Information flows are inherent part of most interdependencies, however, there are exclusive interactions that produce information as an outcome. In this study, the focus is on information produced as an output exclusive from an interdependence. For instance, information received as a feedback for a successful processing of a transaction is referred to as an information flow.

Entities

Entities as a component of DBE partnership represents participants in interdependencies (Senyo *et al.*, 2017). Entities perform activities to support value co-creation in DBEs. Drawing from the DBE interdependence components discussed above, this study proposes three main entities as components of DBE partnerships, namely technologies, processes and partners. Partners represent individuals and organisations who undertake value co-creation in DBEs (e.g., customers). Similarly, DBE processes refer to a set of activities that depict actions that transform inputs into outcomes. Lastly technology objects are innovations that provides improve ways of undertaking tasks. For example, a technology platform that allows interdependent entities to remotely process transactions is a technology entity. Given that entities are the participants in interdependencies, it is prudent to articulate them as components of DBE partnerships. In addition, articulating entities can be regarded as the first step to comprehensively understand interactions in DBEs because it helps to establish other components of DBE partnerships.

Interdependence classification

Interdependence classification refers to the class of interdependence between DBE entities. Interdependence classification is based on the DBE interdependence notation proposed in this study (*see Section 4.4*). The classification distinguishes interactions in DBEs through their interdependence classes. The reason for conceptualising interdependence classification is to identify different classes of interdependencies between entities. With this knowledge, a better understanding can be obtained on interdependencies to support reorganisation of

interdependencies for improved value co-creation. Based on the DBE interdependence notation, this study proposes seven classes of interdependencies, namely PrPr, PaPa, TeTe, PrTe, PaTe, PrPa and PrTePa (see Figure 4.2).

To now address the other part of the research question on *explaining the formation and behaviour of DBE partnerships in value co-creation*, this study relies on the components of DBE partnerships and the organisational morphology approach. The components of DBE partnerships as discussed above are interdependence types, classes, entities and outcome flows. The interdependence types depict the kind of interactions that exist between entities while the classes present the classification of interactions. Through the interdependence classification is becomes easy to determine the entities involved in an interdependence. Lastly, the interdependence outcome flow shows the result of each interaction. By analysing all interdependencies within a DBE's context through the four components, an overall view can be provided to explain the formation of DBE partnerships. For instance, using the components of DBE partnership, the formation of the relationships between a customer and a digital technology that allows the customer to submit a purchase order is decomposed as follows. First, the interdependence type is sequential since it relies on input from another interdependence to undertake the current task. Next, the entities involved are identified as customer (partner) and digital technology. Based on this identification, the interdependence class is partner-technology (PaTe) while the outcome flow is information since successful submission of an order will result in the transmission of the order details to another interdependence. By explaining the underlying mechanisms between the components, a better understanding is obtained on the DBE partnership.

In line with the semiotic methodology, this study uses the organisational morphology to analyse behaviours in DBE partnerships. The morphology is an Organisational Semiotics approach for classifying norms to understand their behavioural dynamics *(see Figure 2.6)*. Organisational morphology classifies norms into three main behavioural taxonomies, namely substantive, communication and control as well as sub-taxonomies (Stamper *et al.*, 2000). Substantive norms define core behaviour within socio-technical environments while communication norms concern exchange of information. Control norms monitor and regulate substantive and communication norms. As DBE is a socio-technical environment and its interdependencies are undertaken through interactions between entities, the classification of norms by organisational morphology is considered appropriate to establish DBE partnership behaviours. Using the example above, if the order processing is a core function, then it can be classified as a

substantive behaviour. However, this behaviour also involves information sharing hence the final behavioural classification is designated as *substantive.communication*. Drawing a parallel between the norm taxonomies and DBE interdependencies, this study argues for the categorisation of behaviours in DBE partnerships as substantive, communication and control as well as the combination of these three main types.

In sum, to understand DBE partnerships, there is a need to first examine the underlying formation of interdependencies using the four components (interdependence types, classes, entities and outcome flows) and subsequently analysing the behavioural dynamics of interactions through the norm taxonomies of organisational morphology. Using these two procedures, a better understanding can be obtained on DBE partnerships.

4.4 Visualising DBE Partnerships

To offer a better understanding of DBE partnerships, there is a need for an effective process to capture and present the dynamics of interdependencies. Thus, this study offers a visualisation technique to represent DBE partnerships. The importance of the visualisation technique include: (1) simplification of complex interdependencies to enable a better understanding of their formation and behaviour of DBE partnerships, (2) easy and quicker identification of DBE partnership aspects that need improvement, (3) highlighting critical entities and interdependencies within DBE partnerships, (4) understanding of the relationship between entities, and (5) providing the knowledge needed to support strategic choices on how to reorganise DBE interdependencies to improve value co-creation.

The visualisation technique comprises the following:

Table 4.2 Interdependence visualisation technique

Entities	Interdependence Types	Interdependence Classes	Behaviour Taxonomies	Interdependence Outcome Flows	Interdependence Total Impact
Entity name	*Refer to subsection 2.5.1*	*Refer to subsection 4.2*	*Refer to subsection 2.8*	*Refer to subsection 4.2*	*Refer to subsection 7.4.2*

- *Entities:* Refers to a brief description of a DBE interdependence participant, which could be a reference for processes, partners or digital technologies.

- *Interdependence Types:* Indicates the kind of relationships that exist between two or more interacting entities. It could be pooled, sequential or reciprocal as illustrated in subsection 2.51.
- *Interdependence Classes:* Refers to the category of DBE interdependence based on the notation developed in subsection 4.2. The interdependence class enables identification and articulation of the classes of DBE interdependencies, be it between processes, technology and process, or partners and technologies.
- *Behaviour Taxonomies:* Describes the kind of function an interdependence performs in a DBE partnership. The behaviour taxonomies as presented in subsection 3.8 include substantive, communication and control behaviours as well as sub-taxonomies.
- *Interdependence Outcome Flows:* Refers to the result an interdependence produces in a DBE partnership. The conceptualisation of the interdependence outcome flows is presented in subsection 4.2.
- *Interdependence Total Impact:* Illustrates the overall effect of an interdependence in a DBE partnership. In this study, the total impact of an interdependence is obtained by summing up the social, operational and strategic impact scores of an interdependence as illustrated in subsection 7.4.2.

The visualisation technique provides objects to facilitate the DBE partnership illustration process. These objects are:

- *Entities* within interdependencies are represented by a *circle* with their name inscribed.
- *Interdependence type* is represented by *links* between entities. Three different links are conceptualised in the visualisation technique. *A single headed arrow* represents a sequential interdependence while a *double-headed arrowed* indicates reciprocal interdependence. On the other hand, *a dotted line* represents pooled interdependence.
- *Interdependence outcome flows* are represented by a *rounded rectangle* and placed along the interdependence link.
- *Interdependence ID* is a text the shows the unique identifier of an interdependence. It is located on the link it presents.
- *Interdependence class and behaviour taxonomies* are represented by a *curly bracket* close to an interdependence.
- *Interdependence total impact* is represented by the *thickness* of the link between entities, as compare to other interdependencies in a DBE partnership.

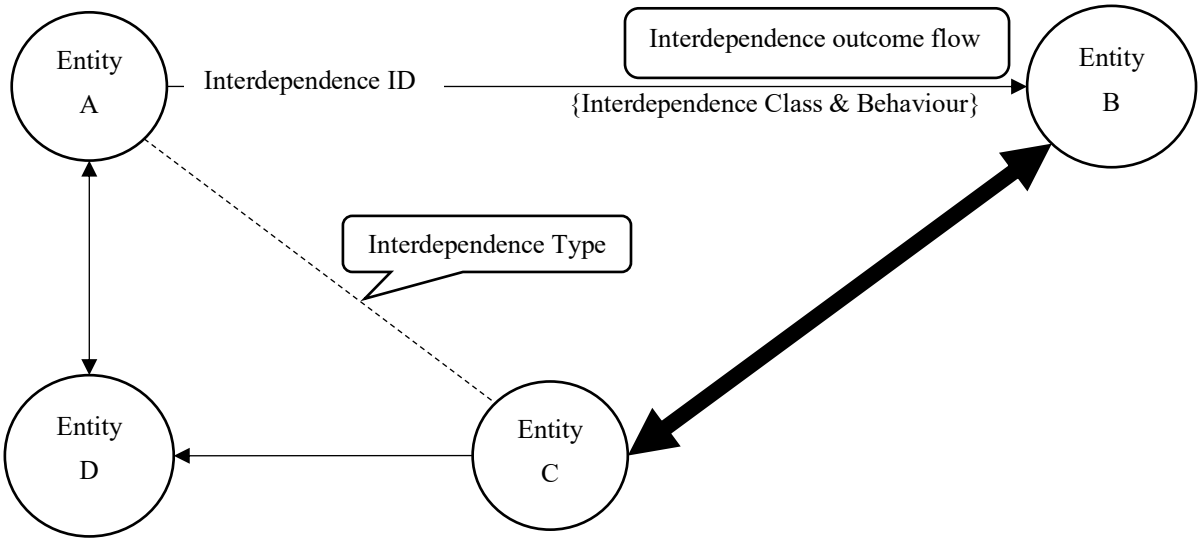

Figure 4.3 Sample DBE partnership visualisation

Using the objects of the interdependence visualisation technique provided above, a sample DBE partnership is illustrated in Figure 4.3. The figure shows entities, interdependencies and their classes, types, outcome flows as well as behaviour taxonomies. The circles show the entities in the interdependencies (A, B, C and D) while the one headed arrow shows the type of interdependence. The rounded rectangle shows the interdependence outcome flow while the ID is located on the link between entity A and B. Lastly, the curly bracket indicates the interdependence class and behaviour. From Figure 4.3, it is evident that the interdependence between entity A and D is reciprocal due to the use of the double headed arrow. This is same for the interdependence between entities B and C. However, the thickness of the link is an indication of a greater impact of this interdependence in value co-creation than other interdependencies. On the other hand, the interdependence between entities A and C indicate pooled interdependence due to the dotted link in the relationship. By visualising all interdependencies in value co-creation, it is envisaged that a better understanding can be obtain on the DBE partnership formation and behaviour. This study considers the interdependence visualisation technique as useful approach, as such, it is integrated into the method of evaluating the impact of DBE interdependencies in Chapter 6 to offer a better understanding of DBE interdependencies and partnership.

4.5 Summary

In this chapter, this study addressed the *second research question* by explaining DBE partnerships and providing solutions to understand their formation and behaviour. As a prelude to answering the research question, DBE interdependence was discussed from which a

definition was proposed to address limitations in the extant literature. Next, the chapter presented a notation to classify DBE interdependencies for easy identification and support in understanding of DBE partnerships. The notation provided 7 distinct classes of interdependencies to accommodate all kinds of interactions in DBEs. Following this, the chapter discussed DBE partnership by first conceptualising their components and explaining the underlying mechanisms of their interactions. Lastly, the chapter presented a visualisation technique to illustrate DBE partnership to enable a better understanding.

Chapter 5

Metrics, Kernel Theory and Meta-Model for Evaluating the Impact of DBE Interdependencies

This chapter presents metrics, a kernel theory and a meta-model for the development of a method to evaluate the impact of DBE interdependencies to address the *third research question*. DBE as a multifaceted phenomenon presents a challenge that requires consideration of all its characteristics in the development of its methods. On this premise, this study proposes three metrics (operational, social and strategic) as dimensions to evaluate the impact of DBE interdependencies. These dimensions are proposed because they holistically address the multifaceted nature of DBE interdependencies and directly affect performance issues in value co-creation. First, the chapter discusses the three metrics and how individual criteria are selected for each dimension. Next, the chapter develops a kernel theoretical proposition based on the metrics. Lastly, the chapter discusses the design process and components of the meta-model for the method in Chapter 6.

5.1 Metrics for Operational Impact Assessment

In both organisations and organisational networks, operational activities are the means by which products and services are created and delivered. Operational activities in DBEs are characterised by several interdependencies. As a result, to determine the performance of DBEs, the operational impact of interdependencies is considered an important dimension. Given that operational activities can clearly be identified, in seeking to improve performance, decision makers explore measures that can directly result in efficient and effective business processes (Galvagno and Dalli, 2014). Operational activities are part of a larger management function related to day-to-day running of DBEs. In course of undertaking business functions, operational issues may emerge. Some of these issues include delays, inefficient processes, wastage, service unavailability, excessive cost and so on. The need for improved performance and effective business activities may sometimes motivate the evaluation of these operational issues (Faed, 2010). In DBEs, operational functions are underpinned by interdependencies between several entities. As a result, to determine the impact of interdependencies in DBEs, it is prudent to explore these relationships through operational activities. Thus, in this study, operational

impact is defined as the effect of an interdependence on business activities (Fayoumi, 2016; Tan *et al.*, 2017).

Operational impacts of interdependencies can be directly attributed to the execution of business processes. As a result, different aspects of business processes are candidates for evaluating the operational impact of DBE interdependencies. This situation creates a challenge in the selection of the criteria to evaluate the operational impact of DBE interdependencies. This challenge is complicated by the many-to-many interdependencies between DBE entities. In the literature, there is arguably no clear-cut set of criteria defined as metrics for operational impact assessment of DBE interdependencies. Thus, this study conceptualises a set of criteria based on the following guidelines: (1) is generic and can be adapted across a wide range of DBEs, (2) entails both financial and non-financial measures and (3) is quantifiable.

From the management literature, several factors have been pointed as criteria for evaluating operational impacts. For instance, Roseira et al. (2010) point to logistics, payment, production, sales, customer services and cost as factors that influence operational business processes. Similarly, Lim et al. (2013) identify operational factors to range from operating cost, production lead times to customer services. In the same vein, Fayoumi (2016) identifies cost, time, quality and waste as drivers of operational effects in ecosystem environments. Also, Tan et al. (2017) identify ability to respond quickly to business opportunities, accurately and in a cost-effective manner in interdependencies as mediums to achieve operational agility. Bakshi et al. (2011) and Brooks and Pallis (2008) highlight turnaround time, delays and bureaucratic processes as critical factors that affect operational processes. Similarly, Parasuraman et al. (1985) and Galvagno and Dalli (2014) identify service quality as an important factor of operational processes.

A critical look at the factors in the extant literature shows that there is no consensus on operational impact assessment criteria. However, some factors such as cost, turnaround time, service quality remain dominant in the extant literature as operational impact assessment issues. In conjunction with these revelations from the literature, this study follows the guideline proposed above as a baseline in selecting the criteria of operational metrics to evaluate the impact of DBE interdependencies. In the end, this study selects *cost, turnaround time* and *service quality* as a set of operational metrics to evaluate the impact of DBE interdependencies. These criteria are considered suitable for the operational impact assessment because they cover both financial and non-financial aspects of interdependencies; they can be quantified; and are

generic and can be easily used in a wide range of DBEs. Table 5.1 presents the operational impact assessment criteria and their description.

Table 5.1 Operational impact assessment criteria

Criteria	Description	Source
Cost	Refers to the amount of money incurred to obtain goods or services in an interdependence.	(Fayoumi, 2016; Lim *et al.*, 2013; Poon and Wagner, 2001; Roseira *et al.*, 2010; Tan *et al.*, 2017)
Turnaround time	Refers to the period of carrying out a processing cycle of an outcome in an interdependence	(Brooks and Pallis, 2008; Fayoumi, 2016; Poon and Wagner, 2001; Tan *et al.*, 2017)
Service quality	Refers to the contrast between perceived expectation and actual satisfaction derived from an interdependence	(Cronin and Taylor, 1992; Galvagno and Dalli, 2014; Parasuraman *et al.*, 1985)

Rationally, most focal firms in DBEs will strive to reduce and keep cost of operation low so that partners can gain more profit. However, this desire is sometime very difficult to achieve due to competing interest among DBE participants. Cost refers to the amount of money incurred to obtain goods or services (Lim *et al.*, 2013) in an interdependence. For instance, the payment of a delivery charge by a customer is an example of an operational cost. However, how high or low the amount involved will determine the impact of the cost to partners within interdependencies. Given the vague nature of cost, for this study, the cost criterion is expressed as amount of money incurred in an interdependence. Thus, cost is decomposed as processing and logistic cost. Processing cost refers to payments within an interdependence that facilitate delivery of goods and services. For instance, payment of application processing or registration fees. On the other hand, logistics cost describes payment for delivery of goods and services within an interdependence. An example of logistic cost is money paid for movement of goods from a supplier to a customer. Given that cost is mostly associated with DBE operations, this study deemed its selection as a criterion to evaluate the operational impact of interdependencies appropriate.

Another critical operational factor considered in this study is turnaround time. In a hyper environment like DBE where time influences many decisions, outcomes and other processes, it is required that there are fast and efficient processes. Turnaround time is defined as the period of carrying out a processing cycle of an outcome in an interdependence (Brooks and Pallis, 2008). Analysing turnaround time is significantly important in DBEs because it determines the

amount of output produce. Given that output of operational processes has some bearing on profitability, turnaround time is important in operational activities. For instance, if it takes 2 hours to complete a request in an interdependence on average while it should have taken 30 minutes, it means maximum output will not be produced. This in turn will affect the amount of revenue generated. As such, for focal firms in DBEs, turnaround time is extremely important to achieve greater outputs and also satisfy other interdependence partners. From the discussions, it is evident that turnaround time can be a good measure of operational activities. Also, turnaround time is generic, easily quantifiable and can be applied to most interdependencies. Thus, this study selects turnaround time as a criterion for evaluating the operational impact of DBE interdependencies.

Lastly, another generic factor that accounts for the operational impact of interdependencies is service quality. Service quality refers to a partner's contrast between the perceived expectation and perceived performance of a particular interdependence (Parasuraman et al., 1985). Hence, if perceived performance exceeds perceived expectation, then service quality is high. However, if performance is below perceived expectation then service quality is low. Service quality is a subjective concept and may only be determined by the beneficiary. In view of this, Parasuraman et al. (1985) conceptualise 10 determinants of service quality as reliability, responsiveness, competence, access, communication, courtesy, credibility, security, understanding and tangibles. In DBEs, the nature of interactions between partners and flexibility of relationships (Darking *et al.*, 2006) makes service quality very important. If a partner constantly receives bad service quality, the flexible nature of DBEs affords the partner the ability to easily switch. As such, it is argued that in evaluating the operational impact of interdependencies, the effect of service quality is an important criterion to consider since it has a bearing on revenue, reputation and continuous survival of organisations (Galvagno and Dalli, 2014) in DBEs.

5.2 Metrics for Social Impact Assessment

In addition to operational effects of interdependencies, there are also social effects that must be considered to have a holistic frame to evaluate the impact of interdependencies. Given that DBEs are made up of socio-technical entities, it is important to consider the social perspective of interdependencies. Social effects are based on human interactions and behaviour as a result of perception of a phenomenon. Thus, social impact is defined as the social effect of interdependencies on DBE participants (Stamper, 1973). Social effects are underpinned by factors such as beliefs, values and norms that shapes peoples' perception. For instance, the effect of a new interdependence on someone's job security could be referred to as a social

impact since this new relationship could lead to job loss. In this case, the new interdependence may be seen to have a negative impact from the perspective of some DBE participants. As a result, it may affect their morale and value co-creation. Thus, it is important to consider the social impact of DBE interdependencies in value co-creation.

Even though social effects of interdependencies can contribute significantly to value co-creation in DBEs, less is known in the extant literature with exception of a few (e.g., Senyo *et al.*, 2018). Although social effects have not been largely accounted for in prior interdependence assessment approaches, calls have been made (Liu *et al.*, 2006; Sun *et al.*, 2016) for this consideration as these factors may affect productivity of individuals. Largely, interdependence and DBE literature have not accounted for the social impact of independencies. This situation creates a challenge in the development of metrics to evaluate the social impact of interdependencies in value co-creation. On this premise, this study followed Senyo et al.'s (2018) adaptation of Hall's (1959) ten social dimensions. The ten social dimensions evaluate the impact of an innovation based on the perception of participants (Liu *et al.*, 2006).

Hall's (1959) social dimensions are selected as the criteria for the social impact metrics based on the following reasons. First, Hall's classification of social impacts covers arguable many social factors. Also, the approach has been tested in prior study (e.g., Liu *et al.*, 2006; Sun *et al.*, 2016; Senyo, et al., 2018) as a mechanism to effectively delineate social effects of a phenomenon. The ten social dimensions are: association, subsistence, classification, territoriality, temporality, learning, recreation, protection, exploitation and interaction. Table 5.2 presents the ten-social dimension as criteria to articulate the impact of DBE interdependencies. These social dimensions are further elaborated below.

Association is defined as the impact of an interdependence on the ability of DBE participants to form alliances or groups. As social beings, people like to congregate or associate with a group of other individuals (Stamper, 1973). Thus, in a situation where an interdependence foster association between DBE participants, it is likely that the interdependence will be seen to have a high social impact. On the other hand, an interdependence that does not foster association of DBE participants may be rated to have a negative impact.

Subsistence refers to the process by which DBE participants satisfy the basic physical and economic means of life such as income, food, work etc. Hence, if an interdependence causes DBE partners not to obtain basic physical and economic needs, that interdependence might be

perceived to have a negative effect in value co-creation. In this study, subsistence is conceptualised in terms of the impact of an interdependence on DBE partners' job security.

Table 5.2 Social impact assessment criteria (Adapted from Hall, 1959; Liu *et al.*, 2006)

Dimensions	Description
Association	Grouping, alliances, e.g., formation of teams to evoke competitiveness and sense of belonging of participants
Subsistence	Physical and economic matters related to existences, e.g., impact of an interdependence on income or job security
Classification	Differentiation of people by sex, age, level of education, e.g., whether an interdependence improves equal opportunity for all
Territoriality	Accessibility, e.g., impact of an interdependence on erosion of control, influence or loss of authority
Temporality	Time division, synchronous, asynchronous, e.g., issues of time zone differences caused by an interdependence
Learning	Sharing knowledge, gaining awareness, e.g., de-skill or more opportunity for learning new skills within an interdependence
Recreation	Fulfilment, joy, e.g., whether the job becomes more interesting or boring within an interdependence
Protection	Fairness, rights, e.g., granting file rights access to the appropriate groups of people and maintaining the confidentiality of information
Exploitation	Individual versus organisation interests, e.g., cutbacks on operating costs with salary-cut, retrenchment or longer working hours with an interdependence
Interaction	Interrelations and communications, e.g., fostering collaborative attitudes in the work place

Classification refers to a situation where an interdependence leads to differentiation between DBE partners by demographic characteristics such as age, gender and education. Given the diverse set of characteristics that constitute the classification dimension of social impacts, this study view classification from the perspective of equality. Equality determines whether an interdependence leads to discrimination or partiality. Hence, the social impact of DBE interdependencies is assessed based on the ability of an interdependence to ensure equal opportunity for all.

Territoriality refers to the impact of an interdependence on the control and authority of DBE partners. Both social and digital entities perform activities in DBEs. As a result, digital entities may be delegated some authority to regulate other entities. This situation may lead to loss of authority from DBE partners if they used to make decisions. Hence, in the social impact assessment, this study examines whether the effect of DBE interdependencies on value co-creation is influenced by issues of territoriality.

Temporality refers to a situation where an interdependence affords opportunity to DBE partners to work irrespective of their location. DBE as an Internet driven environment reduces physical interaction and fosters remote activities. Thus, this dimension of social impact of interdependencies explores whether an interdependence offers flexibility in value co-creation by enabling remote working. Depending on the type of outcome an interdependence produces, temporality could be good or bad in value co-creation. Thus, this study considers it importance to examine the social effect of temporality in evaluating the impact of DBE interdependencies.

Learning refers to a situation where an interdependence offers opportunity for DBE partners to learn new skills. DBE as a dynamic environment consists of routine and non-routine activities. As such, partners expect to learn new skills and again new knowledge by participating in DBE interdependencies. Hence, from the learning dimension, the social impact of DBE interdependencies is determined by their ability to offer opportunity to develop new skills.

Recreation refers to a situation where interdependencies enable DBE partners to derive pleasure or satisfaction from their work. It has been argued that people work hard when they derive pleasure from their work. For some people, pleasure from work can be derived intrinsically as they solve problems while others derive pleasure from freedom to organise their own pattern of work (Stamper, 1973). Thus, if an interdependence offers its participants ability to derive satisfaction, it is envisaged that better value co-creation can occur. On this basis, this study argues that the social impact of DBE interdependencies can be assess by the capability of an interdependence to offer satisfaction or pleasure to its participants.

Protection dimension determines if an interdependence offers fairness and confidentiality to participants. DBEs are comprised of several partners who compete and collaborate. As such, DBE participants exchange resources during value co-creation. The nature of DBE relationships raises the issues of security and confidentiality of resources shared between partners. Given that DBE relationships are underpinned by interdependencies, this study examines the social impact of interdependencies from the dimension of protecting partners' rights through confidentiality and fairness.

Exploitation examines if DBE interdependencies leads to abuse of partners. In the work environment, employers aim for higher profits while employees seek higher salaries. As a result, there is always disparity between what is a fare wage for work done by employees. This situation is similar in DBEs where each partner has individual motives for higher returns. In

effect, this situation may lead to exploitation or abuse of some partners. Thus, this study examines if DBE interdependencies lead to exploitation from the social dimension.

Interaction is conceptualised as the social impact of an interdependence to offer abilities for DBE partners to communicate explicitly with each other. In DBEs, communication occurs between several entities through different mediums. Some communications occur through face-to-face dialogue while others occur virtually. In the interaction dimension, the social impact of interdependencies is assessed on the capability of an interdependence to enable better communication.

5.3 Metrics for Strategic Impact Assessment

While operational and social effects may influence specific entities in DBEs, on the other hand, strategic issues have wider implications. Strategic impact refers to a network-wide effect (Chand *et al.*, 2005) of an interdependence on the survival of DBEs. For example, a fall in revenue as a result of an interdependence will affect an entire DBE thus, represents an effect of strategic nature. On the other hand, a single case of delay in delivering a service to a customer may only affect a specific aspect of a DBE and thus, does not largely result in a DBE wide affect. As such, is not simple to identify and define strategic factors (Lee and Kwon, 2017) that affect DBEs' performance. By the nature of DBEs, focal partners are participants that are mostly concerned about strategic impact effects since they will be the most affected in case of problems. Thus, for focal partners, it is important to constantly assess the strategic impact of interdependencies in their DBEs.

A key challenge however is the set of metrics to assess the strategic impact of DBE interdependencies. This challenge is further complicated by the heterogeneous nature of interdependencies in DBEs between several entities. Hence, it is incumbent to develop a generic set of metrics that account for the nature of different DBE interdependencies. Arguably, no metrics exist in the IS literature to assess the strategic impact of DBE interdependencies. Thus, in conceptualising a metric to evaluate the strategic impact of DBE interdependencies, this study is guided by the need for metrics that: (1) is generic and can be adapted across a wide range of DBEs, (2) entails both financial and non-financial criteria, and (3) is quantifiable.

In the management literature, several strategic factors have been identified. For instance, in investigating strategic impact, Chand et al. (2005) identify regulatory, competitive, technology and radical environmental changes as key effects of strategic outcomes. Also, Negi and

Brohman (2015) highlight customer satisfaction, sales and market growth as critical factors that impact on value co-creation in DBEs. Similarly, Ramanathan (2014) and Mccarthy and Golicic (2002) posit that revenue, collaborative effectiveness and earnings are factors that reflect overall performance in a networked environment. In the same vein, Frambach et al. (2016) identify strategic orientations, strategy types and market conditions as strategic factors that influence performance. Also, Abalo et al. (2007) argue that priority ranking is an important metric in performance analysis because it offers cost-saving opportunities without requiring significant changes. Chand et al. (2005) and Tsatsou (2010) highlight regulatory effect as one key strategic factor that affect performance. From the extant management literature, it is evident that the business context influences the choice of strategic factors. Therefore, the choice of strategic impact assessment criteria is context-dependent and highly subjective. Thus, this study is guided by the nature and characteristics of DBEs in the choice of strategic impact assessment metrics.

Going by the three guidelines defined above as the baseline for conceptualising strategic impact metric criteria, this study selects *revenue, customer satisfaction, regulatory issues (violation of laws/policies) and priority ranking of interdependencies* as measures for strategic impact assessment. These criteria are selected because of the following reasons. First, they provide a generic baseline to assess the impact of DBE interdependencies. That is, these criteria can be applied to all DBE interdependencies irrespective of their form, be it either between partners, technologies or processes. Second, these criteria offer a balance between financial and non-financial aspects of DBE interdependencies as recommended by Gunasekaran (2004). Thus, these criteria can be used to evaluate both financial and non-financial impact of DBE interdependencies. Lastly, these criteria have a bearing on value co-creation performance assessment since this is the overall aim of the interdependence impact evaluation method. This study does not claim that the criteria identified as strategic impact metric is exhaustive and universally applicable. However, these criteria are offered as a guide for analyst. Thus, additions and subtractions could be made depending on the form, type and context of a DBE being evaluated. Table 5.3 presents the criteria selected as measure for the strategic impact evaluation metric.

Table 5.3 Strategic impact assessment criteria

Criteria	Description	Source
Revenue	Refers to income generated from undertaking business activities	(Allee, 2000; mccarthy and Golicic, 2002; Negi and Brohman, 2015; Ramanathan, 2014)
Customer satisfaction	Refers to the degree of happiness a customer derived from a service received.	(Fornell *et al.*, 1996; Frambach *et al.*, 2016; Graça and Camarinha-Matos, 2017; Negi and Brohman, 2015)
Regulatory issues	Refers to whether the operation of an interdependence infringes on laws or policies	(Chand *et al.*, 2005; Darking *et al.*, 2008; Tsatsou *et al.*, 2010)
Priority ranking	Refers to the criticalness and overall importance of an interdependence to the functioning of a DBE	(Abalo *et al.*, 2007; Ban *et al.*, 2016; Phadermrod *et al.*, 2018)

As in any business environment, DBEs rely on revenue as one of their performance achievement measure. Revenue simply refers to income generated from undertaking business activities. Revenue as a crucial resource demonstrates financial power and strength of DBEs. Hence, a negative impact of an interdependence on revenue is regarded as a strategic level issue. Indeed, a dip in revenue that result in higher cost can lead to DBE desertion (Tiwana, 2015b). Generally, in performance evaluation, revenue remains a key measure (Allee, 2008) since it provides an objective means to compare. Similarly, in DBEs, revenue is considered as an important strategic issue since its effect have an ecosystem-wide implication. As a result, it is argued that to evaluate the effect of DBE interdependencies in value co-creation, it is prudent to consider the impact of an interdependence on revenue. Thus, to evaluate the effect of interdependencies in value co-creation, this study considers revenue as an appropriate criterion for the strategic impact metric.

For any business, customers are essential to its survival. Likewise, in DBEs, customers are important actors. Indeed, the ecosystem literature recognises customers as essential partners (Moore, 1996). Traditionally, customers refer to individuals and organisations that utilise goods and services by another organisation. However, from the contemporary view, customers refer to individuals and organisations that co-create goods and services with other organisations (Prahalad and Ramaswamy, 2004a). As a result of this new conceptualisation, organisations have become closely coupled with their customers and this relationship has become more open and fragile. In this new view, customer satisfaction has become an important element in value co-creation in the business environment, particularly in DBEs. Customer satisfaction is defined as the degree of happiness a customer derived from a service or product received (Fornell *et al.*,

1996). Thus, customers may desert DBEs if they are not satisfied with services and if there are viable alternatives. Due to the openness of some DBEs, partners have the liberty to move from one DBE to another. Similarly, the era of value co-creation has made customers more powerful. As a result, unsatisfied customers may leave a DBE resulting in disruptions that can affect smooth value co-creation and performance. On these premises, this study considers the effect of interdependencies on customer satisfaction an important strategic impact assessment criterion since it may lead to attrition if expected value is not delivered to customers.

Regulation in the form of laws and policies dictate conditions under which interdependencies should operate in DBEs (Tsatsou *et al.*, 2010) . Issues related to laws and policies have strategic implication in DBEs because their violation could affect an entire DBE. Even though DBEs are self-organising, without centralised authority, inherent checks and balances in the form of business norms exist. Similarly, there are international laws and policies that regulate the conduct of contracting parties. The business norms dictate who should participate, how and when interdependencies should operate. Hence, if these conditions are not followed, there could be disruption in the harmony in value co-creation. As DBE interdependencies exist between several entities, informal relationships detrimental to value co-creation may develop. In some cases, these informal interdependencies may be violating laws or policies. As a result, this could be detrimental to the entire DBE. Similarly, at the strategic level, focal firms may have to assess if redesigning, removing or replacing an interdependence will violate existing laws or policies. Based on these premises, this study argues that in assessing strategic impact of DBE interdependencies, regulatory issues are important to be considered as their effect cut across an entire DBE. Thus, from the strategic impact assessment perspective, the impact of DBE interdependencies on laws and policies is considered as a criterion for consideration.

Interdependencies in DBEs are all not equal. While some are very critical, others as insignificant (Abalo *et al.*, 2007). This is why some interdependencies have mandatory while others have optional conditions. Some interdependencies are considered more critical than others due to several reasons. In some cases, the nature of critical business processes interdependencies support determines their importance in DBEs. In other cases, outcomes, entities involved, functions performed and number of dependent interdependencies determines of the importance (Ban *et al.*, 2016) of interdependencies. On this premise, this study conceptualises interdependence priority ranking as a criterion to evaluate the impact of DBE interdependencies. It is argued that assessing the criticalness of interdependencies will help determine the impact they have in value co-creation in DBEs. With this understanding, decision

makers can leverage the priority ranking in conjunction with other criterion to decide on how to reorganise interdependencies for improved value co-creation. Given that interdependence priority ranking is a DBE-wide endeavour that is sometimes explicit in strategic plans, this study argues for its consideration in the strategic impact assessment.

5.4 Kernel Theory Development

As an emerging research field, DBE lacks its own theories, as a result, extant studies have borrowed theories from other areas. Consequently, calls have been made for DBE studies to consider theorisation (Tan *et al.*, 2015; 2016). In response, this study develops a kernel theory on the metrics to measure the impact of DBE interdependencies. A kernel theory is a theoretical foundation for design artefacts that explain and predict phenomena of interest (Goldkuhl, 2004; Kuechler and Vaishnavi, 2008; Walls *et al.*, 1992). In design science research, a design theory is a blueprint that guides the construction and behaviour of an artefact by providing outcome specifications (Vaishnavi and Kuechler, 2004). Also, a design theory can take many forms such as a fully developed theory, nascent design theory as well as exploratory or predictive theory.

As pointed by Vaishnavi and Kuechler (2004), a single design project cannot create a full flesh theory, however with multiple iterations and refinement, a well-established theory can be developed. This study does not claim to have created a fully developed theory but, have partially conceptualised a nascent theory with the potential of growing into a full flesh design theory. This effort is acceptable in design science research because kernel theories have been identified as one of the artefacts through which novel contributions can be made to knowledge (Gregor and Hevner, 2013; Kuechler and Vaishnavi, 2008). Given that there is limited theorisation in DBE research and calls have also been made in the extant literature, this study develops a kernel theory on the metrics to evaluate the impact of DBE interdependencies in value co-creation.

According to Gregor and Jones (2007), a design theory should fulfil requirements of the following components: purpose and scope, constructs, principles of form and function, abstraction and generalisation, evaluation and validation of propositions, justificatory knowledge as well as expository instantiation. Table 5.4 provides a description of each components while detailed discussions are presented below.

Table 5.4 Components of an IS design theory (Adapted from Gregor and Jones, 2007)

Components	Description
Core Components	
Purpose and scope	Specifies the goal and boundary of the new theory
Constructs	Specifies the entities or concepts of interest in the new theory
Principles of form and function	Specifies the blueprint that describes the new theory
Abstraction and generalisation	Specifies that the abstract and general levels of an artefact resulting from the theory could evolve without affecting its foundation
Evaluation and validation of propositions	Refers to true statements about the design theory
Justificatory knowledge	Specifies the underlying theoretical foundation of the kernel theory
Additional Components	
Principles of implementation	Specifies the theory implementation process
Expository instantiation	Refers to the empirical implementation of the design artefact to support representation of the theory

Purpose and scope: this component specify the goal and boundary of the new theory. In effect, this component advocates for more information to determine what is new and novel in the new theory and how relevant it is to research and practice.

Constructs: this component requires that all entities and concepts within the new theory are described to enable a better understanding. For instance, the informal, formal and technical layers represent the constructs of the organisational onion.

Principles of form and function: this component specifies the blueprint of the new theory. It provides the body of the theory and explain in detail each aspect of the theory.

Abstraction and generalisation: this component specify that the abstract and general levels of an artefact resulting from the theory could evolve without affecting the foundation of the theory. As such, a theory should be broad enough to accommodate adaptation, change and evolution without losing its core proposition. In this case, the theory can stand the test of time and will not require creation of a new version to account for new situations.

Evaluation and validation of propositions: this component advocates that a design theory is true in addressing its purpose. That is, a design theory must be valid in addressing its intended

aim. This requirement can be achieved through evaluation and validation to demonstrate proof of concepts to attest to the validity of the theory.

Justificatory knowledge: requires specification of the underlying theoretical foundation of the kernel theory to demonstrate its likelihood to be true. By leveraging an existing theory as the foundation, it provides some justification to the validity of the new theory in addition to the results from the evaluation and validation.

Principles of implementation: this component concerns the implementation process of the new theory. That is, how can the new theory be integrated into the design of an artefact. Hence, this component concerns actualisation of the new theory during the development stage in design science research.

Expository instantiation: this component refers to the empirical implementation of the design artefact to support representation of the new theory. As a requirement of design science research, there is a need to produce viable artefacts such as methods, constructs, instantiations and models. Thus, by developing an artefact based on the principles of the new design theory, expository instantiation is fulfilled.

Based on the components of the design theory and the metrics developed in the discussions above, this study postulates a kernel theory that **the impact of interdependencies between entities in DBEs can be measured using criteria from operational, social and strategic metrics.** The theory derives support from the theory of Organisational Semiotics by leveraging its valuation framing technique for the social impact metrics. Similarly, the theory derives support from the general management literature in the formulation of operational and strategic metrics. It is argued that these three metrics provide a holistic base to measure the impact of interdependencies since they (1) address the multifaceted aspects of DBE interactions (2) easily expandable to accommodate other criteria (3) are generic enough to be applicable to several DBEs. To verify the completeness of this kernel theory, this study uses Gregor and Jones' 8 components of design theory as a guide. Table 5.5 shows how explanations from the kernel theory address the requirements of the components of the design theory.

Table 5.5 Components of the developed kernel theory

Components	Explanation
Purpose and scope	The purpose of the kernel theory is to provide metrics to measure the impact of interdependencies in DBEs. In the current form, the theory is applicable to DBEs
Constructs	The constructs are: operational, social and strategic metrics
Principles of form and function	The operational metric is composed of the following criteria: *cost, turnaround time and service quality* The social metric is composed of the following criteria: *association, subsistence, classification, territoriality, temporality, learning, recreation, protection, exploitation and interaction* The strategic metric is composed of the following criteria: *revenue, customer satisfaction, regulatory issues and priority ranking*
Abstraction and generalisation	This study acknowledges the effect of a DBE's context on the criteria in each metrics, hence the theory allows for the addition of other criteria to enable wider application in several DBEs.
Evaluation and validation of propositions	The kernel theory is tested through the results from the application and validation processes (see chapter 7)
Justificatory knowledge	The theory derives support from Organisational Semiotics by leveraging its valuation framing technique for the social impact metrics while the general management literature support the formulation of operational and strategic metrics. Given that some of these metrics have been empirically validated previously, the kernel theory is considered valid
Principles of implementation	The kernel theory is integrated into the method for evaluating the impact of DBE interdependencies as the interdependence measurement technique
Expository instantiation	The meta-model and the developed method in this study based on the constructs of the kernel theory demonstrates how it can be instantiated

5.5 Meta-model for DBE Interdependence Impact Evaluation Method

To support the development of the method for evaluating the impact of interdependencies in DBEs, this study designs a meta-model. As a prelude, the meta-model is a blueprint that depicts the structure and components of the final method. As DBEs are dynamic and constantly changing, the design of the meta-model went through several iterations to reflect emerging changes. With this meta-model, the development phase of the method becomes easier. The meta-model draws inspiration from DBE, interdependence and value co-creation literature as well as the kernel theory and Organisational Semiotics theory. The meta-model as presented in Figure 5.1 is constituted by three main components, namely *DBE environment, interdependence analysis and interdependence rationalisation*.

The *DBE environment* component represents the operating context of a DBE. To delineate the DBE environment, the meta-model proposes the context articulation concept which is enabled by two elements, namely unit system definition and interdependence articulation. The unit system definition enables specification of specialised domains in DBEs that perform specific functions. The interdependence articulation element supports the identification of interdependence within unit systems. Interdependencies are the medium by which value co-creation is achieved through interaction between DBE entities. As the first component of the meta-model, the outcomes from the DBE environment supports the interdependence analysis.

The *interdependence analysis* component offers the opportunity to distil more information on interdependencies identified in the DBE environment. The main concept under this component is interdependence profiling. The interdependence profiling concept supports elicitation of detailed information on each interdependence identified within the unit systems. For each interdependence, information pertaining to entities involved, business processes, business norms and outcome are derived. The outcomes from the interdependence profiling component helps to obtain a better understanding of an interdependence's structure and underlying issues driving the interdependence impact evaluation.

The last component of the meta-model is the *interdependence rationalisation*. This component is supported by interdependence measurement, impact assessment and change management concepts. The interdependence measurement concepts support the calculation of the impact scores of interdependencies using the three metrics of the kernel theory–operational, social and strategic. Each three metrics are supported by a set of generic criteria that strand both financial and non-financial dimensions (Gunasekaran *et al.*, 2004). The interdependence impact assessment concept determines the significant effect of an interdependence in value co-creation based on the three metrics. This concept matches the impact scores of an interdependence to determine if it has either low, medium or high effect on value co-creation. The concept proposes a benchmark with inherent decisions that serve as recommendations to reorganised interdependencies in DBEs to achieve improved performance. Lastly, the interdependence change management concept proposes series of steps to implement recommendations made after evaluation of interdependencies.

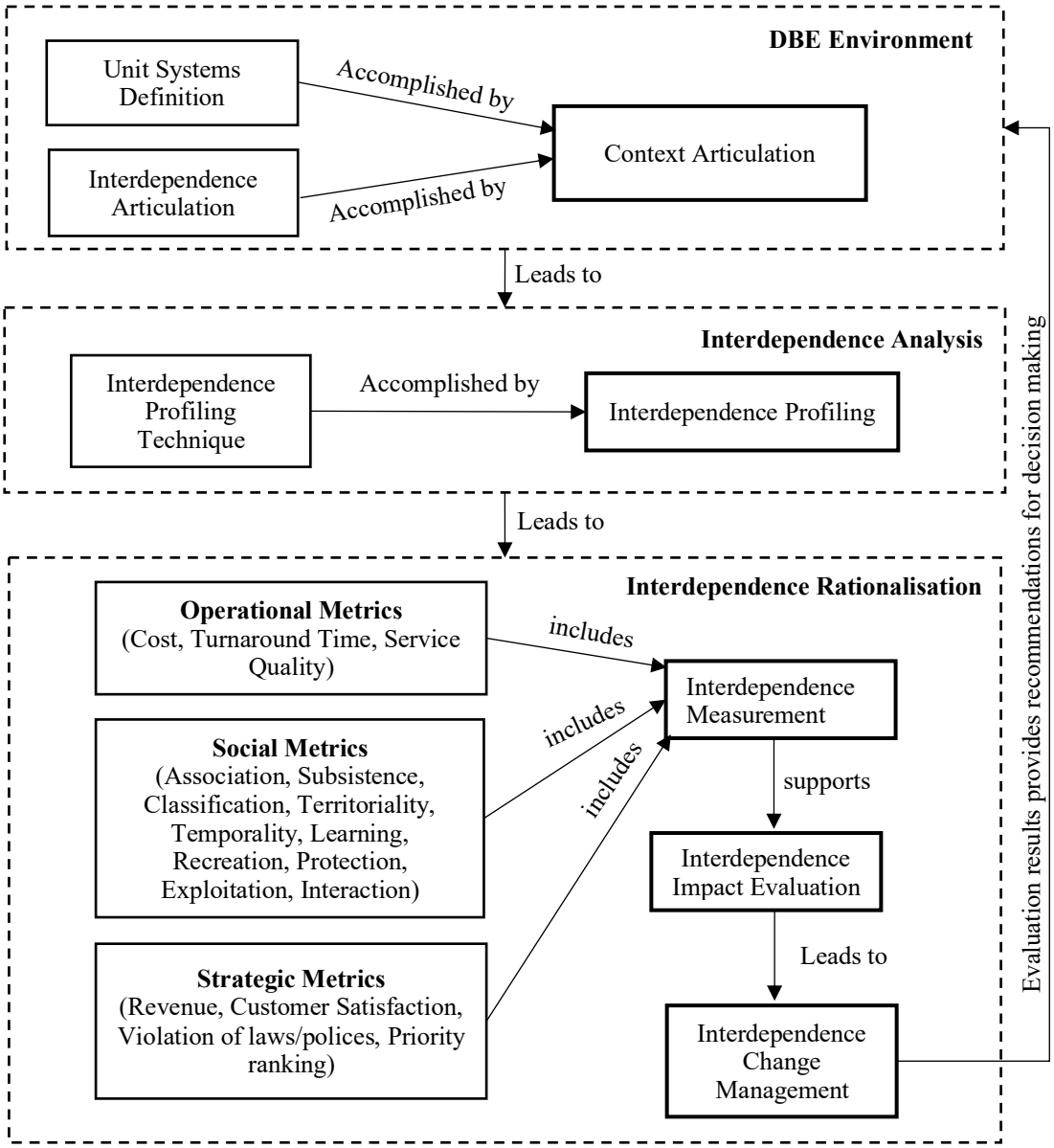

Figure 5.1 Meta-model for DBE interdependence impact evaluation method

In its current form, the meta-model offers a generic frame to articulate interdependencies in DBEs and subsequently evaluate their impact in value co-creation. From the conceptualisations presented in the meta-model, it is argued that a useful blueprint is offered to support the development of a method for evaluating the impact of DBE interdependencies. Given that the meta-model offers useful components and concepts to articulate interdependencies in DBEs and subsequently evaluate their impact, it is considered an important contribution to research and practice. During the design of the meta-model, it went through several individual iterations and evaluations as posited in the design science research paradigm. These individual iterative processes demonstrate the validity of the meta-model since new additions were made to addressing emerging issues. Also, by deriving theoretical support from Organisational

Semiotics, the kernel theory and the extant literature, the meta-model is considered sound. In the extant literature, design science research artefacts in the form of meta-models have been validated through similar approaches (Ostrowski *et al.*, 2012). As such, this study considered the meta-model designed to satisfy validation requirements.

5.6 Summary

In this chapter, this study addressed the *third research question* by conceptualising metrics to measure the impact of DBE interdependencies in value co-creation. The chapter first discussed the three-metrics conceptualised for the interdependence impact evaluation. Specifically, the chapter presented discussions on how the three metrics and their respective criteria were chosen to evaluate the impact of DBE interdependencies. The three metrics covered operational, social and strategic aspects of interdependencies. Next, the chapter developed a kernel theory on the metrics to evaluate the impact of DBE interdependencies. Thereafter, the chapter presented the meta-model as a blueprint for the method for evaluating the impact of DBE interdependencies. Through the conceptualisation of metrics, development of a kernel theory and design of a meta-model, this study provides the necessary outcomes required in Chapter 6.

Chapter 6

MEII: Method for Evaluating the Impact of Interdependencies in DBEs

The previous chapter presented metrics, a kernel theory and a meta-model for the development of MEII. Building on the blueprint designed in Chapter 5, this chapter presents MEII as the methodological solution for evaluating the impact of DBE interdependencies to address the *fourth research question*. First, the chapter provides an overview of MEII and its development processes. Thereafter, the chapter discusses the three stages of MEII and their individual techniques. In the discussions, the chapter explicates how each technique can be used during the evaluation of DBE interdependencies in value co-creation.

6.1 MEII Solution

This subsection presents MEII, a methodological solution to evaluate the impact of DBE interdependencies. MEII's development derives support from artefacts designed in Chapter 5. The development process went through several iterations as per the principles of design science research until the current version is deemed suitable. MEII, as presented in Figure 6.1, comprises three main iterative stages, namely *context articulation, interdependence analysis and rationalisation.* Each of these stages comprises techniques that support the overall interdependence evaluation. The context articulation stage helps to define the scope of the DBE. With the scope defined, the unit systems and interdependencies within can be articulated. The interdependence analysis stage provides a technique to examine each interdependence to derive additional information to support the impact evaluation processes. Lastly, the interdependence rationalisation stage provides techniques to measure the impact of DBE interdependencies and recommendations on reorganisation of interactions towards performance improvement. Each of these stages and their inherent techniques are further elaborated below.

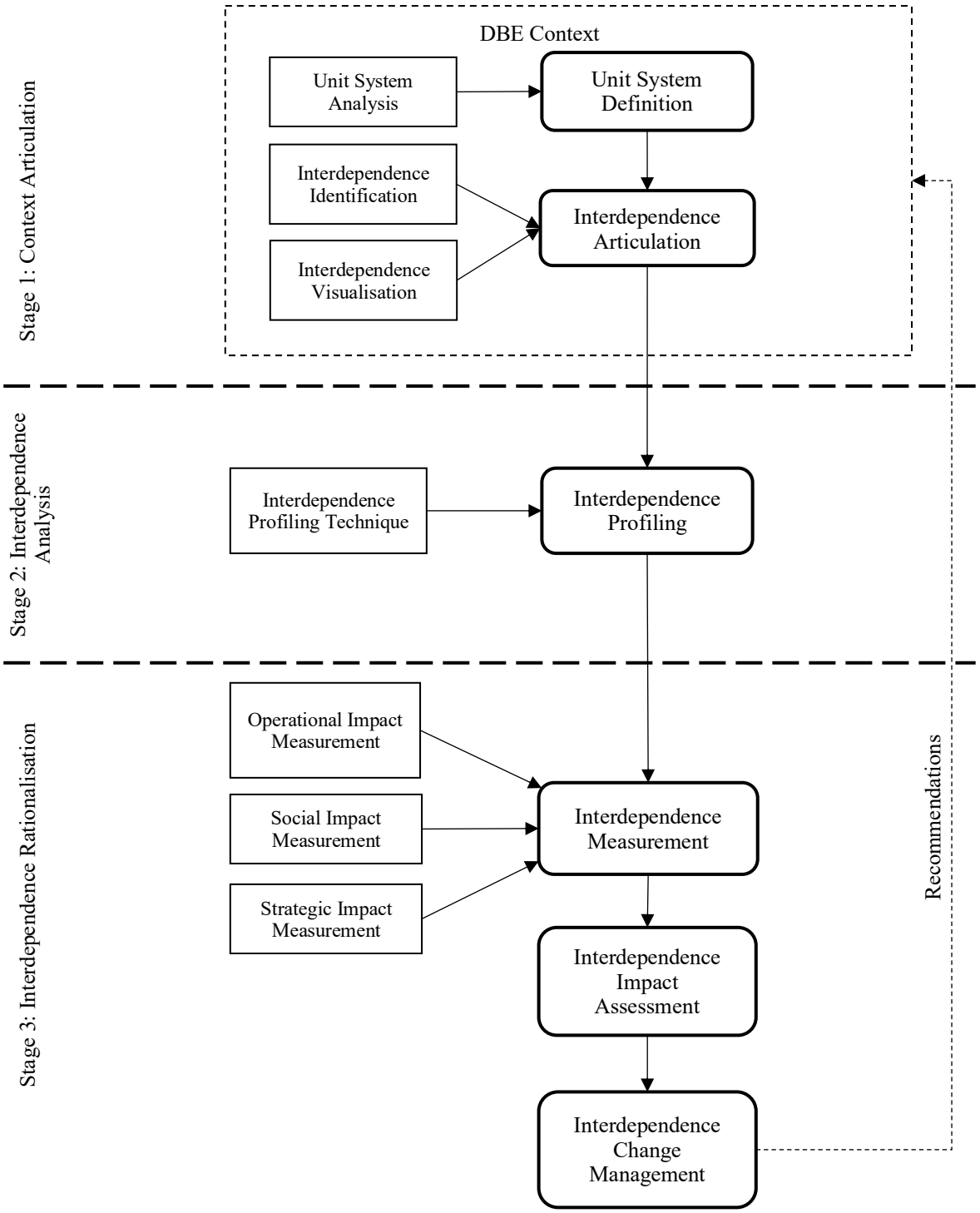

Figure 6.1 Method for evaluating the impact of interdependencies (MEII) in DBEs

6.2 Stage 1: Context Articulation

Typically, DBEs are large in scope and have several relationships. Thus, it is important to clearly delineate the scope of evaluation. This stage of the method establishes the setting for evaluating the impact of DBE interdependencies. The context articulation stage covers the structure, domains and interdependencies in DBEs. The purpose of the context articulation

stage is to identify and understand the major aspects of DBEs, the nature of interdependencies and the entities involved. The context articulation stage of MEII consists of two components – *unit system definition and interdependence articulation* which are supported by three techniques: unit system analysis, interdependence identification and visualisation.

6.2.1 Unit System Analysis

Unit system definition enables articulation of subsystems that constitute the context of a domain (Liu *et al.*, 2006). By performing a unit system definition, the scope of a DBE can be clearly defined. To aid the unit system definition, MEII proposes the unit system analysis technique. The unit system analysis technique as presented in Table 6.1 involves identification and examination of the various subsystems in a DBE's context. The main elements of the unit systems analysis are date, version of analysis, unit system ID, unit system name, description as well as sub-unit systems. MEII proposes the following processes to undertake the unit system analysis:

- Identify the overall structure of functions in the DBE (e.g., import and export functions)
- Determine the aspect of a DBE the evaluation will focus (e.g. Import aspect)
- Examine the primary business processes in the selected DBE aspect
- Determine the sub-unit systems in the selected DBE aspect

Table 6.1 Unit system analysis technique

Date:	**Version:**
Unit system ID	
Unit System Name	
Unit System Description	
Sub-Unit Systems	

6.2.2 Interdependence Identification

Interdependence identification technique enables articulation of interdependencies within unit systems in DBEs. The purpose of this technique is to clearly identify and match interdependencies to the various unit systems for further analysis. The interdependence identification technique (see Table 6.2) aids the articulation process. The main elements of the interdependence identification techniques are unit system ID, interdependence ID and name as well as entities involved. The interdependence identification can be undertaken by observation, review of standard operating procedures and interaction with relevant stakeholders. MEII proposes the following steps to undertake interdependence articulation:

- Select a unit system to articulate
- Examine the interactions and procedures of executing activities
- Identify interdependencies that occur in each activity during execution of work and assign them unique identifiers
- Identify entities in these interdependencies using the interdependence notation classification

Table 6.2 Interdependence identification technique

Date:	**Version No:**
Unit System ID	
Interdependence ID	
Interdependence Name	
Entities Involved	

6.2.3 Interdependence Visualisation

This technique of MEII relies on the visualisation approach conceptualised in chapter 4 (*see subsection 4.4*) of the study. The purpose of the visualisation technique (*see Table 6.3*) is to provide a better understanding of interdependencies and DBE partnerships. The technique comprises, entities, interdependence types, classes, behaviour taxonomies, outcome flow and total impact. The visualisation technique comprises the following:

Table 6.3 Interdependence visualisation technique

Entities	Interdependence Types	Interdependence Classes	Behaviour Taxonomies	Interdependence Outcome Flows	Interdependence Total Impact
Entity name	*Refer to subsection 2.5.1*	*Refer to subsection 4.2*	*Refer to subsection 2.8*	*Refer to subsection 4.2*	*Refer to subsection 7.4.2*

- *Entities:* Refers to a brief description of a DBE interdependence participant, which could be a reference for processes, partners or digital technologies.
- *Interdependence Types:* Indicates the kind of relationships that exist between two or more interacting entities. It could be pooled, sequential or reciprocal as illustrated in subsection 2.51.
- *Interdependence Classes:* Refers to the category of DBE interdependence based on the notation developed in subsection 4.2. The interdependence class enables identification and articulation of the classes of DBE interdependencies, be it between processes, technology and process, or partners and technologies.

- *Behaviour Taxonomies:* Describes the kind of function an interdependence performs in a DBE partnership. The behaviour taxonomies as presented in subsection 3.8 include substantive, communication and control conducts as well as sub-taxonomies.
- *Interdependence Outcome Flows:* Refers to the result an interdependence produces in a DBE partnership. The conceptualisation of the interdependence outcome flows is presented in subsection 4.2.
- *Interdependence Total Impact:* Illustrates the overall effect of an interdependence in a DBE partnership. In this study, the total impact of an interdependence is obtained by summing up the social, operational and strategic impact scores of an interdependence as illustrated in subsection 7.4.2.

In addition, the technique offers objects to visualise interactions in DBEs. These objects are:

- *Entities* within interdependencies are represented by a *circle* with their name inscribed.
- *Interdependence type* is represented by *links* between entities. Three different links are conceptualised in the visualisation technique. *A single headed arrow* represents a sequential interdependence while a *double-headed arrowed* indicates reciprocal interdependence. On the other hand, *a dotted line* represents pooled interdependence.
- *Interdependence outcome flows* are represented by a *rounded rectangle* and placed along the interdependence link.
- *Interdependence ID* is a text the shows the unique identifier of an interdependence. It is located on the link it presents.
- *Interdependence class and behaviour taxonomies* are represented by a *curly bracket* close to an interdependence.
- *Interdependence total impact* is represented by the *thickness* of the link between entities, as compared to other interdependencies in a DBE partnership.

This visualisation technique outlines the following steps to undertake the approach

Step 1: Articulate interdependencies – this involves identifying and deriving interdependencies within the context of a DBE. This step largely depends on the outcome of the interdependence identification technique above (see subsection 6.2.2). With the interdependence identification technique, interactions within unit systems in DBEs can be clearly identified for further analysis.

Step 2: Analyse interdependencies – this step involves examining the articulated interdependencies to determine their total impact scores, classifications, outcome flows and behaviour taxonomies. The total impact is an aggregate of the operational, social and strategic impact scores while the interdependence class determines the category of interaction. The interdependence behaviour determines the function of an interaction while the outcome flow concerns the result produced by an interdependence. This analysis is supported by the conceptualisation of DBE partnerships provided in Chapter 4 (see section 4.3) and the interdependence impact assessment in section 6.4.2.

Step 3: Visualisation of DBE interdependencies – this last step involves using the objects provided by the visualisation technique to depict DBE partnerships. The visualisation process involves drawing the entities, linking them with appropriate interdependence types, indicating their unique identifiers, presenting outcome flows, classes and behaviour taxonomies. The effect of each interdependence is represented by the thickness of the link based on the total impact score.

Figure 6.2 shows a sample DBE partnership visualisation where the entities are represented by the circle, the links by the lines as well as interdependence classes, outcome flow and behaviour.

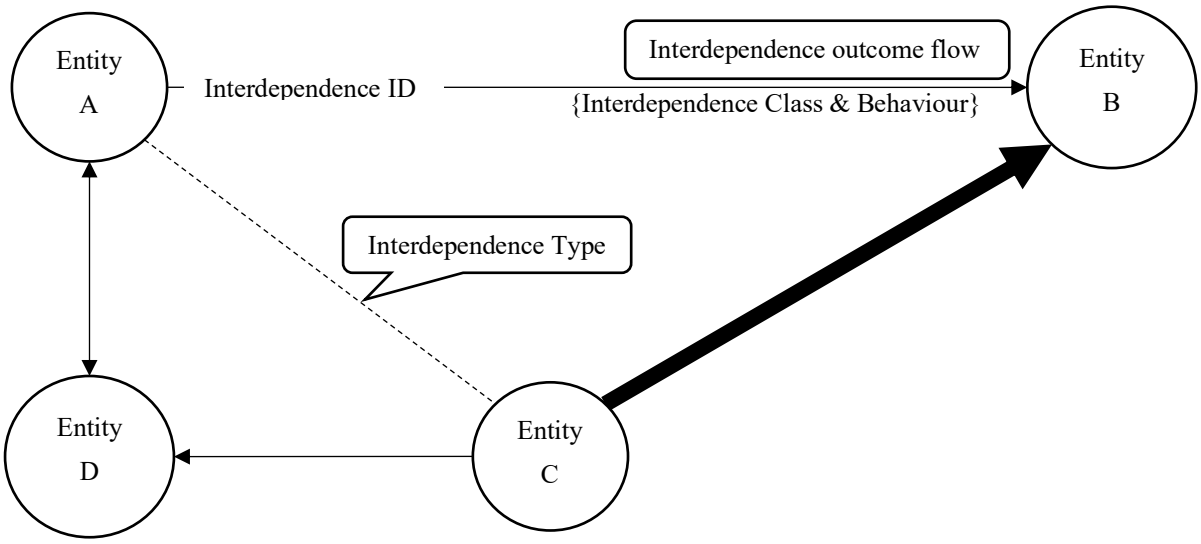

Figure 6.2 Sample DBE partnership visualisation

6.3 Stage 2: Interdependence Analysis

This stage of MEII examines interdependencies articulated in the context articulation phase. The main component of this stage is *interdependence profiling.* This component is supported by the interdependence profiling technique. The purpose of undertaking interdependence

profiling at this stage is to derive information on DBE interdependencies that affect their value co-creation. Specifically, the interdependence analysis stage supports a comprehensive examination of all interdependences in a DBE, taking into consideration their outcomes, business issues, norms as well as entities and their respective responsibilities. These elements are considered important for interdependence profiling because they help to establish an overall view of DBE interdependencies and determine their shortcomings. The interdependence analysis stage also provides support to the last stage of MEII by establishing interdependencies whose impact scores are to be measured, indicating possible reasons for inefficient performance of some interactions.

Interdependence Profiling Technique

The interdependence profiling technique examines all articulated interdependencies to derive additional information to enable their impact measurement. Table 6.4 presents the interdependence profiling technique and its element. For each interdependence profiled, the date, version number, interdependence ID, name, description, outcome, business issues and norms well as entities involved are clearly delineated. It is recommended that interdependence profiling is conducted periodically to determine if unofficial relationships have developed in a DBE since this cannot be known without regular profiling.

Table 6.4 Interdependence profiling technique

Date:		**Version No**:				
Interdependence ID:		**Interdependence Name:**				
Interdependence Description:						
Interdependence Outcome:						
Business Issues:						
Entities Involved	**Entity**	**Responsibility**				
Norm Analysis	**Norm ID**	**Whenever** *<condition>*	**if** *<state>*	**then** *<agent>*	**is** *<deontic operator>*	**to** *<action>*

Given that interdependence profiling can be undertaken regularly, it is important to take note of the period and number of iterations performed. *Date* and *version number* elements are needed to take record of the interdependence profiling process. The flexibility of MEII allows analysts to perform several interdependence profiling until a final version is derived. *Interdependence ID* is a unique identifier designated to each interaction for easy identification while the

interdependence name is a short phrase that identifies an interdependence. With this identification, there are limited avenues to commit errors. *Interdependence description* provides a concise detail of what an interdependence entail. From an interdependence description, it is possible to identify the goal and entities involved in an interdependence. *Interdependence outcome* represents the goal an interdependence should achieve. It acts as a trigger for interdependence impact evaluation if proposed goals are not being met. *Business issues* represent shortcomings and limitations in an interdependence that evaluation seeks to overcome. *Business norms* indicate rules that govern how an interdependence operate and what is expected of participants. *Entities* represent participants involved in interdependencies while *responsibility* describes actions required of entities.

The norm analysis articulates the behaviours that govern interdependencies in DBEs to offer a better understanding of constraints under which they operate and how these norms influence value co-creation. As DBEs include technical and social entities, the norm analysis covers formal, informal and technical rules. Hence, an interdependence may be influenced by multiple norms in its operation in DBEs. As presented in Figure 6.6, the norm analysis records the identification number and the norm specification. For interdependencies with more than one norm, the technique allows for the articulation of multiple norms

6.4 Stage 3: Interdependence Rationalisation

This last stage of MEII measures and determines the impact of DBE interdependencies in value co-creation. In addition, this stage offers recommendations on how to reorganise interdependencies based on their impact scores. The interdependence rationalisation stage comprises three techniques*: interdependence measurement and impact assessment* as well as *change management.* The interdependence measurement component derives inputs from the three metrics (*operational, social and strategic impact measures).* These three metrics are used to balance the measurement and ensure the business, social and technical nature of DBE is represented. In addition, these metrics are used to strike a balance between financial and non-financial measures as recommended in the management literature (Gunasekaran *et al.*, 2004). The interdependence impact assessment component accumulates the measurement scores and determines their effect in value co-creation. This component provides a set of score ratings to determine the impact levels of interdependencies. Based on the impact level, a set of interpretations is provided for decision making. Lastly, the change management component provides recommendations and steps to systematically reorganise interdependencies based on their impact assessment scores.

6.4.1 Interdependence Measurement

The interdependence measurement technique calculates the impact score of interdependencies based on the three metrics of MEII. Specifically, the interdependence measurement technique computes the operational, social and strategic impact scores of all interdependencies. The result of the measurement becomes the basis for the interdependence impact assessment. Given that the criteria for the metrics have different influence, the technique allows addition of weights to each criterion.

Operational impact measurement

Operational impact measurement is based on a set of criteria, namely *turnaround time, cost incurred in an interdependence and service quality* experiences proposed in the meta-model of MEII in chapter 5. From the literature, the main drivers of operational excellence are cost of operation, turnaround time and service quality experiences. The current hyper business environment demands quicker turnaround times to reduce operational cost. Hence, if delays occur, the cost of operation may automatically increase. In addition, service quality experiences determine if customers will continue a relationship. As such, this study deems the support an interdependence offers to its entities as an important criterion for operational effectiveness measurement. It is worth noting that other criteria may emerge if the DBE develops or if the context of a unit system changes. Table 6.5 presents the operational impact criteria for measuring each interdependence. For the operational impact measurement, the scores of each interdependence are computed based on each criterion to arrive at the overall operational impact score (OpIS).

Table 6.5 Operational impact measurement

Criteria	Criteria weight	INT001	INT002	INT003	INT…n
Cost					
Time					
Service Quality					

Social impact measurement

The social impact measurement determines the social effect of interdependencies on DBE partners. MEII draws on Hall's (1959) ten social dimensions as criteria for the social impact measurement. Table 6.6 shows the social impact measurement instrument that articulates the impact scores of how partners perceive interdependencies in DBEs. Each partner's perception is assessed with a positive and negative scale where +3 and -3 represent the most positive and

negative impacts respectively. In the end, the final summated value for each interdependence based on the ten social dimensions becomes the social impact score (SoIS).

Table 6.6 Social impact measurement criteria

Criteria	Criteria weight	INTD001	INT002	INT003	INT…n
Subsistence					
Classification					
Territoriality					
Temporality					
Learning					
Recreation					
Protection					
Exploitation					
Association					
Interaction					

Strategic impact measurement

Strategic impact measurement calibrates the importance of interdependencies based on their effect on the value co-creation in DBEs. As established in the meta-model, strategic impact measurement is defined by the effect of interdependencies on revenue, customer satisfaction, regulatory issues and their priority ranking in DBEs. These criteria can differ and evolve based on the context and development of a unit system. Table 6.7 shows the instrument for deriving the strategic impact measurement score. For each interdependence, the impact values are summated based on each criterion to attain the strategic impact scores (StIS).

Table 6.7 Strategic impact measurement

Criteria	Criteria Weight	INTD001	INTD002	INTD003	INTD…n
Priority ranking					
Customer satisfaction					
Revenue					
Laws Violation					

MEII proposes 3 steps to undertake interdependence measurement, namely *interdependence impact score normalisation, criteria scores computation and calculation of the overall impact score for each metric*. In this first step, the scores on the various interdependencies are normalised since different scales are used for each measurement dimension. The data normalisation step aims to create a common scale to measure the scores of the interdependencies. For this purpose, MEII adapts the min-max normalisation technique (Shalabi *et al.*, 2006) as presented in equation (1) to standardize the data into a Likert scale form of 1-5. Where 1 is the minimum value and 5 being the maximum value. The normalised value is defined as $Nj\alpha$ using the normalisation conversion equation:

$$Nj\alpha = \frac{1 + |Vj\alpha - V\alpha_{min}| \times (5-1)}{|V\alpha_{max} - V\alpha_{\mathrm{Min}}|} \quad (1)$$

where $V\alpha_{max}$ and $V\alpha_{\mathrm{Min}}$ are the highest and lowest scores respectively in the dataset

In the second step, the summated average score for each criterion is computed. Given that MEII allows inputs from multiple stakeholders on each interdependence, this step support computation of the average impact score of each criterion on an interdependence. To aid this step, equation (2) is proposed. The summated average score defined as $V_{j\alpha}$ of criterion α (e.g., time, cost, subsistence, learning, service quality) in relation to interdependence j is given as:

$$V_{j\alpha} = \frac{1}{n} * \sum_{i=1}^{n} V_{j\alpha}(i) \quad (2)$$

where n is the total number of responses, i is the response for an interdependence and Vjα(i) are the scores from the respondent i

In the last step, the interdependence impact values for each measurement criterion is summated to determine a final impact score. For each criterion, the impact value for an interdependence is summated to attain the final score. Thus, the operational impact score for an interdependence is defined as:

$$OpIS_j = \sum_{\alpha \in \Omega} N_{j\alpha} \quad (3)$$

where $OpIS_j$ is the operational impact score for interdependence j; Ω is a set of criteria including {cost, time, service quality}

For the social impact measurement, MEII defines equation (4) which is given as:

$$SoIS_j = \sum_{\alpha \in \Lambda} N_{j\alpha} \quad (4)$$

where $SoIS_j$ is the social impact score for interdependence *j;* Λ is a set of criteria including {Subsistence, Classification, Territoriality, Temporality, Learning, Recreation, Protection, Exploitation, Association Interaction}

Lastly, to compute the strategic impact score, MEII defines equation (5):

$$StIS_j = \sum_{\alpha \in \Gamma} N_{j\alpha} \qquad (5)$$

where $StIS_j$ is the strategic impact score for interdependence *j;* Γ is a set of criteria including {revenue, customer satisfaction, regulatory issues, priority ranking}

6.4.2 Interdependence Impact Assessment

Interdependence impact assessment approach aims to determine if DBE interdependencies are making significant effects in value co-creation. In other words, this component of MEII determines the relevance of interdependencies to the achievement of a DBE's performance goals. The interdependence impact assessment approach relies on the results of the interdependence measurement technique. Based on the result, the impact assessment technique determines if an interdependence has a low, medium or high effect in value co-creation in a DBE. A low impact score indicates that an interdependence is performing poorly in value co-creation. Similarly, a medium impact score indicates that an interdependence is performing moderately in value co-creation whereas a high impact score indicates an excellent performance of an interdependence. MEII proposes three steps to undertake the interdependence impact assessment.

Step 1: Map the various impact scores from the three metrics (operational (OpIS), social (SoIS) and strategic (StIS) of an interdependence to the interdependence impact score rating levels.

Step 2: Map each interdependence's impact levels to a corresponding benchmark.

Step 3: Propose recommendations for each interdependence based on impact assessment result.

Step 1: Mapping Interdependence Impact Scores to Impact Levels

In this step, the interdependence impact scores obtained during the measurement stage (see section 6.4.1) are matched onto an interdependence impact score rating guide to determine their appropriate level. Specifically, this step determines whether an interdependence has a low, medium or high impact in value co-creation. MEII provides the interdependence impact score

rating guide to aid this process. The interdependence impact score rating guide provides 1 to 5 calibrated ratings that matche to three impact levels. The guide as presented in Table 6.8 shows the impact score ratings and levels where a score between 1 to 2.99 indicates a low impact level whereas a score between 2 to 3.99 indicates a medium impact. Lastly, an impact score between 4 to 5 corresponds to a high impact level. Thus, for each interdependence, the operational, social and strategic impact scores are matched against the levels to determine their respective impact level. The impact score rating guide was developed after several iterative stages of the design science research phases. As such, the guide is a result of a data-driven simulations.

Table 6.8 Interdependence impact score rating guide

Impact Score Ratings	Impact Level
1.0 – 1.99	Low
2.0 – 2.99	Medium
3.0 – 3.99	
4.0 – 5.0	High

Step 2: Mapping Interdependence Impact Levels to Benchmark

In this step, the impact levels obtained in step 1 are mapped to the interdependence impact benchmark. The interdependence impact benchmark is supported by four decision categories proposed to reorganise DBE interdependencies towards improved value co-creation. The interdependence impact decision category guides actions to be taken on interdependence impact scores. Table 6.9 presents the interdependence decision categories and their descriptions. Like the interdependence impact score rating guide, the decision categories were also developed through iterative design science phases of the research. As such, the decision benchmark guide is an outcome of design cycles.

Table 6.9 Interdependence impact decision categories

Decision Categories	Descriptions
Retain	When an interdependence contributes optimal operational, social and strategic impacts in value co-creation and must be retained in a DBE
Redesign	When an interdependence makes moderate operational, social and strategic impacts in value co-creation and needs some upgrade to reach its full potential
Replace	Where an interdependence contributes average operational, social and strategic impacts in value co-creation and must be substituted
Remove	When an interdependence makes low operational, social and strategic impacts in value co-creation and must be removed.

Based on the decision categories and the impact score ratings, MEII develops the interdependence impact benchmark to determine recommended decision. The benchmark

provides decision rules, interpretations and corresponding decisions based on various interdependence impact levels (see Table 6.10)

Table 6.10 Interdependence impact benchmark

Decision Rule	Decision	Interpretation
If (Three metrics=Low) THEN	Remove	If all metrics (operational, social and strategic) record low impacts scores, then remove the interdependence
If (Two metrics=Low) AND (One metric=Medium) THEN	Replace	If two metrics record low impact scores and one records a medium impact score, then replace the interdependence
If (Two metrics=Low) AND (One metric=High) THEN	Remove/Replace	If two metrics record low impact scores and the other records a high impact score, then either remove or replace the interdependence
If (One metric=Low) AND (Two metrics=Medium) THEN	Remove/Replace	If one metric records a low impact score and the other two records medium impact scores, then either remove or replace the interdependence
If (One metrics=Low) AND (One metric=Medium) AND (One metric=High) THEN	Replace/Redesign	If one metric records a low impact score and another records medium impact score while the last one records a high impact score, then either replace or redesign the interdependence
If (Three metrics=Medium) THEN	Replace/Redesign	If all metrics (operational, social and strategic) record medium impact scores, then either replace or redesign the interdependence
If (One metric=Low) AND (Two metrics=High) THEN	Redesign	If one metric records a low impact score and the other two records high impact scores, then redesign the interdependence
If (Two metrics=Medium) AND (One metric=High) THEN	Redesign	If two metrics record medium impact scores and one records a high impact score, then redesign the interdependence
If (One metric=Medium) AND (Two metrics=High) THEN	Redesign/Retain	If one metric records a medium impact score and the other two records high impact scores, then redesign or retain the interdependence
If (Three metrics=High) THEN	Retain	If all metrics (operational, social and strategic) record high impact scores, then retain the interdependence

Step 3: Propose recommendation

In this last step, a set of recommendations are proposed for each interdependence based on the impact benchmark in step 2. These recommendations will form the basis of change management to improve value co-creation. In this step, critical attention should be paid to interdependencies with *remove* and *replace* decision since these recommendations will require additional effort in change implementation. Especially when it comes to removing interdependencies, further qualitative assessments should be made to complement the results of MEII before a final decision is implemented. Given that the interdependence impact benchmark in some cases provides two recommendations, for example *replace/redesign*, it is important for an analyst to back these decisions with other qualitative measures.

6.4.3 Interdependence Change Management

The last approach is the interdependence change management. The aim of this approach is to provide steps to implement recommendations from the impact assessment. The change management approach provides a list of revisions recommended by the measurement and impact assessment processes. It also guides the processes involved in reorganising interdependencies and keeps track of change history for record and comparison purposes. It is worth noting that the final decision on interdependencies is at the prerogative of decision makers since all environmental conditions cannot be accounted for in this method. The change management approach as presented in Table 6.11 comprise the following elements, date, version, change recommendations, interdependencies involved, change impact and approval entity. MEII outlines the following steps to carry out the change management approach:

- **Step 1:** Compile a list of all recommendations from the interdependence impact assessment. This involves recording all recommendations and clearly identifying interdependencies that require changes in the DBE's context.
- **Step 2:** Identify all affected interdependencies. This involves documenting all interdependencies that are affected by the change recommendations.
- **Step 3**: Determine the impact of the change on the DBE. This step determines the effect of implementing recommendations in a DBE.
- **Step 4**: Seek approval from designated individuals. If approval is given, then execute Step 5 else perform another cycle of MEII evaluation and/or other additional analysis if required.
- **Step 5**: Implement change recommendation in the DBE's context by either retaining, redesigning, replacing or removing interdependencies.

Table 6.11 Interdependence change management approach

Date	**Version No:**
Change Recommendations:	
Interdependencies Involved:	
Change Impact:	
Approved by:	

6.5 Summary

This chapter presented MEII, the method for evaluating the impact of DBE interdependencies in value co-creation. First, the chapter provided an overview of MEII and discussed its building blocks. Next, the chapter discussed the stages of MEII and its techniques. The chapter also discussed how techniques under each stage are operationalised to articulate DBEs' context, identify, visualise, analyse, profile, measure and assess the impact of interdependencies. By following the stages and applying the techniques in MEII, recommendations can be derived to support better decision making on how to reorganise DBE interdependencies for improved value co-creation.

Chapter 7

Application and Validation of MEII

This chapter presents discussions on the application and validation of MEII through a case study and expert review to address the *fifth research question* of this study. First, the chapter presents an overview of the vehicle clearing domain of Ghana's port DBE. Next, the chapter applies MEII to articulate the DBE's context, identify, analyse, measure and assess the impact of interdependencies. In addition, the chapter visualised interdependencies in the case study to provide an overall view of the DBE partnerships. Finally, the chapter validates the findings from the application of MEII through expert review interviews by assessing the validity, utility, generality and innovativeness of MEII.

7.1 Overview of Ghana's Port Digital Business Ecosystem

The empirical case for illustration in this study is Ghana's port DBE. Specifically, this study focuses on the vehicle clearing domain in Ghana's main port, Tema Harbour hereinafter referred to as Ghana's port DBE. The choice of this case is based on the following reasons. First, the port's operation involves interactions between different entities such as partners, technologies and processes which collectively co-create value, thus, a good instantiation of a DBE. Second, vehicle clearing is the dominant function and a major revenue earner at the port for the Government of Ghana. Hence, it presents a unique domain to apply MEII to obtain results that are useful to improve value co-creation, thus, a revelatory fit for this study. Third, Ghana as a developing country offers an opportunity to introduce contrasting insights into the DBE literature since most prior studies are situated within the developed country context. Lastly, the researcher is Ghanaian, therefore he believed his social ties could lead to gaining research access.

Ghana is a developing country in Sub-Saharan Africa, bordered by the Gulf of Guinea and the Atlantic Ocean to the South. Due to Ghana's boundary with the sea, some landlocked countries heavily utilise Ghana's ports as a transit point. As such, the volume of transaction in Ghana's port continues to increase yearly. Ghana's main port, Tema Harbour was commissioned for trade facilitation in 1962 (GPHA, 2017). Since then, there have been significant volumes of trade in the port due to its strategic location. The immediate partners in the port are the Ghana

Ports and Harbours Authority (GPHA), the Customs Division of the Ghana Revenue Authority (hereafter referred to as Customs), shipping lines, scanner operators, freight forwarders, terminal operators, Government Ministries, Departments and Agencies (MDAs) as well as importers and exporters.

GPHA is responsible for managing most activities at the port ranging from docking allocation, container movement, security, inspection scheduling and so on. Customs, on the other hand, is responsible for collecting taxes and duties on transactions in the port on behalf of the Government of Ghana. The scanner operators are responsible for scanning containers going through the port to determine their contents. Shipping lines are organisations that transport cargo with their vessels to and from the port. Terminal operators work with GPHA to manage the movement of containers and operations in the inland containerised deports. MDAs such as Ministry of Trade and Industry (MOTI), Ghana Standard Authority (GSA), Food and Drugs Authority (FDA), Environmental Protection Agency (EPA), Driver and Vehicle Licensing Authority (DVLA) and National Petroleum Authority (NPA) are some state organisations responsible for enforcing conformity laws on import or export of goods under their jurisdiction. Freight forwarders are Customs agents that facilitate clearing and export processes on behalf of individuals who are not self-declarants. Lastly, importers and exporters are individuals and organisations who bring goods into Ghana or send them abroad. The main activities at the port include, vessel and cargo handling, stevedoring, ship repairs, bunkering and ship chandlery as well as storage and warehousing services (GPHA, 2017). However, the dominant activity at the port is clearing of import cargo from abroad since Ghana is highly import-dependent.

Officially, the use of ICT in the port began in 1986 through the introduction of the Automated System for Customs Data (ASYCUDA). ASYCUDA was used mainly by Customs for record management alongside the single administrative document (SAD) processes. Thereafter, was the deployment of the TRADENET system, Ghana Customs Management System (GCMS), eMDA and the Ghana Integrated Cargo Clearance System (GICCS) by the Ghana Community Network Services Limited (GcNet). Later, an additional information system named the Pre-Arrival Assessment Reporting System (PAARS) by West Blue consulting was introduced to enable Customs to perform classification and valuation operations after taking over from destination inspection companies (DICs). Lastly, on 1st September 2017, a new era began in the port through the introduction of the paperless regime. This regime is an attempt to harmonise trade activities among numerous partners, processes and technologies by eliminating excessive

use of some paper documents, reducing face-to-face interactions and facilitating single document submission for trade transaction in the port.

In recent years, there has been increased development and use of technology in the port to improve efficiency. Thus, this development has led to numerous interdependencies among technology platforms, processes and partners. As a complex environment, the port's operations involve numerous individuals and organisations such as freight forwarders, importers and exporters, Customs, MDAs and shipping lines. Similarly, the port's operations involve many processes such as import clearing, export, transit and Customs bonded warehousing. Technology platforms supporting these processes and partners include PAARS, TRADENET, GCMS, Joint Examination Management Information Systems (JMIS), eMDA and GICCS. The presence of these numerous technology platforms, processes and partners has created a web of interdependencies in the port, resulting in lots of inefficiencies and revenue losses.

While in general there have been significant improvements in port efficiencies in some developed economies such as Singapore, China, USA and Germany (Brooks and Pallis, 2008), the case is opposite in Ghana. Preliminary observations show serious problems of inefficiencies at the port. Some causes of inefficiencies at Ghana's port include duplication of functions and processes, high-level of bureaucracy and political interference as well as low level of accountability and performance appraisal. In fact, two focal partners in Ghana's main port, Customs and GPHA have indicated the challenge of having a holistic understanding of their DBE partnerships and systematically evaluating the impact of interdependencies in value co-creation. Indeed, these focal partners have alluded to the non-existence of a comprehensive method to evaluate the impact of interdependencies in the port.

A typical vehicle clearance at Tema port entails the following: 1) importer obtains unique consignment reference number (UCR) and submits import declaration form (IDF) through the eMDA platform, 2) importer obtains required permits, licenses and certifications if necessary, 3) importer applies for Customs classification and valuation report (CCVR) through PAARS, 4) Customs officers perform valuation, ascertain appropriate duties and issue CCVR using PAARS, 5) importer pays import duties, taxes and other charges at the bank, 6) importer submits Customs declaration (bill of entry) through GCMS, 7) Customs officers undertake compliance processes using Customs processing codes (CPCs) through GCMS, 8) Customs officers perform physical examination of vehicles to be cleared and submit results through GCMS, 9) importer makes request for shipping release if physical examination is successful

and all charges are paid, 10) importer buys temporarily number plate from DVLA to move vehicles from the port, 11) Customs officers perform preventive processes by examining all documents and previous clearance procedures before vehicles are finally released through GCMS.

It is worth noting that the generic import clearing processes enumerated above may vary depending on the CPCs and type of vehicles involved in the clearance process. Though the clearance procedures enumerated above is brief, data collected through observations, review of standard operating procedure and interviews with key information relevant respondents in Ghana's port DBE featured in the entire application of MEII. For instance, by reviewing the standard operating procedures on vehicle clearing, this study easily deduced the unit systems in the vehicle clearing context of Ghana's port DBE.

The data used for application of MEII was collected from key actors in the port DBE. Data was collected from importers, customs valuation officers, examination officers, compliance officers and preventive officials. The respondents from these groups of participants were selected through the purposive random sampling technique due to their knowledge of vehicle clearing processes. For a respondent to be selected, he/she must have at least two years' working experience in a role. By using this criterion, only information relevant participants were selected as respondents. For the application process of MEII, questionnaires were administered to selected participants. In all, a total of 18 survey responses were collected for analysis.

The key challenge encountered during the application of the MEII was not having access to operational data due to privacy and security concerns in the case study domain. Ideally, it would have been good to have access to operational data in the form of transactional statistics and system logs. The transactional data would have help to determine an exact number of activities each interdependence perform. Similarly, the systems log would have help to determine the volume and duration of transactions processed in technology interdependencies. In addition, it was difficult to get the full attention of respondents as they were working and at the same time responding to interview and survey questions. As such, there were lots of delays in collecting data for the application of MEII. Lastly, some respondents did not respond to the online version of the survey. Thus, multiple reminders were sent before some responses were collected. As some of these challenges were anticipated, appropriate measures were put in place to address their effect on the research. In the end, adequate responses were collected for application of MEII.

7.2 Context Articulation

This stage of MEII articulates the scope of investigation by delineating sub-systems and interdependencies. The context articulation stage utilises the unit system analysis technique to articulate various subsystems in the vehicle clearing domain of Ghana's port DBE. Based on the subsystems the interdependence identification technique articulates interactions.

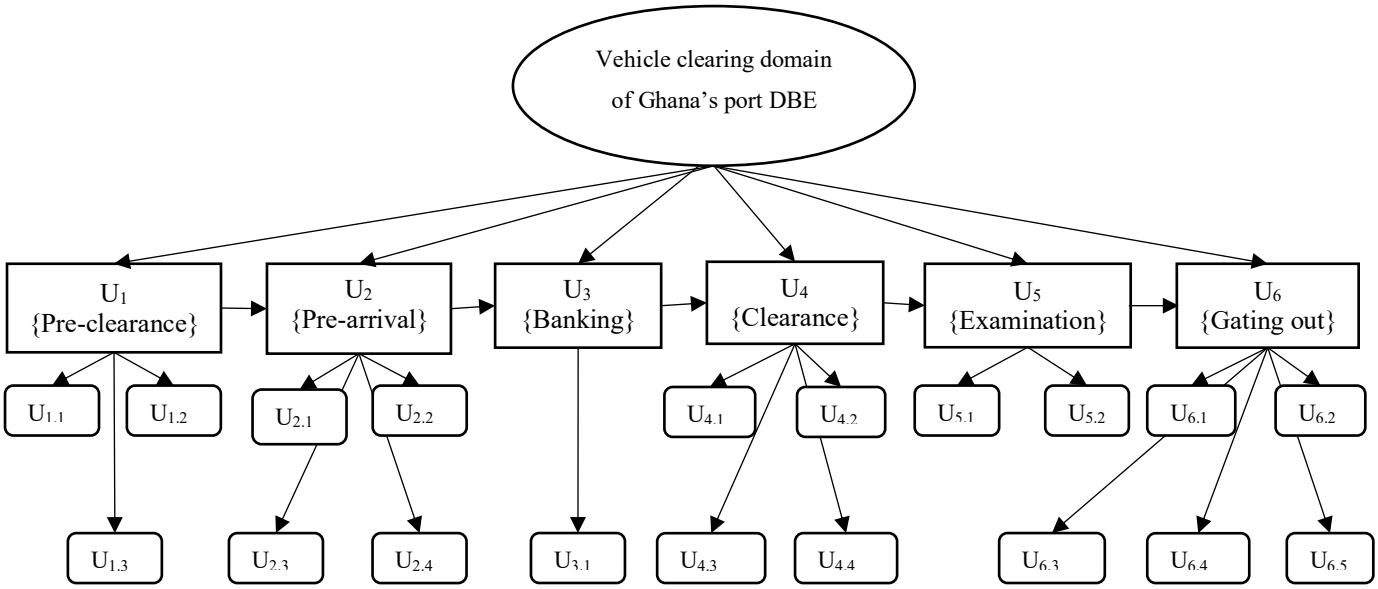

Figure 7.1 Vehicle clearing domain of Ghana's port DBE

7.2.1 Unit System Definition

Using the unit system analysis techniques of MEII, six unit systems are identified from the vehicle clearing domain of Ghana's port DBE. These six-unit systems as presented in Figure 7.1 are pre-clearance, pre-arrival, banking, clearance, examination and gating out. The pre-clearance unit system entails prerequisite activities necessary to initiate clearance procedure. The pre-arrival unit system entails clearance activities that can be performed before the vehicle arrived in Ghana as permitted by law. Some of these activities include seeking permits, submitting applications for CCVR and so on. The banking unit system entails payment procedures in the DBE. The clearance unit system depicts Customs processes required to clear vehicles in Ghana's ports. The clearance unit system ensures the right duties are paid and the right Customs regimes are used for the clearance procedure. The examination unit system entails physical inspection activities required in vehicle clearing at Ghana's port DBE. Lastly, the gating out unit system entails activities required so that vehicles can be released from the port.

Table 7.1 presents results of the unit system analysis approach on the pre-clearance unit system. From the result, the pre-clearance (U_1) unit system can be decomposed into three sub-unit systems. These sub-unit systems are UCR and IDF processing as well as the use of eMDA platform to process UCR number and IDF application. The three sub-unit systems can be further decomposed to lower granularity if necessary. The unit system description details the function of U_1 whiles the version number indicates the number of analysis cycle undertaken. Also, the date and unit system ID represents the time of analysis and unit system identification respectively. Similarly, the unit system analysis is applied to the other unit systems in the vehicle clearing context of Ghana's port DBE to understand their activities and compositions.

Table 7.1 Pre-clearance unit system analysis

Date: 17/1/2018	**Unit system ID: U_1**	**Version: 1.0**
Unit System Name	{Pre-clearance}	
Unit System Description	This unit system covers interdependencies involved in pre-clearance procedures of the vehicle clearing domain of Ghana's port DBE	
Sub-Unit Systems	$U_{1.1}$ UCR processing $U_{1.2}$ IDF processing $U_{1.3}$ Obtaining UCR and submitting IDF electronically through the eMDA platform	

7.2.2 Interdependence Articulation

The aim of the interdependence articulation is to delineate interdependencies within the unit systems of the vehicle clearing domain. The interdependence articulation analysis supports the identification of interdependencies through examination of unit systems. Based on the results of the unit system analysis, the interdependence articulation analysis is performed. From the analysis of sub-unit systems in the vehicle clearing context, 19 interdependencies were articulated. These interdependencies are articulated through analysis of the interactions between entities as described by the DBE interdependence notation.

For instance, in the pre-arrival unit system of the vehicle clearing domain, an importer as a partner requires PAARS (a technology) to submit an application for CCVR. This interaction is an indication of an interdependence between the importer (partner) and PAARS (technology). Specifically, this interdependence demonstrates the partner-technology (PaTe) class of DBE interdependence. Similarly, Customs valuation officers rely on a set of evaluation processes to examine CCVR application before issuing a report. The reliance of the Customs officers on the set of valuation processes also indicates an interdependence because, without the procedure in the valuation processes, it will be difficult for Customs officers to objectively examine CCVR applications and issue reports. Table 7.2 shows the interdependencies articulated from the

vehicle clearing domain of Ghana's port DBE. The table shows the unit systems, interdependencies, their unique identifiers, entities as well as their classes.

Table 7.2 Interdependencies articulated from the vehicle clearing domain

Unit System	ID	Interdependence Name	Entities Involved	Interdependence Class
U_1 {Pre-clearance}	INT1	Importer relies on pre-clearance processes to compete UCR application	Importer Pre-Clearance Processes	PaPr
	INT2	Importer relies on MDA processes to complete IDF application	Importer MDA processes	PaTe
	INT3	Importer relies on the e-MDA platform to obtain UCR number and submit IDF	Importer eMDA	PaTe
U_2 {Pre-arrival}	INT4	Importer relies on the pre-arrival processes to complete CCVR application	Importer Pre-Arrival Processes	PaPr
	INT5	Importer depends on the PAARS platform to submit an application for CCVR	Importer PAARS	PaTe
	INT6	Customs officer relies on valuation processes to evaluate application and issue CCVR	Customs Valuation Processes	PaPr
	INT7	Customs valuation officer relies on PAARS to process CCVR	Customs PAARS	PaTe
U_4 {Banking}	INT8	Importer relies on banks to make duty and other charges payment	Importer Bank	PaPa
U_3 {Clearance}	INT9	Importer depends on Customs regime procedure code (CPC) processes to prepare declaration application	Importer CPC Processes	PaPr
	INT10	Importer depends on the GCMS platform to submit Customs declaration application	Importer GCMS	PaTe
	INT 11	Customs compliance officer relies on CPC processes to evaluate declarations	Customs CPC Processes	PaPr
	INT 12	Customs officer depends on the GCMS platform to process declarations	Customs GCMS	PaTe
U_5 {Examination}	INT 13	Customs officer replies on vehicle examination processes to perform physical inspection	Customs Examination Processes	PaPr
	INT 14	Customs examination officer depends on the GCMS platform to process vehicle inspection report	Customs GCMS	PaTe
U_6 {Gating out}	INT 15	Importer relies on DVLA for temporary number plate	Importer DVLA	PaPa
	INT 16	Importer relies on the cargo release processes to apply for shipping release	Importer Shipping Release Processes	PaPr
	INT 17	Importer depends on the GICCS platform to submit shipping release request	Importer GICCS	PaTe
	INT 18	Customs officer relies on preventive processes to scrutinise vehicles and their documentation	Customer Officer Preventive Processes	PaPr
	INT 19	Customs preventive officer uses the GCMS platform to process final inspection result and release vehicle	Customs GCMS	PaTe

7.3 Interdependence Analysis

Based on the second stage of MEII, this study analyses interdependencies articulated from the vehicle clearing domain of the case study. The interdependence analysis is supported by the interdependence profiling technique of MEII which decomposes interdependencies to derive more information on their functionalities. For instance, using the interdependence profiling technique, interdependence INT 5 is analysed as follows in Table 7.3. The table shows the interdependence ID, version number of the analysis and the interdependence name and description. The profiling reveals the outcome of the interdependence, associated business issues that require attention, entities involved and their responsibilities as well as business norms in the form of informal and formal rules. In profiling DBE interdependencies, MEII advocates for norm analysis on each interdependence to understand the rules that guide their performance. Thus, the norm analysis is applied to the interdependencies articulated in the vehicle clearing domain of Ghana's port DBE. From the norm analysis, norm N005 presents the rules governing the submission of CCVR application through the PAARS platform. From the norm analysis, it is revealed that certain requirements are needed for an importer to successfully submit an application for CCVR, of which failure could result in delays or unsuccessful application process.

Table 7.3 Sample independence profiling based on INT 5

<table>
<tr><td colspan="3">Interdependence ID: INT5</td><td colspan="3">Date: 5/07/2017</td><td>Version No:2</td></tr>
<tr><td colspan="6">Interdependence Name: Importer depends on the PAARS to apply for CCVR</td></tr>
<tr><td colspan="6">Interdependence Description: This interdependence supports the importer to submit an application for CCVR using the PAARS platform</td></tr>
<tr><td colspan="6">Interdependence Outcome: Enables successful, timely and cost-efficient CCVR processing</td></tr>
<tr><td colspan="6">Business Issues:
1. Importers complain about the frequent connectivity issues with the PAARS platform.
2. Interoperability issues with the eMDA platform</td></tr>
<tr><td rowspan="3">Entities Involved</td><td>Entity</td><td colspan="4">Responsibility</td></tr>
<tr><td>Importer</td><td colspan="4">Submits CCVR application through PAARS</td></tr>
<tr><td>PAARS</td><td colspan="4">PAARS allows the importer to submit an application if all necessary requirements are met</td></tr>
<tr><td rowspan="2">Norm Analysis</td><td>Norm ID</td><td>whenever <condition></td><td>if <state></td><td>then <agent></td><td>is <deontic operator></td><td>to <action></td></tr>
<tr><td>N005</td><td>CCVR application is prepared</td><td>All documentation requirements are met (e.g. Packing list, invoice, etc)</td><td>Importer</td><td>Permitted</td><td>Submit an application for CCVR</td></tr>
</table>

Given that control in this interdependence is given to a digital agent (that is the PAARS) to perform, it reduces errors and incidents of favouritism which used to characterise this interdependence. Hence, from the result of the norm analysis, it is evident that application for CCVR can only be successful if certain conditions are met by the importers. For example, with

the result of the norm analysis, control related issues of INT 5 can be matched if the evaluation recommendation needs a change in required documentation to enable better value co-creation. According to MEII, interdependence profiling should be conducted on all interdependencies to have a better understanding of their functionalities.

7.4 Interdependence Rationalisation

Interdependence rationalisation is the last stage of MEII. The aim of this stage is to enable interdependence impact measurement, assessment and change management. These key techniques of this stage are the activities that lead to reorganisation of interdependencies towards improved value co-creation. The discussions below show the results of the application of MEII in the vehicle clearing domain of Ghana's port DBE.

7.4.1 Interdependence Measurement

The interdependence measurement technique assesses the impact scores of all interdependencies articulated in the vehicle clearing domain based on the responses from relevant partners. Specifically, the technique measures the operational, social and strategic impacts of the 19 interdependencies articulated. During the interdependence measurement processes, the following three steps of MEII were followed.

Step 1: Normalisation of individual scores

Given that MEII is designed to accommodate data from different sources and formats, the normalisation technique was applied to the data collected. Different instruments were used to collect data from respondents in the vehicle clearing domain, as such, it was necessary to normalise the individual scores to standardise the data. For instance, the social and operational impact assessment data was collected on a scale of -3 to +3 while the strategic impact data was collected using a scale of 1 to 5. Thus, to have a common lens to assess the impact of the interdependencies, it was necessary to standardise all the data to a scale of 1 to 5. To normalise the operational and social impact data, equation (1) was applied (*see Section 6.4.1*). First, the minimum and maximum values were calculated from responses on each interdependence using the MIN and MAX Microsoft excel functions. In most cases, the minimum and maximum values were -3 and +3 respectively. Next, equation (1) was applied to each response on an interdependence based on individual criteria of the three metrics. For instance, in the case of interdependence INT1, the first social impact responses of **-3** was normalised to **1** using the formula: (*H4-G9)/(G10-G9) * (5-1) +1, where H4 is the cell for the original response*

of -3, G9 is the cell for the minimum response, G9 is the cell for the maximum response of 3.

Step 2: Calculating average score for multiple responses

As multiple responses were collected on each interdependence, MEII advocates the process of calculating the average responses for each interdependence based on the normalised scores. In calculating average scores, equation (2) is applied to the normalised scores of the individual criterion in each metric. For instance, in the social metric, the average score is calculated for each criterion based on the number of responses collected on an interdependence.

Step 3: Measuring impact scores for interdependencies.

In this last step of the measurement process, the average score for each criterion of an interdependence is computed. First, the average scores are multiplied by criteria weight. Given that the criteria for measuring the impact of interdependencies may have different levels of importance, a criteria weight (cw) is introduced to aid this computation. As DBEs are different and the importance of each criterion may differ, the weight assignment is at the discretion of the analyst in consultation with best practices and relevant stakeholders. In this study, the values of criteria weight are defined per the views of respondents and review of operating procedure in Ghana's port DBE. Second, the final scores are aggregated using equation (3), (4) and (5) for the operational, social and strategic dimensions respectively (*see Section 6.4.1*). Each of these equations is used to aggregate the various criteria in each dimension to arrive at the final impact score. Table 7.4, 7.5 and 7.6 show the final operational impact scores (OpIS), social impact scores (SoIS) and the strategic impact scores (StIS) respectively for all the 19 interdependencies articulated in the vehicle clearing domain of Ghana's port DBE.

Table 7.4 Operational impact scores for interdependencies in the vehicle clearing domain

Criteria	*cw*	INT 1	INT 2	INT 3	INT 4	INT 5	INT 6	INT 7	INT 8	INT 9	INT 10	INT 11	INT 12	INT 13	INT 14	INT 15	INT 16	INT 17	INT 18	INT 19
Cost	0.40	0.87	0.87	0.53	0.40	0.60	1.63	1.74	1.20	0.87	0.80	1.20	1.20	1.64	1.20	0.80	0.60	1.36	1.20	0.40
Turnaround Time	0.25	0.83	0.79	0.50	0.25	0.42	1.02	1.13	0.71	0.75	0.83	1.00	1.17	0.97	0.42	0.54	0.42	0.95	0.92	0.92
Service Quality	0.35	1.40	1.11	0.88	0.53	0.82	1.28	1.53	0.70	0.88	1.17	1.63	1.17	1.59	0.74	0.70	0.58	1.26	1.28	1.28
OpIS		**3.10**	**2.77**	**1.91**	**1.18**	**1.84**	**3.93**	**4.40**	**2.61**	**2.50**	**2.80**	**3.83**	**3.54**	**4.20**	**2.36**	**2.04**	**1.60**	**3.57**	**3.40**	**2.60**

Table 7.5 Social impact scores for interdependencies in the vehicle clearing domain

Criteria	*cw*	INT 1	INT 2	INT 3	INT 4	INT 5	INT 6	INT 7	INT 8	INT 9	INT 10	INT 11	INT 12	INT 13	INT 14	INT 15	INT 16	INT 17	INT 18	INT 19
Subsistence	0.15	0.55	0.73	0.60	0.58	0.58	0.51	0.41	0.65	0.68	0.65	0.75	0.75	0.62	0.68	0.38	0.45	0.36	0.75	0.75
Classification	0.10	0.43	0.45	0.42	0.38	0.35	0.33	0.32	0.38	0.47	0.35	0.43	0.47	0.50	0.48	0.22	0.23	0.38	0.50	0.50
Territoriality	0.10	0.48	0.43	0.45	0.40	0.28	0.27	0.37	0.23	0.47	0.45	0.20	0.35	0.10	0.37	0.10	0.20	0.38	0.50	0.50
Temporality	0.10	0.35	0.33	0.47	0.42	0.25	0.18	0.23	0.18	0.27	0.43	0.10	0.20	0.23	0.50	0.18	0.30	0.38	0.10	0.50
Learning	0.15	0.65	0.58	0.58	0.70	0.48	0.51	0.46	0.45	0.53	0.58	0.60	0.75	0.75	0.42	0.23	0.30	0.36	0.75	0.75
Recreation	0.05	0.21	0.24	0.22	0.23	0.15	0.15	0.23	0.16	0.20	0.21	0.13	0.25	0.24	0.25	0.08	0.10	0.15	0.05	0.25
Protection	0.10	0.42	0.43	0.35	0.45	0.25	0.34	0.36	0.25	0.43	0.42	0.38	0.38	0.37	0.46	0.20	0.22	0.38	0.17	0.50
Exploitation	0.10	0.30	0.32	0.30	0.23	0.25	0.15	0.37	0.18	0.30	0.43	0.28	0.48	0.21	0.43	0.18	0.20	0.36	0.17	0.50
Association	0.05	0.18	0.17	0.23	0.18	0.18	0.12	0.21	0.13	0.17	0.23	0.24	0.25	0.17	0.21	0.10	0.09	0.16	0.22	0.25
Interaction	0.10	0.37	0.45	0.38	0.35	0.32	0.33	0.36	0.22	0.40	0.42	0.48	0.43	0.50	0.26	0.20	0.22	0.32	0.50	0.50
SoIS		**3.94**	**4.13**	**4.00**	**3.92**	**3.09**	**2.89**	**3.32**	**2.83**	**3.92**	**4.17**	**3.59**	**4.31**	**3.69**	**4.06**	**1.87**	**2.31**	**3.23**	**3.71**	**5.00**

Table 7.6 Strategic impact scores for interdependencies in the vehicle clearing domain

Criteria	*cw*	INT 1	INT 2	INT 3	INT 4	INT 5	INT 6	INT 7	INT 8	INT 9	INT 10	INT 11	INT 12	INT 13	INT 14	INT 15	INT 16	INT 17	INT 18	INT 19
Priority Ranking	0.25	0.75	0.75	0.56	0.88	0.69	0.85	0.80	0.94	0.94	0.75	1.25	1.13	1.25	1.17	0.63	0.25	0.88	1.25	1.25
Customer Satisfaction	0.20	0.50	0.35	0.65	0.35	0.75	0.72	0.52	0.70	0.30	0.70	0.50	0.70	0.53	0.60	0.20	0.25	0.40	0.20	0.60
Revenue	0.25	0.69	0.88	0.44	0.50	0.63	1.10	0.85	1.25	0.50	0.56	1.13	0.94	0.92	0.92	0.81	0.25	0.25	0.25	0.25
Regulatory issues	0.30	1.13	1.43	0.68	0.83	1.05	1.38	0.90	1.43	0.68	1.05	1.35	0.60	0.90	0.90	0.98	0.30	0.30	0.30	0.30
StIS		**3.07**	**3.41**	**2.33**	**2.56**	**3.12**	**4.05**	**3.07**	**4.32**	**2.42**	**3.06**	**4.23**	**3.37**	**3.60**	**3.59**	**2.62**	**1.05**	**1.83**	**2.00**	**2.40**

7.4.2 Interdependence Impact Assessment

This technique of MEII determines the influence of DBE interdependencies in value co-creation. In other words, the interdependence impact assessment technique determines the relevance of an interdependence to the achievement of DBEs' performance goals. The interdependence impact assessment was conducted in the following steps.

Step 1: First, the impact scores of the three metrics, namely OpIS, SoIS and StIS of an interdependence are mapped to the interdependence impact score rating levels (*see Figure 6.10*). Based on the impact rating levels defined by MEII, the interdependence scores are mapped to determine their appropriate ratings. Table 7.7 shows the impact levels of each interdependence based on the three metrics. For instance, interdependence INT 6 recorded 3.93, 2.89 and 4.05 as the operational, social and strategic impact scores. Thus, the corresponding impact levels based on the impact score rating guide by MEII is {Medium, Medium, High}. The two *medium* impacts correspond to the operational and social impact scores while the *high* corresponds to the strategic impact level.

Table 7.7 Interdependence impact assessment

Interdependencies	OpIS	SoIS	StIS	Impact levels
INT1	3.10	3.94	3.07	{Medium, Medium, Medium}
INT2	2.77	4.13	3.41	{Medium, High, Medium}
INT3	1.91	4.00	2.33	{Low, High, Medium}
INT4	1.18	3.92	2.56	{Low, Medium, Medium}
INT5	1.84	3.09	3.12	{Low, Medium, Medium}
INT6	3.93	2.89	4.05	{Medium, Medium, High}
INT7	4.40	3.32	3.07	{High, Medium, Medium}
INT8	2.61	2.83	4.32	{Medium, Medium, High}
INT9	2.50	3.92	2.42	{Medium, Medium, Medium}
INT10	2.80	4.17	3.06	{Medium, High, Medium}
INT11	3.83	3.59	4.23	{Medium, Medium, High}
INT12	3.54	4.31	3.37	{Medium, High, Medium}
INT13	4.20	3.69	3.60	{High, Medium, Medium}
INT14	2.36	4.06	3.59	{Medium, High, Medium}
INT15	2.04	1.87	2.62	{Medium, Low, Medium}
INT16	1.60	2.31	1.05	{Low, Medium, Low}
INT17	3.57	3.23	1.83	{Medium, Medium, Low}
INT18	3.40	3.71	2.00	{Medium, Medium, Medium}
INT19	2.60	5.00	2.40	{Medium, High, Medium}

Step 2: In this step, decisions are made on the 19 interdependencies by mapping their impact scores and levels to the interdependence impact benchmark of MEII (*see Table 6.1*). From the result presented in Table 7.8, it is evident that none of the 19 interdependencies in the vehicle clearing domain satisfied the conditions to been retain automatically. This indicates that at

present, interdependencies in the vehicle clearing domain are not offering optimal contributions in value co-creation. As such, there is a need for an overhaul of interdependencies in the vehicle clearing domain of the port DBE. Largely, the results indicate that interdependencies in the vehicle clearing domain need to be redesigned and, in some cases, replaced or removed completely. From the results, interdependencies, INT 2, 6, 7, 8, 10, 11, 12, 13 and 14 need redesigning. However, interdependencies INT 1, 3, 9, 18 and 19 need either replacement or redesign. Conversely, interdependencies INT 4, 5, 15 and 17 needs either removal or replacement. For instance, interdependence INT 1 which requires an importer to rely on pre-clearance processes to complete UCR application recorded replace or redesign decision based on the medium impact it contributes in value co-creation. This interdependence requires an importer to purchase a serial number from a designated bank and use this number to generate a unique consignment reference number. In all, importers view this interdependence as a nuisance and a way to extort money from them since other processes in the vehicle clearing still generates unique identifications.

Table 7.8 Interdependence impact decision

Interdependencies	OpIS	SoIS	StIS	Impact levels	Decision
INT1	3.10	3.94	3.07	{Medium, Medium, Medium}	Replace or Redesign
INT2	2.77	4.13	3.41	{Medium, High, Medium}	Redesign
INT3	1.91	4.00	2.33	{Low, High, Medium}	Replace or Redesign
INT4	1.18	3.92	2.56	{Low, Medium, Medium}	Remove or Replace
INT5	1.84	3.09	3.12	{Low, Medium, Medium}	Remove or Replace
INT6	3.93	2.89	4.05	{Medium, Medium, High}	Redesign
INT7	4.40	3.32	3.07	{High, Medium, Medium}	Redesign
INT8	2.61	2.83	4.32	{Medium, Medium, High}	Redesign
INT9	2.50	3.92	2.42	{Medium, Medium, Medium}	Replace or Redesign
INT10	2.80	4.17	3.06	{Medium, High, Medium}	Redesign
INT11	3.83	3.59	4.23	{Medium, Medium, High}	Redesign
INT12	3.54	4.31	3.37	{Medium, High, Medium}	Redesign
INT13	4.20	3.69	3.60	{High, Medium, Medium}	Redesign
INT14	2.36	4.06	3.59	{Medium, High, Medium}	Redesign
INT15	2.04	1.87	2.62	{Medium, Low, Medium}	Remove or Replace
INT16	1.60	2.31	1.05	{Low, Medium, Low}	Replace
INT17	3.57	3.23	1.83	{Medium, Medium, Low}	Remove or Replace
INT18	3.40	3.71	2.00	{Medium, Medium, Medium}	Replace or Redesign
INT19	2.60	5.00	2.40	{Medium, High, Medium}	Replace or Redesign

Step 3: In this last step, a set of recommendations are proposed for interdependencies based on the rationalisation result. In making proposals, the individual impact scores for the three metrics, namely operational, social and strategic are important indicators of which aspect of an interdependence requires critical attention. Also, the interdependencies that recorded *remove or replace* decision require additional information to make definite decisions. In this study,

interviews were conducted with some participants in the vehicle clearing domain, as such, additional information was elicited to understand issues pertaining to the interdependencies. To illustrate the process of making final recommendations, interdependence 4 is used as an example. From the results in Table 7.8, interdependence INT 4 recorded {Low, Medium, Medium} impacts in value co-creation in the vehicle clearing domain. Hence, based on the interdependence impact benchmark of MEII, the decision is to either *remove or replace* the interdependence. Interdependence INT 4 involves an importer relying on pre-arrival processes to complete CCVR application. As such, an importer is required to furnish Customs with accurate information on the vehicle to be cleared so that appropriate taxes can be calculated. In this interdependence, there are multiple quality checks and balances to make sure the right duties are calculated. When this interdependence is completed, the importer has to still complete another Customs process for compliance, leading to duplication of processes, increased cost and delays in the vehicle clearing domain. Thus, it is not surprising that interdependence INT 4 has a remove or replace decision. Given that activities in interdependence INT 4 could be performed in INT 9 or vice versa, the final recommendation is to *remove* interdependence INT 4.

7.5 DBE Partnership Visualisation

The aim of the DBE partnership visualisation is to offer a better understanding of formation and behaviour of DBE interdependencies. The visualisation process relies on steps and elements conceptualised in MEII. The following steps from the technique are followed to visualise interactions in the vehicle clearing domain of Ghana's port.

Step 1: Articulate interdependencies – This step relies on the 19 interdependencies articulated in the vehicle clearing domain of Ghana's port DBE using the interdependence articulation technique. Hence, there was no need to perform another round of interdependence articulation.

Step 2: Analyse interdependencies – In this step, the interdependencies articulated are analysed to derive information required to conduct the visualisation. First, the operational, social and strategic scores from the measurement of interdependencies are retrieved. Next, the scores are aggregated to obtain the total impact scores needed to show the impact of an interdependence in value co-creation. Following this, the operational arrangement of interdependencies in the vehicle clearing domain was analysed to determine the type of interdependencies between entities. The analysis revealed that there are sequential interdependencies between entities due to the serialised nature of transactions in the port. As a result, a first step must be performed a

preceding one can be undertaken. For example, in the vehicle clearing domain, there is a need to receive CCVR before payment can be made. Similarly, compliance processes will not be performed until duty payment has been made. Lastly, each individual interdependence is analysed to determine their classes, outcome flows, and behaviour taxonomies based on the conceptualisation in MEII. Table 7.9 shows the information used to visualise the DBE partnership of the vehicle clearing domain of Ghana's port DBE.

Table 7.9 DBE partnership visualisation analysis

ID	OpIS	SoIS	StIS	Total Impact	Interdependence Flow	Interdependence Class	Behaviour Taxonomy
INT1	3.10	3.94	3.07	10.11	Information	PaPr	Substantive (S)
INT2	2.77	4.13	3.41	10.31	Information	PaPr	Substantive (S)
INT3	1.91	4.00	2.33	8.24	Information	PaTe	Substantive .communication (S.C)
INT4	1.18	3.92	2.56	7.66	Information	PaPr	Substantive
INT5	1.84	3.09	3.12	8.05	Information	PaTe	Substantive .communication (S.C)
INT6	3.93	2.89	4.05	10.87	Information	PaPr	Substantive .control (C.Ctrl)
INT7	4.40	3.32	3.07	10.79	Information	PaTe	Substantive .communication (S.C)
INT8	2.61	2.83	4.32	9.76	Finance	PaPa	Substantive (S)
INT9	2.50	3.92	2.42	8.84	Information	PaPr	Substantive (S)
INT10	2.80	4.17	3.06	10.03	Information	PaTe	Substantive .communication (S.C)
INT11	3.83	3.59	4.23	11.65	Information	PaPr	Substantive .control (C.Ctrl)
INT12	3.54	4.31	3.37	11.22	Information	PaTe	Substantive .communication (S.C)
INT13	4.20	3.69	3.60	11.49	Information	PaPr	Substantive .control (C.Ctrl)
INT14	2.36	4.06	3.59	10.01	Information	PaTe	Substantive .communication (S.C)
INT15	2.04	1.87	2.62	6.53	Goods	PaPa	Substantive (S)
INT16	1.60	2.31	1.05	4.96	Information	PaPr	Substantive (S)
INT17	3.57	3.23	1.83	8.63	Information	PaTe	Substantive .communication (S.C)
INT18	3.40	3.71	2.00	9.11	Information	PaPr	Substantive .control (C.Ctrl)
INT19	2.60	5.00	2.40	10.00	Goods	PaTe	Substantive .control (C.Ctrl)

Step 3: Visualisation of DBE partnership – In this last step, the objects offered in the visualisation technique are used to illustrate the DBE partnership. This step relies on the result of the DBE partnership visualisation analysis in Table 7.9. Based on this result, the DBE partnership is visualised by drawing the entities, linking them with appropriate interdependence type, indicating their unique identifiers, presenting the interdependence outcome flow, class and behaviour taxonomy. The effect of each interdependence is represented by the thickness of

the link based on the total impact score. The outcome of this step is the DBE partnership visualisation presented in Figure 7.2.

The DBE partnership of the vehicle clearing domain as presented in Figure 7.2 provides some interesting revelations. From the DBE partnership, it is evident that an importer is a very important entity. This is visible in the number of interdependencies an importer undertook during the value co-creation process. As such, without importers, there will not be value co-creation in the vehicle clearing domain of the port DBE. In addition, the DBE partnership reveals that interactions are dominated by information flow with minimal financial and good flows since most interdependencies produce information as outcomes. Also, the DBE partnership shows interactions in the vehicle clearing domain are dominated by interdependencies between partners and processes. Similarly, the DBE partnership reveals that the vehicle clearing domain of the port DBE is dominated by substantive and substance.communication behaviour taxonomies which are mostly undertaken by partners and digital technology platforms respectively. Lastly, the DBE partnership shows that some interdependencies, namely INT 11,12 and 13 contribute greater impact to value co-creation that others such as interdependence INT 15, 16 and 4. This assertion is revealed by the thickness of the interdependence link. Hence, the ticker the interdependence link, the better impact it contributes to value co-creation. By visualising the DBE partnership of the vehicle clearing domain, it is easier to understand the overall interaction between entities. In addition, the visualisation provides a quick snapshot of the structure and nature of interactions of the DBE partnership through revelation of interdependence types, classes and outcomes. With these revelations, a better understanding can be obtained on the DBE partnerships.

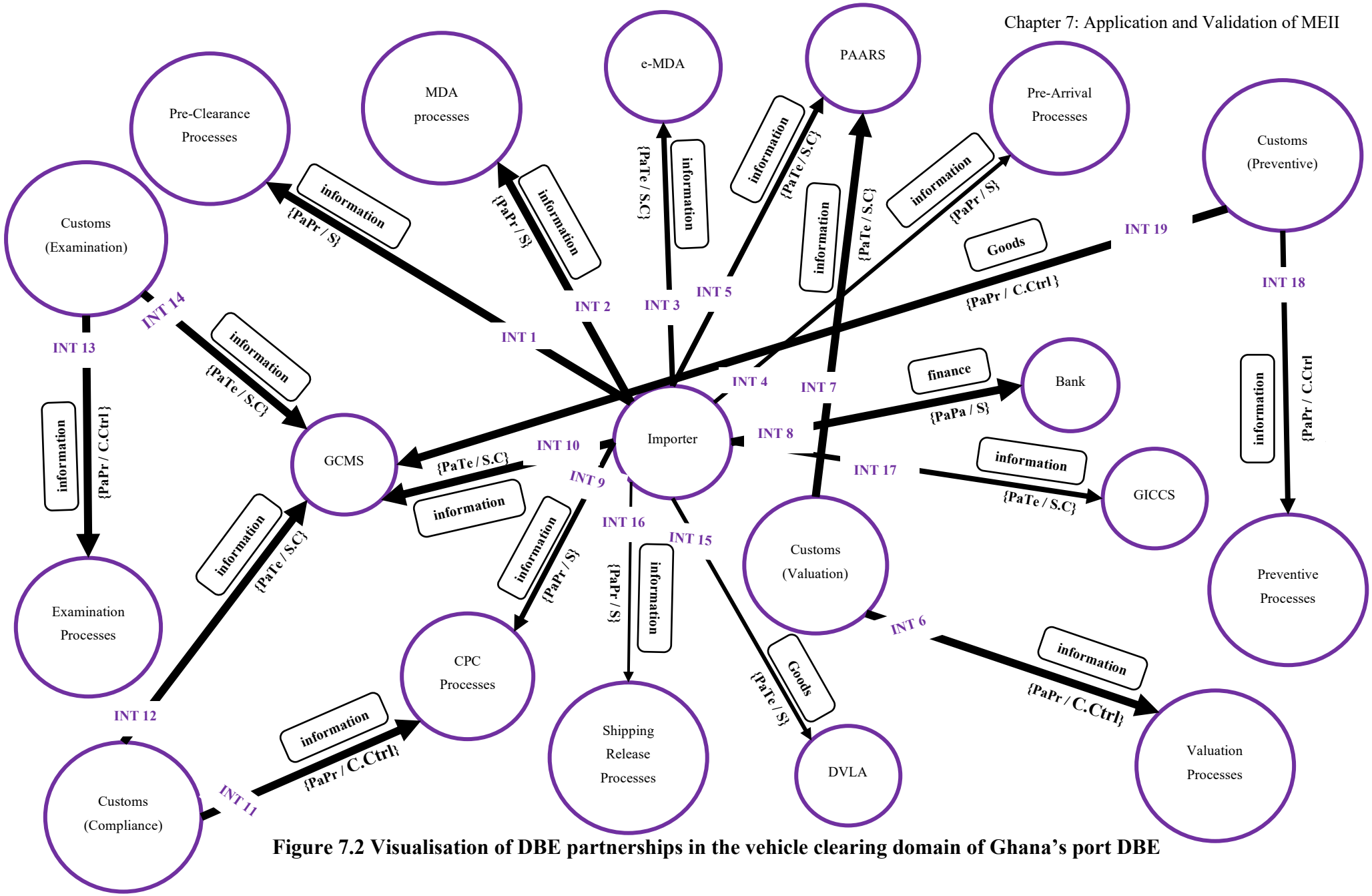

Figure 7.2 Visualisation of DBE partnerships in the vehicle clearing domain of Ghana's port DBE

7.6 Validation

In addition to the application of MEII in Ghana's port DBE, this study uses expert review interviews for validation. Expert review is an approach of seeking authoritative and independent opinion on a subject from individuals with well-known expertise about a phenomenon (Sandelowski, 1998). In design science research, expert review is pointed as one of the approaches in determining the worth of artefacts (Gregor and Hevner, 2013). Thus, in this study, expert review feedback is used to support validation of the results from the application of MEII. The expert review interviews cover the validity, usability, generality and innovativeness of MEII as a solution to evaluate the impact of DBE interdependencies in value co-creation. In all, a total of five expert review interviews were conducted with individuals with both academic and industry experience on DBE, interdependence and value co-creation. These individuals were selected because they have the theoretical and practical knowledge to provide an independent assessment of MEII, its techniques and results. Two of the experts are from Ghana while three from the United Kingdom. The two experts from Ghana are systems analysts within the port DBE. On the other hand, the three experts from the United Kingdom doubles as academics and systems analytics. The expert reviews were conducted through semi-structured interviews. To aid the interview, an interview guide was designed to elicited responses on the validity, utility, generality and innovativeness of MEII (*see Appendix B*). The results of the expert review interviews are discussed below.

7.6.1 Validity

In design science research, validity determines if an artefact works and does what it is meant to do (Gregor and Hevner, 2013). Thus, in this study, the validity of MEII was evaluated to determine if it works correctly in evaluating the impact of DBE interdependencies in value co-creation. In evaluating validity, this study examines the results from the application of MEII in the vehicle clearing domain of the port DBE. The study first determines if MEII was successful in evaluating the impact of DBE interdependencies. Second, this study evaluates if the results of the application of MEII in the vehicle clearing domain provides information on the impact of the interdependencies. After examining the steps in the application of MEII and the results produced, the experts agreed that the method satisfy the requirement of validity because it works. One expert who doubles as a system and data analyst averred that *"MEII absolutely facilitate interdependence impact evaluation in vehicle clearing in the port DBE"*. He added that *"MEII works perfectly and can be used not only in the vehicle clearing domain but in other aspects of the port DBE. This should tell you that the method works, and it is a needed tool that is long overdue in both research and practice."*

In addition, the experts found MEII to be very useful to both research and practice because the results from its evaluation can support better value co-creation as well as form the basis of strategic planning and decision making. Some of the experts acknowledged that in practice, some interdependence evaluation occurs. However, some of these evaluations are done in silos without considering the holistic effect of other entities. In addition, the experts suggested that most evaluations in practice are more focused on IT systems. Similarly, others claim that some efforts have been made in practice, but these efforts have not been presented in a systematic manner as MEII. As such, MEII is considered a useful and beneficial method that will awake both practitioners and academics to examine interdependencies from a different angle. One expert highlighted the views of others by indicating that *"... most often, there is much focus on software evaluation while there is limited attention on assessing interdependencies that use the software. This method moves a step further to combine all perspectives to enable a holistic evaluation, thus MEII is a very vital artefact. With this method, there can be a better understanding of the value of each interdependence in DBEs so that decisions can be made to remove detrimental ones. Also, without evaluation, it is difficult to effect change in DBEs, therefore this method is valuable and timely."*

7.6.2 Utility

In design science research, utility is one of the key requirements at the evaluation phase. Given that MEII is an outcome of design science research, its utility is evaluated in the expert review. According to Hevner et al. (2004), utility refers to the efficacy of an artefact to perform its intended objective in real use. Specifically, utility demonstrates the usability and efficacy, performance and reliability of a design artefact. It has been acknowledged in the extant literature that utility is a complex concept with different criteria (Venable *et al.*, 2016). Thus, in this study, the utility of MEII is evaluated based on its ease of use (usability), performance and appropriateness.

In terms of usability, responses from the experts support the ease of use capability of MEII in interdependence impact evaluation. The experts asserted that MEII is easy to use because the steps and approaches needed to complete evaluation of DBE interdependencies are self-explanatory. As such, using MEII required less mental effort especially for an analyst who have an understanding of technical and business operations. One expert asserted that *"... the three steps of MEII makes it very easy to follow without detailed training. In cases where training is required to use MEII, less mental effort will be required*. Similarly, another expert posited that "*… for an analyst who understands business operations, this method is easy to follow with little*

or no training but those with limited understanding of business operations may need more training before they can be able to use the method. However, the lack of business knowledge of some analyst is not the fault of the method."

In terms of performance, the experts unanimously agreed that MEII possesses the capabilities to evaluate the impact of DBE interdependencies in value co-creation. Given that MEII is able to articulate all classes of interdependencies between heterogeneous entities, it is considered capable to evaluate the impact of DBE interdependencies. In addition, the experts asserted that based on the results produced by the application of MEII in the vehicle clearing domain, there is no doubt that MEII successfully evaluates the impact of DBE interdependencies. Specifically, the ability of MEII to decompose DBE domains into unit systems, profile interdependencies, measure and assess the impact of interdependencies are highlighted as evidence that demonstrates the efficacy of the method to perform it intended goals. In sum, the experts acclaimed that *"MEII has proven it possesses the efficacy to evaluate the impact of DBE interdependencies in value co-creation as presented by the results."*

Lastly, the experts asserted that MEII is appropriate for interdependence impact evaluation since the results produced provide useful information that was previously not available. Also, the experts argued that MEII is not only appropriate for the vehicle clearing domain but the entire port DBE and beyond because it focuses not only on software, hardware or organisations but on their relationships, hence a suitable fit for interdependence impact evaluation. One expert captured the views of others by saying *"... the method is very appropriate because it will actually draw an attention of most business and data analysts as well as organisations since in practice focus has largely been on only technologies and partners and not the interdependencies that actually lead to value co-creation. As one of the first method in the field to evaluate the impact of interdependencies, I believe it is very apt but as time goes on, improvements can be made."*

7.6.3 Generality

Generality assesses the generic nature of a design artefact to be easily adapted and applicable to other contexts (Venable *et al.*, 2016). In this study, the generality of MEII is evaluated to determine if it is applicable to other contexts of the port DBE and DBEs widely. From the expert feedback, there was a consensus that MEII is a generic solution. The main reason for this consensus is the focus of MEII on interdependencies and not directly on specific organisations, technologies and processes. As such, it is easy to apply MEII in other DBEs. One expert who

doubles as an analyst for Customs asserted that *"the method can be used in all aspects of the port and not only in vehicle clearing. For example, when it comes to the clearing of frozen items, this method can be used to evaluate the impact of those interdependencies in that aspect of the port. Similarly, the method can be used in the export aspect of the port DBE."*

Also, the experts asserted that the results obtained in the application of MEII in the vehicle clearing domain can easily be translated to other aspects of the port. However, they note that there will be some minor changes to the structure and number of interdependencies since entities in other contexts and DBEs may differ. Nonetheless, the experts maintained that the steps of applying MEII and the results of the evaluation will remain unchanged. Another expert posited *"I do not see why this method cannot be used in other aspects of the port DBE because entities are still present in other aspects of the port DBE. I will also say the method is applicable to other business domain apart from the port thus I consider the method to be generic"*

7.6.4 Innovativeness

Innovativeness determines if MEII offers novel contributions to research and practice. In addition, this aspect of the expert review examines if MEII provides some techniques and approaches that advance knowledge on DBE interdependence evaluation. The experts acknowledged the effort in developing MEII as a one-step method that helps to evaluate the impact of DBE interdependencies in value co-creation. Some experts recounted how some attempts have been made already and how MEII improves some of the weaknesses. As such, they considered MEII a novel contribution to both practice and research. For instance, one expert argued, *"…in practice, evaluation is not a new thing, however, developing a method to evaluate the impact of interdependence is very new and a useful contribution".* He continued, *"… people have been doing systems, hardware and other evaluations in practice, however, these activities are sometimes not underpinned by theories and are done in silos. Thus, for a method to be developed with sound theoretical based to evaluate the impact of interdependencies, I will say the method is a needed contribution."*

Also, the experts applauded the innovativeness of MEII in drawing on well-established concepts for its techniques. In MEII, new techniques such as DBE context articulation, interdependence profiling, measurement and impact assessment as well as change management were developed to support the evaluation of DBE interdependencies. Even though some of the techniques are well-grounded in literature, advancements were made by introducing new perspectives that brought inspirations that advance knowledge in research and practice. One

expert asserted *"... bringing approaches from their well-grounded areas to a new area like DBE and realigning them with new components to evaluate the impact of interdependencies is very interesting and a novel contribution to knowledge."* Another expert asserted the innovative of MEII by saying *"the method moves from the realms of theory to practice and thus, a novel contribution. For instance, change management is a well-grounded concept in itself, however, by successfully embedding this concept in the method to guide implementation of recommendations after the evaluation shows the novelty of MEII.*" In sum, the experts considered MEII a timely and needed solution that contributes to both research and practice in new ways.

7.7 Summary

This chapter illustrated the application and validation of MEII using the vehicle clearing domain of Ghana's port DBE as a case study. The chapter first presented an overview of the case study and explicated interdependencies within the vehicle clearing domain. Next, the chapter began the application of MEII by articulating the context of the vehicle clearing domain. Using the unit systems analysis technique, the chapter articulated the unit and sub-unit systems in the vehicle clearing domain. Based on the result, interdependencies within each sub-unit system were articulated. Thereafter, the chapter illustrated the application of the interdependence profiling technique to analyse interactions between entities. After this, the chapter demonstrated the application of techniques approaches within the interdependence rationalisation stage by successfully measuring and assessing the impact of interdependencies in the vehicle clearing domain. Following this, the chapter demonstrated the application of the DBE partnership visualisation technique to provide an overall view of interdependencies within the vehicle clearing domain of the port DBE. The findings from the interdependence evaluation were validated through expert review interviews. In the end, the interviews supported the validity, utility, generality and innovativeness of MEII as a methodological solution to evaluate the impact of DBE interdependencies between entities in value co-creation.

Chapter 8

Critical Discussion

This chapter presents critical discussions of the entire research to demonstrate the value of the study. First, this chapter evaluates the appropriateness and significance of the research problems investigated. Next, the chapter assesses the suitability of the research design used to address the research problems. Thereafter, the chapter provides justifications for investigating DBE partnerships. Following this, the chapter evaluates the significance and the development processes of the meta-model, the kernel theory and MEII. Finally, the chapter evaluates the appropriateness of the application and validation processes.

8.1 Justification for the Research Problems

DBE as a socio-technical environment advocate for better value co-creation through interdependencies between several heterogeneous entities. As such, the success of a DBE does not rest entirely on one entity but on the collective efforts of others. While some interdependencies may be contributing highly to value co-creation outputs, others may be co-destructing value through inefficiencies. Hence, there is a need to have an overall understanding of DBE partnerships and the impact of various interdependencies. Without a systematic evaluation of DBE interdependencies, it will be difficult to (1) foster healthy collaboration between entities to achieve better value co-creation, (2) determine the resilience of DBEs to withstand turbulent periods, (3) advance individual growth of participants, (4) distinguish healthy relationships from harmful ones, (5) support strategic planning initiatives and (6) support decision making.

While the discussions above highlight the importance of understanding DBE partnerships and evaluating the impact of interdependencies, the following limitations exist in both research and practice justifying the importance of the research problems this study addressed.

- First, in the extant IS literature, DBE and interdependence have been largely investigated separately, although interdependencies are identified as core elements of DBEs. In addition, only a few studies in the IS literature investigate interdependencies. Moreover, these studies largely focus on task (e.g., Bailey *et al.*, 2010), process (e.g., Crowston, 1994), routine (e.g.,

Spee *et al.*, 2016) and actor (e.g., Gupta and Maltz, 2015) interdependencies. To a large extent, there have been limited studies on interdependencies between a collection of digital technologies, processes and organisations at the DBE level. In the DBE literature, much research exists on open private sector DBEs while limited research exists on closed public sector DBE, creating a lacuna in knowledge.

- Second, due to the origin and the contemporary nature of DBE, one stream of the extant literature largely focuses on providing an understanding of foundational aspects such as definition, characteristics and genesis (e.g., Nachira *et al.*, 2007; Stanley and Briscoe, 2010). In another stream, other studies have focus on lessons from executed DBE projects (e.g., Darking and Whitley, 2007; Herdon *et al.*, 2012). Although these areas of research are important, there is limited theorisation in DBE research. While there is clarity on the types of interdependencies between entities in DBEs, previous studies (e.g., Pentland *et al.*, 2016; Senyo *et al.*, 2017) have not gone beyond this to explore how the types of interdependencies can be combined with other components such as interdependence classes, outcome flows, behaviour taxonomies and entities to offer a better understanding of DBE partnerships. Hence, there is a need to first articulate components in DBE interdependencies to examine their underlying interactions. However, there is currently no explicit definition for DBE interdependence and partnership, though they are important foundation for other investigations on DBE interactions, hence, there is a need for a clear definition.

- Third, though the design science research enables the creation of artefacts to address business problems (Hevner *et al.*, 2004), it is however weak in advancing the theoretical development of emerging research areas in terms of formulating definitions and providing an understanding of building blocks (Baskerville, 2008). Hence, there is a need to combine design science research with approaches such as Semiotics to advance the development and understanding of a fundamental aspect of contemporary research areas like DBE. Within IS research, the theory of Organisational Semiotics has been useful in investigating socio-technical phenomena within organisations. However, there is limited use of Organisational Semiotics in other research areas like DBE. While Organisational Semiotics offers the valuation framing technique to evaluate the impact of an innovation, the focus is only on social effect whereas operational and strategic impacts are unaccounted for. As interdependencies produce multifaceted impacts, there is a need to extend the valuation framing technique of Organisational Semiotics so that it can holistically evaluate the social, operational and strategic impacts of innovations.

- Fourth, although it has been acknowledged that interdependence evaluation is important (Pentland *et al.*, 2016), there are currently limited methods to carry out this assessment. While the design science research paradigm offers principles to develop artefacts (Hevner *et al.*, 2004), ironically, there is little design-focused research in the DBE field. Currently, some interdependence evaluation approaches exist, however, the focus of these approaches is on value exchanges (Weigand *et al.*, 2007), intangible interdependencies (Allee, 2008), network structure (Battistella *et al.*, 2013) and interdependence patterns (Pentland *et al.*, 2015). In addition, some of these studies largely focus on interdependence modelling and analysis at the business ecosystem level (Fayoumi, 2016; Tian *et al.*, 2008). Thus, there is a need for a sound methodological solution to evaluate the impact of interdependencies in value co-creation at the DBE level.

- Fifth, notwithstanding the limited designed-focused artefacts in DBE research, some few approaches exist, however they are largely conceptual without empirical validation. In addition, these approaches mainly focus on technical issues in DBEs such as risks detection (Hussain *et al.*, 2007b), process interoperability (Figay *et al.*, 2012), technology integration (Korpela *et al.*, 2016) and systems architecture (Svirskas *et al.*, 2008). In contrast, there are limited approaches that address business issues such as formation and behaviour of DBE partnerships as well as interdependence impact evaluation. As most existing DBE artefacts focus on technical issues, they are largely not underpinned by theory. As a result, their logical development processes are missing in the literature, thus these artefacts are difficult to replicate. Therefore, there is a dire need for the development and empirical validation of theoretically sound artefacts that address business issues in DBEs.

- Lastly**,** in practice, DBEs are becoming apparent, resulting in increased collaboration and competition between different organisations across industry boundaries. However, one key trend in practice is that performance evaluation is largely IT-focused, while less attention is paid to interdependencies. Given that interdependencies occur between IT and business entities, they present a generic and a more holistic medium to conduct performance evaluations. In addition, evaluations in practice are sometimes undertaken in isolation without considering the effect of interdependent entities as required at the DBE level. In the current era of DBEs, it is not prudent for organisations to focus solely on internal performance evaluation. In cases where an organisation is a focal link to others, it will be prudent to consider other interdependent relationships in performing evaluations to determine their impact on the overall performance. Also, some existing approaches in

practice for interdependence evaluation are not theoretically-driven, as such, they the lack required rigour for generalisation.

This study resolves the problems enumerated above by offering approaches to gain a better understanding of DBE partnerships and evaluate the impact of interdependencies so that measures can be deployed to address inefficiencies in value co-creation. By demonstrating the importance of the research problems, the next subsection justifies the research process that addresses the aim of this study.

8.2 Justification for the Research Design

Given that methodological choices shape research processes, data collection, analysis, interpretation and findings, it is important to use appropriate approaches. Usually, the choice of research approaches is based on research aim, questions and philosophical inclination of the researcher (Guba and Lincoln, 1994). The justified research problems indicate the need to offer a better understanding of DBE partnerships and a methodological solution as outcomes of this study, which are backed by the research aim. Hence, it was incumbent to select research approaches that align with the research problems and aim. Based on these considerations, this study selects the Semiotics methodology and the design science research after a comprehensive review of existing approaches as an appropriate anchor for the research. Semiotics supported the first aspect of this study's aim through identification and justification of the research problems as well as the establishment of a methodological lens to define and understand DBE partnerships. On the other hand, the design science research supported the awareness of the justified research problems, the suggestion of appropriate theoretical lens, the design of the meta-model and development of the kernel theory and MEII as well as the evaluation processes.

In line with the Semiotics methodology and the design science research, this study adopted the mixed methodology to guide the selection of suitable research method and techniques. Given that this study set out to comprehensively address the research aim, it was required to use both qualitative and quantitative data, hence the choice of the mixed methodology. This choice requires selection of suitable research methods and techniques. As DBE is an emerging phenomenon, there is a blurred boundary in its context. Also, as this study seeks deeper insights into DBE, there is a need to select appropriate methods to demonstrate proof of concepts, ascertain validity, utility generality and innovativeness of its outcomes. Hence, the study uses both qualitative and quantitative data to holistically address the research problems. In the end,

this study selected the case study as the method of inquiry since it aligns with the research methodology, techniques and contextual requirements.

By selecting the Semiotics methodology and the design science research, the mixed methodology and the case study method, this study demonstrates the logical process by which the research aim was addressed (see Figure 3. 2 and 3.3) under the research design. As the methodological choices enabled this study to address the research problems and aim, the choice is considered justified. Based, on these justified methodological choices, processes leading to addressing the first leg of the research aim is justified in the next subsection.

8.3 Justification for Conceptualising DBE Interdependencies and Partnerships

There are different forms of interdependencies that have been discussed in the extant literature such as process, task, actor and technology interdependence. However, these forms of interdependencies generally study one particular object at a time. For instance, process interdependence investigates interactions between processes while actor interdependence examines interactions between individuals and organisations. In DBEs, interdependencies occur between several processes, partners and technologies concurrently. As such, the interdependence conceptualisations in the literature are not suitable to investigate DBE interdependencies. Given that there is no explicit definition in the literature for DBE interdependence and partnership, this study addressed this limitation. As interdependence is a core characteristic of DBEs, it is appropriate to have a definition to drive understanding. Also, having a definition for DBE interdependence support further investigation into interactions in DBEs such as partnerships and interdependence impact evaluation. Hence, this study considers the conceptualisation of a definition for DBE interdependencies and partnerships a necessary prerequisite for further investigation and as such a well-justified endeavour.

Based on the conceptualisation of the definitions, this study moves a step further to provide an understanding of DBE partnerships through their formation and behaviour. DBE involves interdependencies between several entities, as a result, it is important to have an overall understanding of interdependencies and how they are composed. Specifically, understanding DBE partnerships enable delineation of dominate interdependence types, entities, outcome flows, underpinning interactions, interdependence classes and behaviour taxonomies. With these understanding, the fragility of DBEs can be known to address weaknesses. This study proposes articulation of DBE partnership components and analysis of their underlying interactions as a way to explain their formation and behaviours.

Applying this information in a series of steps enables visualisation of DBE partnerships. The result of the DBE partnerships visualisation enables a better understanding of the overall structure of relationships. It also offers a better understanding of the connection between entities. Again, it offers a better appreciation of the link between the operations and results in DBEs. Lastly, this knowledge is important to support strategic choices of how value co-creation can be reorganised based on results from the interdependence evaluation. Given that understanding DBE partnerships is an essential step in the overall interdependence evaluation and it also provides useful knowledge on the structural view of interactions, it is considered a critical endeavour in this study. As such, discussions on DBE partnerships through analysis of their formation, behaviour and visualisation are regarded as a justifiable undertaking.

8.4 Justification for the Development of a Meta-Model and a Kernel Theory for MEII

The design science research basically involves two main activities, namely build and evaluate. The build activity involves design and development of artefacts to solve business problems. Given that the second aspect of this study's aim is to develop a method to evaluate the impact of interdependencies in value co-creation, the build action of the design science research was invoked. As a result, a metal-model was first designed to serve as a reference for the development of MEII. Because, without first designing the meta-model, MEII might not be properly developed. The meta-model as a blueprint leverages theoretical principles to form the core concepts of MEII. As any artistic endeavour, the design of the meta-model went through several iterative processes where individual evaluation episodes were used to determine the fit between the philosophical and logical alignments between underlying concepts.

As Organisational Semiotics is the theoretical lens of this study, principles from its methods such as unit analysis and valuation framing were in the design of the meta-model. As a socio-technical theory, Organisational Semiotics principles supported context articulation and social impact assessment components of the meta-model. Given that Organisational Semiotics theory is limited to social impact assessment through valuation framing. This study leverages the extant management literature to develop two additional impact metrics, namely operational and strategic effects to present a holistic interdependence measurement approach. In the end, three impact measurement metrics, operational, social and strategic are integrated into the meta-model to enable MEII assesses the impact of interdependencies. For each metric, there are individual criteria that support the impact evaluation of interdependencies.

Building on, this study develops a kernel theoretical proposition that the impact of DBE interdependencies can be measured through social, operational and strategic metrics. The kernel theory supported the design of the meta-model and MEII in evaluating the impact of DBE interdependencies as demonstrated in the case study of the vehicle clearing domain. As such, the kernel theory is considered justified. The kernel theory recognises the effect of a DBE's context on the measurement criteria, thus, generic elements were used for each metric. In all, the meta-model demonstrated how principles from existing theory and the kernel theory can be used as underlying concepts of design science research artefacts. The findings from the application and validation of MEII resulted in the successful visualisation of interactions, which in turn offered a better understanding of the DBE partnership. Similarly, the application process also resulted in the successful evaluation of the impact of the interdependencies in the case study domain. By these outcomes, this study considers the design of the meta-model and the kernel theory justified.

8.5 Justification for the Development Process of MEII

From the blueprint of the meta-model, MEII is developed as a methodological solution to evaluate the impact of DBE interdependencies. MEII as the final artefact of this study presents a solution to the research aim. Specifically, MEII offer techniques to understand DBE partnerships through visualisation of interactions, articulation of DBEs' context, identification, analysis, measurement and assessment of the impact of interdependencies. The development process of MEII benefited from the conceptualisations in the blueprint of the meta-model. However, the operationalisation of individual components required iterative development process to successfully align all concepts. After several iterations, a final version of MEII was developed as presented in Figure 6.1. The current version of MEII details three stages of conducting interdependence impact evaluation. In the first stage, MEII develops the unit system analysis, interdependence identification and visualisation techniques to define the scope of the evaluation and illustrate relationships between DBE entities. In the second stage, MEII develops the interdependence profiling technique to analyse interactions identified from a DBE context. Lastly, MEII develops the interdependence measurement, impact assessment and change management techniques in stage 3. For instance, it was during the development phase of MEII that the interdependence profiling technique was finally established to enable analysis of interdependenceies. Similarly, the development phase enables formulation of mathematical equations to normalise data from different instruments and calculate overall impact scores from the three metrics.

In the current form, the stages and components of MEII have been made explicit so that analyst can easily understand DBE partnerships and perform interdependence impact evaluation whereas this was not clear during the design of the meta-model. As such, the development phase of MEII is considered critically evaluated to justify its importance in this study. As a design science research artefact, MEII requires evaluation to demonstrates its appropriateness. As such, the next section justifies the application of MEII in the vehicle clearing domain of Ghana's port DBE.

8.6 Justification for the Application and Validation of MEII

As a requirement in design science research, developed artefacts need application to demonstrate their appropriateness and utility. In this study, MEII was applied in the vehicle clearing domain of Ghana's port DBE. The application of MEII in the case study reveals some issues and challenges encountered. For instance, due to privacy and security concerns, there was no access to operational data such as system logs and transaction data. Ideally, it would have been good to have access to these data, however, in their absence, this study utilised survey and interview data. This DBE was used because it provided an empirical instantiation, hence, a revelatory fit to demonstrate validity and utility of MEII.

To complement results from the empirical application, expert review interviews were conducted with IS professionals and academics to validate MEII. Given that there was no access to operational data, the expert review result was deemed critical. For the expert review interviews, a series of questions were designed to elicit responses on the validity, utility, generality and innovativeness of MEII. The findings from the expert review interviews in addition to the case study demonstrate the capabilities of MEII to successfully articulate DBEs context, identify, visualise, analyse, measure and assess the impact of DBE interdependencies in value co-creation. The application and validation of MEII through the case study and the expert reviews enabled the establishment of the research contributions and limitations. As such, the application and validation are deemed justified because, without these, it would have been difficult to attain the findings.

8.7 Summary

This chapter presented a critical evaluation of the entire research process through justifications of key aspects of the study. First, the chapter discussed the relevance of the research problems to justify the value of the outcomes achieved. Based on the justified research problems, the chapter discussed the rationale for the research design. Following this, the chapter provided a

justification for conceptualising DBE interdependencies and partnerships. Next, the chapter provided a critical evaluation of the meta-model and the kernel theory by justifying the process of leveraging concepts from Organisational Semiotics and the management literature to support the development of MEII. The development process of MEII was also critically evaluated to demonstrate its importance and how the meta-model featured in the final method. Lastly, the chapter provided a critical evaluation of the application and validation of MEII to justify its validity, utility, generality and innovativeness as a holistic solution to understand DBE partnerships and evaluate the impact of DBE interdependencies.

Chapter 9

Conclusion, Contributions, Limitations and Future Works

This chapter concludes the study by presenting the summary of previous chapters, the contributions, limitations and recommendations for future research. First, the chapter presents concluding remarks which summarise discussions in the preceding chapters on how the research questions were addressed. Then, the chapter presents theoretical, methodological and practical contributions, after which the chapter presents limitations. Finally, the chapter provides recommendations for future works.

9.1 Concluding Remarks

This section presents concluding remarks on the entire research process and assesses how the research aim and the objectives were addressed in the thesis. While DBE offers numerous benefits and can be an effective organisational strategy, some of its interdependencies can be detrimental to value co-creation (Fayoumi, 2016). Thus, some interdependencies make positive contributions to value co-creation in DBEs while others lead to inefficiencies. In addition, there is less clarity on the formation and behaviour of DBE partnerships in the literature. To this end, it is important to understand DBE partnerships and evaluate the contributions of various DBE interdependencies towards improved value co-creation.

However, in the extant IS literature, there is limited understanding of DBE partnerships while approaches for evaluating the impact of interdependencies are arguably not available due to the paucity of interdependence research. Though some approaches exist, they largely focus on interdependence modelling and analysis (e.g., Fayoumi, 2016; Senyo *et al.*, 2017; Tian *et al.*, 2008), value exchanges (e.g., Weigand *et al.*, 2007), intangible interdependencies (e.g., Allee, 2008), network structure (e.g., Battistella *et al.*, 2013) and interdependence patterns (e.g., Pentland *et al.*, 2015) at the business ecosystem level with little emphasis on measuring the impact of interdependencies. Moreover, one key trend in practice is that performance evaluation is largely IT-focused, while less attention is paid to interdependencies. Also, some of these evaluations are sometimes undertaken in isolation without considering the effect of interdependent entities as required at the DBE level.

In response to these limitations, this study began with the aim to understand DBE partnerships and develop a method to evaluate the impact of interdependencies between entities in value co-creation. The developed method accommodates the culture of physical interactions between transacting parties. As such, both physical and digital interactions are acceptable in the method. With this, the Ghanaian culture of physical interaction between contracting parties is capture by the method. In line with this aim, the study formulated five research questions: (1) What are the limitations in the extant DBE literature and interdependence evaluation approaches? (2) What are DBE partnerships and how can we explain their formation and behaviour in value co-creation? (3) How can a set of metrics be developed to measure the impact of DBE interdependencies? (4) How can a method be developed to evaluate the impact of DBE interdependencies? and (5) How can a method for evaluating the impact of DBE interdependencies be used in practice? How these research questions were addressed in this thesis are as follows:

Chapter 2 addressed the first research question by providing a critical review of the DBE literature and identifying gaps that motivated this study. The chapter discussed the evolutional development of DBE as the foundation for the review. Building on this, the chapter reviewed the extant DBE literature and derived four themes, namely business, technical, DBE conceptualisation and artefacts. In addition, the chapter reviewed the literature on interdependence where types and forms of interdependencies were discussed. Also, the chapter reviewed existing interdependence evaluation approaches and highlighted their limitations. The review shows that there is limited research on interdependence in the extant DBE literature. In addition, there is less clarity on DBE partnerships as most studies only discuss interdependence types. Moreover, the literature shows that some interdependence evaluation approaches exist, but attempts have not been made to move beyond analysis and modelling to holistically measure the impact of DBE interdependencies.

Chapter 3 supported the entire study by discussing the foundation to address the research questions as stated in Chapter 1. The chapter discussed the philosophical assumptions from the perspective of ontology, epistemology and methodology to support the research design. The chapter discussed the four main research paradigms: positivism, interpretivism, critical and design science research. In terms of methodology, the chapter discussed the qualitative, quantitative and the mixed methodologies. Similarly, the chapter discussed some dominant research methods in IS to support the selection of an appropriate research strategy. In the end, the Semiotics methodology and the design science research were selected as the methodological

lens to address the dual aims of the study. In line with the principles of these approaches, the chapter provided solutions to explain the formation and behaviour of DBE partnerships and evaluate the impact of interdependencies.

Chapter 4 addressed the second research question of this study by conceptualising DBE partnerships and providing an explanation of their formation and behaviour. The chapter first provided a definition of DBE interdependence as the foundation for partnerships. Next, the chapter developed a notation to identify and delineate DBE interdependencies. In addition, the chapter also discussed DBE partnership and its components to understand their formation and behaviour. The chapter highlighted limitations in the extant literature as the motivation for the conceptualisation of DBE interdependence and partnership. The chapter also shows that DBE partnerships can be understood through the collective effort of the underlying relationships between components such as interdependence types, classes, outcome flows and behaviour. Specifically, understanding DBE partnerships enable delineation of dominate interdependence types, entities, outcome flows, underpinning interactions, interdependence classes and behaviour taxonomies.

Chapter 5 extended the discourse by conceptualising metrics, a kernel theory and a meta-model for MEII by addressing the third research question. The chapter discussed the rationale behind conceptualising operational, social and strategic metrics to evaluate the impact of DBE interdependencies in value co-creation. For each metric, the chapter presented the process for selecting individual criterion and the justification for each choice. In addition, the chapter designed a meta-model as a blueprint for MEII. Based on the metrics, the chapter postulated a kernel theory on metrics to evaluate the impact of DBE interdependencies. In all, the chapter shows how metrics, a meta-model and a kernel theoretical proposition can be created to facilitate the development of MEII as a DBE artefact.

Chapter 6 developed MEII, the methodological solution to evaluate the impact of DBE interdependencies to address the fourth research question. The chapter first presented MEII by explicating its development processes, stages and components. Thereafter, the chapter detailed the three stages of MEII and how to operationalise inherent techniques. The chapter shows how the first stage of MEII can help in context articulation through decomposition of DBEs' domain and elicitation of interdependencies. Similarly, the chapter demonstrates how the second stage of MEII supports interdependence analysis through the interdependence profiling technique. Lastly, the chapter shows how the interdependence rationalisation stage of MEII enables

interdependence measurement, impact assessment and change management to complete the entire evaluation procedure. In all, this chapter demonstrated the main contribution of this study by developing MEII.

Chapter 7 addressed the fifth research question of this study by demonstrating how to apply and validate MEII in an empirical setting. The chapter first provided an overview of Ghana's port DBE and the vehicle clearing domain as the case study. Then the chapter explicated entities in the case study and the nature of their relationships. Following this, the chapter illustrated the application of MEII using the case study to articulate the DBE's unit systems, profile, measure and assess the impact of interdependencies. After this, the chapter validated MEII and its findings through expert review feedback. In all, the empirical findings and expert review feedback show that MEII is an appropriate method to understand DBE partnerships and evaluate the impact of DBE interdependencies. The findings also attest to the generality of MEII to be applicable to other DBEs and its innovativeness as a novel contribution to research and practice.

Chapter 8 provided a critical discussion of the entire study to demonstrate how the research aim and the objectives were addressed. The chapter provided justifications for the research problems, research design and exploration of DBE partnerships as well as their formation and behaviour. In addition, the chapter justified the rationale for the theorisation on the metrics for interdependence evaluation, the design of the meta-model, development and the application and validation of MEII. The outcomes of the chapter informed the discussion on the research contributions, limitations and future research directions. Ultimately, the chapter demonstrated the importance of the research aim, appropriateness of the research process, usefulness of the research outcomes and validity of the findings.

9.2 Contributions

In IS research, contributions can be judged by originality in the form of theory development, application of an existing theory in a novel way, development of new methods and approaches as well as the revelation of new empirical insights into a phenomenon useful for research and practice (Ågerfalk, 2014; Gregor, 2006). In design science research, in particular, research contributions can be in the form of developing useful artefacts such as methods, models, frameworks, meta-models, instantiations and kernel theories (Gregor and Hevner, 2013; Kuechler and Vaishnavi, 2008). Given that this research followed in part the design science research, several contributions were made throughout the research process in terms of problem

conceptualisation, research protocol, development of solutions, reflections and communication of results. Overall, the contributions of this study are organised along three main strands, namely theoretical, methodological and practical.

9.2.1 Theoretical Contributions

This study makes several theoretical contributions to IS research in general as well as DBE and interdependence fields in particular in the following ways. First, this study makes a theoretical contribution by designing a meta-model and subsequently developing MEII with inherent techniques to comprehensively evaluate the impact of DBE interdependencies. As established in this study, most DBE research largely focus on platform, (Gawer, 2014; Tiwana, 2015a), capability development (Selander *et al.*, 2013), DBE conceptualisation (Nachira *et al.*, 2007; Stanley and Briscoe, 2010) and system integration (Korpela *et al.*, 2016, 2017). As such, limited approaches exist to evaluate the impact of DBE interdependencies. Also, in the extant literature, DBE and interdependence have largely been studied separately. However, this study demonstrates the theoretical link between the two concepts and how they can be integrated to understand interactions in DBEs as well as evaluate the impact of interdependencies. Again, prior interdependence studies largely focused on task, routine, process and actor relationships (Bailey *et al.*, 2010) within a single organisation while limited understanding exists at the DBE level. The meta-model and MEII in this study move beyond existing studies to integrate three forms of interdependencies in their design and evaluation at the DBE level by considering interactions between multiple heterogeneous entities such as processes, technologies and partners. As such the meta-model and MEII are considered important and timely as they offer capabilities to gain better insights into interdependencies in emerging collaborative networks (Barrett *et al.*, 2016).

Second, this study contributes theoretically to Organisational Semiotics by extending it with two new metrics to theorise and assess the effect of DBE interdependencies on value co-creation. So far, impact evaluation in Organisational Semiotics through valuation framing only focus on social effects. However, this study extends impact assessment in Organisational Semiotics theory with the introduction of operational and strategic effects. This extension is found useful because it provides a complete view to assess the effects of innovation in general and interdependencies in particular. Also, this extension offers Organisational Semiotics the capability to appropriately respond to emerging issues within socio-technical research and practice. With this extension, future studies can conduct comprehensive evaluation through Organisational Semiotics theory. In addition, Organisational Semiotics has largely been used

for systems design (e.g., Li *et al.*, 2014; Liu *et al.*, 2002; Pereira and Baranauskas, 2015), requirement analysis (e.g., Liu, 2005; Sun and Liu, 2001) and IT system evaluation (e.g., Liu *et al.*, 2006; Sun *et al.*, 2016). Thus, this study is among the few to have utilised organisational semiotic theory in DBE and interdependence domains. Thus far, not much is known in Organisational Semiotics literature about DBE and interdependence. The successful application of Organisational Semiotics theory in this study brings new theoretical inspirations and provides a guide that future research can follow.

Third, this study contributes theoretically by demonstrating the application of Semiotics as a research methodology. So far, in the extant literature, Semiotics has largely been used as an analytical lens. However, this study moves beyond the current practices to theoretically extend application of Semiotics as a research methodology. In addition, this study contributes theoretically to IS literature by demonstrating how Semiotics can complement design science research. Arguably, this study is the first to combine Semiotics methodology with design science research. With this exposition, a good foundation has been provided for future studies. Hence, this study contributes an alternative perspective to address design research issues which were previously missing in the literature. Though Mingers and Willcocks's (2017) Semiotics methodology is useful, it lacks empirical application and validation. Again, the methodology does not provide concrete Semiotics approaches as tools in its operationalisation. Hence, this study extends their methodology by first validating it empirically and also pointing out Semiotics tools useful to fully apply the methodology. With this, the study theoretically extends the development of the semiotic methodology

Fourth, this study contributes theoretically by proposing a definition and a notation for DBE interdependence as these important building blocks are not available in the literature. The study defines DBE interdependence as the interactions between two or more processes, digital technologies and partners in a socio-technical network to co-create value. As such, this definition is considered an important contribution to advancing the development of DBE interdependence. As established earlier, there is limited research on interdependence in DBEs. One possible explanation could be the unavailability of a definition to provide a better understanding. Hence, the definition of DBE interdependence is considered critical to the development of DBE research in general. Based on the definition, this study also contributes by developing a notation with seven classes of DBE interdependencies, namely PrPr, PaPa, TeTe, PrTe, PaTe, PrPa and PrTePa to identify and articulate interactions between entities. The notation removes the abstract nature of some DBE interdependencies and offers an empirical

conceptualisation of interactions in real life scenario. The notation also provides inimitable benefits to DBE partnerships in understanding their formation and behaviour. The notation limits mistakes and confusions in DBE partnerships analysis by removing semantic ambiguity. Lastly, the notation provides different classes to accommodate different combinations of DBE interdependencies.

Fifth, this study proposes a kernel theoretical proposition (Kuechler and Vaishnavi, 2008) on metrics to evaluate the impact of DBE interdependencies. Specifically, this study proposes that the impact of DBE interdependencies on value co-creation can be evaluated using operational, social and strategic metrics (see section 5.5). Even though the proposition has not been widely tested, design science research acknowledges the contribution of kernel theories as an artefact to fill knowledge gaps (Gregor, 2006; Gregor and Jones, 2007). Given that there is currently an absence of theoretical proposition on the metrics to evaluate the impact of DBE interdependencies, this study considers the attempt made a contribution to knowledge and a foundation for future theorisations.

Lastly, this study contributes by advancing understanding of the underlying concepts (Corley and Gioia, 2011; Sutton and Staw, 1995) of DBE partnerships, their formation and behaviour in value co-creation. This study highlights the components of DBE partnerships as interdependent types, outcome flows, classes, and behaviour taxonomies that supports understanding of partnership interactions. With this revelation, an overall understanding can be obtained through visualisation of interdependencies based on the components of DBE partnerships. As such, these revelations demonstrate originality and contribution to existing knowledge since this study is arguably the first to make these conceptualisations explicit. This knowledge advances efforts at DBE theorisation since there is currently a limitation in the literature.

9.2.2 Methodological Contributions

This study contributes methodologically by offering new approaches and techniques to understand DBE partnerships and evaluate the impact of interdependencies. Although there are some DBE artefact in the extant literature, the focus has been on technical approaches such as risks detection (Hussain *et al.*, 2007b), technology integration (Korpela *et al.*, 2016) and systems architecture (Svirskas *et al.*, 2008). In contrast, there are limited methodological artefacts that address business-related issues such as interdependence evaluation in DBEs. Hence, the artefacts developed in this study contribute significantly to a critical aspect of DBE

that is in dire need of new methods. MEII's methodological contributions are centred on the investigation of DBE interdependencies, depicting a logical design process and extension of MEASUR methods. This study makes methodological contributions in the following ways:

First, although interdependence has been identified in the literature as the driver and critical part of value co-creation in DBEs, there is lack of appropriate method to evaluate the impact of interdependencies. This problem is compounded by the lack of approaches in practice on interdependence evaluation due to relative newness and requirements involved in developing DBE approaches. Until now, there has not been a single study in the literature that has developed a method to comprehensively evaluate the impact of DBE interdependencies. Thus, this study developed MEII as a methodological solution to evaluate the impact of DBE interdependencies. MEII possesses some unique characteristics that prove its usefulness. First, MEII's generic nature makes it applicable to a wide range of DBEs. Second, MEII is flexible in design to accommodate both objective (e.g., transaction data, process logs, etc.) and subjective data (e.g., perceptual survey). This characteristic of MEII allows for the consideration of both financial and non-financial criteria of interdependencies in the evaluation. Thus, this study considers the development of MEII as a methodological solution for interdependence impact evaluation in DBEs a critical addition to knowledge.

Second, this study contributes methodologically by depicting the logical process of developing MEII through the design of meta-models. In doing so, this study highlights the importance of iterative design process, leveraging theoretical support and systematically deriving components the from literature. In the design of the meta-model, this study performed several iterations until a final meta-model was derived. Within each iteration, this study performed concurrent evaluation episodes to assess philosophical and logical alignment between key concepts. To develop a theoretically sound method, the meta-model leverage approaches from Organisational Semiotics theory such as NAM and PAM. NAM supports elicitation of business rules in interdependence profiling while PAM is adapted for DBE context articulation and definition of social impact assessment metric. Given that interdependence is an amorphous concept, it is difficult to define a set of metrics to measure its impact. However, through a critical analysis process of the extant literature, this study was able to define operational and strategic impact assessment metrics as additional measure to evaluate DBE interdependencies. By demonstrating the logical processes of designing a meta-model for MEII, this study contributes methodologically to existing design science knowledge.

Lastly, though some DBE artefacts exist in the literature, their empirical application and validation are conspicuously missing. A number of reasons such as access to operational data, lengthy processes and validation complexities have been posited (Del Chiappa and Baggio, 2015; Korpela *et al.*, 2017). While there have been some efforts in the design science research on evaluation (e.g., Venable *et al.*, 2016), there are still some limitations since examples provided are not generic and remain vague without clear-cut procedures. As such, the processes echoed in this study on how to apply and validate design science research artefacts such as the MEII makes methodological contributions. Given that most DBE artefacts developed in the literature are still conceptual without rigorous validation, this study can become a useful guide for future studies in validating design science artefacts as empirical validation goes a step further to attest to the utility of artefacts in real life. Thus, by explicating the processes of applying and validating DBE artefacts, this study makes methodological contribution to research.

9.2.3 Practical Contributions

As DBEs are becoming dominant in recent times, this study deliberately set out to make practical contributions in the following ways. First, this study develops MEII as a methodological solution to evaluate the impact of DBE interdependencies. As such, focal partners can use the results from MEII to reorganise interdependencies to foster better value co-creation between entities towards improved performance and overall resilience of DBEs. MEII and its techniques offer a comprehensive medium to articulate DBE contexts, analyse, measure, assess, the impact and reorganise interdependencies. Inherent in MEII are components such as unit system definition that helps to define the scope of evaluation to avoid digression. Similarly, the interdependence profiling technique of MEII enables analysis of DBE interactions to determine underlying problems, business rules, entities and their relationships. In the same vein, the interdependence measurement approach of MEII supports calculation of operational, social and strategic impact scores of interdependencies to comprehensively determine their effect in value co-creation. Due to the flexible nature of MEII, it provides mechanisms to integrate both operational and survey data through data normalisation technique in evaluating DBE interdependence impact scores. As a three-stage method, MEII is user-friendly and easy to be used by both novice and experienced analyst. In addition, MEII provides easily automated mathematics equations to support interdependence impact measurement. With these characteristics, MEII address the perceived ease of use challenge associated with evaluation methods.

Second, as a generic DBE method, the results from MEII are intuitive and applicable to different aspects of DBEs. The results from MEII are directly linked to individual interdependencies, as such, analysts can easily determine which aspects of interdependencies require improvement from the onset. For instance, after performing interdependence impact measurement in MEII, the results are matched to an impact level rating guide that determines whether an interdependence has low, medium or high effect in value co-creation. From this initial result, analysts can know whether an interdependence has a low, medium or high impact in operational, social or strategic dimensions. With this result, analyst have a fair understanding of which aspects of interdependencies may be reorganised. In addition, the impact benchmark guide in the interdependence impact assessment technique of MEII provides some recommendations on reorganisation of interdependencies towards improved value co-creation. These recommendations set the tone for restructuring of interdependencies and provide an indication of which aspects of DBEs require more attention. Given that there is arguably no existing approach that provides intuitive result reporting levels like that of MEII, this study considers this capability a critical contribution in practice.

Lastly, in the DBE literature, the focus has mainly been on open DBEs such as Amazon.com, Alibaba.com and Apple.com. This one-sided focus creates a lacuna in knowledge on closed public sector DBEs. In open private sector DBEs, there are fewer constraints such as legal requirements, strategic direction and membership processes compared to the closed ones. Arguably, our knowledge of DBE in the literature has been restricted to open private sector DBEs while less is known on the closed public sector counterparts. As a result, this study digresses from the norm in the extant literature to investigate closed public sector dominated DBEs to bridge the knowledge gap. From this study, closed public sector DBEs now have their domain-specific artefacts and approaches. Thus, this study not only contributes to practice in general but addresses a key knowledge gap in the literature. By providing a number of contributions to practice, this study demonstrates additional value of MEII in addressing real-life problems. Given that IS research in recent time is strongly advocating dual contributions of studies to research and practice, the contributions echoed in this subsection and preceding ones demonstrate the value of this study.

9.3 Limitations

As no research is without limitations, this study is not an exception, the following are identified as limitations. First, the use of a single embedded case for application and validation limits wide generalisation of this study. Generally, single case studies are criticised by their limitation in

generalisation. This study uses Ghana's port DBE as a case and collected data from multiple partners, making it a single embedded case. Thus, this criticism can be made as a limitation of this study. However, the capabilities of the artefacts developed in this study and their rigorous evaluation process through expert review attest to the generality and utility of MEII. Thus, the developed method as per the tenets of the design science research overcomes the issue of limited generalisation.

Second, this study is limited by not having access to operational data due to privacy and security concerns in the case study domain. As a result, the study used perceptual data collected through surveys and interviews from participants and experts for application and evaluation. Ideally, it would have been good to have access to operational data in the form of transactional statistics and system logs. The transactional data would have help to determine an exact number of activities each interdependence perform. Similarly, the systems log would have help to determine the volume and duration of transactions processed in technology interdependencies. Indeed, to address this concern, this study made conscious effort to make MEII flexible to accommodate both perceptual and system generated data. In mitigating the effect of not having access to transactional data, this study used data triangulation to verify responses from perceptual data collected from participants in Ghana's port DBE. In addition, this study used expert review interviews as a second stage validation. In effect, the limitation of not having access to operational data was not seen to have a significant impact on the outcome of this study.

Lastly, this study is limited by the sole use of a closed public sector DBE as a case study. It would have been ideal to use both closed and open DBEs for evaluation so that the results are easily generalised across both forms. Given that there are some peculiar characteristics of each form of DBE, it would have been interesting to determine if there are differences in the results of evaluation in both DBEs. Even though this study used only one form of DBE for evaluation, it is believed that the positive results from the expert review indicate the applicability of MEII to other contexts. Similarly, the generic nature of MEII and its techniques is an indication that there may not be a vast difference in the result when applied in other DBEs.

9.4 Future Works

Though the aim of this study to understand DBE partnerships and develop a method to evaluate the impact of interdependencies in value co-creation was achieved, some limitations have emerged as an avenue for future studies. Until now, DBE research has largely paid limited

attention to interdependence evaluation in general, thus this study identifies several potential avenues for future studies. As it is impossible to list all avenues for future works, the following significant recommendations are outlined.

First, future studies should validate MEII and its techniques in other DBEs since the current study used a single embedded case study. Given that MEII was evaluated using the vehicle clearing domain of Ghana's port DBE, it is suggested that future studies validate the method in other clearing regimes of the DBE such as export and transit using heterogeneous goods. Similarly, future studies may validate MEII in other DBEs, especially, open private sector DBEs since the current study focused solely on a closed one so that the results can be compared for generalisation purposes.

Second, future studies should incorporate operational data such as system logs and transactional statistics for applicability and validation processes. While the use of perceptual data through survey still provides concrete findings, it would be interesting to complement this with operational data. Thus, future studies should consider using both perceptual and operational data such as system logs, transactional statistics in the application and validation of MEII.

Third, the metrics and techniques in MEII for measuring the impact of DBE interdependencies is purely based on quantitative values. There is a possibility that some qualitative characteristics of interdependencies are not captured in MEII. As these qualitative characteristics could account for some impacts of interdependencies, it is highly recommended for future studies to consider developing qualitative measures to complement the result of MEII.

Finally, in the IS literature, Organisational Semiotics theory has been limited to investigating systems design, modelling, requirement engineering and communication. Even though the theory has the capability to support the study of complex phenomena such as DBE, there has been limited application in a wide range of contexts. As this study is arguably the first to demonstrate the applicability of Organisational Semiotics principles in DBE and interdependence research, it has provided a good example for future works. Thus, it is recommended that future studies use this study as a guide to expand the application and validation of Organisational Semiotics principles in other aspects of DBE research.

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Appendix A

Henley Business School

Research Ethics Committee

Dear Participant,

INFORMATION SHEET

I am a doctoral researcher at the University of Reading, United Kingdom. I am conducting a research that seeks to understand digital business ecosystem (DBE) partnerships and develop a method to evaluate the impact of interdependencies between entities. DBE refers to a network of individuals, organisations and technologies that collectively co-create value. The outcomes of this research are to enable a better understanding of DBE partnerships and a method with embedded approaches that support evaluation of the impact of DBE interdependencies in value co-creation. The outcomes of this research are envisaged to enable improved decision-making towards performance improvement and competitiveness of DBEs such as Ghana's ports.

Please, your participation is entirely voluntary, thus, you can withdraw from the study at any time if you so wish. Also, be assured that the information provided will be treated confidentially and securely disposed after the research. This research has been reviewed for ethical appropriateness by the Ethics and Research Committee of the school. After completion, you can access the research results upon request. Please, do not hesitate to contact me by email if you have queries, or seek clarifications at p.k.senyo@pgr.reading.ac.uk.

Thank you.

Prince Kwame Senyo
(Doctoral Researcher)
Business Informatics, Systems and Accounting
Henley Business School
University of Reading
United Kingdom

Research Questionnaire - Importers

PART A: Demographic Information

1. Name of your organisation ……..

2. What is the employee size of your firm?

☐ 1-10 Employees ☐ 11-50 Employees ☐ 51 – 100 Employees Others…….

3. How long have you been working on the vehicle clearing process at Tema port?

☐ 1 – 2 Years ☐ 3 – 5 Years ☐ 6 – 10 Years ☐ More than 10 years

4. What is your role in your organisation? ……

PART B: Social impact of interdependences in vehicle clearing processes (This aspect of the questionnaire is based on the original scale of Hall (1959) and Liu et al. (2006)

Please rate your perception about how interdependencies in the vehicle clearing processes at Tema Port influence your productivity. Each measure is rated: −3 (strongly disagree); −2 (disagree); −1 (slightly disagree); 0 (not applicable); 1 (slightly agree); 2 (agree) and 3 (strongly agree)

	-3	-2	-1	0	1	2	3
Obtaining UCR							
Do the current processes of obtaining a UCR ensure your job security?							
Do the current processes of obtaining a UCR improve equal opportunity for all?							
Do the current processes of obtaining a UCR allow you to work remotely?							
Do you think the current processes of obtaining a UCR will reduce your importance?							
Do you think the current processes of obtaining a UCR offer opportunity to learn new skills?							
Do you think the current processes of obtaining a UCR offer personal satisfaction?							
Do you think the current processes of obtaining a UCR ensure confidentiality?							
Do you think the current duration of obtaining a UCR is too long?							
Do you think the current processes of obtaining a UCR ensure competitiveness?							
Do you think the current processes of obtaining a UCR foster collaborative attitude?							
IDF Submission							
Do the current IDF submission processes ensure your job security?							
Do the current IDF submission processes improve equal opportunity for all?							
Do the current IDF submission processes allow you to work remotely?							
Do you think the current IDF submission processes will reduce your importance?							
Do you think the current IDF submission processes offer opportunity to learn new skills?							
Do you think the current IDF submission processes offer personal satisfaction?							
Do you think the current IDF submission processes ensure confidentiality?							
Do you think the duration of the current IDF submission process is too long?							
Do you think the current IDF submission processes ensure competitiveness?							
Do you think the current IDF submission processes foster collaborative attitude?							
Application for CCVR							
Do the current CCVR application processes ensure your job security?							

	-3	-2	-1	0	1	2	3
Do the current CCVR application processes improve equal opportunity for all?							
Do the current CCVR application processes allow you to work remotely?							
Do you think the current CCVR application processes will reduce your importance?							
Do you think the current CCVR application processes offer opportunity to learn new skills?							
Do you think the current CCVR application processes offer personal satisfaction?							
Do you think the current CCVR application processes ensure confidentiality?							
Do you think the duration of the current CCVR application process is too long?							
Do you think the current CCVR application processes ensure competitiveness?							
Do you think the current CCVR application processes foster collaborative attitude?							
Customs declaration submission (BoE)							
Do the current declaration submission processes ensure your job security?							
Do the current declaration submission processes improve equal opportunity for all?							
Do the current declaration submission processes allow you to work remotely?							
Do you think the current declaration submission processes will reduce your importance?							
Do you think the current declaration submission processes offer opportunity to learn new skills?							
Do you think the current declaration submission processes offer personal satisfaction?							
Do you think the current declaration submission processes ensure confidentiality?							
Do you think the duration of the current declaration submission process is too long?							
Do you think the current declaration submission processes ensure competitiveness?							
Do you think the current declaration submission processes foster collaborative attitude?							
Application for shipping release							
Do the current shipping release application processes ensure your job security?							
Do the current shipping release application processes improve equal opportunity for all?							
Do the current shipping release application processes allow you to work remotely?							
Do you think the current shipping release application processes will reduce your importance?							
Do you think the current shipping release application processes offer opportunity to learn new skills?							
Do you think the current shipping release application processes offer personal satisfaction?							
Do you think the current shipping release application processes ensure confidentiality?							
Do you think the duration of the current shipping release application process is too long?							
Do you think the current shipping release application processes ensure competitiveness?							
Do you think the current shipping release application processes foster collaborative attitude?							
Duty, shipping line and waybill payment							
Do the current duty, shipping line and waybill payment processes ensure your job security?							
Do the current duty, shipping line and waybill payment processes improve equal opportunity for all?							
Do the current duty, shipping line and waybill payment processes allow you to work remotely?							

	-3	-2	-1	0	1	2	3
Do you think the current duty, shipping line and waybill payment processes will reduce your importance?							
Do you think the current duty, shipping line and waybill payment processes offer opportunity to learn new skills?							
Do you think the current duty, shipping line and waybill payment processes offer personal satisfaction?							
Do you think the current duty, shipping line and waybill payment processes ensure confidentiality?							
Do you think the duration of the current duty, shipping line and waybill payment processes is too long?							
Do you think the current duty, shipping line and waybill payment processes ensure competitiveness?							
Do you think the current duty, shipping line and waybill payment processes foster collaborative attitude?							
Obtaining temporary (DP) number plate							
Do the current processes of obtaining a DP plate ensure your job security?							
Do the current processes of obtaining a DP plate improve equal opportunity for all?							
Do the current processes of obtaining a DP plate allow you to work remotely?							
Do you think the current processes of obtaining a DP plate will reduce your importance?							
Do you think the current processes of obtaining a DP plate offer opportunity to learn new skills?							
Do you think the current processes of obtaining a DP plate increase offer personal satisfaction?							
Do you think the current processes of obtaining a DP plate ensure confidentiality?							
Do you think the duration of the current processes of obtaining a DP plate is too long?							
Do you think the current processes of obtaining a DP plate ensure competitiveness?							
Do you think the current processes of obtaining a DP plate foster collaborative attitude?							
Using the e-MDA platform							
Do you think the use of the e-MDA platform reduces errors?							
Do you think the use of the e-MDA platform improves equal opportunity for all?							
Do you think the use of the e-MDA platform will reduce your importance?							
Do you think the use of the e-MDA platform assists better and faster decision-making?							
Do you think the use of the e-MDA platform increases your efficiency?							
Do you think the use of the e-MDA platform enables you to work remotely?							
Do you think the use of the e-MDA platform supports self-learning for problem solving?							
Do you think the use of the e-MDA platform improves communication with key stakeholders?							
Do you think the use of the e-MDA platform motivates you to achieve excellent job performance?							
Do you think the use of the e-MDA platform increases your personal satisfaction in achieving quality output?							
Using the PAARS platform							
Do you think the use of the PAARS platform reduces errors?							
Do you think the use of the PAARS platform improves equal opportunity for all?							
Do you think the use of the PAARS platform will reduce your importance?							
Do you think the use of the PAARS platform assists better and faster decision-making?							
Do you think the use of the PAARS platform increases your efficiency?							

	-3	-2	-1	0	1	2	3
Do you think the use of the PAARS platform enables flexible work style or mode?							
Do you think the use of the PAARS platform supports self-learning for problem solving?							
Do you think the use of the PAARS platform improves communication with key stakeholders?							
Do you think the use of the PAARS platform motivates you to achieve excellent job performance?							
Do you think the use of the PAARS platform increases your personal satisfaction in achieving quality output?							
Using the GCMS platform							
Do you think the use of the GCMS platform reduces errors?							
Do you think the use of the GCMS platform improves equal opportunity for all?							
Do you think the use of the GCMS platform will reduce your importance?							
Do you think the use of the GCMS platform assists better and faster decision-making?							
Do you think the use of the GCMS platform increases your efficiency?							
Do you think the use of the GCMS platform enables flexible work style or mode?							
Do you think the use of the GCMS platform supports self-learning for problem solving?							
Do you think the use of the GCMS platform improves communication with key stakeholders?							
Do you think the use of the GCMS platform motivates you to achieve excellent job performance?							
Do you think the use of the GCMS platform increases your personal satisfaction in achieving quality output?							
Using the GICCS platform							
Do you think the use of the GICCS platform reduces errors?							
Do you think the use of the GICCS platform improves equal opportunity for all?							
Do you think the use of the GICCS platform will reduce your importance?							
Do you think the use of the GICCS platform assists better and faster decision-making?							
Do you think the use of the GICCS platform increases your efficiency?							
Do you think the use of the GICCS platform enables flexible work style or mode?							
Do you think the use of the GICCS platform supports self-learning for problem solving?							
Do you think the use of the GICCS platform improves communication with key stakeholders?							
Do you think the use of the GICCS platform motivates you to achieve excellent job performance?							
Do you think the use of the GICCS platform increases your personal satisfaction in achieving quality output?							

Part C: Operational impact assessment

Please rate your perception about the effectiveness and efficiency of the following in the vehicle clearing processes at Tema port. Each measure is rated: −3 (strongly disagree); −2 (disagree); −1 (slightly disagree); 0 (indifferent); 1 (slightly agree); 2 (agree) and 3 (strongly agree).

		-3	-2	-1	0	1	2	3
Obtaining UCR	The cost involved in processing a UCR is acceptable.							
	The duration for processing a UCR is acceptable.							
	The quality of service received in processing a UCR is acceptable.							
IDF Submission	The cost involved in processing an IDF is acceptable.							
	The duration for processing an IDF is acceptable.							

		-3	-2	-1	0	1	2	3
	The quality of service received in processing an IDF is acceptable.							
Application for CCVR	The cost involved in applying for a CCVR is acceptable							
	The timeframe for getting a CCVR is acceptable							
	The service quality in getting a CCVR is acceptable							
Declaration submission	The cost involved in processing vehicle declaration is acceptable							
	The time involved in processing vehicle declaration is acceptable							
	The service quality of processing a vehicle declaration is acceptable							
Duty payment	How will you rate the cost involved in the process of duty payment?							
	How will you rate the time involved in the process of duty payment?							
	How will you rate the service quality involved in the process of duty payment?							
Request for shipping line release of vehicle	How will you rate the cost involved to request for release a vehicle from a shipping line?							
	How will you rate the duration of a request for shipping line release of a vehicle?							
	How will you rate the service quality during the release of a vehicle from the shipping line?							
Vehicle examination	The cost incurred in vehicle examination is acceptable							
	The duration of vehicle examination is acceptable							
	The service quality received from vehicle examination is acceptable							
Obtaining temporary number plate	The cost of obtaining a temporary DVLA plate is acceptable							
	The time to obtaining a temporary DVLA plate is acceptable							
	The service quality received in obtaining a temporary DVLA plate is acceptable							
Preventive crosscheck	How will you rate the cost incurred in the process of preventive crosscheck and release of vehicle?							
	How will you rate the time spent in the process of preventive crosscheck and release of vehicle?							
	How will you rate the service quality during the process of preventive crosscheck and release of vehicle?							
eMDA platform	The cost incurred using the e-MDA platform is acceptable							
	The time it takes the e-MDA platform to process transactions is acceptable							
	The service quality and support from the e-MDA platform is acceptable							
PAARS platform	The cost incurred using the PAARS platform is acceptable							
	The time it takes the PAARS platform to process transactions is acceptable							
	The service quality and support from the PAARS platform is acceptable							
GCMS platform	The cost incurred using the GCMS platform is acceptable							
	The time it takes the GCMS platform to process transactions is acceptable							
	The service quality and support from the GCMS platform is acceptable							
GICCS platform	The cost incurred using the GICCS platform is acceptable							

		-3	-2	-1	0	1	2	3
	The time it takes the GICCS platform to process transactions is acceptable							
	The service quality and support from the GICCS platform is acceptable							

Part D: Strategic Impact Assessment

(1) Please rate your perception about the priority ranking of the following interdependencies in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Obtaining UCR					
Submission of import declaration form (IDF)					
Application for CCVR					
Declaration submission					
Duty payment					
Vehicle examination					
Application for shipping line					
Obtaining temporary number plate					
Preventive crosschecking and release					
Using the eMDA platform					
Using the PAARS platform					
Using the GCMS platform					
Using the GICCS platform					

(2) Please rate your perception about the effect of these interdependencies on customer satisfaction in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest importance) and 5 (highest importance)

	1	2	3	4	5
Obtaining UCR					
Submission of import declaration form (IDF)					
Application for CCVR					
Declaration submission					
Duty payment					
Vehicle examination					
Application for shipping line					
Obtaining temporary number plate					
Preventive crosschecking and release					
Using the eMDA platform					
Using the PAARS platform					
Using the GCMS platform					
Using the GICCS platform					

(3) Please rate your perception about the effect of the following interdependencies on revenue in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Obtaining UCR					
Submission of import declaration form (IDF)					
Application for CCVR					
Declaration submission					
Duty payment					
Vehicle examination					

Application for shipping line					
Obtaining temporary number plate					
Preventive crosschecking and release					
Using the eMDA platform					
Using the PAARS platform					
Using the GCMS platform					
Using the GICCS platform					

(4) Please rate your perception about the effect of the following interdependencies on regulatory issues in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Obtaining UCR					
Submission of import declaration form (IDF)					
Application for CCVR					
Declaration submission					
Duty payment					
Vehicle examination					
Application for shipping line					
Obtaining temporary number plate					
Preventive crosschecking and release					
Using the eMDA platform					
Using the PAARS platform					
Using the GCMS platform					
Using the GICCS platform					

Research Questionnaire - Customs Examination Officers

PART A: General information about vehicle clearing processes

1. What is your role in Ghana Customs? ……
2. How long have you been working with Ghana Customs?.....
3. How long have you been working on vehicle clearing?.....

4. What are the current processes of performing a vehicle examination?

5. Which technology platforms (e.g. GCMS, JIMIS, PAARS, etc.,) do you use when performing vehicle examination?

6. What are the challenges with the current vehicle clearing processes?

7. What possible solutions do you think can resolve some of the challenges?

8. How is the impact of interdependencies between agencies, processes and technologies on vehicle clearing processes at Ghana's ports currently evaluated?

9. Do you think there is a need for a systematic approach to evaluate the impact of interdependencies on efficiency and effectiveness at Tema port? IF YES or NO, why?

10. What do think should be included in an approach to evaluate the impact of interdependencies at Tema port?

11. Can Customs examination officers be replaced in the vehicle clearing processes? If YES or NO provide some justifications?

PART B: Social Impact Assessment

Please rate your perception about the impact of the following interdependencies in the vehicle clearing processes at Tema Port influence your productivity. Each measure is rated: −3 (strongly disagree); −2 (disagree); −1 (slightly disagree); 0 (not applicable); 1 (slightly agree); 2 (agree) and 3 (strongly agree)

	-3	-2	-1	0	1	2	3
Performing vehicle examination							
Do the current vehicle examination procedures ensure your job security?							
Do the current vehicle examination procedures improve equal opportunity for all?							
Do the current vehicle examination procedures allow you to work remotely?							
Do you think the current vehicle examination procedures reduce your importance?							
Do you think the current vehicle examination procedures offer opportunity to learn new skills?							
Do you think the current vehicle examination procedures offer personal satisfaction?							
Do you think the current vehicle examination procedures ensure confidentiality?							
Do you think the duration of the current vehicle examination procedures is too long?							
Do you think the current vehicle examination procedures ensure competitiveness?							
Do you think the current vehicle examination procedures foster collaborative attitude?							
Using the GCMS platform							

Do you think the use of the GCMS platform reduces errors?							
Do you think the use of the GCMS platform improves equal opportunity for all?							
Do you think the use of the GCMS platform will reduce your importance?							
Do you think the use of the GCMS platform assists better and faster decision-making?							
Do you think the use of the GCMS platform increases your efficiency?							
Do you think the use of the GCMS platform enables flexible work style or mode?							
Do you think the use of the GCMS platform supports self-learning for problem solving?							
Do you think the use of the GCMS platform improves communication with key stakeholders?							
Do you think the use of the GCMS platform motivates you to achieve excellent job performance?							
Do you think the use of the GCMS platform increases your personal satisfaction in achieving quality output?							

Part C: Operational impact assessment

Please rate your perception about the effectiveness and efficiency of the following in the vehicle clearing processes. Each measure is rated: −3 (strongly disagree); −2 (disagree); −1 (slightly disagree); 0 (indifferent); 1 (slightly agree); 2 (agree) and 3 (strongly agree).

		-3	-2	-1	0	1	2	3
Vehicle examination procedures	The cost involved in vehicle examination procedures is acceptable.							
	The timeframe for vehicle examination is acceptable.							
	The service quality in vehicle examination procedures is acceptable.							
GCMS platform	The cost incurred in using the GCMS platform is acceptable.							
	The timeframe for processing transactions on the PAARS platform is acceptable.							
	The service quality and support from the GCMS platform is acceptable.							

Part D: Strategic impact assessment

(1) Please rate your perception about the priority ranking of the following interdependencies in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Vehicle examination procedures					
GCMS platform					

(2) Please rate your perception about the effect of these interdependencies on customer satisfaction in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest importance) and 5 (highest importance)

	1	2	3	4	5
Vehicle examination procedures					
GCMS platform					

(3) Please rate your perception about the effect of the following interdependencies on revenue in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Vehicle examination procedures					
GCMS platform					

(4) Please rate your perception about the effect of the following interdependencies on regulatory issues in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Vehicle examination procedures					
GCMS platform					

Research Questionnaire - Customs Compliance Officers

PART A: General information

1. What is your role in Ghana Customs? ……
2. How long have you been working with Ghana Customs?.....
3. How long have you been working on vehicle clearing?.....

4. What are the current compliance processes during vehicle clearing?

5. Which technology platforms do you use when conducting compliance procedures?

6. What are the challenges with the current vehicle clearing processes?

7. What possible solutions do you think can resolve some of the challenges?

8. How is the impact of interdependencies between agencies, processes, and technologies on vehicle clearing processes at Ghana's ports currently evaluated?

9. Do you think there is a need for a systematic approach to evaluate the impact of interdependencies on efficiency and effectiveness at Tema port? IF YES or NO, why?

10. What do think should be included in an approach to evaluate the impact of interdependencies at Tema port?

11. Can Customs be replaced in the vehicle clearing processes? If YES or NO provide some justifications?

PART B: Social Impact Assessment

Please rate your perception about the impact of the following interdependencies in the vehicle clearing processes on your productivity. Each measure is rated: −3 (strongly disagree); −2 (disagree); −1 (slightly disagree); 0 (not applicable); 1 (slightly agree); 2 (agree) and 3 (strongly agree)

	-3	-2	-1	0	1	2	3
Validating declarations for compliance							
Do the current compliance procedures ensure your job security?							
Do the current compliance procedures improve equal opportunity for all?							
Do the current compliance procedures allow you to work remotely?							
Do you think the compliance processing procedures will reduce your importance?							
Do you think the current compliance procedures offer opportunity to learn new skills?							
Do you think the current compliance procedures offer personal satisfaction?							
Do you think the current compliance procedures ensure confidentiality?							
Do you think the duration of the current compliance procedures is too long?							
Do you think the current compliance procedures ensure competitiveness?							
Do you think the current compliance procedures foster collaborative attitude?							
Using the GCMS platform							
Do you think the use of the GCMS platform reduces errors?							
Do you think the use of the GCMS platform improves equal opportunity for all?							
Do you think the use of the GCMS platform will reduce your importance?							
Do you think the use of the GCMS platform assists better and faster decision-making?							
Do you think the use of the GCMS platform increases your efficiency?							
Do you think the use of the GCMS platform enables flexible work style or mode?							
Do you think the use of the GCMS platform supports self-learning for problem solving?							
Do you think the use of the GCMS platform improves communication with key stakeholders?							
Do you think the use of the GCMS platform motivates you to achieve excellent job performance?							
Do you think the use of the GCMS platform increases your personal satisfaction in achieving quality output?							

Part C: Operational impact assessment

Please rate your perception about the effectiveness and efficiency of the following in the vehicle clearing processes. Each measure is rated: −3 (strongly disagree); −2 (disagree); −1 (slightly disagree); 0 (indifferent); 1 (slightly agree); 2 (agree) and 3 (strongly agree).

		-3	-2	-1	0	1	2	3
Validating declarations for compliance	The cost involved in compliance procedures is acceptable.							
	The timeframe for validating declarations for compliance is acceptable.							
	The service quality provided during compliance procedures is acceptable.							
GCMS platform	The cost incurred in using the GCMS platform is acceptable.							
	The timeframe for processing transactions on the GCMS platform is acceptable.							
	The service quality and support from the PAARS platform is acceptable.							

Part D: Strategic impact assessment

(1) Please rate your perception about the priority ranking of the following interdependencies in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Validating declarations for compliance					
GCMS platform					

(2) Please rate your perception about the effect of these interdependencies on customer satisfaction in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest importance) and 5 (highest importance)

	1	2	3	4	5
Validating declarations for compliance					
GCMS platform					

(3) Please rate your perception about the effect of the following interdependencies on revenue in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Validating declarations for compliance					
GCMS platform					

(4) Please rate your perception about the effect of the following interdependencies on regulatory issues in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Validating declarations for compliance					
GCMS platform					

Research Questionnaire - Custom Valuation Officers

PART A: General information about vehicle clearing processes

1. What is your role in Ghana Customs? ……
2. How long have you been working with Ghana Customs?.....
3. How long have you been working on vehicle clearing?.....

4. What are the current processes of performing a vehicle valuation and finally issuing a CCVR?

5. Which technology platforms do you use when processing CCVRs?

6. What are the challenges with the current vehicle clearing processes?

7. What possible solutions do you think can resolve some of the challenges?

8. How is the impact of interdependencies between agencies, processes, and technologies on vehicle clearing processes at Ghana's ports currently evaluated?

9. Do you think there is a need for a systematic approach to evaluate the impact of interdependencies on efficiency and effectiveness at Tema port? IF YES or NO, why?

10. What do think should be included in an approach to evaluate the impact of interdependencies at Tema port?

11. Can Customs be replaced in the vehicle clearing processes? If YES or NO provide some justifications?

PART B: Social Impact Assessment

Please rate your perception about the impact of the following interdependencies in the vehicle clearing processes at Tema Port influence your productivity. Each measure is rated: −3 (strongly disagree); −2 (disagree); −1 (slightly disagree); 0 (not applicable); 1 (slightly agree); 2 (agree) and 3 (strongly agree)

	-3	-2	-1	0	1	2	3
Processing CCVR							
Do the current CCVR processing procedures ensure your job security?							
Do the current CCVR processing procedures improve equal opportunity for all?							
Do the current CCVR processing procedures allow you to work remotely?							
Do you think the current CCVR processing procedures will reduce your importance?							
Do you think the current CCVR processing procedures offer opportunity to learn new skills?							
Do you think the current CCVR processing procedures offer personal satisfaction?							
Do you think the current CCVR processing procedures ensure confidentiality?							
Do you think the duration of the current CCVR processing procedures is too long?							
Do you think the current CCVR processing procedures ensure competitiveness?							
Do you think the current CCVR processing procedures foster collaborative attitude?							
Using the PAARS platform							
Do you think the use of the PAARS platform reduces errors?							
Do you think the use of the PAARS platform improves equal opportunity for all?							
Do you think the use of the PAARS platform will reduce your importance?							
Do you think the use of the PAARS platform assists better and faster decision-making?							
Do you think the use of the PAARS platform increases your efficiency?							
Do you think the use of the PAARS platform enables flexible work style or mode?							
Do you think the use of the PAARS platform supports self-learning for problem solving?							
Do you think the use of the PAARS platform improves communication with key stakeholders?							
Do you think the use of the PAARS platform motivates you to achieve excellent job performance?							
Do you think the use of the PAARS platform increases your personal satisfaction in achieving quality output?							

Part C: Operational impact assessment

Please rate your perception about the effectiveness and efficiency of the following in the vehicle clearing processes. Each measure is rated: −3 (strongly disagree); −2 (disagree); −1 (slightly disagree); 0 (indifferent); 1 (slightly agree); 2 (agree) and 3 (strongly agree).

		-3	-2	-1	0	1	2	3
Valuation of application for CCVR	The cost involved in processing a CCVR is acceptable.							
	The timeframe for processing a CCVR is acceptable.							
	The service quality in processing a CCVR is acceptable.							
PAARS platform	The cost incurred in using the PAARS platform is acceptable.							
	The timeframe for processing transactions on the PAARS platform is acceptable.							
	The service quality and support from the PAARS platform is acceptable.							

Part D: Strategic impact assessment

(1) Please rate your perception about the priority ranking of the following interdependencies in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Valuation of application for issuing Custom Classification and Valuation Report (CCVR)					
PAARS platform					

(2) Please rate your perception about the effect of these interdependencies on customer satisfaction in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest importance) and 5 (highest importance)

	1	2	3	4	5
Valuation of application for issuing Custom Classification and Valuation Report (CCVR)					
PAARS platform					

(3) Please rate your perception about the effect of the following interdependencies on revenue in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Valuation of application for issuing Custom Classification and Valuation Report (CCVR)					
PAARS platform					

(4) Please rate your perception about the effect of the following interdependencies on regulatory issues in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Valuation of application for issuing Custom Classification and Valuation Report (CCVR)					
PAARS platform					

Research Questionnaire - Custom Preventive Officers

PART A: General information about vehicle clearing processes

1. What is your role in Ghana Customs? ……
2. How long have you been working with Ghana Customs?.....
3. How long have you been working on vehicle clearing?.....

4. What are the current processes of performing preventive examination procedures on a vehicle?

5. Which technology platforms (e.g. GCMS, JIMIS, PAARS, etc.,) do you use when performing vehicle examination?

6. What are the challenges with the paperless clearing processes?

7. What possible solutions do you think can resolve some of the challenges?

8. Can Customs Preventive Officers be replaced in the vehicle clearing processes? If YES or NO provide some justifications?

PART B: Social Impact Assessment

Please rate your perception about the impact of the following interdependencies in the vehicle clearing processes at Tema Port influence your productivity. Each measure is rated: −3 (strongly disagree); −2 (disagree); −1 (slightly disagree); 0 (not applicable); 1 (slightly agree); 2 (agree) and 3 (strongly agree)

	-3	-2	-1	0	1	2	3
Performing preventive examination procedures							
Do the current preventive examination procedures ensure your job security?							
Do the current preventive examination procedures improve equal opportunity for all?							
Do the current preventive examination procedures allow you to work remotely?							
Do you think the current preventive examination procedures reduce your importance?							
Do you think the current preventive examination procedures offer opportunity to learn new skills?							
Do you think the current vehicle examination pro preventive examination procedures offer personal satisfaction?							

	-3	-2	-1	0	1	2	3
Do you think the current preventive examination procedures ensure confidentiality?							
Do you think the duration of the current preventive examination procedures is too long?							
Do you think the current preventive examination procedures ensure competitiveness?							
Do you think the current preventive examination procedures foster collaborative attitude?							
Using the GCMS platform							
Do you think the use of the GCMS platform reduces errors?							
Do you think the use of the GCMS platform improves equal opportunity for all?							
Do you think the use of the GCMS platform will reduce your importance?							
Do you think the use of the GCMS platform assists better and faster decision-making?							
Do you think the use of the GCMS platform increases your efficiency?							
Do you think the use of the GCMS platform enables flexible work style or mode?							
Do you think the use of the GCMS platform supports self-learning for problem solving?							
Do you think the use of the GCMS platform improves communication with key stakeholders?							
Do you think the use of the GCMS platform motivates you to achieve excellent job performance?							
Do you think the use of the GCMS platform increases your personal satisfaction in achieving quality output?							

Part C: Operational impact assessment

Please rate your perception about the effectiveness and efficiency of the following in the vehicle clearing processes. Each measure is rated: −3 (strongly disagree); −2 (disagree); −1 (slightly disagree); 0 (indifferent); 1 (slightly agree); 2 (agree) and 3 (strongly agree).

		-3	-2	-1	0	1	2	3
Customs Preventive procedures	The timeframe for vehicle examination is acceptable.							
	The service quality in vehicle examination procedures is acceptable.							
GCMS platform	The timeframe for processing transactions on the PAARS platform is acceptable							
	The service quality and support from the GCMS platform is acceptable.							

Part D: Strategic impact assessment

(1) Please rate your perception about the priority ranking of the following interdependencies in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Customs preventive procedures					
GCMS platform					

(2) Please rate your perception about the effect of these interdependencies on customer satisfaction in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest importance) and 5 (highest importance)

	1	2	3	4	5
Customs preventive procedures					
GCMS platform					

(3) Please rate your perception about the effect of the following interdependencies on revenue in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Customs preventive procedures					
GCMS platform					

(4) Please rate your perception about the effect of the following interdependencies on regulatory issues in the vehicle clearing processes at Tema port. Each measure is rated: 1 (lowest) and 5 (highest)

	1	2	3	4	5
Customs preventive procedures					
GCMS platform					

Appendix B

Expert Review Interview Guide

Questions
Validity
Do you think MEII enables interdependence evaluation in the vehicle clearing domain of the port DBE?
Do you think MEII enables a better understanding of the partnership in vehicle clearing domain of the port DBE?
In what ways do you think MEII enhances understanding of interdependencies in the vehicle clearing domain of the port DBE?
Do you think the results produced by MEII is valuable to effect changes in the vehicle clearing domain of the port DBE?
Utility
Do you think MEII is appropriate for interdependence evaluation in the vehicle clearing domain of the port DBE?
Do you think MEII is easy to use for interdependence evaluation in the vehicle clearing domain of the port DBE?
Do you consider the design of MEII user friendly and easy to understand?
Do you think using MEII will not require a lot of metal effort?
Do you consider the steps of MEII easy to follow?
Generality
Do you think MEII is generic to be used in other port DBEs?
Do you think MEII will provide the same result if used in areas of the port DBE?
Innovativeness
Does MEII provide new approaches and techniques that advance interdependence evaluation?
Does MEII provide techniques to address difficulties in interdependence evaluation?
Do you consider the embedded approaches for interdependence analysis and measurement of MEII novel?