Investigating the Role of Knowledge Management in Driving the Development of an Effective Business Process Architecture

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A thesis submitted in partial fulfilment of the requirements of the University of the West of England, Bristol for the degree of Doctor of Philosophy

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2019

Abstract

Business Process Architecture (BPA) modelling methods are not dynamic and flexible enough to effectively respond to changes. This may create a barrier that contributes to a lack of knowledge and learning capabilities which can affect the BPA regarding its support for a sustainable competitive advantage in an organisation. New business challenges are driving business enterprises to adopt knowledge management as one means of making a positive difference to their performance and competitiveness. However, shortcomings still remain in utilising knowledge management in business processes.

The resource-based view suggests a number of key factors to be investigated and taken into consideration during the development of knowledge management systems. These key factors are known as Knowledge Management Enablers (KMEs). KMEs are crucial for representing knowledge management and understanding how knowledge is created, shared and disseminated. They are also essential to identify available assets and resources in an organisation.

This research is aimed at investigating the role of the KMEs in the development of an effective process architecture. An effective process architecture needs to be dynamic and supports a sustainable competitive advantage in an organisation. Identifying the KMEs, selecting an appropriate BPA method, aligning these KMEs with this method as well as undertaking a critical evaluation of this alignment are the main objectives set for this research. In order to accomplish the research aim and objectives, a resource-based and semantic-enriched framework, namely the KMEOntoBPA has been designed using KMEs to drive the process of BPA development. Organisational structure, culture, information technology, leadership, knowledge context and business repository have been selected as representatives of the KMEs. The object-based BPA modelling, specifically the semantically enriched Riva BPA method has been adopted in order to embrace the knowledge resources generated by KMEs and utilise them in the derivation and re-configuration of its elements. The Design Science Research Methodology is used to guide the research phases with an emphasis on the design and development, demonstration and evaluation of the research framework. The KMEOntoBPA has been demonstrated using sufficient and representative core banking case studies of the *Treasury*, *Deposits* and *Financing*.

The results have revealed that KMEs utilisation provides a dynamic generation of Riva BPA elements, which reflect the real business in each of the core banking business studies. In addition to these results, the research framework, i.e, the KMEOntoBPA has shown an understanding of the flow of knowledge in the bank and has provided several possible

advantages such as the accuracy of service delivery and the improvement of the financial control. It also supports the sources of sustainable competitive advantage: technical capabilities, core competences and social capital. Finally, a number of significant contributions and artefacts have been attained such as the abstract KMEs ontology (aKMEOnt) and a banking Riva-based BPA.

To my mother Sanaa' and my father Omar

To my wife Eman and my daughters Sanaa' and Maria

To my brothers Samer and Saleh

To the spirit of my grandfathers and grandmothers

To my beloved aunts and uncles

To my relatives alive or dead

To my best friends

To the spirits that seek justice and freedom

Acknowledgements

To Allah all praise and glory.

*The Messenger of Allah, peace and blessings be upon him, said, "**He has not thanked Allah who has not thanked people**."*

I would like to thank my teacher and director of studies, Mohammed Odeh and my tutor and second supervisor, Mohammed Saad, for their patience and continuoual support of my PhD research. I would also like to thank every person who supported or contributed to the completion of this work.

My sincere thanks also to my sponsor, Zarqa University, and to the management and employees of the Bank in Jordan and specifically Khalid Rasheed, Rae'd Abu Oun and Nafith Al-Hersh who facilitated the conducting of this research.

I would also like to thank the staff at the University of the West of England, specifically Chris Foggin, Marisa Downham, Bridgett and Stewart Green.

I must also never forget to thank my colleagues who shared with me this long journey. Hamzeh, Ahmad, Eman, Suhair, Sami, Al-Khateeb, Jalabneh, Mais, Dalia, Noura, Shadan, Gaith, Bushra and Rawad.

Finally, I am grateful to my parents, my brothers, my wife and my daughters for their support and patience over all these years which has helped me to complete this journey.

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Glossary

Business Function is a description of an internal behaviour that groups behaviour according to things such as knowledge, required skills and resources. It is also performed by a single business role within enterprise in order to produce products and services. An example of a business function is such as accounting.

Business Process Architecture (BPA) is the map of the core processes that shows the flow of business in an organisation.

Business Service is an external visible functionality that is realised by a business process or function or interaction and meaningful to the environment.

Case Management Process is a Riva BPA element that manages the flow of case processes or the unit of work instances.

Case Process is a Riva BPA element that represents an instance or occurrence of unit of work we look after. Each unit of work is translated into case process and case management process.

Core Competences are the skills and expertise that are shared across an organisation and are difficult to imitate by competitors. They support a sustainable competitive advantage.

Dynamic Business Process Architecture (BPA) is a BPA that reflects up-to-date changes of the environment by showing flexibility in adopting new elements and acting as a near-real-time BPA.

Dynamic Capabilities are the organisation's abilities to integrate, develop and reconfigure the internal and external resources in order to meet rapidly changing business environments.

Essential Business Entity is an entity that characterises the business or part of the essence of the business and cannot get away from. These entities are the first essential building blocks of the Riva BPA method.

Interoperability is the ability to exchange knowledge between different systems or components and utilise this knowledge.

Knowledge Management Enablers are factors that facilitate and stimulate the creation of knowledge in an organisation.

Knowledge Management is the process of creating, capturing, assimilating, adapting, utilising and sharing knowledge in an organisation.

Learning Capability is an evolutionary criterion that shows the system's ability to learn from its experience and the surrounding environment.

Ontology is a set of concepts and their relationships that formally represent knowledge in a specific domain.

Resource-based Theory is a theory that suggests utilising existing resources and capabilities in order to improve an organisation's abilities to adapt changes and sustain its competitive advantage. It also assumes that these resources are valuable, inimitable, rare, and non-substitutable.

Riva BPA method is an object-based BPA method that is used to derive process architecture diagrams through business entities.

Riva "as-is" BPA is the development of the Riva BPA without using any new or external approaches.

Robustness is an evolution criterion that is defined by the ability to respond to the environmental changes.

Semantic Heterogeneity related to the problem of conflict regarding naming while mapping ontologies; it includes synonyms and homonyms.

Social Capital is the collection of resources that are reached through network relationships and represent a source that can support a sustainable competitive advantage.

Static Business Process Architecture (BPA) is a BPA that does not consider up-to-date changes of the environment and lacks flexibility to adopt new elements in order to be a near-real-time BPA.

Sustainable Competitive Advantage is a key indicator for a successful business in an organisation. This indicator is assessed by the ability to create a long-term economic value that is better than competitors in the same market.

Technical Capabilities are the abilities of an organisation to support a sustainable competitive advantage based on new technologies in a changing environment.

Unit of Work is a Riva BPA element that is considered as an essential business entity and has a lifetime during which we look after.

Acronyms

aKMEOnt: Abstract Knowledge Management Enablers Ontology

BPA: Business Process Architecture

CEBEs: Candidate Essential Business Entities

CMP: Case Management Process

CP: Case Process

CSP: Case Strategy Process

DSRM: Design Science Research Methodology

EBEs: Essential Business Entities

EIA: Enterprise Information Architecture

FDA: Frequency Distribution Analysis

IS: Information System

IT: Information Technology

Jess: Java Expert System Shell

KM: Knowledge Management

KMEs: Knowledge Management Enablers

OWL-DL: Ontology Web Language-Description Logic

PA: Process Architecture

RBT: Resource-based Theory

RBV: Resource-based View

SCA: Sustainable Competitive Advantage

SLR: Simple Linear Regression

SOA: Service Oriented Architecture

srBPA: Semantic Enriched Riva Business Process Architecture

SWRL: Semantic Web Rule Language

UOWs: Units of Work

SMEs: Small and Medium-Sized Enterprises

Chapter 1

Introduction

Organisations recognise that increasing their competitiveness requires 'improving the effectiveness and predictability of their design processes' (Browning and Eppinger, 2002). Design processes in an enterprise would not be right and effective without identifying their main activities or processes which involve the dynamic relationships that are crucial in understanding how an enterprise works (Ould, 2005). This set of key processes and their relationships constitute the business process architecture (BPA) of an organisation. A business process architecture is a map of the processes that are required to conduct business and shows how these processes interact, managed and modified over time (Siviy, Penn and Stoddard, 2007). BPA provides an "abstracted view on interrelated processes" and reveals how processes of an enterprise are organised in a way that can assist modellers to "arrive at a consistent and integrated collection of process models" (Eid-Sabbagh et al., 2013, p. 533; Dijkman, Vanderfeesten and Reijers, 2016, p. 129).

Managing knowledge in an organisation with other resources and core competences is significant in order to improve its business processes and develop its sustainable competitive advantage (Du Plessis, 2007; Dawson, 2000). Managing knowledge or knowledge management (KM) refers to "any deliberate efforts to manage the knowledge of an organisation's workforce" (Hislop, 2013, p.56). These efforts can be described as a process for creating, capturing, assimilating, adapting, utilising and sharing knowledge using direct methods such as information and communication technologies (ICT) or indirect ones such as specific organisational culture and social processes (Hislop, 2013; Jafari and Maleki, 2013).

Knowledge is an essential strategic capability in an organisation (Stokvik et al., 2016). However, applying knowledge alone without an appropriate infrastructure and organisational arrangements will not necessarily result in a successful organisation or business. These organisational and infrastructural arrangements or capabilities are known as Knowledge Management Enablers (KMEs) (Mills and Smith, 2011).

Different approaches seek to improve business processes through knowledge management. Nevertheless, none of these approaches has utilised KMEs in order to develop an abstract

level of these processes to represent the BPA of a particular organisation. Thus, this research aims to identify and investigate the relevance of KMEs in developing an effective BPA.

In this chapter, the research problem and motivations are discussed in Section 1.1. Based on the research problem and motivations, the aim and objectives of the research are identified in Section 1.2 to lead into the formulation of the research hypothesis and questions in Section 1.3. Finally, the chapter is concluded with the thesis structure and the list of publications in Sections 1.4 and 1.5, respectively.

1.1 The Research Problem and Motivations

Current approaches of BPA modelling are still static and do not take into consideration the dynamic aspect of the BPA elements. Moreover, developed BPAs are not adding a competitive value to the organisations they are representing. Therefore, a new approach to developing BPA is required to resolve these shortcomings building on current BPA modelling methods.

1.1.1 The Problem Statement

BPA modelling methods are not dynamic in tracing and adopting regular changes that affect BPA processes (Lapouchnian and Sturm, 2015). They are therefore not achieving a competitive advantage during the BPA development, which involves innovation, incremental development and the accumulation of knowledge (Porter, 2011). These disadvantages in the current approaches can affect the development of the strategic alternatives that lead to BPA evaluation for organisational effectiveness (Armistead et al., 1999). To be more specific, this main research problem is hypothesised as follows:

'C*urrent BPA approaches lack a development approach that produces a structurally dynamic, competitive and thus a more effective BPA'*

The structurally dynamic aspect of the BPA modelling approaches is missing according to Lapouchnian and Sturm (2015), while lacking the features of competitive advantage and thus effectiveness is related to dynamism aspect since both features require collection of knowledge and continuous development (Porter, 2011) which are not reasonably achieved on static mode of BPA modelling.

The determination of process effectiveness is based on two factors. The first one is related to the assessment of current and future performance, whilst the second is about the future goals defined by the enterprise strategy (Sayuthi, 2015). ISO/IEC 25010 defines effectiveness as the "accuracy and completeness with which users achieve specified goals" (ISO/IEC 25010,

2011, p.8). In this research, BPA effectiveness is defined as the extent to which the goals of the BPA with regard to *dynamism* and *sustainable competitive advantage* (SCA) are achieved. The *dynamism* refers here to the potential of continuous generation and re-configuration of BPA elements in relation to the structural level. The *sustainable competitive advantage* extends to the social and organisational level; it needs to take into consideration support for its critical sources such as: technical capabilities, core competencies and social capital. An elaboration of the above problem statement has generated the following sub-problems:

1) Current BPA modelling approaches have static elements which are developed without regular revising, expanding to result in the addition of new elements (Lapouchnian and Sturm, 2015). These BPA elements should be dynamic through continuous development and some form of automated generation.
2) Current BPA modelling approaches do not reflect the continuous changes that are made to the business and eventually the BPA. Therefore, any changes to the organisation's resources or processes are not updated or tracked by these approaches.
3) The static modelling of BPA methods does not support collective learning and development of the organisation they represent. These disadvantages will affect the organisational learning and sustainable competitive advantage of the enterprise (Argote and Ingram, 2000; Dixon, 2017).

1.1.2 The Research Motivations

The research motivators stem from the significance of applying a dynamic and competitive process architecture. These two main features can be supported in the development of an effective BPA by applying knowledge management (KM). KM is considered a key factor in achieving a competitive advantage; furthermore, knowledge infrastructural capabilities or KMEs have a strong relationship with organisational effectiveness and performance (Wen, 2009; Mills and Smith, 2011). The value of using KMEs in the development of the BPA can be strategic and provides a resource-based view of the firm and sustains its competitive advantage (Barney, Ketchen and Wright, 2011). In addition, it develops a socio-technical view by not only applying technology, but also placing a greater emphasis on soft issues such as the organisational infrastructure (or the way that relates roles and individuals within the context of organisational structure), culture and knowledge resources (Meso and Smith, 2000), which can be utilised by the BPA. Accordingly, the application of KMEs in the development of the BPA is motivated by, and aimed at, bridging the gap between KM and

business process modelling disciplines. Based on the latter and the research problem, the corresponding motivators are summarised as follows:

(M1) Continuous development of BPA supports adopting and tracking changes to the business environment and keeps BPA up-to-date. These changes can result in adding or removing crucial processes which can be detected by the dynamic generation of BPA elements using some form of automation.

(M2) Developing a dynamic BPA allows collective learning and innovation which are significant in organisational learning, and hence adding a sustainable competitive advantage to the organisation.

(M3) Developing a BPA using KMEs creates a map for the available resources that are used in the enterprise, and adds a resource-based view for the BPA which can support the development of strategic alternatives towards a sustainable competitive advantage (Barney, Ketchen and Wright, 2011).

(M4) Applying KMEs in the development of the BPA assists in presenting a formal representation for KM, which is mostly difficult to understand and handle in organisations (Quintas, 2004).

(M5) Using KMEs in the development of BPA can support knowledge management processes in an organisation. This implies creating, sharing and disseminating knowledge which adds new and innovative forms of a sustainable competitive advantage (SCA) (Teece, 2010).

1.2 Research Aim and Objectives

Organisations need to develop, accumulate, update and manage their knowledge resources to innovate and self-renew in order to respond to changing market conditions (Nonaka et al., 2006). Furthermore, an effective KM through the implementation of KMEs/knowledge infrastructure capabilities can have a significant impact on organisational effectiveness (Bharadwaj, Chauhan and Raman, 2015). Thus, it can be argued that utilising KMEs in the development of BPA can help organisations to recombine/reinforce their current capabilities and learn new skills in order to develop a more dynamic view of BPA, and hence to enhance organisations' effectiveness (Wilhelm, Schlömer and Maurer, 2015). Thus, the general aim of this research is to:

'Investigate the role of the use of knowledge management enablers in leading the development of an effective process architecture'

The process architecture effectiveness as mentioned in the research problem (Section 1.1) is concerned with achieving goals related to a dynamic and sustainable competitive advantage.

The following four main objectives have been proposed to address the aim of this research:

Objective 1: *To explore the potential KMEs for the development of process architecture*.

Using KMEs to drive the development of BPA requires identifying the most appropriate KMEs which are expected to be efficient in the BPA modelling. These KMEs should support defining knowledge resources or entities in the enterprise for use in driving the process of BPA development.

Objective 2: *To select an appropriate BPA method in order to identify the role of using KMEs in BPA development.*

An object-based BPA method is proposed in developing BPA using KMEs. It captures the entire business objects of the organisation and distinguishes their interrelations (Dijkman, Vanderfeesten and Reijers, 2016). These business objects are more important than other approaches in providing a comprehensive understanding of the enterprise's knowledge resources and capabilities. The object-based BPA method should also be obvious, practical and support the automation and the dynamic generation of BPA elements. An object-based BPA method that applies a semantic approach using ontology could be appropriate in meeting these requirements. It offers a formal representation and common (or shared) semantics of the elements of process architecture of organisation in order to communicate between stakeholders. It is also significant in providing the flexibility that is necessary for a dynamic BPA that accepts continuous changes; in addition, it supports linking the BPA elements to other disciplines such as knowledge management. Thus, an object and ontology-based method needs to be investigated in order to inform whether the knowledge resources of the KMEs can be sufficient to utilise in developing an effective BPA.

Objective 3: *To align the BPA method with the KMEs.*

This objective cannot be achieved in isolation from the previous objectives. Therefore, the selection of a semantic BPA method that supports the dynamic generation of its elements should consider using semantic KMEs in its development. A semantic approach that aligns the BPA method with KMEs using an ontology needs to be investigated to inform producing a flexible and automated framework.

Objective 4: *To undertake a critical and empirical evaluation of the effectiveness of the use of KMEs through the adoption of a case study method in which the impact of using KMEs in the development of an effective BPA is critically assessed.*

Achieving this objective requires the verification and validation of the new produced BPA in addition to evaluating its dynamism and competitive advantage using a sufficient and representative case study. Dynamism and competitive advantage evaluation will inform the effectiveness of the new BPA.

In conclusion, this research is aimed at utilising the KMEs in driving the development of a BPA using semantic ontologies in order to introduce a novel KME-driven approach for developing a BPA. This utilisation is anticipated to enrich BPA modelling approaches and support their integration with knowledge management. In addition, it contributes to simplifying the implementation of KM in organisations and supporting the control of its different processes such as creating, capturing, sharing and disseminating knowledge. The selected BPA method considers the extent to which automation can be undertaken in order to adopt changes and address the dynamic and competitive advantage features that are expected to be achieved using the KMEs. The KMEs should be systematically introduced in order to drive the BPA development. The research aim and objectives have been utilised to formulate the research hypothesis and its associated research questions as presented in the next section.

1.3 Research Hypothesis and Associated Research Questions

In this research, the main hypothesis is as follows:

'*The use of knowledge management enablers results in the development of an effective object-based business process architecture'.*

The research work involves discussing the appropriate KMEs that can be utilised to develop an effective BPA. The BPA method should also be appropriate in order to be aligned with these KMEs. The selection of both appropriate KMEs and a BPA requires finding out an approach to align them. The effectiveness of this alignment or the resultant knowledge-based BPA is evaluated through dynamic and competitive advantage features. Accordingly, testing the research hypothesis requires a set of research questions to be formulated in line with the research objectives in the previous section.

RQ1. What existing knowledge management enablers are appropriate to drive the process of BPA development? (**Chapters 2 and 3**)

RQ2. What BPA method is appropriate to investigate the role of knowledge management enablers in driving the development of process architectures? (**Chapters 2 and 3**)

RQ3. How can knowledge management enablers be used to drive the development of BPA? (**Chapters 3, 4 and 5**)

RQ4. To what extent can knowledge management enablers drive the development of an effective BPA? (**Chapters 4, 5, 6**)

1.4 Thesis Structure

The thesis is structured as follows:

Chapter 1 presents and discusses the rationale behind the research. It clarifies the problem and defines the motivation for applying KM in the development of BPA. Accordingly, the research aim and objectives are presented followed by the research hypothesis and associated questions. Finally, the chapter is concluded with the thesis structure and research publications.

Chapter 2 discusses the background and literature review of this research. An overview of BPA modelling approaches including the object-based Riva BPA method and its semantic approach is presented. The literature review of BPA modelling approaches is followed by introducing knowledge from a resource-based perspective in addition to its enablers that are used in this research. The literature review of BPA modellings approaches and knowledge forms the base for formulating the research gap analysis which concludes this chapter.

Chapter 3 includes revisiting the research hypothesis and associated research questions followed by the formulation of the research framework design, the KMEOntoBPA framework (see Figure 3.4 Chapter 3). A brief overview of research methodologies is presented followed by the adopted research methodology with reference to the Design Science Research Methodology (DSRM) (Peffers et al., 2007).

Chapter 4 presents the first iteration of the DSRM process adopted in this research. The iteration includes the design and development, demonstration and evaluation of the research framework. This framework constructs the KMEOntoBPA ontologies which link the abstract knowledge management enablers' ontology (aKMEOnt) to the semantically enriched Riva business process architecture (srBPA) ontology. It is also instantiated and evaluated using the *Treasury* case study of the bank. The Riva "as-is" BPA of the same case study is also generated as a benchmark in order to validate the knowledge-based BPA that the KMEOntoBPA framework has produced. Finally, this chapter ends the first iteration by providing an evaluation feedback that determines whether changes are necessary to the

KMEOntoBPA framework design before conducting an evaluation of dynamism and competitive advantage in the next chapters.

Chapter 5 presents the second iteration of the DSRM. The research framework design is revisited and some changes to the KMEOntoBPA ontologies are addressed according to the feedback from the first iteration of the previous chapter. The new KMEOntoBPA design is demonstrated and evaluated using the *Deposits* case study of the bank. Similar to Chapter 4, the Riva "as-is" BPA of the same case study is also generated in this chapter. An evaluation of dynamism and competitive advantage is performed after the validation of the KMEOntoBPA framework. Accordingly, the chapter concludes with feedback regarding the new KMEOntoBPA framework with further modifications if needed, revealing whether the KMEOntoBPA can develop a dynamic BPA with a competitive advantage.

Chapter 6 is the last iteration of the DSRM. A final revisit to the KMEOntoBPA framework is performed in order to complete all the core functionalities of the bank in this research and conclude the evaluation. The KMEOntoBPA is demonstrated and evaluated using the *Financing* case study of the same bank. The Riva "as-is" BPA of the same case study is developed to validate the knowledge-based BPA. The dynamism and competitive advantage of the KMEOntoBPA is finally evaluated and the chapter concludes with feedback regarding this evaluation, which shows the extent of the role of KMEOntoBPA in developing an effective BPA.

Chapter 7 informs the research questions and research hypothesis along with bridging the research gap analysis, in addition to presenting the research's main findings and contributions, and finally the research boundaries and limitations.Suggested future work directions conclude the research.

Chapter 2

Background and Literature Review

2.1 Introduction

Adapting rapid changes is a key challenge when designing a BPA, which means that BPA modelling is still static (Lapouchnian and Sturm, 2015) and thus has no sustainable competitive advantage. The resource-based view (RBV) presents an influential theoretical framework in order to understand how to achieve and sustain a competitive advantage within an organisation. It assumes that resources should be valuable, rare, inimitable and non-substitutable to be a potential source of competitive advantage (Barney, Ketchen and Wright, 2011). The RBV provides a strategic vision based on the entire organisation resource. It also recommends that business processes exploit intangible capabilities and knowledge as a source to sustain a competitive advantage (Ray, Barney and Muhanna, 2004).

Knowledge can be defined as part of the hierarchy that consists of data, information and knowledge (Braganza, 2004; Rowley, 2007): data are raw facts or observations without specific meaning which turn into information in a specific context; information is data that have been shaped and processed for useful purpose; while knowledge is information with understanding and capabilities that results in a valuable asset or resource which supports decision making. Knowledge has two types: (1) explicit knowledge such as written documents, guidelines, policies and procedures which can be knowledge resources that are shared with others; and (2) un-captured tacit knowledge such as individuals' experience that is gained, internalised and owned by individuals (Cooper, 2017).

Sharing of knowledge is not a normal action and knowledge might be tacit and embodied in people minds. Thus, knowledge and capabilities are not usually transferable and interactive without presenting incentives or enabling factors to stimulate their creation in organisations (Magnier-watanabe et al., 2011). Such enabling factors are like organisational structure, culture and leadership. These enabling factors of knowledge creation are defined as the knowledge management enablers (KMEs). KMEs are the pillars for successful knowledge management implementation and are also critical for knowledge sharing and dissemination (Bixler, 2002). A semantic representation that identifies and automates the KMEs with their interrelations paves the way for a flexible generation of resources and capabilities which can be utilised as object entities to drive the development of a dynamic BPA with a competitive advantage. Ontologies enable the accomplishment of a semantic approach (Antoniou, Franconi and Van Harmelen, 2005) and specify the necessary abstract level of the KMEs domain in order to develop a dynamic BPA. Moreover, they support the linking of isolated information, traceability and the semantic evolution of the KMEs and the BPA domains (Happel and Seedorf, 2006).

In this chapter, current BPA modelling approaches are presented in order to select an appropriate BPA method. This method should support the continuous changes and alignment with other disciplines such as knowledge management. KMEs are also identified and discussed showing their necessity in the KM domain in order to apply them in developing an effective BPA. Finally, a research gap analysis is conducted to identify the gaps in the BPA and KM domains which are in relation to this research.

2.2 Business Process Architecture Modelling

Business process architecture is the outcome of business process identification which represents "an organised overview of the processes that exist within an organisational context" (Dumas et al., 2013, p. 38). It maps the current overall core business processes that are necessary to conduct business in an organisation (Ould, 2005). It is also essential to improve and transform organisational business processes into technical and executable process models that are implemented by the information technology (IT) systems (Peisl, 2009).

BPA focuses our attention on the organisation's main activities; it involves all the dynamic relationships that are crucial to understand how an enterprise works. A right division of enterprise activities into processes will avoid complex designs or models (Ould, 2005) and hence lead to an aligned information systems infrastructure. Therefore, BPA and the business organisation should be in a mutual relationship in order to improve business performance (Patel, 2007).

2.2.1 BPA Modelling Approaches

BPA modelling can be classified into methodological and non-methodological or empirical approaches (Yousef, 2010). Malinova, Leopold, and Mendling (2013) identified two main approaches to process architectures (PAs) based on the findings of an empirical study. The first approach is the decompositional PAs which includes the hierarchal, the pipeline and the divisional PAs. The second approach is the service-oriented PAs. The study showed that many organisations use the decompositional approach in the design of the PA. However, the type and structure of an organisation play a significant role in its PA design. Non-methodological or empirical approaches depend on general principles to represent the business process architecture of an enterprise. However, they are still non-systematic (Yousef, 2010) and are, as a result, excluded from this study.

Methodological BPA approaches provide a systematic method and a structured technique (Ould, 2005) to derive BPA based on the business process management. Different

methodological BPA approaches have been identified to date. Dijkman, Vanderfeesten and Reijers (2016) presented an overview of the current methodological BPA approaches to design BPA, where forty-eight approaches were surveyed stemming from the following question: "On what basis are processes and their relations identified according to this approach?". The answer to this question led to the identification of five different classes of BPA modelling approaches:

(i) *goal-based,* where a BPA is derived from business goals and relationships between these goals. The benefit of using a goal-based approach is that associating goals with processes helps to determine why certain processes are significant and are in demand?

(ii) *action-based,* which consists of business actions and their relations. A business action is an activity loop in which a provider completes certain work for an internal or external customer. A business action is very similar to a business process; the main difference is that business action theory assumes each human action, and therefore each business action follows certain standard patterns and phases. All action-based approaches use the idea that each action moves through a number of phases ;

(iii) *object-based,* where the BPA is designed after studying business objects that exist in the enterprise as well as their interrelations. Examples of object types include permanent objects that have long life cycles in the enterprise (e.g. client) and case objects (e.g. order , application) that guide business process execution;

(iv) *function-based,* where a function hierarchy is designed to represent the decomposition of business functions into more detailed business functions. A business function is defined as a functional capability of the organisation such as production or procurement. Therefore, BPA can subsequently be structured according to the function hierarchy; and finally

(v) *reference-based,* where an existing BPA or a reference model is reused and adapted to design a new business process architecture. To a certain degree, reference model-based approaches are similar to other approaches, because the new reference model might be developed using one of the other approaches.

A summary of the main BPA modelling approaches according to Dijkman, Vanderfeesten and Reijers (2016) classification is presented in Table 2.1. The table covers the goal, object, function and action- based approaches in process architecture. In addition to these classifications, there are thirty reference model-based approaches adopted from Fettke, Loos and Zwicker's, (2005) survey and are grouped under the reference model-based classification. Fettke, Loos and Zwicker (2005, p. 476) described these models as domain-specific and suspected they would be found in the "reality of enterprise modelling".

Table 2.1: A Summary of BPA Modelling Approaches based on Dijkman, Vanderfeesten and Reijers (2016) Classifications

Author	Description
Goal-based approaches	
Lee (1993)	Goal-based process analysis (GPA) which has the following steps: (1) identify missing goals; (2) ensure implementation of all the goals; (3) identify non-functional parts of a process; and (4) explore alternatives to a given process.
Antón, McCracken and Potts (1994)	Operational concept definitions (OCDs) which describe business processes through critical incidents, scenarios or examples of significant problems that are connected to the goals of the organisation. It is a combination of goal decomposition and scenario analysis.
Yu and Mylopoulus (1996)	Goals, rules and methods are used in finding reasons that support the design of business processes. Two main components are defined: Strategic Dependency model which describes a process through intentional dependencies among actors, and the Strategic Rationale model that supports reasoning during process redesign.
Kavakli and Loucopoulos (1999)	Three main sub-models are integrated. The enterprise goal view, the enterprise process view and the information systems components view. An enterprise goal sub-model is realised by the enterprise process sub-model. Enterprise process sub-model is implemented in the information system component sub-model.
Koubarakis and Plexousakis (2002)	Five sub-models are used to formally describe different aspects of an organisation: (1) organisational sub-model describes the actors in the enterprise, their roles, their responsibilities and their capabilities; (2) objectives and goals sub-model describe what the enterprise and its actors are trying to achieve; (3) process sub-model describes how it achieves them; (4) concepts sub-model describes non- intentional entities; and (5) constraints sub-model, describes factors limiting what the enterprise and its components can do.
Lunn et al. (2003)	This is an iterative approach based on the following steps: (1) identification of stakeholders and their goals; (2) comprehensive overview of business processes; (3) detailed elaboration of processes; (4) identification of functionality (telecare systems functionality) (5) definition of functionality; and (6) detailed elaboration of functionality.
Object-based approaches	
Joosten (2002)	Identifying existing documents and files in an organisation. Accordingly, processes are identified by describing what is happening to the documents.
Ould (2005)	The Riva method which develops process architectures from business entities. Further details about the Riva method will be provided in this research in the next Section 2.2.2.

Function-based approaches	
Scheer and Nüttgens (2000)	A BPA is presented based on the Architecture of Integrated Information Systems (ARIS) which consists of four levels: (1) process engineering; (2) process planning and control; (3) workflow control; and (4) applications systems. The framework claims to include the whole lifecycle starting from business process design and ending in IT deployment. Business processes are modelled at the process engineering level according to a manufacturing work schedule.
Aitken, Stephenson and Brinkworth (2015)	Service and functional views are used to classify descriptions of organisational behaviour. The service view describes how organisations operate and the functional view describes how organisations or their activities are structured and controlled.
Dumas et al. (2013)	They design a process architecture using the following steps: (1) Identify case types; (2) identify functions of these case types; (3) Identify processes; and (3) complete the process architecture.
Action-based approaches	
Medina-Mora et al. (1993)	Processes design is based on the theories of communicative activity as language/action. Three main domains are distinguished to describe organisations activities: (1) material processes domain which indicates physical activities; (2) information processes domain which is related to information technology; and (3) business processes domain in which language actions have consequences for future activities.
Lind and Goldkuhl (1997)	Processes design is based on the business action theory, which is based on the language/action approach. The criteria for distinguishing business processes are based on generic communicative action types, such as offer, desire and demand, contract and claim.
Dietz (2006)	A language-action perspective, which is based on DEMO theory, is used to show the essential structures of business processes. DEMO is the Design and Engineering Methodology for Organisations. The DEMO theory has subjects that perform two acts: production acts and coordination acts. In production acts, the subjects' contribution is related to the goods and services that are delivered to the environment. Coordination acts involve the subjects' commitment towards each other regarding the performance of the production acts. Examples of coordination acts are "promise", "request", "decline".

The summarised BPA approaches in Table 2.1 do not show support for the agile development of a BPA except for Lunn et al. (2003) who describe an iterative goal-based approach. These approaches also do not show a comprehensive adoption of different knowledge resources in the development of their BPA, except in the object-based approaches through documents, files and business entities (Joosten, 2002; Ould, 2005).

Developing a dynamic BPA with competitive advantage requires applying an approach that aligns with the utilisation of organisation changeable knowledge resources (see Figure 2.1). Object-based BPA approaches can be appropriate in meeting this requirement since it is

more comprehensive in adopting resources under several object types. It may also apply to the relationship between different organisational resources and capabilities using the relation between permanent objects and case objects in order to identify processes (Dijkman, Vanderfeesten, and Reijers, 2016). Moreover, establishing a BPA from the knowledge perspective is more consistent with business objects, which are supported by an object-based BPA approach. Other approaches are more specialised and unable to employ different organisational resources. Some are also based on static resource elements such as the function-based approach (Teale and Jarvis, 2004). All these are not approaches of research interest.

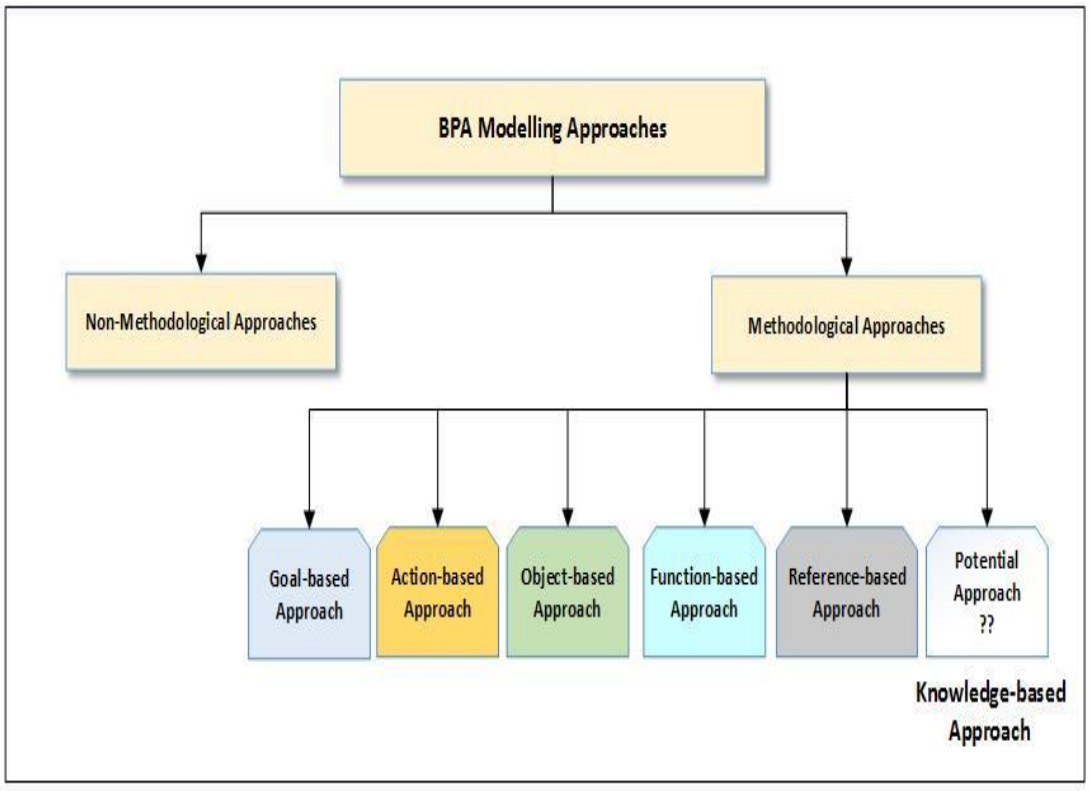


Figure 2.1: BPA Different Modelling Approaches

The Riva method (Ould, 2005) is classified as one of two object-based BPA approaches that are found in this field. Ould (2005) introduced Riva as a clear and practical methodological approach for developing process architectures from the essential business entities (EBEs). The other method (Joosten, 2002) is limited to identifying files and document objects in the organisation and, as far as the researcher knows, is not automated. Therefore, the Riva method is considered in this research alone. Further details about the Riva method follow.

2.2.2 The Riva BPA Method

Riva is an object-based method that includes the following techniques (Ould, 2005, p.12): determining what processes are necessary for an organisation to be in the business it is in;

discovering and modelling existing processes; defining existing processes; designing intended processes; using process models for requirement definitions for information and workflow systems; and developing process models for business process management systems development.

Ould (2005) asserts that the Riva BPA is an invariant for an organisation that remains in the same business. It is also considered a significant approach to be utilised in this research for a number of reasons which are concerned with the findings of Beeson, Green and Kamm (2009):

(1) it provides a clear and practical method for developing a process architecture from business entities;

(2) it enables the modelling of the internal structure of each organisational process using role-based business process modelling languages such as RAD (Ould, 2005);

(3) BPA can be rendered as the blueprint for the implementation of business processes, which might be partly or fully automated;

(4) it includes a bold hypothesis of architectural invariance among businesses of the same type, which makes it possible to validate; and

(5) BPA developed for one business can be transferred to, or reused in, another business of the same type.

The Riva method identifies an organisation's process architecture through the following steps (see Figure 2.2):

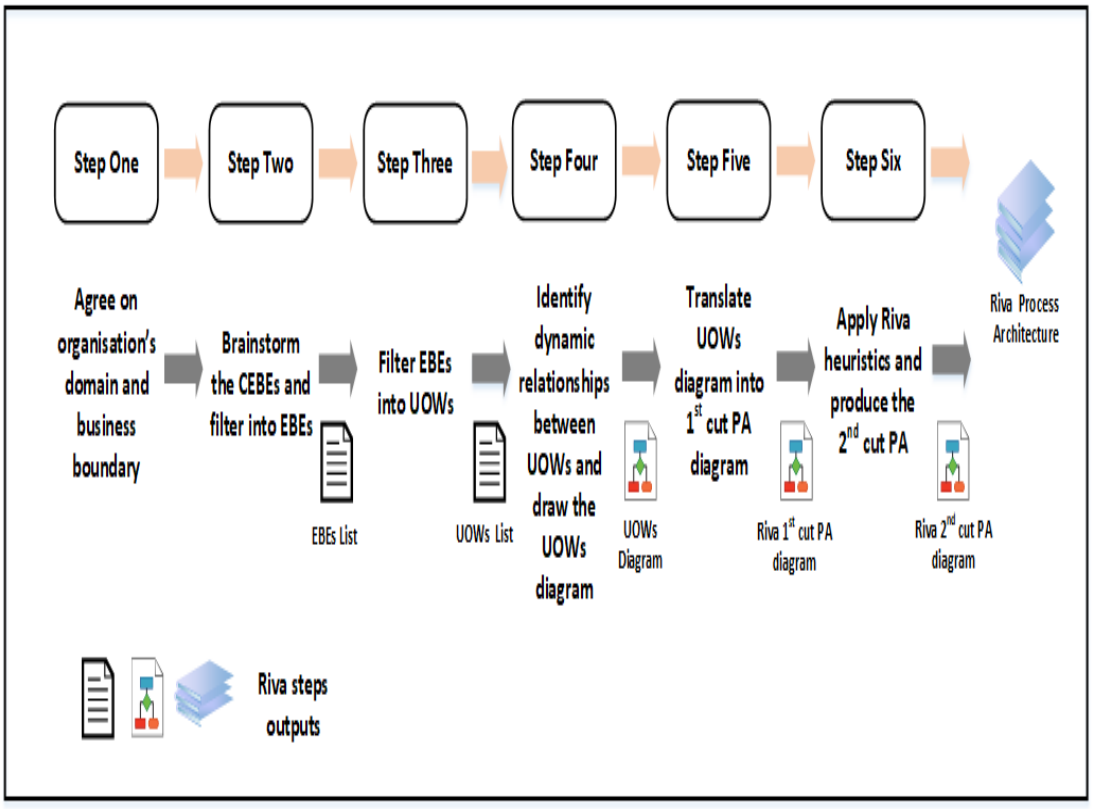


Figure 2.2: The Fundamental Steps of the Riva BPA Modelling Process based on Ould Riva BPA (2005)

Step one: This step is aimed at identifying the organisation and agreeing on its domain and business boundary. According to Ould (2005, p. 171) an organisation is "whatever we want to look at". It can be a hospital, an airport or a stock market. In this research what is being looked at is a bank, specifically, the Treasury, the Deposits and the Financing businesses in a bank.

Step two: This step is concerned with brainstorming the candidate's essential business entities (CEBEs) that characterise the business of the organisation and extracting the essential business entities (EBEs). The business entities are the factors that one cannot get away from in any business. For example, candidates for EBEs in a modular programme in a university faculty can be entities such as Modules, Student Assessment and External Examiners (Beeson, Green and Kamm, 2013). These business entities are called "essential because they are part of the essence of the business" (Ould, 2005, p. 173). Finding CEBEs can be supported by some prompt questions (Ould, 2005). These prompt questions provide a list of CEBEs. Some examples of these CEBEs with Ould's (2005) prompt questions are as follows (see Table 2.2):

Table 2.2: Ould Prompt Questions with Examples of CEBEs adopted from the King Hussein Cancer Center (KHCC) in Jordan (Odeh et al., 2018)

No.	Riva Ould Suggested Question (Ould,2005)	Examples of CEBEs
Q1	What do we make? Or What do we care for?	Cancer Prevention, Cancer Prevention Programme, Breast Cancer Awareness, Cancer Research
Q2	What do we sell or provide?	Cancer Detection, Cancer Investigation, Cancer Diagnosis, Palliative Care, Therapy
Q3	What product lines do we have?	In-patient Cancer Care, Outpatient Cancer Care, Government Referred Patient,Cancer Detection, Cancer Investigation, Surgical Treatment Gene Therapy, Physiotherapy
Q4	What services do we offer?	
Q5	What service lines do we have?	
Q6	What things can we simply not get away from?	Data protection act, Ethical Approval, National Standard,International Standard National Regulation
Q7	Who are our external customers?	Public Hospitals, Patient Referral Report, Private Hospitals, National Cancer Registry
Q8	Who are our internal customers?	Cancer Care Financial Advisor, Physicians, Biomedical Engineers, Clinical Scientists
Q9	Are there things that our customers have, or want, or do, that might be EBEs for us?	Catalogue of Cancer Care Services, Cost of Cancer Care Services, Patient Report
Q10	What things do we think differentiate our organisation from others in the same business?	Empathetic cancer care, Cancer Care Ethos, Staff welfare
Q11	What sort of things do we deal with day in, day out?	Cancer Detection, Cancer Investigation , Chemotherapy Treatment, Radiotherapy Treatment, Surgical Treatment
Q12	What events in the ‘outside world’, the world outside our organisation, do we need to respond to?	National Cancer Registration, Cancer Incident Reporting
Q13	What entities are listed in our corporate data model?	Not possible to infer feedback about
Q14	What things do our information systems keep information on?	Not possible to infer feedback about

A number of filters are applied in Riva steps two and three. These filters are used to derive the EBEs from the CEBEs (step two) in addition to deriving the units of work (UOWs) from EBEs (step three).

In this step, the filters are applied to the entire list of the brainstormed candidate essential business entities (CEBEs) and are to be tested to examine whether each CEBE is truly an

entity that could be deemed part of the core of the business. These filters, to be used by business analysts, are necessary in order to determine the EBEs after extracting or generating the CEBEs from brainstorming using the Riva BPA approach. The filters imply the following:

(1) Testing each CEBE by putting the word ‘a’ or ‘the’ in front of each suggestion. Examples: ‘A’ Cancer Detection, ‘The’ Surgical Treatment.

(2) Bracketing any designed entity which is not essential and only exists because there has been a choice to work in a particular way. Ould (2005) mentioned in this filter the example of invoice as a designed entity, when there is an organisation that has an invoicing department but is not in the business of issuing invoices. However, this filter is still subjective regarding the consideration of an entity as essential or not essential; this depends on the organisation, the business and the era we are living. In this research, a few entities were discussed with bank domain experts in order to classify them as designed entities, but at the end they were all considered as EBEs. Thus, no designed entities have been nominated in this research.

(3) Bracketing entities that are simply roles and not part of the essence of the business. Example: The Account Department in a hospital can be a role but is not in the essence of the business.

Step three determines which of these entities has a lifetime to be classified as units of work (UOWs) and excludes other non-UOW entities. A UOW is an EBE that has a lifetime during which it must be looked after. Further filters are applied to reduce the number of EBEs to only those that are UOWs. These filters include:

(1) Bracketing EBEs that are clearly not UOWs. For example, Cancer Prevention is clearly not UOWs since it does not have a lifetime to look after.

(2) Bracketing EBEs that are not considered UOWs, even if they are for someone else. For example, certain standards for a Quality Management Group have a lifetime but for other businesses they are just controllers for processes (Ould, 2005). Data Protection Acts, Ethical Approvals and Nationals Standard are examples of EBEs that are not considered UOWs in a hospital, but can be UOWs for someone else such as a Quality Management Group.

(3) Bracketing EBEs that are only roles that play a part in processes. For example, Biomedical Engineers in a hospital are roles that play a part in processes.

(4) Bracketing any EBE that is only part of another EBE and does not have a separate lifetime of its own. For example, a Surgical Mistake can be an EBE that is part of another EBE such as Surgical Treatment and does not have a separate lifetime.

Step four: This step involves identifying the dynamic relationships between UOWs and drawing the UOW diagram. In the UOW diagram, a dynamic relationship arises when UOW (A) 'generates' or 'involves' another UOW (B) during the lifetime of UOW (A). Each relationship is named and implemented by an arrow from the generating UOW to the generated UOW. There is no requirement for each UOW to be connected to another. An arrow arrives from the outside world when a UOW is generated by an agent outside the organisation with which the BPA is associated with. Figure 2.3 shows how the 'generates' relationship is presented between two UOWs.

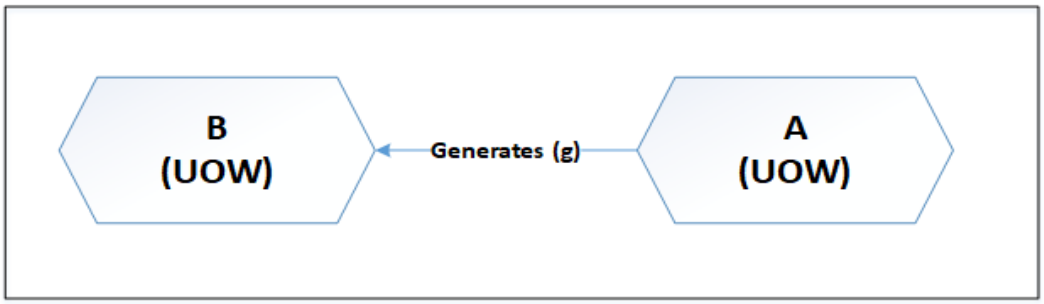


Figure 2.3: The 'Generates' Relationship between two UOWs

Step five: A 1st cut of the process architecture (PA) is produced in this step. For each UOW in the UOW diagram, there is: (a) a case process (CP); (b) a case management process (CMP); and (c) a case strategy process (CSP). The case strategy processes are excluded from this research since they are not developed as well as the CP and CMP concepts (Beeson, Green and Kamm, 2013). Each new process starts an instance or an occurrence of a case process. A CMP deals with the flow of instances or occurrences. The CP starts with the word 'Handle' and the CMP begins with the phrase 'Manage the flow of'. The 'generates' or 'involves' relationship between two UOWs is translated into relationships between the corresponding processes. These relationships are 'requests' (r), 'starts' (s) and 'delivers' (d). Figure 2.4 shows how the UOWs and their 'generates' relationship is translated in the 1st cut PA diagram.

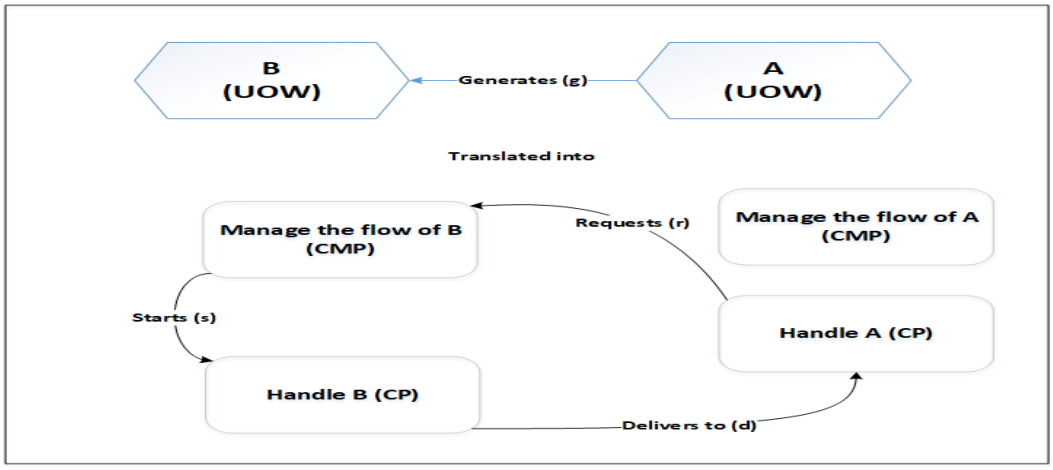


Figure 2.4: Translation of UOWs and their Relationship in Riva 1st cut PA Diagram

In this research, the relationships in the 1st and 2nd cut PA diagrams will be preceded by their original 'generate' (g) or involve relationships and their numbers in order to highlight the original 'generate' (g) or involve relationships before translation. For example, the translation of 'generate' relationship g1 will be g1r, g1s, g1d, and the translation of 'involve' relationship involve2 will be involve2r, involve2s, involve2d. Figure 2.5 presents this research approach in the translation of UOWs and their relationship.

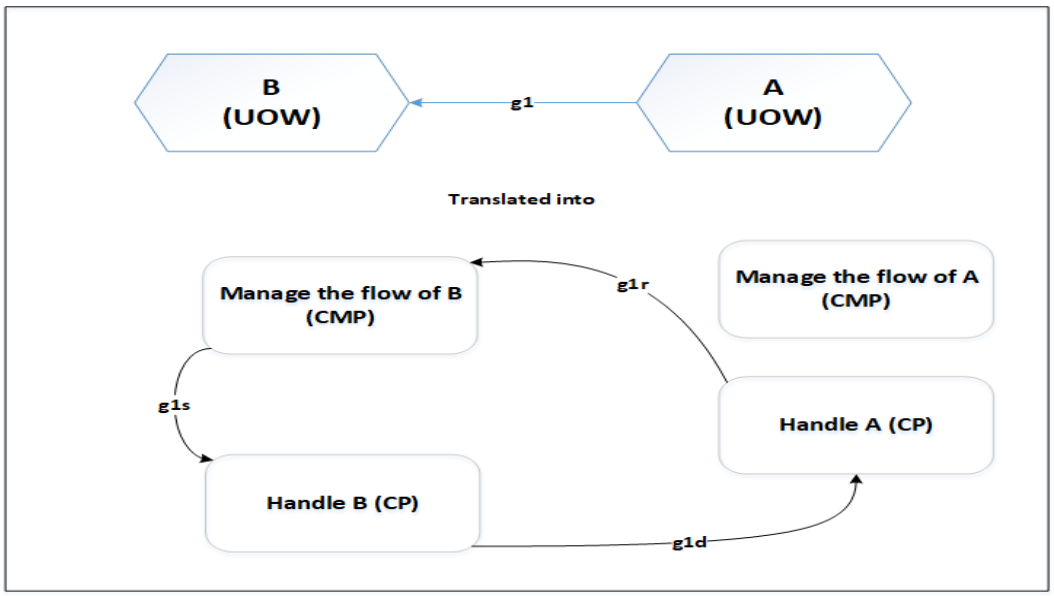


Figure 2.5: Research Approach in Translation of UOWs and their Relationship in Riva 1st cut PA Diagram

Step six: In this step a 2nd cut process architecture is produced using heuristics. Ould (2005) represents heuristics as reductions that are made in the 1st cut process architecture for further reflection or mirroring of the real world, as in practice it reveals more than what exists. The heuristics are as follows (Ould, 2005):

(1) Folding a task force CMP into the requesting CP where there is a task force relationship and CMP receives requests which are encapsulated in the requesting CP; CMP can be folded into the requesting CP. For example, the CMP *Manage the flow of B* is encapsulated in the CP *Handle A* (see Figure 2.6). In folding, CMP is considered to be part of the request CP. Folding does not "mean that CMP does not exist or there is no case management to be done, it means that CMP should be within the requesting CP and is best modelled there" (Ould, 2005, p. 187).

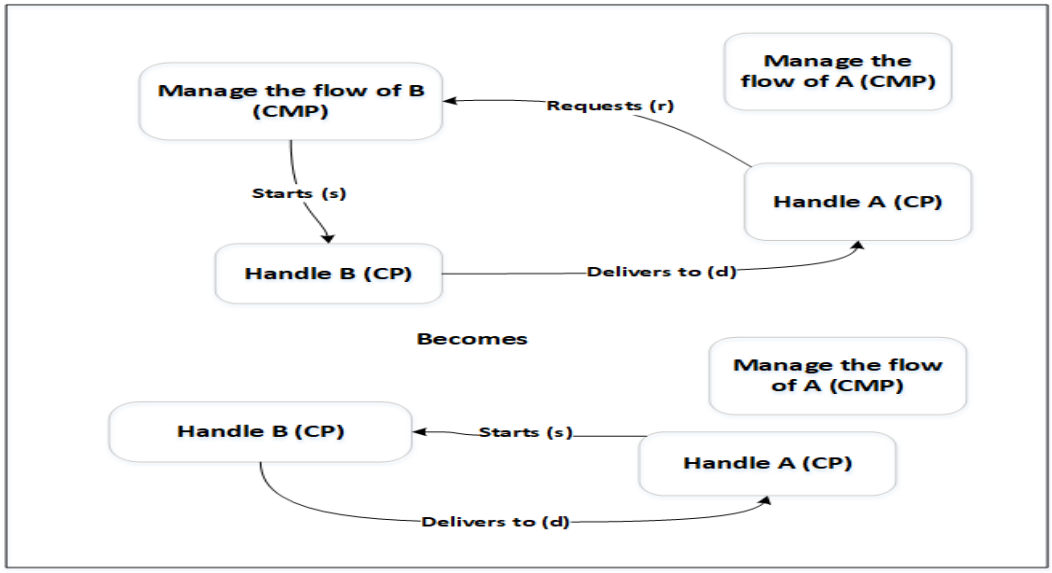


Figure 2.6: Folding a Task Force CMP into the Requesting CP in Riva 2nd cut PA Diagram

(2) Dealing with 1:1 'generates' relationships in certain (1:1) relationships when both UOWs are necessary but we cannot distinguish between the CMPs for both UOWs, therefore one CMP can replace both. This heuristic was not found in this research because of the conditions that are mentioned which are: (i) dealing with (1:1) relationships; and (ii) being unable to distinguish between CMPs for both UOWs, are not achieved together.

(3) Dealing with delivery interactions and delivery chains when there is no interaction or 'delivery' from the requested case to the requesting case. Therefore, delivery interaction can be deleted or short-circuited. Figure 2.7 shows how the delivery is short-circuited since the real interaction is between *Handle C* and *Handle A.*

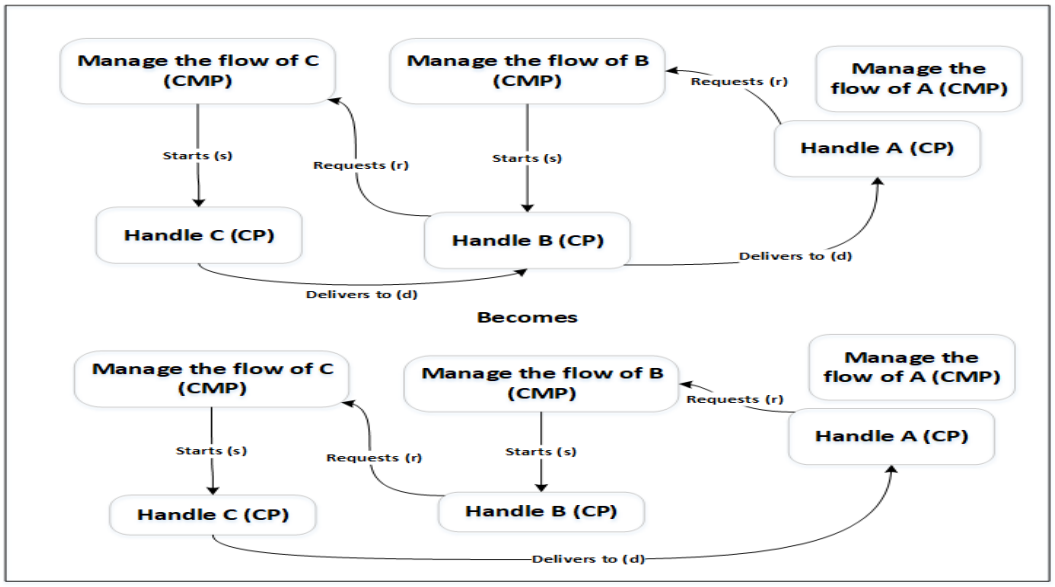


Figure 2.7: Dealing with Delivery Chain in Riva 2nd cut PA diagram

(4) Dealing with collections when it is found that a UOW is a collection of another UOW and the CMP for the component is contained within the requesting CP. Thus, CMP can be folded into the requesting CP as in heuristics one (review Figure 2.6). Examples are where a Programme is a collection of Projects, and a Project that is a collection of Work Packages (Ould, 2005). In this research, no UOW has been considered as a collection of another UOW. The reason is that stakeholders of the bank case studies find folded CMPs as a task force rather than a component within the requesting CP.

(5) Dealing with empty CMPs in certain cases when there is only one instance of the CP. There will be no calling for a CMP and thus it will be removed. For example, a Transmission System in an electricity distribution enterprise has only one instance (Ould, 2005).

Finally, it can be concluded that the Riva method has clear and detailed steps with several advantages that support its utilisation in this research. However, Riva method can be criticised by the following:

- Extracting CEBEs and their filtered EBEs is time consumable and needs regular meetings to make them up-to-date.
- The different CEBEs/EBEs are not well classified or grouped according to their sources in order to know how these CEBEs are generated. Furthermore, the Riva method requires “an EBE-independent method for classifying businesses objectively and accurately” (Beeson, Green and Kamm, 2013, p.56).
- The CSP concept and its heuristics are not highlighted or developed as the CP and CMP concepts in the Riva method (Beeson, Green and Kamm, 2013).

2.2.3 The srBPA and Semantic BPA Development

The success of the semantic web depends on the emergence of shared ontologies (Pauwels, Zhang and Lee, 2017). Ontologies are "a set of well-founded constructs that can be leveraged to build meaningful higher level knowledge. It also contributes in knowledge management basic processes, namely, integration, communication and reasoning" (Varma, 2007, p.23).

Ontologies support sharing and reusing knowledge among systems by representing a common vocabulary of this knowledge; therefore it was defined as an "explicit specification of a shared conceptualisation" (Bartussek et al., 2018; Gruber, 1993, p.199) that facilitates formal use, portability and interoperability of knowledge (Breitman et al., 2003; Roussey et al., 2011). According to the ontology definition, some of the reasons for its use can be identified (Noy and McGuinness, 2001):

- Sharing understanding of information among individuals or software agents.
- Facilitating the reuse of domain knowledge.
- Explicating the assumptions of the domain.
- Separating the operational knowledge from domain knowledge.
- Analysing knowledge of the domain knowledge.

The role of ontologies is increasing in many fields such as information integration, cooperative information systems, machine learning, complex event processing, electronic commerce and knowledge management (Bartussek et al., 2018; Staab and Studer, 2009). Futhermore, the semantic ontologies have been used in different projects such as Ontology-driven Requirements Engineering Methodology (OntoREM) in cooperation with airbus (Kossmann et al., 2009), Air Traffic Services Ontology (Keller, et al., 2016) and Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE) (Masolo et al., 2003).

A semantic representation of the BPA using ontology supports an understanding of the BPA domain and conceptualises the elements of the BPA and the relationships between them. It also extracts useful approaches to link BPA with other disciplines such as knowledge management and its enablers. Furthermore, it provides more automated functions such as reasoning, discovering services and information (Lassila and McGuinness, 2001), which are necessary to reasonably identify, generate and reconfigure new BPA elements with a flexibility in its adoption, and thus developing a dynamic BPA.

Semantic Riva BPA (srBPA) ontology developed by Yousef and Odeh (2014) is a significant example of a BPA method that is presented and developed in the BPA domain using

Ontology Web Language-Description Logic (OWL-DL) , the standard recommended by the Wide Web Consortium (W3C) (Roussey et al., 2011). The srBPA ontology conceptualises the elements of the Riva-based BPA and their relationships. This conceptualisation facilitates an understanding of the relations between these elements: EBEs, UOWs, CPs and CMPs. It also enriches the Riva method semantically by using in different frameworks in order to derive information entities (Ahmad, 2014) and identify services (Yousef, 2010). Further details of srBPA elements are available in Appendix A.

The srBPA ontology is important to apply in this research since it is Riva-based and thus an object-based approach. These features make the srBPA ontology flexible to adopt new knowledge resources as business entities and convert them into Riva elements in real-time design. However, the srBPA ontology reflects the same criticisms to Riva method without using ontologies. The CEBEs and their filtered EBEs are not up-to-date and are provided by business analysts after a brainstorming meeting which is not regular. In addition, these CEBEs/EBEs are not classified or grouped to be easily tracked and understand how they are generated. Thus, the srBPA ontology lacks the discovery and generation of its initial elements, the EBEs, in order to create a dynamic BPA. This disadvantage should be resolved in this research.

2.3 Knowledge as a Resource

Every business has to build its own information systems and discover what makes the transformation of information into action possible and leads to knowledge production (Rowley and Hartley 2008). Moreover, business environments drive enterprises to adopt KM systems in order to effectively learn and nurture innovation (Hershberg, Nabeshima and Yusuf, 2007). It is therefore critical that businesses improve their knowledge-based resources which are increasingly seen as the main asset for growth and sustainable competitive advantage (Barney, Ketchen and Wright, 2011; Hill and Levenhagen, 1995; Desouza and Awazu, 2006). Knowledge-based resources are increasingly being considered as crucial for organisations and countries as they relate positively to value-added measures, productivity and competitiveness (OECD, 2013). The Organisation for Economic Co-operation and Development (OECD) reported that knowledge-based resources in 2012 account for 13-28% of total employment in many OECD economies, whereas the rate of UK workers contributing to knowledge-based resources activities accounted for approximately 27% of the employed workforce, ranking the UK second after the USA (OECD, 2013). Thus, utilisation of knowledge resources in information systems can be significant in supporting organisations' performance and there competitive advantage.

2.3.1 Resource-based Theory

Resource-based theory (RBT) is recognised as one of the most significant theories for explaining the permanent optimal performance of organisations in the field of strategic management (Barney and Clark, 2007). Furthermore, it is effective in other management fields such as marketing and "provides a ground work for a set of mutually exclusive and exhaustive information systems assets and capabilities" (Wade and Hulland, 2004, p. 110).

The idea of considering an organisation as a set of resources goes back to Penrose's work and was formulated as a Resource-Based View (RBV) term or concept by Wernerfelt (1984). RBV suggests improving an organisation's ability to adapt changes and sustain a competitive advantage through the development of existing resources and capabilities (Esteve-Pérez and Mañez-Castillejo, 2008). A competitive advantage is the ability "to create more economic value than the marginal (breakeven) competitor in its product market" (Peteraf and Barney, 2003, p.314).

Three different approaches to positioning the RBV are related to three different resource-based theories of competitive advantage (Barney, 2001). The first approach is related to Structure-Conduct-Performance (SCP) based theories of competitive advantage. SCP based theories define the relationship between environment or market conditions and a firm's performance. This approach can be included or classified within the second approach. The second approach is related to the neo-classical microeconomics theory. This theory is concerned with market forces and how they determine the quality, quantity and price of services and commodities in the market. The final approach is related to the evolutionary theory of competitive advantage. The most significant work in this theory focuses on the routines that can generate more sustainable competitive advantages for firms. The development versions of the evolutionary approach are highly involved in how the capabilities of enterprise change over time, which can be supported by KMEs, and the implications of these changes, with a dynamic and competitive BPA. The three approaches share the common assumption that resources and capabilities can be heterogeneously or differently distributed across enterprises. They also focus on different abilities to improve new capabilities in a changing environment in addition to the processes by which these capabilities are evolved.

Another explanation of the RBV combines three different views regarding the firms (Seoudi, 2008): (1) The resource-based view. This is the rational-equilibrium school that considers all the firm's resources including assets, capabilities, processes, and knowledge, are most likely a source of SCA (2) The dynamic capability-based view. This is the behavioural-evolutionary school which focuses on the dynamic process aspects of the RBV (3) The

competence-based view. This is the social constructionist school that is concerned with the creation of new competencies or capabilities which are intangible or knowledge-based resources. Barney and Clark (2007) argue that these different approaches share the same assumptions and assertions of the resource-based theory and state that "what makes resources a potential source of sustained competitive advantage are the same as what make capabilities, dynamic capabilities, routines, and so forth potential sources of sustained competitive advantage" (Barney and Clark 2007, p.249). El Shafeey and Trott (2014) concluded, after reviewing the RBV schools and their criticisms, that the real source of a sustainable competitive advantage is competences and capabilities. In addition to these sources of sustainable advantage, social capital (or social resources) is another main source of SCA that are derived from "the relationships that bind together members of organisation" (Jackson, DeNisi and Hitt, 2003, p. 6).

Among intangible resources of the organisation, knowledge is the most significant resource that can provide an effective use of other resources and capabilities in order to sustain a competitive advantage. Therefore, a knowledge-based view was articulated as an outgrowth or extension of the resource-based view (Grant, 1996).

2.3.2 Resources, Capabilities and Knowledge

One of the key challenges that an organisation should handle is identifying the origins of the resources that support and improve a sustainable competitive advantage (Kostopoulos, Spanos and Prastacos, 2002). Enterprise resources imply all tangible assets, processes, capabilities, information and knowledge. Amit and Schoemaker (1993, p. 35) distinguish between resources and capabilities and define resources as "stocks of available factors that are owned or controlled by the firm", while capabilities refer to "a firm's capacity to deploy resources usually in combination, using organisational processes to effect a desired end".

Knowledge is a critical strategic resource that needs to be explicitly managed in order to sustain an organisation's ability to compete in a dynamic environment (Zack, McKeen, and Singh, 2009). Knowledge can involve skills, information, competence, experience, know-how, learning, capability or practical ability. All these definitions depend on the context in which knowledge is used (Sveiby, 1997). However, knowledge cannot be generated, captured and utilised without its intentional development by means of KMEs such as technology, leadership and organisational structure (Ichijo, Von Krogh and Nonaka, 1998). These KMEs, as discussed, will foster the acquisition, assimilation, adaptation and effective use of new and/or external knowledge.

2.3.3 Knowledge Life-Cycle

A knowledge life-cycle has several phases that differ from model to another such as the knowledge management cycle (KMC) model which contains seven phases (Evans, Dalkir and Bidian, 2014): identify/create, store, share, use, learn and improve. In this research the knowledge life-cycle is related to the role of KM in the development of the Riva BPA. Therefore, the knowledge life-cycle includes the following phases (see Figure 2.8):

- Identify: This phase identifies the organisational knowledge resources of the KMEs which can be suggested as CEBEs.
- Generate/Create: The CEBEs that represent the required knowledge are generated or created in this phase in order to be inspected by the business analysts.
- Filter: The CEBEs are filtered into EBEs and UOWs Riva BPA elements.
- Utilise: The filtered Riva BPA elements which are originally extracted from the KMEs are used to drive the development of the UOWs, 1st and 2nd cut process architecture diagrams.
- Evaluate: The CEBEs and their corresponding BPA elements are evaluated in order to check how far these CEBEs (or knowledge resources) are effective and achieve their role in BPA development.
- Learn: After the evaluation of the BPA elements that represent the flow of knowledge in this research, the impact of these elements with their original KMEs is determined and any shortages or disadvantages are learned.

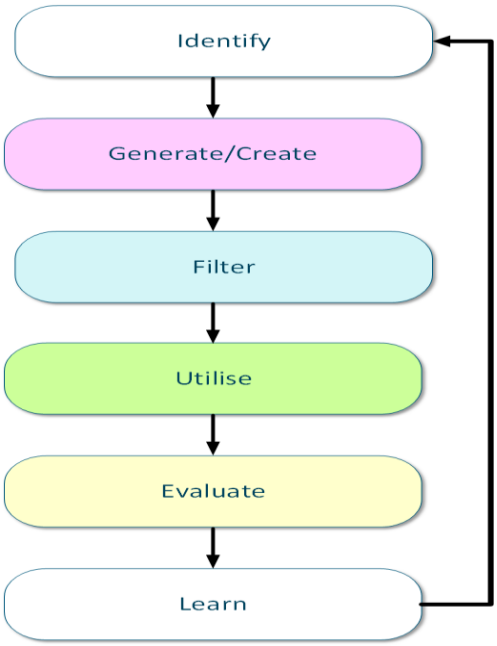


Figure 2.8: Research Knowledge Life-Cycle

2.4 Knowledge Management Enablers

The knowledge role is increasing in modern enterprises and managers are surrounded by challenges to optimise the integration of an organizations' business processes to ensure effective use, sharing and the retention of crucial knowledge (Holsapple and Wu, 2011). Therefore, knowledge management is essential and is described as central to process innovation, decision making, and organisational learning and development (Earl, 2001). However, knowledge is not usually in a state of interaction and dissemination without the facilitators that stimulate the knowledge creation in organisations in addition to its sharing and protection (Yeh, Lai and Ho, 2006). These facilitators are called the Knowledge Management Enablers (KMEs).

In the area of KM, early work and recent research have examined different facilitators affecting knowledge transfer such as relational, cognitive, motivational and emotional factors, apart from the impact of knowledge sharing and organisational learning on competitive advantage and strategic behaviour (Argote, 2011). A resource-based view on knowledge management motivates the consideration of factors such as technology and the organisational infrastructure to be used during the cycles of managing, developing and applying KM systems (Meso and Smith, 2000). Arthur Anderson and the American Productivity and Quality Centre (APQC) developed an organisational KM model that defines four key KM enablers: leadership, culture, IT, and performance measurement (Arthur Andersen, American Productivity and Quality Centre, 1996). IT, structure and culture were classified as significant KM enabling factors (Bharadwaj, Chauhan and Raman, 2015; Gold, Malhotra and Segars, 2001). A business repository of the enterprise processes is also a main knowledge enabler; it captures knowledge of how an organisation runs its business and shares knowledge of different internal and external resources (Weske, 2007; Loucopoulos and Kavakli, 1999).

Knowledge requires certain conditions or a suitable climate to facilitate its creation and development. The context in which knowledge is created and utilised is now global (Teece, 1998). A context can be described as a set of relevant factors and surrounding impacts that make a business situation unique and inclusive (Pomerol and Brézillon, 2001). Usually individuals are not conscious of these interacting factors which are rarely captured by technology (Pomerol and Brézillon, 2001; Degler and Battle, 2000).

Based on the previous overview of KMEs, six KMEs have been selected in order to utilise in this research. Four of these KMEs (information technology, organisational structure, culture and leadership) were found common in different research and are considered as key factors

or pillars in the implementation and development of organisational KM models (Bixler, 2002; Arthur Andersen, American Productivity and Quality Centre, 1996; Gold, Malhotra and Segars, 2001; Meso and Smith, 2000). The remaining KMEs include business repository and knowledge context. The business repository can be considered part of information technology, it acts as an electronic storage for all the knowledge that organisation needs to store, codify and facilitate to use (Bock, Sabherwal and Qian, 2008). However, this KME is independent in this research since it needs to be highlighted alone as a knowledge storage apart from other information technology tools. Finally, a knowledge context is an essential component for a full understanding of knowledge and knowledge can be damaged if it is separated from its context (Ahn et al., 2005). Therefore, a knowledge context has been selected as a KME in this research.

In addition to the significance of these KMEs according to previous literature, all selected KMEs provide organisational knowledge resources that are related to or classified as candidate business entities (or CEBEs) that characterise the business of an organisation. For example, information technologies are based on different functions that are covered by the main processes and business modules of the organisation; any changes in these technologies or their input data can affect these dependent processes and modules (Gunasekaran and Nath, 1997). Therefore, *IT* has the potential of generating CEBEs that can be essential in driving changes and developing BPA. *Leadership* has an important role in the development of business processes and their strategies in order to succeed in a dynamic environment (Bixler, 2002). It also sets goals and provides resources and team members with the knowledge and skills to enable task accomplishment (Morgeson, DeRue and Karam, 2010). These leadership roles can have an impact on the creation and reconfiguration of CEBEs that drive the development of BPA. *Organisational structure* has a critical impact on business performance and achieving organisational goals. Furthermore, an organisational change implies a continuous matching between its structure and processes (Todnem, 2005). Thus, organisational structure should be considered while building a dynamic BPA and has the potential of generating CEBEs. *Organisational culture* is involved in process management, specifically with regard to the right way in which processes are accomplished or problems are understood in an enterprise (Martins and Terblanche, 2003). These methods or assumptions can have an important effect on how CEBEs and process architecture are developed in an organisation. Other KMEs that are not less important than previous ones in KM implementation, are *business repository* and *knowledge context*. A business repository is distinguished from information technology in its importance as a storage of organisational memory or experience (Girard, 2009). A description or definition of different CEBEs, business processes and work procedures are expected to be found in organisation repository.

Any changes in the business repository should reflect these descriptions and impact CEBEs and thus the BPA. Finally, the development of different models and business processes will not be productive without understanding the context of knowledge in organisations (Goldkuhl and Braf, 2001), which can be important in providing CEBEs and developing BPA. Accordingly, the adopted KMEs in this research are expected to be appropriate in substituting the second step of Riva method and drive the development of BPA.

2.4.1 Information Technology

Information technology (IT) refers to the capabilities of the technology infrastructure that supports the building of KM architecture (Allameh, Zare and Davoodi, 2011). IT infrastructure is an enabler that comprises resources and tools which acquire processes and store and disseminate knowledge (López, Peón, and Ordás, 2009). A comprehensive infrastructure involves the effective management of a critical type of knowledge which includes knowledge mapping, knowledge discovery, collaboration, security and business intelligence (Gold, Malhotra and Segars, 2001). Technology tools can incorporate communication technologies such as video conferencing and emails, or decision-aiding technologies such as decision support systems (Song et al., 2001). Information technology supports knowledge management in two directions (Davison, 2013): formal systems which are designed to identify and share knowledge based on structured rules; and interactive IT applications which provide an informal context to share knowledge between groups and individuals.

Depending on information technology alone to implement knowledge and promote members of an organisation to be willing to share it among others is insufficient (Lin, 2007). Therefore, other KMEs should be utilised in order to apply knowledge management and increase knowledge creation and sharing in an organisation.

2.4.2 Leadership

Leadership refers to "the process of influencing others to understand and agree about what needs to be done and how to do it, and the process of facilitating individual and collective efforts to accomplish shared objectives" (Yukl, 2013, p.23). Leadership plays a critical role in generating crucial knowledge for decision makers; moreover, it provides individuals with a vision through an appropriate presentation (Nonaka, 2006). Leadership requires leaders to integrate KM processes with an organisation's strategy, support the value of KM and promote the evolution of a learning organisation (Ramachandran, Chong and Wong, 2013). Leaders should also support the dissemination of knowledge and new ideas, encourage the

use of KM programs, record past learned lessons and ensure the use of relevant knowledge which is essential when applying a successful KM system (Yulk, 2013).

Commitment from members in an organisation is essential with regard to leadership in order to interact and share knowledge (Han et al., 2016). Furthermore, knowledge management requires managers' agreement and a willingness to support its implementation (Yeh, Lai and Ho, 2006). Accordingly, leadership will not be enough to apply knowledge management in an organisation. It will need other KMEs such as the culture and the knowledge context that support leadership and the implementation of knowledge management.

2.4.3 Culture

Culture is defined as "shared motives, values, beliefs, identities, and interpretations or meanings of significant events that result from common experiences of members of collectives and are transmitted across age generations" (House et al., 2004, p.15). Culture can be recognised at three levels; these levels range from tangible artefacts such as visible structures and processes to underlying assumptions such as thoughts, beliefs and feelings. Among these two levels there are espoused beliefs and values such as strategies, goals and rules of behaviour (Schein and Schein, 2017). Culture was considered the biggest barrier to creating a knowledge-based organisation and was described as an active or passive hindrance for producing and developing KM programmes and strategies (Chase, 1997). Three culture components were found significant in order to achieve an effective KM programme: trust, cooperative involvement and incentives (DeTienne et al., 2004). An effective organisational culture establishes an appropriate environment that stimulates knowledge creation, sharing and dissemination, and supports teamwork and collaboration. Furthermore, it motivates individuals and employs reward systems (Allameh, Zare and Davoodi, 2011).

Culture can encourage the behaviour of hoarding knowledge such as sharing knowledge among limited numbers of an organisation's individuals or experts. In order to overcome this obstacle, a supportive culture in addition to other KMEs such as information technology should be stimulated to support the sharing of knowledge (Ardichvili, 2008).

2.4.4 Organisational Structure

An organisational structure is "the formal relationships and allocation of activities and resource among people" (Allameh, Zare and Davoodi, 2011, p. 1216). It defines how roles are formally grouped, divided and integrated. Six elements need to be addressed by managers when building an organisational structure: centralisation and decentralisation; formalisation; work specialisation; departmentalisation; chain of command; and span of

control (Robbins and Judge, 2016, p.272). Organisational structure can encourage employees to interact socially, which improves sharing and the application of knowledge (Rasula, Vuksicand and Stemberger, 2012). There is less probability to share knowledge in highly structured, hierarchical and multi-layered organisations. On the other hand, flat organisations which are not restricted to communication that flows in one direction are more likely to share knowledge (Riege, 2005). A less centralised (or more decentralised) and less formalised structure also supports employee collaboration, information sharing and builds channels of communication to exchange knowledge and expertise (Lee, Shiue and Chen, 2016 ; Chen and Huang, 2007).

Thus, an effective KM system requires less emphasis and a more flexible organisational structure that reinforces openness and enables employees to innovate, create and share new knowledge (Kim and Lee, 2006). Achieving these factors in an organisational structure will require employing different KMEs such as information technology, culture and leadership in order to support flexibility, openness, innovation and the creation of knowledge.

2.4.5 Business Repository

A business repository is a "computer-based warehouse of documentation, knowledge and experiences about a particular domain, where knowledge is collected summarised and integrated across sources" and referred to as "corporate memories" or "experience bases" (Girard, 2009, p. 168). A business repository is crucial in order to use and store all available knowledge assets in an organisation. It facilitates defining, implementing and managing organisational processes and activities. Furthermore, it reduces effort and improves productivity (García et al., 2011). A repository requires users to seek knowledge through search queries; however, it limits the scope to ease this process (Davenport, 2005). Business repositories can be classified into three types (Dingsoyr and Royrvik, 2003): external repositories such as competitive intelligence; structured internal repositories such as work procedures and business reports; and informal internal repositories such as lessons learned, news and important announcements.

Applying a business repository alone cannot achieve a full implementation of knowledge management. Moreover, certain knowledge (or tacit knowledge) might still in employees head and even explicit knowledge can have limited access (Riege, 2005). Therefore, the utilisation of other KMEs such as information technology, culture and organisational structure is necessary to activate and complete the role of a business repository in an organisation.

2.4.6 Knowledge Context

Context is an essential component in understanding knowledge and sharing it with other relevant knowledge in an organisation. Contextual knowledge is defined as "the capacity to do what it takes in a situation" (Aspers, 2006, p. 746). It is related to the surrounding environment and cannot be viewed in isolation of the wider system of relations between individuals, activities and their understanding (Goldkuhl and Braf, 2001). Knowledge context can be classified into two types (Ahn et al., 2005): context-based proactive delivery of knowledge, and the capture and utilisation of contextual knowledge. The first shares knowledge with users based on the context, such as activities, business roles and outputs. The second one, the knowledge context itself, is captured and applied instead of being used as a means for knowledge identification and dissemination.

Without an appropriate knowledge context, relevant knowledge can be isolated and results in a distortion or limitation in understanding (Ahn et al., 2005). Relevant knowledge implies knowledge that is facilitated or stimulated by different KMEs that are used or aligned with that context. Hence, an understanding of the flow of knowledge through KMEs requires an appropriate context that describes or reflects the environment where the knowledge flows in. This environment can differ from one case study to another.

2.5 The Research Gap Analysis

The research gap analysis is summarised by the following:

(1) BPA approaches are static and are unable to address the challenges of a dynamic business environment (Lapouchnian and Sturm, 2015). This observation suggests that the development of a sustainable competitive advantage of an organisation is strongly dependent on new knowledge acquisition and flexibility to adapt and evolve in dynamic settings (Sirmon, Hitt and Ireland, 2007; Zahra and George, 2002).

(2) Applying KMEs is recommended to support the development of dynamic competencies of an organisation and improve its performance and competitive advantage (Tseng and Lee, 2014). Furthermore, KMEs are not formally used in the development of BPA. Thus, the utilisation of KMEs in BPA development is proposed to improve its dynamic capabilities. Dynamic capabilities are "higher-level competencies that determine the firm's ability to integrate, build, and reconfigure internal and external resources/competences to address, and possibly shape, rapidly changing business environments" (Teece, 2012, p. 1395). In light of this definition, the dynamic capabilities of a BPA can be defined as competences that determine

BPA abilities to generate, track, combine, and reconfigure its elements and design its processes in a rapidly changing environment.

(3) Research has only been directed towards the integration of KM and the business process management including planning, analysis, implementation and utilisation (Schmid and Kern, 2014). However, none of these approaches has investigated a BPA that adopts a KM framework that leads to the development of process architectures.

(4) The Riva method and its semantic presentation by Yousef and Odeh (2014) requires "an EBE-independent method for classifying businesses objectively and accurately" (Beeson, Green and Kamm, 2013, p.56), where it can be achieved using semantic KMEs instead of gathering CEBEs manually.

Based on the research gap analysis, the srBPA ontology has been applied in this research to be aligned with knowledge resources. These resources will be provided by the semantic KMEs in order to support the generation of the CEBEs/EBEs of the srBPA ontology. Compared to other BPA approaches, a knowledge-based BPA is hypothesised to assist organisations in recombing/reinforcing their current knowledge capabilities in order to develop a more dynamic view of knowledge creation in their organisations (Villar, Alegre and Pla-Barber, 2014), leading to the development of an effective knowledge-based BPA.

2.6 Chapter Summary

Current BPA approaches are still static and have shortages to meet regular changes in organisations. Adopting a new approach can present a dynamic BPA which corresponds to a rapidly changing environment and adds a competitive advantage to the organisation. A resource-based theory suggests a knowledge-based view that utilises knowledge resources to in order to improve an organisation's abilities to renew, survive and sustain a competitive advantage. It also motivates the use of KMEs to implement knowledge in organisations.

Infrastructural capabilities or KMEs support dynamic capabilities and the performance of an organisation and are proposed to develop a dynamic BPA with a competitive advantage. Using KMEs in a BPA development requires aligning significant KMEs with an appropriate BPA method. An object-based BPA approach, namely the Riva method, has been found appropriate to embrace the output knowledge resources as business objects (or CEBEs), that will be provided by these KMEs and develop a dynamic BPA from a business perspective. The Riva method is an object-based approach that presents clear steps which can be used to develop a BPA from business entities. Information technology, leadership, culture, organisational structure, knowledge context and business repository are the KMEs which

will be aligned with the Riva method. These KMEs are essential in KM implementation and they are anticipated to cover the required knowledge resources in order to develop a dynamic KMEs and Riva-based BPA.

The alignment between KMEs and Riva method is suggested to be implemented using semantic ontologies. Semantic ontologies support a dynamic generation of knowledge resources and provide flexibility and agility to adopt these resources by Riva BPA as CEBEs. In addition, it facilitates integration and reasoning among different elements of KMEs and Riva BPA. The Riva method already has a semantic representation using the srBPA ontology. The srBPA ontology is expected to be driven by semantic KMEs in this research in order to develop a dynamic BPA.

Chapter 3

Research Design and Methodology

3.1 Introduction

Following the literature review in Chapter 2, an ontology-based approach, using the object-based Riva method and KMEs is proposed to drive the development of a knowledge-based BPA approach. This approach is expected to improve the BPA dynamic capabilities and suggests supporting its sustainable competitive advantage. Presenting a dynamic BPA with a competitive advantage requires a framework that leads to an alignment between the KMEs and the BPA. This chapter aims to introduce the KMEOntoBPA framework as a proposed approach in addressing this alignment. The KMEOntoBPA framework uses a semantic representation of KMEs in order to drive the development of an effective Riva BPA. The KMEOntoBPA will be demonstrated through a case study utilising a banking institution in Jordan. The development of the KMEOntoBPA framework (see Figure 3.4) has been guided by adopting the Design Science Research Methodology (DSRM) (Hevner et al., 2004; Peffers et al., 2007).

In this chapter, the research associated questions and hypothesis are re-introduced following the research gap analysis in Chapter 2 to lead to the research framework section. Following the research framework section, a brief review of research methodologies introducing the DSRM is presented in a section. The DSRM has been adopted in order to guide the research phases and inform the development of the research framework. Finally, the sources of sustainable competitive advantage and research case studies are presented.

3.2 Re-Visiting the Research Hypothesis and Associated Research Questions

The research questions involve a set of primary concerns and sub-concerns (or requirements). These primary concerns and sub-concerns generate a roadmap that leads to the acceptance or rejection of the research hypothesis (see Figure 3.1). Accordingly, the research questions are summarised as follows:

The first research question (RQ1) '*What existing knowledge management enablers are appropriate to drive the process of BPA development?*' requires the use of KMEs in order to identify a set of primary concerns which are related to BPA development, and more specifically identifying business resources/capabilities, business objects, and processes. This requirement results in a main sub-concern which is dealt with in Chapter 2.

The second research question (RQ2) '*What BPA method is appropriate to investigate the role of knowledge management enablers in driving the development of process architectures?'* requires an investigation of a BPA modelling method that uses business

objects or entities in order to embrace the knowledge resources that are derived from KMEs. Developing a dynamic BPA method suggests that this method should support the automation of its elements, the flexibility to accept changes and the traceability to track its elements. These features would allow for the alignment with the KMEs and the investigation of their role in developing a dynamic BPA for a particular organisation.

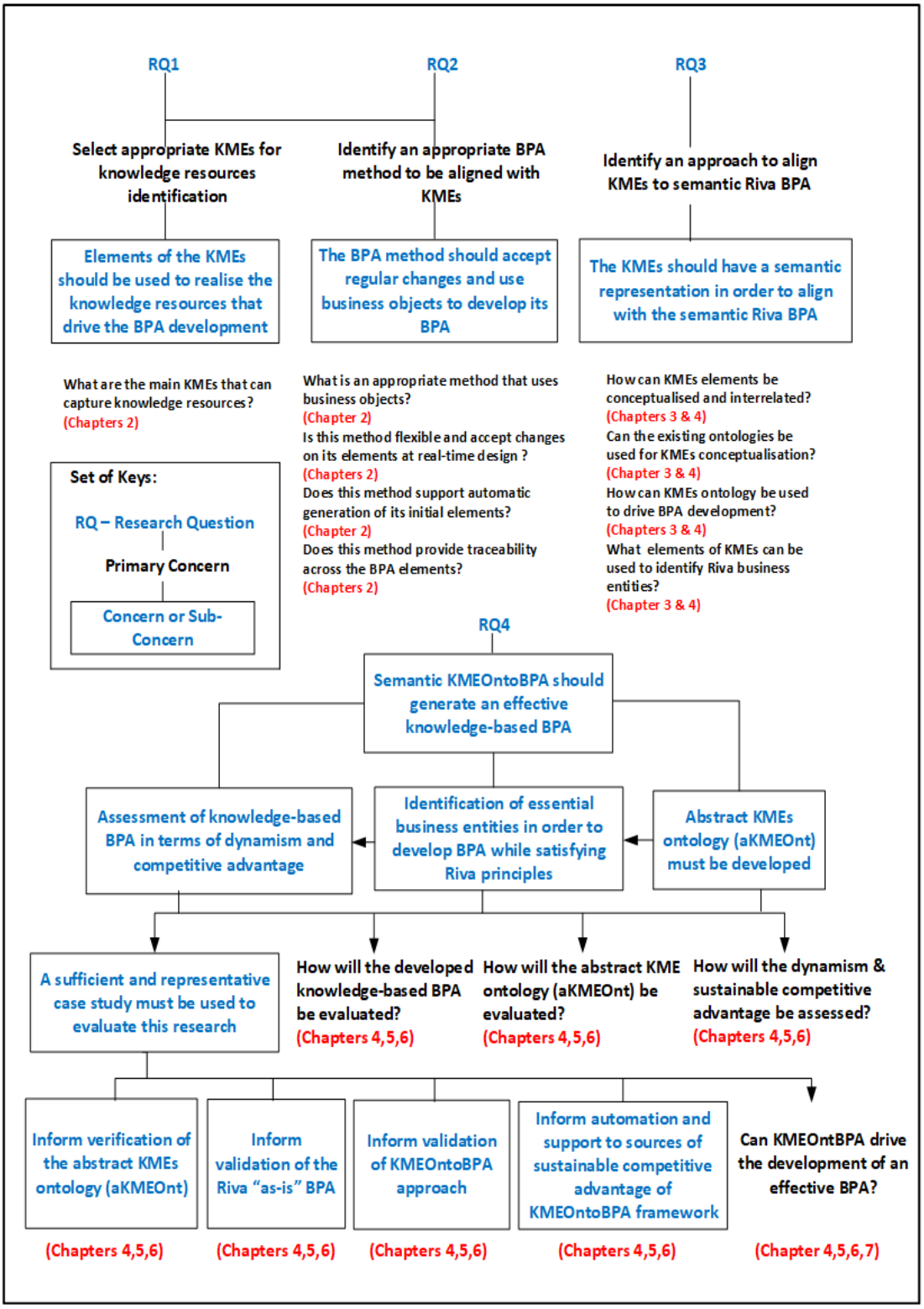


Figure 3.1: The Roadmap of the Research using Primary Concerns and Sub-Concerns

The third research question (RQ3) '*How can knowledge management enablers be used to drive the development of BPA?*' requires explicitly conceptualising and linking the KMEs' elements using ontologies in order to derive knowledge resources and resolve any potential problems of semantic heterogeneity. It is also necessary to map these knowledge resources with the srBPA ontology (Yousef and Odeh, 2014) and decide which of these knowledge resources are appropriate to be utilised in order to generate business entities for the development of a knowledge-based BPA.

Finally, the fourth question (RQ4) '*To what extent can knowledge management enablers drive the development of an effective BPA?* ' requires evaluating the effectiveness of the output knowledge-based BPA. In this research, the effectiveness of the BPA is related to the achievement of two features: dynamism and sustainable competitive advantage. A representative and sufficient case study is used to inform the extent to which the object-based BPA can be developed by KMEs. It also presents a benchmark by which the BPA effectiveness is informed through comparing the BPAs pre-KMEs and post KMEs. The evaluation of dynamism and a sustainable competitive advantage can address this research question and thus, accept or reject the research hypothesis.
This question also requires validation and verification tests which include: (1) verification of the semantic KMEs ontology; (2) validation of the BPA without KMEs, the Riva "as-is" BPA, which is used as a benchmark to validate the knowledge-based BPA; and (3) validation of the KMEOntoBPA approach.

3.3 The KMEOntoBPA Research Framework

The KMEOntoBPA is the main developed artefact in this research. This artefact benefits from the KMEs that are defined in the organisation knowledge management field. Linking these KMEs with the organisation's BPA presents a dynamic view for the organisation's BPA that is based on the flow of knowledge. It also facilitates an understanding of how to utilise the KMEs in the knowledge management domain and find relationships between them. Moreover, it extracts useful approaches to link between the KM and BPA disciplines, resolves semantic heterogeneity, and supports interoperability to exchange knowledge with other systems.

The KMEOntoBPA framework has two main components: the aKMEOnt and srBPA ontologies. The aKMEOnt is the semantic representation of the KMEs using OWL-DL (Roussey et al., 2011). The aKMEOnt is linked to the srBPA ontology (Yousef and Odeh, 2014). The aKMEOnt represents the domain of the KMEs, which defines six KMEs with

their concepts and relationships. The rationale behind the identification of these KMEs and their semantic specification is discussed in Chapter 4.

The aKMEOnt elements drive the development of the srBPA ontology elements in the research framework by creating the Candidate Essential Business Entities (CEBEs) (see Figure 3.2). Identifying the CEBEs in order to extract the EBEs is the alternative step for Ould suggested or brainstorming questions that provide a list of CEBEs in the Riva method. The CEBEs are the main connective concepts between the KMEOntoBPA framework ontologies. These CEBEs are instantiated using sufficient and representative case studies in order to present the potential knowledge-based BPA.

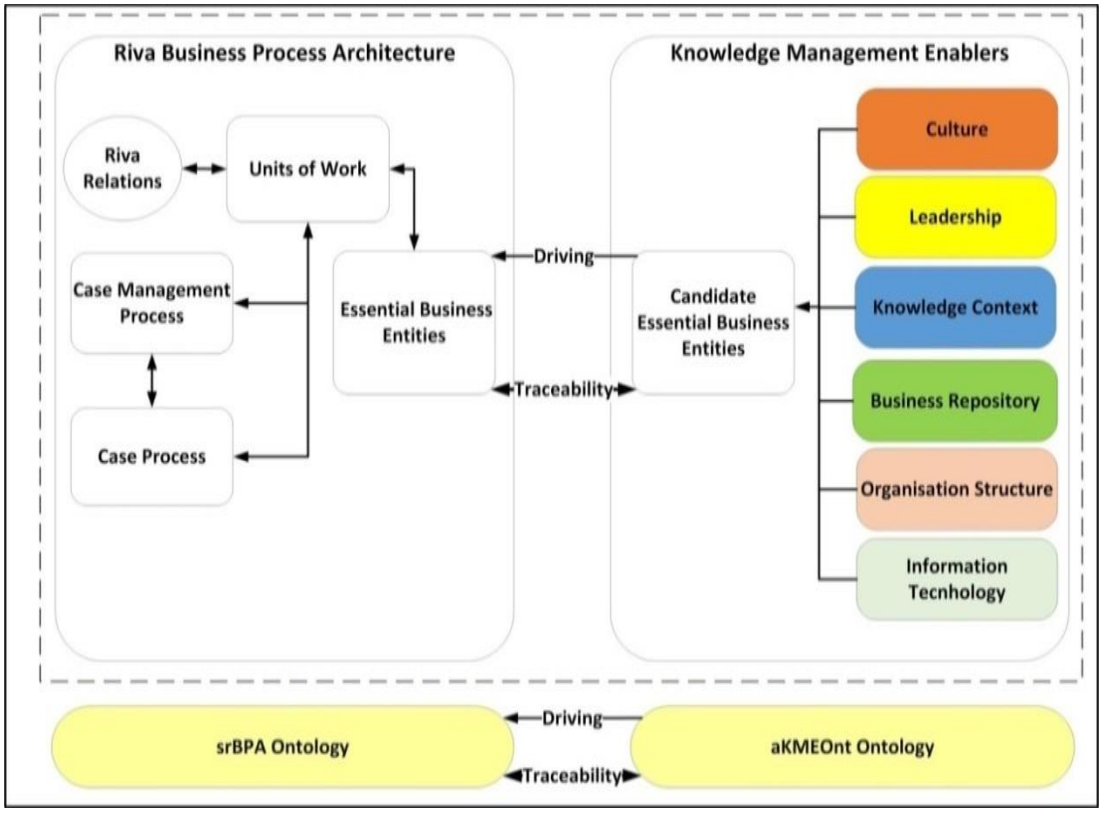


Figure 3.2: The Alignment between the aKMEOnt and the srBPA Ontologies

3.3.1 Characteristics of the KMEOntoBPA

3.3.1.1 Knowledge-Based

The KMEOntoBPA framework is KMEs-driven in the development of the BPA. The KMEs facilitate understanding how knowledge is created and applied in the organisation. The knowledge of the organisation should be considered as a set of capabilities and assets that the organisation owns in order to compete and survive. The KMEs are used in the research framework to identify the enterprise capabilities and extract the business entities that address the first step in the Riva method.

3.3.1.2 Support of Competitive Advantage and Dynamic View

The KMEs help to identify and better manage the new changes that occur in the organisations' environment. Using the KMEs in this research framework provides a tracking feature for the current and new business entities that exist in the organisation. Tracking these entities supports regular updates to the BPA in an organisation. The framework can then be dynamic and responsive to the rapid changes of the business environment. Moreover, it sets out a resource-based view for the organisation by managing different knowledge resources and thus supports a competitive advantage.

3.3.1.3 Ontology-Based

The KMEOntoBPA framework uses common shared concepts in the domain of the KMEs and the BPA. These concepts facilitate the sharing of knowledge between stakeholders in different sectors of the same organisation and consequently support KM implemenation. They also resolve problems of semantic heterogeneity in relation to the different terms of knowledge resources with the same meaning (or different meanging for the same term of knowledge resource) that are used by stakeholders in different sectors. Thus, the aKMEOnt conceptualises KMEs' elements and their relationships in order to share a common understanding of how knowledge resources are created and utilised in an organisation.

3.3.1.4 Domain Independence

The proposed research framework is domain independent as it can be applied to develop the Riva BPA for any organisation irrespective of its business domain. This proposition stems from the two main components that construct the research framework. Each of them is developed using semantic ontologies as an abstract component that can be applied to different domains. The first component (the aKMEOnt) is developed as a generic model that can be instantiated for any enterprise and identify its KMEs' drivers. The aKMEOnt is still not applied to different domains; however, it is applied to different case studies in the same domain which is banking in this research. The second component (the srBPA) which implies the Riva method and its semantic representation is also domain independent and can be instantiated to generate a flexible and adaptable BPA in an organisation. The srBPA ontology is used in different case studies such as the Cancer Care at the King Hussein Cancer Centre (KHCC) in Jordan (healthcare domain) and the CEMS Faculty Programme Administration (higher-education domain) (Yousef et al., 2009; Beeson, Green and Kamm, 2013). Thus, the whole research framework can be described as domain independent.

3.3.2 The Semantic KMEOntoBPA Framework

The KMEOntoBPA framework is a four-layered model that enacts KMEs and BPA components and the relationships between them (see Figure 3.3). The transition from top to bottom layers is semi-automated (more details in Section 4.2.6). The KMEOntoBPA framework stems from the Resource-Based View (RBV) of an organisation. RBV is described to be useful for information systems research (Wade & Hulland, 2004). It provides a strategic vision to evaluate the entire information systems assets and capabilities and to adapt changes in a dynamic environment (Zack, 1999).

The RBV leads the framework to identify KMEs that clarify how enterprise capabilities are created and applied in an organisation. KMEs form the cornerstone layer in our framework, which drives the development in subsequent layers.

Figure 3.3: The Abstract Architectural Representation of the KMEOntoBPA Framework

3.3.2.1 The Abstract KMEs Ontology Construction Layer

The main component in this layer is the abstract knowledge management enablers' ontology (aKMEOnt) (see Figure 3.4). The construction of KMEs' concepts/classes and their relationships is accomplished in this layer. Understanding this layer requires further explanation of the aKMEOnt.

3.3.2.1.1 The Abstract KMEs Ontology (aKMEOnt)

The aKMEOnt is a semantic model that describes the domain of KMEs using an ontology. The aKMEOnt is comprised of six significant KMEs that were discussed in Chapter 2: *information technology*, *leadership*, *culture*, *organisational structure*, *business repository and knowledge context*.

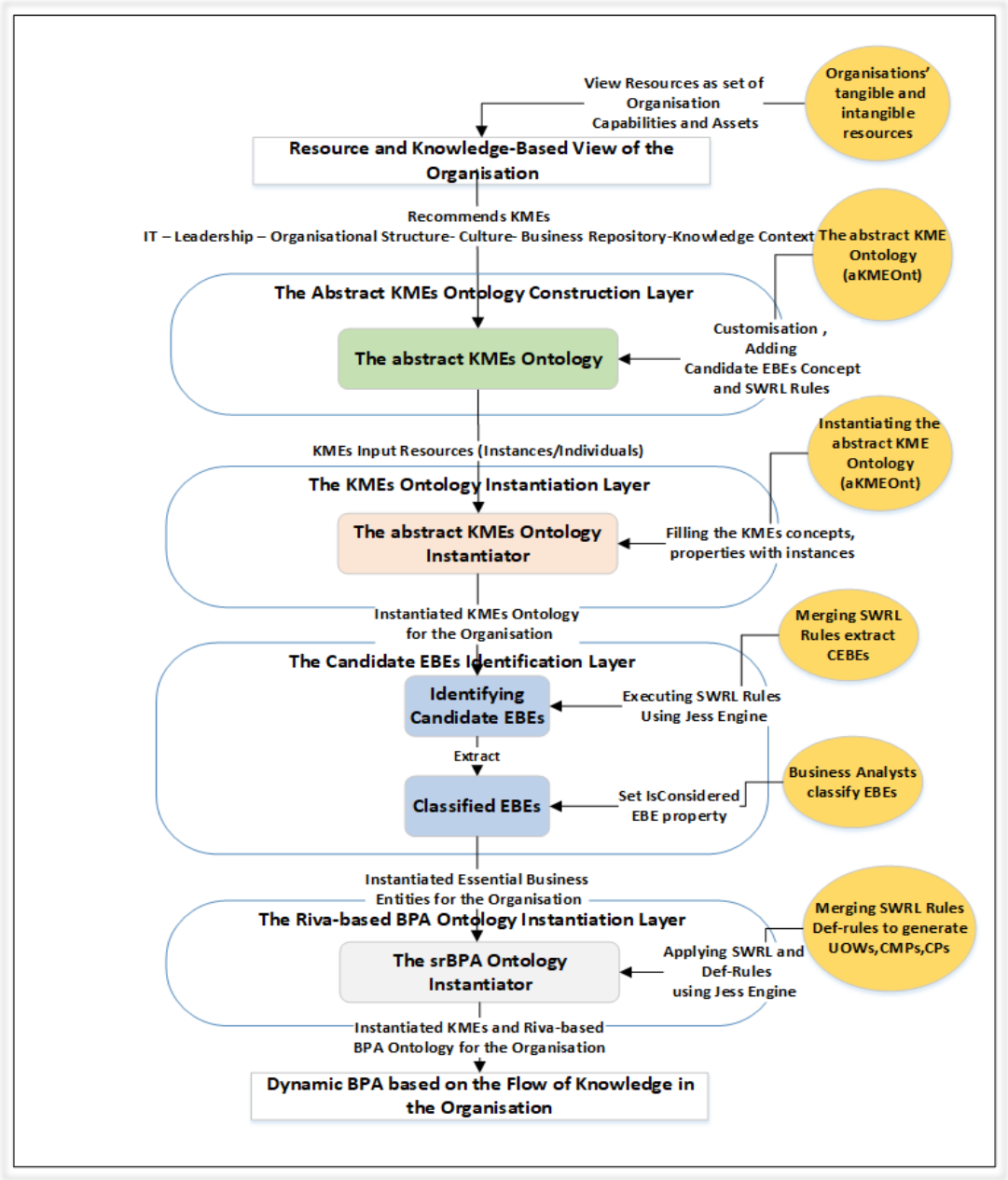


Figure 3.4: The Layered KMEOntoBPA Framework

Different methods were developed for ontology construction. The most popular ones include: general structures of underlying conceptualisation by Hobbs (1995), ASTREE by Reynaud and Tort (1997), Methontology by Lopez et al. (1999), the language extended lexicon (LEL) by Breitman and Leite (2003), the TOVE (TOronto Virtua Enterprise) which

was developed by Grüninger and Fox (1995) and refined by (Uschold 1996; Uschold and Gruninger, 1996), SENSUS by Swartout et al. (1996), and finally the Knowledge-Engineering Method by Noy and McGuinness (2001).

Among these ontology methods, the ontology construction method by Noy and McGuinness (2001) has been adopted to develop the aKMEOnt using the Protégé tool and OWL-DL. Noy and McGuinness (2001) present a simple approach with clear steps to follow while building an ontology. They have also defined three rules while designing an ontology which are:

(1) There is no correct way to model a domain; there are always applicable alternatives. The best solution depends on the application that you have in mind;

(2) Development of an ontology is an iterative process;

(3) Concepts in the ontology should be close to objects and relationships in your domain of interest. These are most likely to be nouns (objects) or verbs (relationships) in sentences that describe your domain.

These rules are considered appropriate to adopt in this research. Rule 1 ensures that the best solution is related to what works better in our case and what ontologies are built for. The design and development of the abstract KMEs' ontology (aKMEOnt) in the KM domain should consider its role in driving the development of BPA which is indicated by Rule 1. The iterative process of the development of an ontology in Rule 2, is also part of the iterative process of the DSRM-based research methodology, which evaluates the whole framework including its ontologies using domain experts and sufficient and representative case studies. The concepts in the aKMEOnt are also close to objects and relationships in the KMEs domain as they are defined and discussed in Chapter 4. This is emphasised in Rule 3.

In addition to these appropriate rules, the Noy and McGuinness (2001) method is also important to determine the KMEs that are used in the research scope and to incrementally identify the KMEs' concepts and their relationships. It also highlights the significant terms or concepts that the research needs to utilise in constructing the ontology. Furthermore, it does not ignore existing ontologies in the same domain.

Noy and McGuinness's method (2001) is comprised of seven steps: (1) determine the domain and scope; (2) consider reusing the existing ontology; (3) enumerate important terms; (4) define the classes and class hierarchy; (5) define the properties/slots of classes; (6) define the facets (restrictions) of the slots; and (7) create instances. These steps have been used to construct the aKMEOnt and decompose it into concepts using definitions, previous studies and existing ontologies as follows:

i. **Information Technology** relates to three essential elements; user, tool and dimension. The dimension describes the tool which can be integrative or interactive (Hayes, 2011).

ii. **Leadership** relates to three main elements; the leader, his followers and the shared goals (Bennis, 2009).

iii. **Culture** conceptualising as an ontology is not simple. However, the definition of culture by Schein and Schein (2017) has been adopted in conceptualisation of the culture KME by using its elements. The problem, the assumption that solves this problem and the reference which is the source of that assumption are the main elements of that definition. Schein's definition is important since it shows the dynamic feature of culture and presents it as a process starting from shared learning and ending by teaching and the rooting of assumptions in an organisation. This dynamic aspect corresponds to the dynamic BPA that this research seeks to achieve.

iv. **Organisational Structure** has already existing ontologies with common concepts that include roles, skills, positions, persons or agents, units and resources (Abramowicz et al., 2008; Reynolds, 2014). Reynolds' (2014) and Abramowicz et al. (2008) ontologies are the main existing ontologies that were found in organisational structure. Reynolds' (2014) ontology has been designed to support the sharing of organisational information across different domains and has been endorsed by the W3C. Abramowicz et al. (2008) designed an organisational structure ontology in order to support the analysis of business processes. Both existing ontologies have significant goals which need to be reached in this research context. Therefore, these ontologies are taken into account in this research by: (1) checking common concepts and their correspondence with other KMEs elements; (2) adopting these common concepts to identify whether they are essential in driving the development of BPA; and (3) checking non-shared concepts and discover whether they are significant in BPA development.

v. **Business Repository** is limited to the metadata schemas or attributes that provide information about the e-documents (Yang, Chen and Shao, 2004). The attributes are type, description, division, creator, and creation date. These attributes represent the basic information about the documents that are needed for the development of the aKMEOnt in this research. The attribute is selected after checking its expected relation with other KMEs.

vi. **Knowledge Context** is related to the conditions that create a unique business situation (Pomerol and Brezillon, 2001). Previous definitions of context refer to the location, the environment and the people surrounding the user in the environment (Abowd et al., 1999). All these elements that represent a context are already found in

the elements of different KMEs. However, there are still some remaining elements that directly represent the factors or conditions that form a business situation. These elements which “intervene in a context, come from the domain” (Brézillon, Pomerol and Saker, 1998, p.359), and are in relation to other KMEs. Units or divisions, business rules, restrictions and customers are surrounding relevant conditions that are produced by the domain and form a business situation. These elements are crucial in describing a knowledge context and can complete the missing description of context by other KMEs. Thus, they are used to build the knowledge context in the aKMEOnt.

These are the main KME concepts that construct the aKMEOnt. Relationships between the KMEs and their concept map, classes and properties are discussed in detail in Chapter 4.

3.3.2.2 The KMEs Ontology Instantiation Layer

The main component in this layer is the aKMEOnt Instantiator. Ontology instantiation refers to adding information or instances into the ontology. Instances or individuals are the basic elements of an ontology. The instances of a class are similar to the elements of a group, but they are volatile and dynamic at any given time (Poli, Healy and Kameas, 2010). Instantiation of the KMEs ontology is accomplished using the case studies in this research which provide the instances that are related to each KME.

3.3.2.3 The CEBEs Identification Layer

The candidate essential business entities (CEBEs) are the linkages between the aKMEOnt and the srBPA components in the KMEOntoBPA framework. They can be extracted from the individuals/instances of the aKMEOnt component. Extracting these CEBEs requires using some rules associated with logic. The ontology development environment, Protégé 3.4.1, supports using Semantic Web Rule Language (SWRL) rules which can be used to extract the CEBEs. Accordingly, business analysts consider which CEBEs are classified as EBEs, which means that CEBEs do not exclude business analysts role in deciding whether a new CEBE is an EBE or not. Thus, these EBEs will be used to instantiate the associated srBPA ontology component.

3.3.2.4 The Riva-based BPA Ontology Instantiation Layer

The srBPA ontology is the main component of this layer. The srBPA ontology is already constructed by Yousef and Odeh (2014) in order to present the main elements in the Riva method: the essential business entities (EBEs), units of work (UOWs), case processes (CPs) and case management processes (CMPs) and their relationships. The instantiation of the

srBPA ontology, specifically providing the EBEs, is no longer manual after adding or aligning the aKMEOnt component and extracting the CEBEs using SWRL rules. No changes are applied to the original srBPA ontology component with these additions. The CEBEs will lead to generating the instances of the Riva elements: EBEs, UOWs, CPs and CMPs and their relationships. The instances of the UOWs, CPs, CMPs and their relationships are utilised to present the UOWs, 1st and 2nd cut process architecture diagrams of the Riva BPA. More details are found in chapters 4, 5 and 6.

3.3.2.5 The Dynamic Knowledge-based BPA

The final output of the research framework is the dynamic knowledge-based BPA that depends on the flow of knowledge in the organisation. This dynamic BPA will be demonstrated using the case studies of a bank in Jordan as explained in Section 3.6, and it is supposed to adopt changes in the bank case studies' environment and reflect these changes in the evolved BPA.

3.4 A Brief Review of Research Methodologies

Collis and Hussey (2014) classified research methods according to the following: (1) purpose as in descriptive, exploratory and predictive research; (2) process as in qualitative and quantitative research; (3) outcome as in applied or basic research; and (4) logic as in deductive or inductive research. These different approaches are associated with two research paradigms or frameworks that guide the research conduction (Collis and Hussey, 2014): the positivism and interpretivism paradigms.

Positivist research is based on the existing relations within phenomena that are described using a structured instrument (Orlikowski and Baroudi, 1991). Positivist research is objective and neglects passions, ideologies and values (Ryan, 2006). Quantitative methods and the deductive process are mainly used in positivist research. Interpretive research is involved with the social context of the phenomena that the research attempts to understand and acquire knowledge from (Rowlands, 2005). In interpretive research, participants' subjective meanings are considered while interacting with the environment (Orlikowski and Baroudi, 1991). Qualitative methods and inductive process are mainly used in interpretive research.

Another significant paradigm that can be integrated with different research approaches is the design science paradigm in the information system (IS) field (Venable, 2006). Design science seeks to understand and solve a problem by presenting and applying a designed artefact that extends human boundaries and enterprise capabilities (Hevner et al., 2004).

In this research, the design science paradigm is adopted for the following reasons:

(1) The design science paradigm is recommended in information system research (Hevner et. al, 2004). The artefact of this research, i.e, the KMEOntoBPA, is an ontology driven information system framework. Thus, the design science can be considered as paradigm to build the KMEOntoBPA.

(2) This research requires developing a socio-technical artefact using ontologies in order to support a dynamic BPA with a sustainable competitive advantage. A design with a socio-technical artefact is an approach that involves individuals/users, organisational and technical factors (Baxter and Sommerville, 2011). Positivism and interpretivism paradigms are socially enabled, but they are not as socio-technologically enabled as the design science paradigm (Vaishnavi and Kuechler, 2004).

(3) The incremental development of the KMEOntoBPA framework using various case studies corresponds to the iterative restriction in design science research which is an essential part of progress through the research phases.

(4) The evaluation of the KMEOntoBPA is concerned with different evaluation approaches. One is related to the structural level or the technical aspect of the ontology and the other is concerned with its impact on the organisational level. The positivism and interpretivism paradigms are more related to the impact of technology on an organisational level, because "these paradigms do not attend to the creation of unique knowledge associated with the development of information systems from their conception to inception" (Gregg, Kulkarni and Vinzé, 2001, p. 172). On the other hand, the multiple evaluations, i.e., the technical and organisational, are both valid for design science research (Venable, Pries-Heje and Baskerville, 2016). Therefore, using different criteria or measurements to evaluate the effectiveness of the KMEOntoBPA framework on both the structural and the organisational levels can be accomplished using the DSRM approach.

3.4.1 The Design Science Research Methodology (DSRM)

The design science concept was coined by Simon (1996), who explained the role of science disciplines in making and designing artefacts with particular settings. Design science research is "a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artefacts, thereby contributing new knowledge to the body of science evidence" (Hevner and Chatterjee, 2010). Hevner et al., (2004, p.83) endorsed the design science paradigm in information systems research and derived the following significant guidelines for design science research:

(1) **Design as an artefact:** design-science research must produce a viable artefact in the form of a construct, a model, a method, or an instantiation.

(2) **Problem relevance:** the objective of design-science research is to develop technology-based solutions to important and relevant business problems.
(3) **Design evaluation:** the quality, utility, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods.
(4) **Research contributions:** effective design-science research must provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/or design methodologies.
(5) **Research rigour:** design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.
(6) **Design as a search process:** the search for an effective artefact requires utilising available means to reach desired ends while satisfying laws in the problem environment.
(7) **Communication of research:** design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

DSRM combines different procedures, principles and practices to address three objectives (Peffers et al., 2007): consistency with previous literature, providing a nominal process model for conducting design science research, and providing a mental model for presenting and evaluating design science research in information systems.

The DSRM process model defines six steps as depicted in Figure 3.5, and are as follows:

1. ***Problem identification and motivation***: define the problem of the research and the rationale behind the solution. The problem will be a motivator to run the solution and approve the results.
2. ***Objectives for solution***: extract possible solution objectives from the problem specification, and select the optimal ones for the defined problem. Objectives can be quantitative where the proposed solution is better than the existing ones, or qualitative where the solution attempts to solve a problem not addressed before.
3. ***Design and development***: create different artefacts such as methods, models, and constructs. This phase comprises the following: perception of the desired artefact, and creating the actual one.
4. ***Demonstration***: verify the use of the artefact as a solution using one of the problem instances. This verification can be accomplished by adopting a case study, simulation, proof, or other experiments.
5. **Evaluation**: measure the efficiency and effectiveness of the artefact in solving the problem. This measurement will involve a comparison between the planned objectives and the actual results after the artefact demonstration. Furthermore, it is important to apply metrics and analysis techniques to the demonstration results.

According to this step, the researcher can determine whether to iterate back to the design and development step in order to improve the artefact, or to continue to the next step.

6. **Communication**: announce the research and share it with other researchers and relevant audiences through the media and publications.

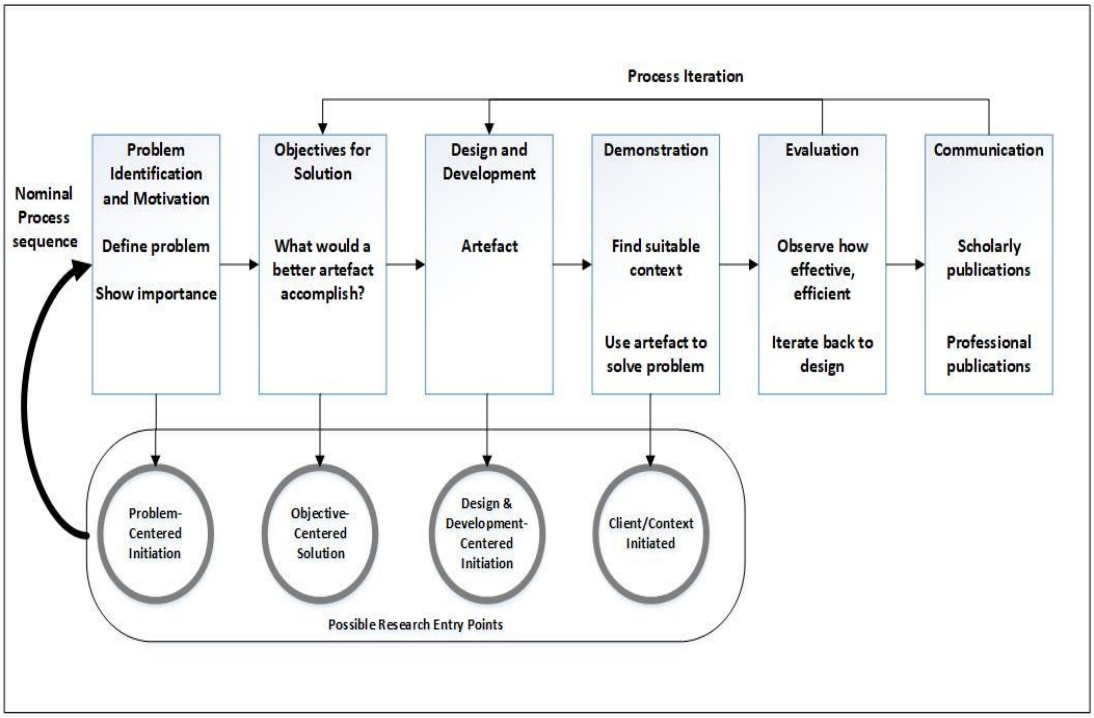


Figure 3.5: Design Science Research Methodology (DSRM) Process Model adopted from Peffers et al., (2007), Licensed under CC-BY-SA-3.0

The research methodology has been designed to employ the DSRM as discussed in the next section.

3.4.2 The Research Methodology

Information system artefacts depend on how all parts work together, not on how each part performs separately (Allee, 2000).The DSRM process model will act as a guide on how to align these parts to create our research artefact. It will also pave the way to reach our research aim and objectives. Figure 3.6 summarises the stages of the adapted DSRM process in undertaking this research.

3.4.2.1 Problem Identification and Motivation

The first phase in this research identifies the problem and its justification in order to continue seeking the solution. The literature review is conducted in this phase in order to identify the research gap analysis, and hence formulate the research problem, aim and objectives.

The output of this stage provides a detailed understanding of two different disciplines: knowledge management/enablers and business process architecture. It also reveals the problem that needs to be investigated in the BPA area. KMEs are the main field of discussion in the KM literature and are considered the upper layer and driver of the research framework (review Figure 3.4). The KMEs are introduced to handle the research problem and contribute to the building of the main research framework.

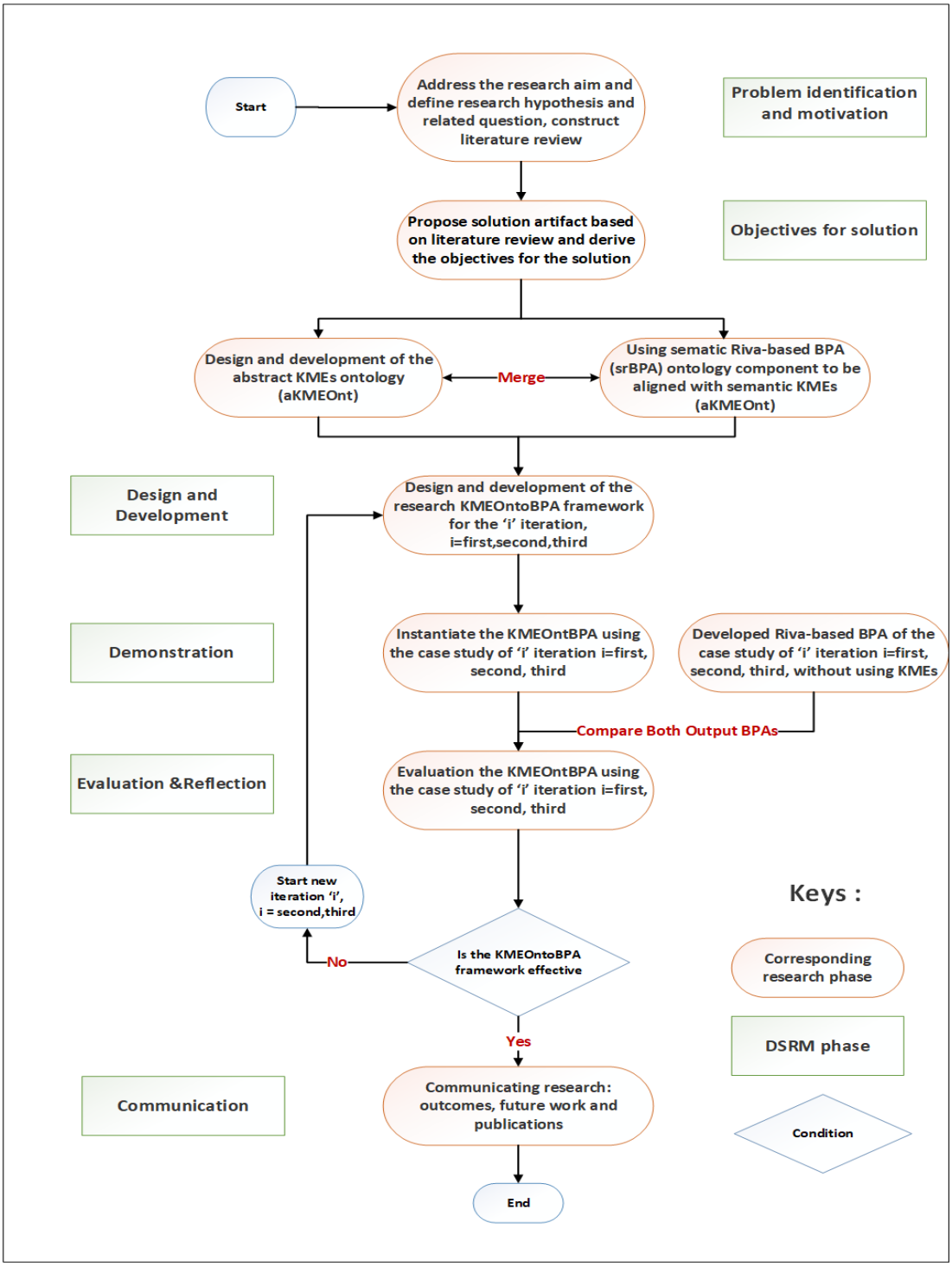


Figure 3.6: Research Methodology adopting the DSRM Process

3.4.2.2 Define Objectives for the Solution

The objective for the solution in the second phase of the DSRM process model is derived from the problem identification in the first stage. By identifying the research gap, stating the research problem and defining the aim and objectives of this research in Chapters 1 and 2, the qualitative objective is presented as a solution to the problem that has not been addressed before. Building an effective knowledge-based BPA is new and no earlier attempts have been conducted to investigate the alignment between the KMEs and the BPA in order to identify the role of KMEs in developing a dynamic BPA with a sustainable competitive advantage.

3.4.2.3 DSRM First Iteration: Application of the 1st Case Study

This DSRM iteration comprises the phases of design and development, demonstration, and evaluation. Adopting these phases is related to the application of the research framework (review Figure 3.4), namely the KMEOntoBPA. The KMEOntoBPA framework is composed of two main components: the aKMEOnt and the srBPA ontologies. Applying the design and development phase requires constructing the abstract KMEs ontology (aKMEOnt) and creating its semantic mapping with the semantic Riva BPA, i.e., the srBPA ontology. The srBPA ontology has already been defined in the previous research work of Yousef and Odeh (2014) and used in different frameworks (Ahmad and Odeh, 2012; Yousef et al., 2009). The aKMEOnt represents a formal description of the KMEs' domain with their entities' relationships. The aKMEOnt is the driver that will lead the instantiation of the srBPA ontology.

Following the design and development phase, the KMEOntoBPA framework is demonstrated using the first case study which is the *Treasury* part of the bank in the research case studies. Knowing when to use a case study in research has no formula, but it is usually related to the type of the research and its associated questions (Yin, 2014). This research is problem-based research which requires an empirical investigation in order to identify the role of KMEs in developing a dynamic BPA within real settings. It also requires evidence to support this identification. The case study approach can meet these requirements and evaluate in depth the research framework in the business environment (Hevner et al., 2004). The demonstration phase involves instantiating the KMEOntoBPA framework components, which are the aKMEOnt and srBPA ontologies, using the *Treasury* case study of the bank.

The evaluation phase in this research is related to the evaluation of the KMEOntoBPA framework. Two perspectives on evaluation are distinguished in the evaluation of the information system and in the DSRM: the ex-ante and ex-post perspectives (Pries-Heje,

Baskerville and Venable, 2008). Ex-ante evaluation is performed before the research artefact construction and ex-post evaluation takes place after the research artefact construction. This phase of the research is considered as ex-post evaluation since the artefact has already been constructed. The ex-post approach offers an opportunity to demonstrate the research framework in a real environment using naturalistic evaluation methods (Pries-Heje, Baskerville and Venable, 2008). A naturalistic method can involve experiments, field and case studies (as this research), ethnography or action research (Venable, Pries-Heje and Baskerville, 2016). It performs evaluation in real settings with real humans facing real problems (Sun and Kantor, 2006). The case study is applied by the research KMEOntoBPA framework in order to measure its effectiveness. Further details of the evaluation of the first iteration are discussed in Chapter 4.

According to Juristo and Morant (1998), an evaluation can include the following: checking the correctness of the system structure, which is referred to as verification; checking the validity of the system content, which is referred to as validation; and checking the objective achievement of the system. Applying these evaluation types to the KMEOntoBPA framework, using the case study of this DSRM iteration, will imply verification of the aKMEOnt, validation of the benchmark Riva "as-is" BPA, validation of the KMEOntoBPA semantic approach in terms of conformance to Riva CEBEs/EBEs and finally, the achievement of the objective by developing an effective KMEOntoBPA approach that generates a dynamic or an agile BPA on a structural level, and consequently, assessing its support to sources of sustainable competitive advantage (SCA) in the organisation. Sources of SCA are core competences, technical capabilities and social capital that are discussed in Section 3.5 The first case study will only include the verification and validation of the KMEOntoBPA framework in order to inform its initial appropriateness with the collaboration of the domain experts in the bank case study that is employed in this iteration. Thus, it can be determined whether the framework is initially appropriate with regard to evaluating its achievement of the objectives. Table 3.1 provides a breakdown of the research evaluation phases of the KMEOntoBPA framework.

Table 3.1: The Research Evaluation Framework

<table>
<tr><th rowspan="2">DSRM Iterations</th><th rowspan="2">KMEOntoBPA Evaluation Components</th><th colspan="3">Evaluation Type for Each Iteration</th></tr>
<tr><th>Verification</th><th>Validation</th><th>Dynamism & Sustainable Competitive Advantage</th></tr>
<tr><td>First Iteration</td><td rowspan="3">The abstract KMEs ontology (aKMEOnt)</td><td rowspan="3">Walk through or inspection method to evaluate the correctness of the aKMEOnt in terms of satisfaction in representing the case study using KMEs.</td><td rowspan="3">–</td><td rowspan="3">–</td></tr>
<tr><td>Second Iteration</td></tr>
<tr><td>Third Iteration</td></tr>
<tr><td>First Iteration</td><td rowspan="3">The “as-is” Riva BPA of the case study</td><td rowspan="3">–</td><td rowspan="3">Validating the elements of the Riva “as-is” BPA of the bank case study with domain experts</td><td rowspan="3">–</td></tr>
<tr><td>Second Iteration</td></tr>
<tr><td>Third Iteration</td></tr>
<tr><td>First Iteration</td><td rowspan="3">The developed knowledge-based BPA using the KMEOntBPA</td><td rowspan="3">–</td><td rowspan="3">1) Validating SWRL rules through the validation of their generated CEBEs

2) Validating the CEBEs with domain experts of the bank case study and mapping the CEBEs with Ould suggested questions

3) Comparing the knowledge-based BPA with the Riva “as-is” BPA using the bank case study.</td><td>–</td></tr>
<tr><td>Second Iteration</td><td rowspan="2">1) Inspection of CEBEs automatic derivation and the potential of agile configuration of BPA elements.
2) Using a mixed methods approach (questionnaires and interviews) to assess the KMEOntoBPA advantages and its impact on the sources of sustainable competitive advantage (core competences, technical capabilities and social capital) in the bank case study</td></tr>
<tr><td>Third Iteration</td></tr>
</table>

Following verification and validation feedback, necessary modifications will be identified to lead into the design and development phase of the second DSRM iteration. The feature that should be verified in the aKMEOnt is correctness. Correctness implies that "there are no surplus or missing items in the model" and is divided into three major criteria: "redundancy, incompleteness and inconsistency" (Juristo and Morant, 1998, p. 153). Accordingly, the number of the KMEs elements in the case study should be equal to their correspondence in the aKMEOnt with no additional or missing items. The aKMEOnt elements should also be consistent with no contradictions between its elements. In addition, no redundant concepts or relations are detected. Validation of the KMEOntoBPA framework includes checking the validity of SWRL rules according to their output CEBEs, checking the validity of the output CEBEs with domain experts regarding characterising business domain, and mapping the CEBEs with Ould suggested questions for CEBEs derivation. It also includes checking if the developed Riva "as-is" BPA elements are right with the domain experts in order to use as a benchmark and compare it with the knowledge-based BPA.

3.4.2.4 DSRM Second Iteration: Application of the 2nd Case Study

The feedback of the DSRM first iteration will determine whether to iterate back to the design and development or demonstration phase and perform a new iteration. Iterating back to the design and development phase implies implementing some modifications to the design of the KMEOntoBPA framework. Modifications to the KMEOntoBPA framework will be followed by its demonstration and evaluation using the second case study, i.e., the *Deposits* part of the bank. The evaluation includes the same verification and validation that have been defined in the DSRM first iteration with a different case study. It also requires assessing the objective achievement of the KMEOntoBPA though the following: (1) an inspection of CEBEs/EBEs automatic generation and agile configuration of their corresponding BPA elements, and (2) a mixed methods approach evaluation of the advantages of the KMEOntoBPA and its support for sources of sustainable competitive advantage. Feedback will be provided in order to start a new DSRM iteration. The detailed implementation of the DSRM second iteration is discussed in Chapter 5.

The mixed methods approach includes quantitative and qualitative approaches. The quantitative approach uses survey questionnaires that are distributed/hand-delivered to the senior employees of the Deposits in a branch of the bank case study. The qualitative approach includes an interview with the manager of the bank branch. Each question in the interview has been labelled to facilitate placing a part of the interview responses within the questionnaires' results discussion. The questionnaire design and interview questions are available in Appendix B. Both of the questionnaire and interview were designed to provide a

comprehensive assessment of the KMEOntoBPA framework advantages and its impact on sources of SCA with consideration of time and information restrictions of the bank. They were also checked with domain experts and piloted by the *Treasury* case study, i.e., the bank first case study in order to gauge whether questions are clear, reflective to their goals and sensible to complete within time.

3.4.2.5 DSRM Third Iteration: Application of the 3rd Case Study

The DSRM third iteration is the last iteration in this research. Feedback from the second iteration leads to a new iteration and a demonstration of the KMEOntoBPA. The KMEOntoBPA framework is demonstrated and evaluated using the third case study, i.e., the *Financing* case study. The evaluation of the KMEOntoBPA will include the same types of evaluation in the second iteration. At the end of this evaluation, the three iterations of the DSRM will have been completed. Hence, the KMEOntoBPA framework's aim and objectives will have been evaluated as to whether these three iterations are sufficient enough to conclude the findings in order for the research to be communicated in the final phase of the DSRM process. These three DSRM iterations will have endorsed the evaluation of the KMEOntoBPA framework using the bank's core business functions. Further details of the DSRM third iteration are discussed in Chapter 6.

A mixed methods approach evaluation is performed similar to the previous /second iteration. A quantitative approach will use survey questionnaires that are hand-delivered to the seniors of the *Financing* case study of the bank headquarters. A qualitative approach will include two interviews with the credit and trade finance managers.

3.4.2.6 Communication

The communication phase is essential in providing a sufficient description about the solution artefact to the relevant audience (Hevner et al., 2004). Moreover, it improves the solution by providing valuable feedback and new suggestions. Research communication is mainly accomplished through publications and with bank experts.

3.5 Sources of Sustainable Competitive Advantage

Sustainable competitive advantage is a key indicator of a successful business in organisations. Therefore, enterprises seek to create opportunities to obtain this advantage (Della Corte and Aria, 2016). A sustainable competitive advantage (SCA) has been introduced or measured by researchers through different aspects such as (Liu, 2013): uniqueness in terms of product, quality and service technology; the excellence in execution; the high involvement in the strategic planning process; the resources and capabilities; and

resource-based strategy. In this research, SCA is measured through the advantages of applying the KMEOntoBPA and its support to sources of SCA.

SCA can be achieved through the support of its sources. These sources can be nurtured and developed by the knowledge resources in an organisation. Core competences, technical capabilities and social capital are three main critical knowledge-based resources that are considered sources of SCA (Jackson, DeNisi and Hitt, 2003).

Core competences are the "skills and areas of knowledge that are shared across business units". They have significant value because they result from the interaction between capabilities which are functionally-based and exist in a specific function (Javidan, 1998, p. 62). Core competences can be viewed as collective learning as they integrate various skills of production, combine with different kinds of technologies and create unexpected products (Prahalad and Hamel, 2003). Therefore, they are difficult to imitate by competitors and represent a source of sustainable competitive advantage.

Technical or technological capabilities refer to "those abilities that competitively distinguish the firm and allow it to create a sustained competitive advantage based on the technology in a changing context" (Dutrénit, 2004, p. 209). These abilities can create and help to accumulate knowledge and innovate new technological capabilities that support a sustainable competitive advantage.

Social capital can be defined as "the sum of the actual and potential resources that can be accessed through the network of relationships" (Nahapiet and Ghoshal, 1998, p.234). Organisations can reach an effective and efficient exchange of knowledge through developing different social capital networks (Inkpen and Tsang, 2005). Thus, they enhance their competitive advantage.

As the support of these sources can lead to SCA in organisations, the KMEOntoBPA framework support to these sources in the bank is evaluated in order to decide whether the KMEOntoBPA can achieve a SCA.

3.6 The Banking Case Studies

The research work, and in particular the effectiveness of the KMEOntoBPA framework, is applied and evaluated using the banking case studies that are part of the core business functions of a major Islamic bank. Islamic banking has been accepted widely in the world for providing a new perspective to financing and banking practices. However, "little academic evidence exists on the functioning of Islamic banks" (Beck, Demirgüç-Kunt and Merrouche, 2013, p. 233). The central idea of an Islamic bank as agreed by the General Secretariat of the

Organisation of the Islamic Conference (OIC) is as follows (Billah, 2007, p.401): "An Islamic Bank is a financial institution, which applies statutes, rules and procedures that expressly state its commitment to the principles of Islamic Shari 'a and prohibit the receiving and paying of interest (riba) on any of its operations".

There are five essentials that distinguish Islamic finance from conventional finance (Beck, Demirgüç-Kunt and Merrouche, 2013): the prohibition on "riba" (usury); the prohibition on "gharar" (risk or uncertainty); the prohibition on financing for illicit sectors such as drugs; the profit and loss sharing rule; and finally the rule that all transactions have to be supported by a real economic transaction that involves a tangible asset.

Islamic Banks usually offer four types of financial contracts: Deposits, Lending/Financing, Treasury, and Trade Finance (ORACLE Financial Services, 2012). Lending to customers and corporations, and deposit-taking are the main business functions of traditional banking (Greenwood and Scharfstein, 2013).

The Islamic banking business can be divided into three essential divisions: the Deposits, the Financing including trade finance, and the Treasury. These three divisions are proposed to represent the overall BPA of the bank:

1. The Treasury

The Treasury function asserts that the bank is financially stable. It "monitors, reports, and forecasts cash inflows and outflows to bank's business activities, while ensuring that the bank remains solvent and any excess cash is effectively invested" (Roszkowska and Prorokowski, 2017, p. 798). The Treasury bank department in an Islamic bank is in charge of funding other bank divisions, managing the bank's mismatch and liquidity risk, and making markets to customers in foreign exchange and sukuk (Islamic bonds). It also supports customers in managing their money market and foreign exchange using Sharia'a compliant contracts (Schoon, 2016).

2. The Deposits

Deposits refer to all money that is placed in the bank by corporate or private customers. They are considered an important source of funding for banks over the world. In addition, their use distinguishes the bank from other firms (Allen, Carletti and Marquez, 2015). The Deposits department in an Islamic bank offers retail financial services in relation to these deposits in the same way for conventional banks (Schoon, 2016). This includes bank branches and employees, automatic teller machines, current accounts with their e-cards and chequebooks, savings account, fixed account, transfers and other related services (Schoon, 2016).

3. The Financing

The main source of bank income is earned by financing operations (Bakar et al., 2018). Financing operations are associated with activities that are related to (Schoon, 2016): project finance, infrastructure finance, capital and debt-raising, the financing of joint ventures, public-private partnerships and privatisations, restructuring debt and other forms of working capital financing. They also require bank branches and many employees to serve customers. The Islamic financing contracts are classified into equity and debts mode (Ahmed, 2014): (a) equity modes are partnership-based contracts of musharakah and mudarabah; and (b) debts modes are related to sale transactions. Debt financial contracts are such as murabaha (cost plus), ijarah (leasing), istisna (contract manufacturing/construction) and salaam (pre-paid sale).

In this research, each division will be considered as one single case study in order to achieve multiple-case designs by applying three case studies. Multiple-case designs are preferable to single-case designs even if they are two or more cases in a single case study since the opportunities of identifying a useful case are higher and the "analytic benefits from having two or more cases may be substantial" (Yin, 2014, p. 64). Evidence is also provided from different resources and generalising the study will be easier. Furthermore, the three core banking functions of Treasury, Deposits and Financing in a domain such as banking are considered representative case studies to use in the incremental development and evaluation of the KMEOntoBPA framework. Therefore, these case studies set the alignment with the three DSRM incremental iterations in evolving and evaluating the KMEOntoBPA framework.

The three case studies of the bank are also considered sufficient to be applied in this research. Each case study of the bank represents a core business function that has KMEs' elements in well-defined boundaries in order to align with the KMEOntoBPA framework. Hence, it is able to generate the necessary knowledge resources in order to derive the CEBEs. The business processes in each case study are also bounded within the context of the core business function to support the development of the related BPA. In addition, domain experts are available and accessible in each case study and they are ready to collaborate in the demonstration and inform the evaluation of the research framework, i.e., the KMEOntoBPA (review Figure 3.4).

Yin (2003) had proposed characteristics of an exemplary/representative case study which were also referred to by Runeson et al., (2012). These characteristics are also mentioned and reflected on in bank case studies as follows:

1. The study is of a significant topic: The significance of a topic can be determined through existing literature, or consulting the stakeholders and participants in the potential case study. This research has involved reviewing the literature and meetings with the board of the bank and related managers of the three case studies: the *Treasury*, *Deposits*, and *Financing*. These meetings revealed the importance of the topic for the bank regarding the following: (a) implementing a knowledge management system that has an impact on the bank processes of the main sectors, the Treasury, Financing and Deposits; (b) automating knowledge resources for each essential part of the bank in relation to its processes; and (c) using their case studies that represent the core business functions of the bank in this research.
2. The study must be complete in regard to the following :
    i. The boundary of the case is made explicit. The case study boundary involves "its physical confines, its activities and the time span of the study" (Cousin, 2005, p. 423). The physical boundary of the *Treasury* case study is the Treasury department in the bank headquarter's building. The *Deposits* case study boundary is a bank branch. The *Financing* case study boundary is the Financing department in the bank headquarter's building. Activities are mainly the processes of these boundaries. The time span of the study is related to the completion of this research.
    ii. There is a comprehensive collection of appropriate evidence. This research involves different approaches to seek information from different resources in order to achieve a comprehensive collection of evidence. Interviews with managers in each case study, hand-delivered questionnaires and the checking of the necessary documents inside the bank are all different ways of collecting evidence agreed upon.
    iii. There are no significant constraints on the conduct of the study. The topic of the case studies is not concerned with significant constraints that might affect the conduction of each study such as financial statistics. The topic of the research is mainly related to the bank environment and its processes.
3. The study must present sufficient evidence when reporting the results and disseminating the artefacts of the case study. Presenting sufficient evidence is related to the ways of conducting investigations, handling and interpreting collected evidence (Yin, 2014). This research clearly presents the methodology and the steps that have been performed in order to demonstrate and evaluate the research framework using the bank case studies. It will also report the results and artefacts of each case study after defining the evaluation approaches and related statistical analyses that are used.
4. The case study must respect the ethical, professional, and legal standards relevant to that study. These standards are mainly related to the policies and procedures of the bank and the Faculty Research Ethics Committee (FREC) of the University of the West of England

(UWE). The case study considers and respects these standards and is committed to them while conducting the research.

The order of applying the banking case studies in this research has been determined by a number of factors. They are, in particular: (1) the number of processes, and hence the resulting number of interactions between processes; (2) the complexity of business procedures embodied in associated processes. Such an order is based on the review of each bank division (Treasury, Deposits and Financing) as mentioned in this section and was also confirmed by the stakeholders of the bank. The Treasury case study has minimum number of processes and does not need bank branches and many employees to execute Treasury business activities. On the other hand, the Deposits and Financing case studies have higher number of processes which also require more bank branches and employees to serve customers. However, the Financing business procedures are more complex than the Deposits business ones since they include different contract modes and associated to complicated financial activities such as project finance, infrastructure finance, capital and debt-raising. As a consequence, the choice of starting with the *Treasury* as the 1st case study, then the *Deposits* and the *Financing* case studies is strengthened. In addition, the number of participants of the evaluation phases of the DSRM iterations is increasing proportionally to the 1st, 2nd and 3rd case studies.

3.7 Chapter Summary

This chapter has revisited the research hypothesis and its associated research questions in order to build a road map for this research. Consequently, the design of the solution artefact of this research, the KMEOntoBPA framework, has been presented with KMEs driving the development of a knowledge-based BPA using a semantic based approach.

The Design Science Research Methodology (DSRM) has been adopted to guide the research process with the phases of problem identification, objectives definition, design and development, demonstration, and evaluation and communication. The DSRM has an iterative feature which drives the research to return to previous full-phased iterations as needed, impacted by the feedback of the evaluation phase in the DSRM iteration. The KMEOntoBPA framework components are incrementally and reflectively developed and evaluated according to the DSRM phases and the associated iterative restriction. Three sufficient and representative case studies of a bank have been identified to demonstrate and evaluate the KMEOntoBPA framework. Each case study represents an iteration which includes the required DSRM phases. The *Treasury*, *Deposits* and *Financing* case studies have been applied to the 1st, 2nd and 3rd DSRM iterations, respectively. By the end of the

evaluation phase in each iteration, feedback is reported. The evaluation phase includes tests of verification and validation in all DSRM iterations as well as checking the dynamism and the sustainable competitive advantage (SCA) of the KMEOntoBPA in developing an effective KMEs driven BPA.

Chapter 4

DSRM First Iteration: KMEOntoBPA Application to the Treasury Case Study

4.1 Introduction

This chapter aims to develop the initial solution artefact of this research and introduce it as represented in the first process iteration of the DSRM. The KMEOntoBPA ontology component, i.e, the abstract KMEs ontology (aKMEOnt) is introduced in the design and development phase of this chapter. The aKMEOnt provides a generic overview of the KMEs and the relationships between them. In addition, it will facilitate an understanding of the main components and the relationships between the KMEs, and link the aKMEOnt to the smenatic Riva BPA (srBPA) ontology. The selected KMEs which are presented in the literature review are the main components of the aKMEOnt. Each KME is constructed semantically according to the Noy and McGuinness (2001) method in ontology construction. The Protégé ontology platform will be used to model the classes and properties of each KME.

After the design and development phase of the DSRM iteration, the KMEOntoBPA framework (review Figure 3.4 Chapter 3) is demonstrated using the *Treasury* case study of the bank. The demonstration phase involves instantiating the KMEOntoBPA components, i.e., the aKMEOnt and srBPA ontologies, using the Treasury knowledge resources. It also includes developing the Riva "as-is" BPA of the Treasury without KMEs in order for it to be used as a benchmark for the evaluation.

Finally, the evaluation phase is conducted using the verification and validation tests of the KMEOntoBPA. Accordingly, feedback is reported in order to iterate back to the design and development phase of the second iteration.

4.2 DSRM First Iteration - Design and Development of the KMEOntoBPA Framework

4.2.1 KMEs Ontology: Significance and Scope

4.2.1.1 Significance

KMEs encourage individuals to develop knowledge and overcome barriers to sharing their own knowledge and experience (Ho, 2009). Furthermore, they contribute to the initial planning and building of the essential infrastructure for the enterprise to reinforce the efficiency and flow of knowledge (Ho, 2009; Lee and Choi, 2003). Hence, the semantic representation of the domain of KM in relation to KMEs is significant. The semantic approach does not only show the ontological representation of the shared concepts and relationships of the KM domain, but it also highlights the required pillars to build a KM

system design. Consequently, the aKMEOnt can provide an infrastructure for the flow of knowledge in the enterprise (Knublauch, 2004).

4.2.1.2 Scope

Based on the literature review in Chapter 2, five KMEs were selected as representatives of the KMEs domain in addition to the knowledge context enabler which is derived from the environment, resources and managerial influences to distinguish the business situation (Pomerol and Brezillon, 2001; Holsapple and Joshi, 2004). This selection which mainly includes leadership, information technology, structure and culture is based on the crucial need and common use of these KMEs in previous studies (Gold, Malhotra and Segars, 2001; Lee and Choi, 2003; Migdadi, 2009; Ho, 2009). Information technology, structure and culture KMEs are also defined in the American Productivity and Quality Centre (APQC) knowledge management model (Arthur Andersen, American Productivity and Quality Centre, 1996). Furthermore, leadership, organisational structure and information technology are addressed as pillars of KM implementation (Bixler, 2002). These KMEs can be ontologised and interrelated to produce a general conceptualisation of the KMEs domain.

The aKMEOnt suggests an essential pillar to define the KM domain; it also covers the main capabilities or resources for the organisation by identifying the aKMEOnt instances (see Figure 4.1). The aKMEOnt can be useful when integrated with the potential semantic representation of other related disciplines. In this research, the aKMEOnt is utilised to drive the development of the Riva-based BPA using its semantic representation in the srBPA ontology.

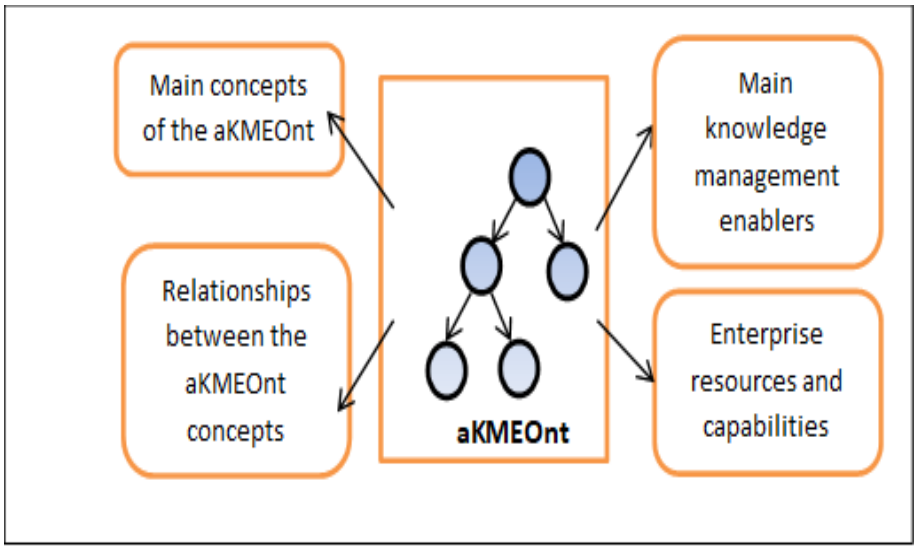


Figure 4.1: Domain of the aKMEOnt

4.2.2 The aKMEOnt Development Method

Building ontology has no standardised methodologies (Uschold and Gruninger, 1996). However, it is an iterative process and relates to the phases of the requirements engineering design, development, integration, validation and feedback (Subhashini and Akilandeswari, 2011). These phases are identified in the knowledge-engineering method of Noy and McGuinness (2001), who consider iteration as a continuous activity through the ontology lifecycle development. The knowledge-engineering method of Noy and McGuinness (2001) is adopted in this research as mentioned and justified in Chapter 3. This method has seven steps which are required in order to develop an ontology (see Figure 4.2). These steps are mentioned and utilised in the development of the aKMEOnt as follows:

(1) Determine the domain and scope: domain and scope are defined by answering the following questions (Noy and McGuinness, 2001): (1) what is the domain that the ontology will cover? (2) what is the ontology going to be used for? By applying these questions to this research, the ontology domain is knowledge management, specifically the infrastructure capabilities/KMEs domain which include information technology, business repository, leadership, culture, organisational structure, and knowledge context. Each of these KMEs covers its area in business organisations. The ontology will be used to identify the knowledge resources and capabilities in an organisation in order to drive the development of the BPA.

(2) Consider reusing the existing ontology: this step will be applied by considering existing ontologies for information technology, leadership, business repository, culture, organisational structure, and knowledge context in previous studies. If there are no existing ontologies to consider for each KME, one of the KME's definitions or classifications in its domain is used instead.

(3) Enumerate important terms: after determining the KMEs existing ontologies or definitions, terms are enumerated or extracted either by adopting existing ontology concepts or findings and extracting the key terms in the KME definition. This step will be aligned with a top-down development of these terms/concepts and their relationship in order to build the concept map for each KME and all KMEs using the concept mapping tool (Cañas et al., 2004). The concept map is a conceptual diagram which illustrates the relationship between the KMEs concepts.

(4) Define the classes and class hierarchy: the KMEs and their concepts will be defined as main/super classes and their sub-classes using the Protégé Tool.

(5) Define the properties/slots of classes: object properties that link classes, in one KME or different KMEs, are identified according to the concept map of KMEs. Data type properties are also identified after description or categorisation of each KME concept in

the concept map. These object properties and types will also be developed using the Protégé Tool.

(6) Define the facets (restrictions) of the slots: slot's cardinality, value-type, domain and range of each KME class are defined according to object and data type properties using the Protégé Tool.

(7) Create instances: individual instances of the KMEs' classes are created using the case study in each of the DSRM iterations.

4.2.3 The aKMEOnt Development Language and Tool

The aKMEOnt has been built using the Ontology Web Language-Description Logic (OWL-DL). OWL-DL provides a well-defined semantics and practical reasoning service (Horrocks, Patel-Schneider and Van Harmelen, 2003), which enriches capabilities to represent KMEs and their relationships semantically. It is also part of the World Wide Web Consortium's (W3C) recommendations for the semantic web (McGuinness and Harmelen, 2004). The Protégé 3.4.1 environment is used to build the aKMEOnt classes and properties as well as edit and execute OWL axioms and SWRL rules (O'Connor, Knublauch and Musen, 2005). This version is selected because it supports Jess Tab which executes SWRL rules, and in addition the srBPA ontology is built using it.

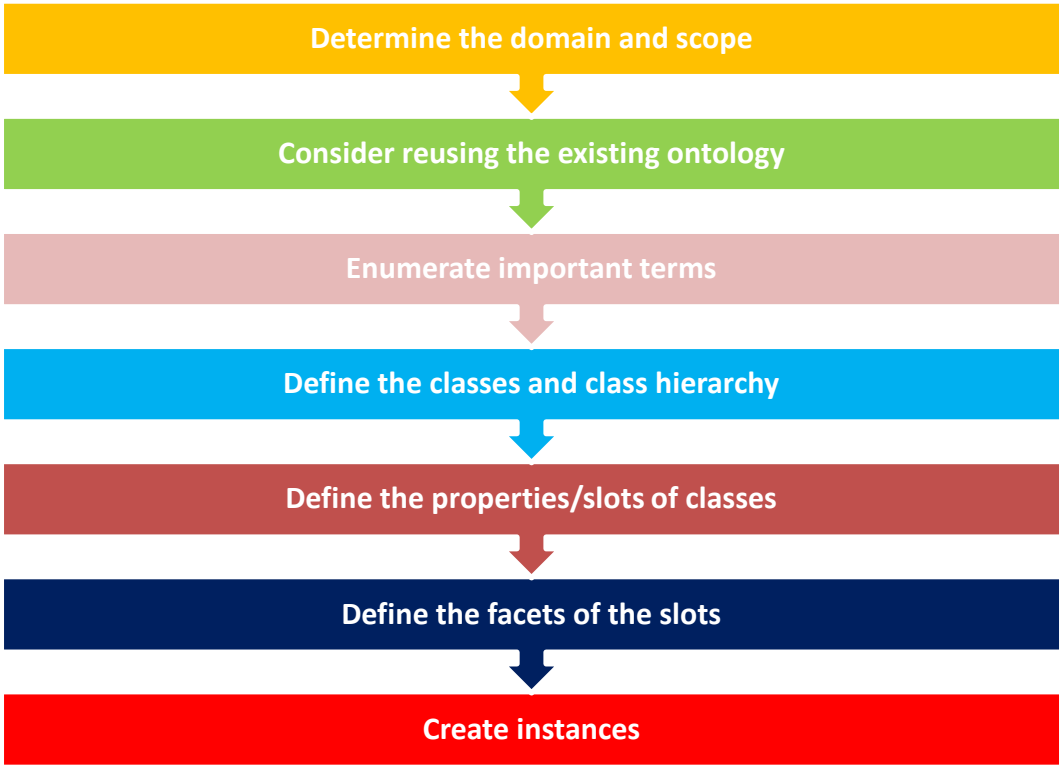


Figure 4.2: Knowledge-Engineering Method based on Noy and McGuinness, (2001)

4.2.4 Design Specification of the aKMEOnt

In this section, the concept map figure of each KME is presented by the researcher in order to facilitate understanding and developing the aKMEOnt classes and properties. Existing ontologies for the leadership and organisation structure KMEs were also found and used in this section, but the researcher has adapted and developed their concept maps accordingly. A general set of figure keys are included under concept map figure of each KME. The keys include: (1) a concept; (2) a concept that has a property; and (3) a concept that has a relationship to another concept. These keys are found in Figures 4.3, 4.4, 4.5, 4.6, 4.7, 4.8 and 4.9. The concept map of all KMEs in Figure 4.9 also has additional figure keys which include: (1) a KME with an arrow that defines all KME concepts; (2) the KME element with a specific colour and a symbol that shows which KME the element belongs to, such as (B) Business Repository, (C) Culture, (IT) Information Technology, (KC) Knowledge Context, (L) Leadership and (OS) Organisational Structure.

4.2.4.1 The Information Technology KME

The capabilities and tools of information technology play different roles in facilitating enterprise KM processes (Alavi and Leidner, 2001). Through KM applications, two types of information technologies can be distinguished: interactive and integrative applications (Hayes, 2011). Another categorisation has been proposed by Revilla, Rodríguez-Prado and Prieto (2009) for whom information technology consists of a combination of both the convergent and the divergent dimensions. Both the convergent and the interactive classifications are related to the connection and communication between the members of the enterprise in order to facilitate knowledge transfer. Tools such as e-mails, blogs, discussion forums and video-conferencing are used in that dimension. On the other hand, integrative or divergent classification is related to the retrieval and accessibility of the stored explicit knowledge. Office applications, decision-support systems and the intranet are examples of tools which refer to the integrative dimension. Categorising technology tools into these two main dimensions summarises the main role of information technology as a knowledge management enabler. Each of these two dimensions generates the conditions to achieve the main two KM processes in organisational knowledge evolution: the exploration and exploitation processes. Thus, the technology KME will be deconstructed into three elements: tool, dimension (integrative/interactive), and user (see Figure 4.3).

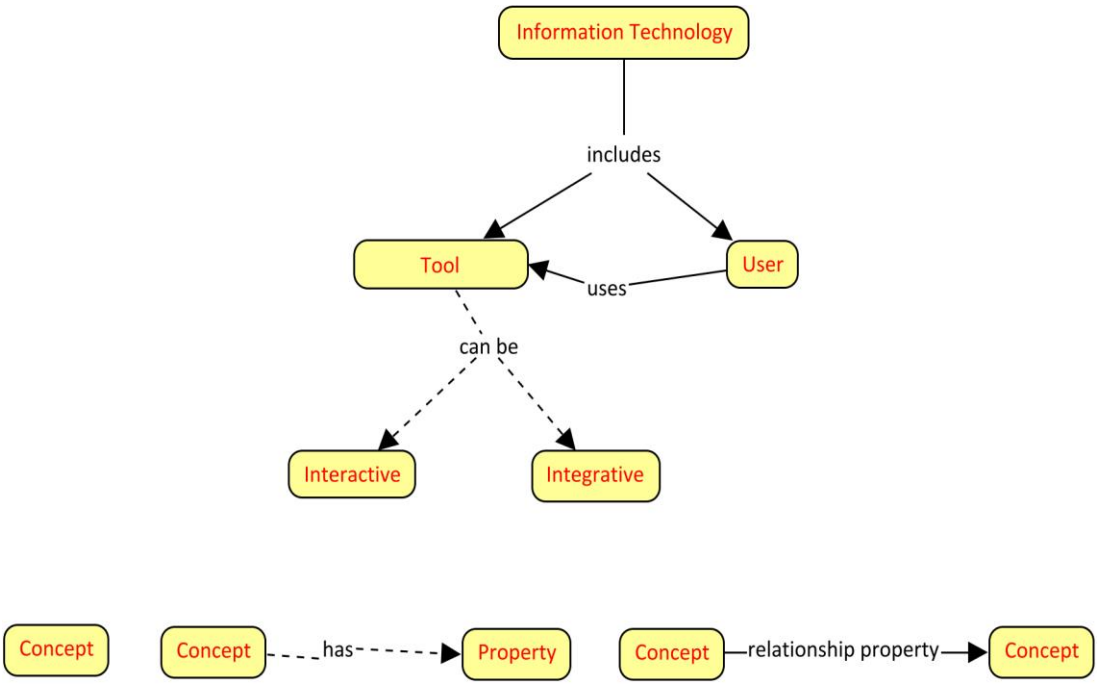


Figure 4.3: Concept Map of the Information Technology KME

4.2.4.2 The Leadership KME

Leadership was introduced as one of the pillars for successful KM implementation (Bixler, 2002). It is a persistent factor which organisations adopt to facilitate the transfer of knowledge and encourage their members to collaborate (Theriou, Maditinos and Theriou, 2011). Deconstructing the leadership KME for ontology use was already coined by Bennis and Biederman's proposition (2009, p.350), who argued that "leadership is grounded in a relationship; in its simplest form, it is a tripod, There is a leader or leaders, followers, and the common goal they want to achieve". Based on this proposition, the main components of the leadership KME include the leader, the follower and a goal (see Figure 4.4).

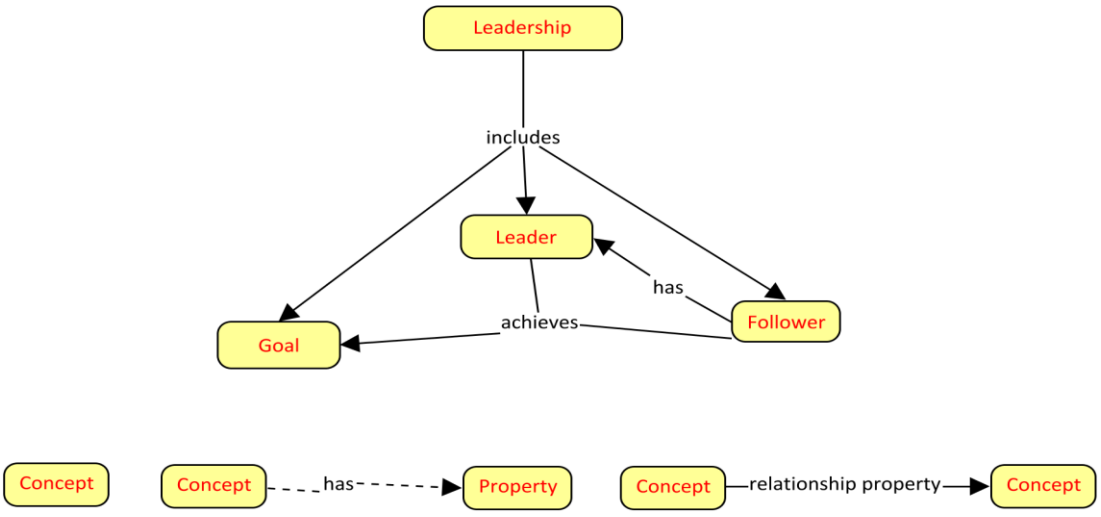


Figure 4.4: Concept Map of the Leadership KME

4.2.4.3 The Culture KME

An organisational culture that prepares suitable settings can have a motivating role in knowledge exchange and activities (Allameh, Zare and Davoodi, 2011). One of the most significant definitions of culture that has been mentioned in Chapter 3 is Schein's (2017) definition. This definition shows the dynamic aspect of the culture KME which can support a dynamic BPA. Therefore, it is useful to deconstruct and ontologise it after its introduction. Schein and Schein (2017, p.6) define culture as "a pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems". According to this definition, the culture KME can be deconstructed into different components: assumption, external adaptation or internal integration problems, and reference (see Figure 4.5). The pattern of shared assumptions is the solution to handle these problems. Basic assumptions are the basic principles, guiding beliefs and mental models of the culture (Schein and Schein, 2017). The reference is the evidence and support of that assumption.

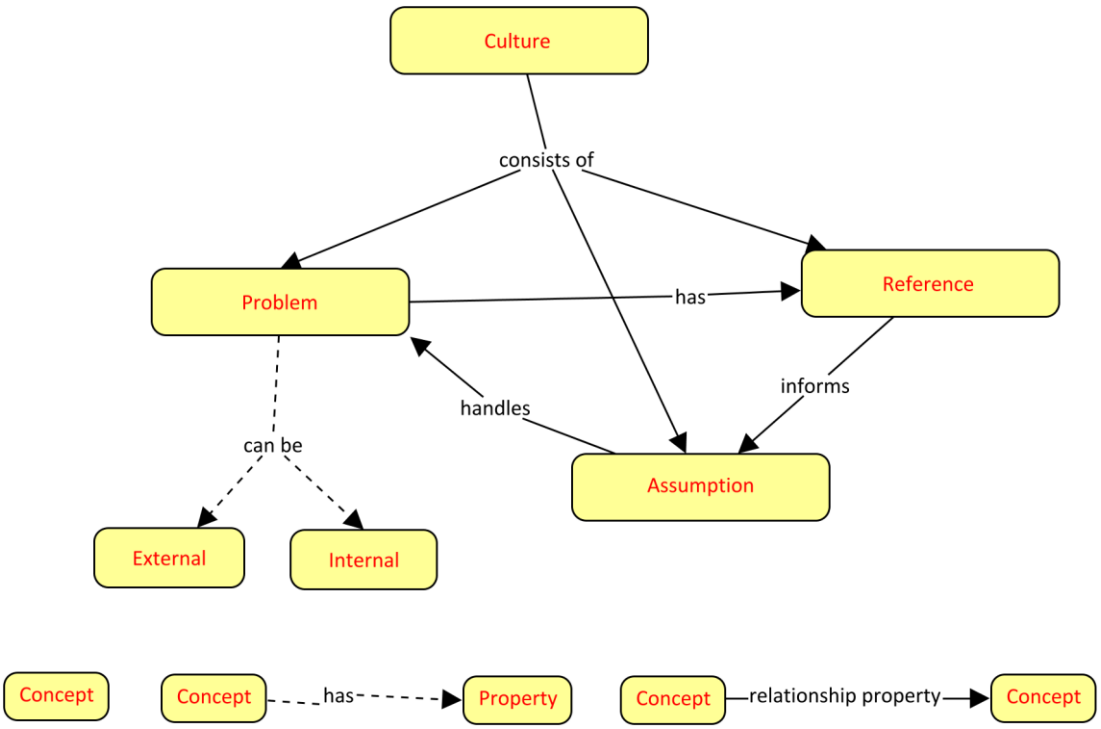


Figure 4.5: Concept Map of the Culture KME

4.2.4.4 The Organisational Structure KME

Choosing the right enterprise structure can be a significant aspect when applying KM (Migdadi, 2009). It promotes social interaction and facilitates the flow of knowledge within the organisation (Rasula, Vuksicand and Stemberger, 2012). Organisational structure implies

"an enduring configuration of tasks and activities" (Skivington and Daft, 1991, p.46), and is usually classified into centralisation, formalisation and integration (Chen and Huang, 2007). Ontologies representing organisational structure already exist in previous research. As mentioned in Chapter 3, Reynolds' (2014) organisational structure ontology is endorsed by the W3C and was designed to support the sharing of organisational information across different domains. Abramowicz et al. (2008) ontology was designed in order to support the analysis of business processes. Both ontologies consider goals which are necessary in this research. These ontologies are considered by: (a) checking common concepts and their correspondence with other KME elements; (b) adopting these common concepts if they are essential in driving the development of BPA; and (c) checking non-shared concepts and finding if they are significant in BPA development. The concepts that are extracted from the existing organisational structure ontology are: unit, position, agent, resource, business function, role and skills (see Figure 4.6). The concept map of the organisational structure will assist in the integration with other KMEs forming a major building block of the aKMEOnt.

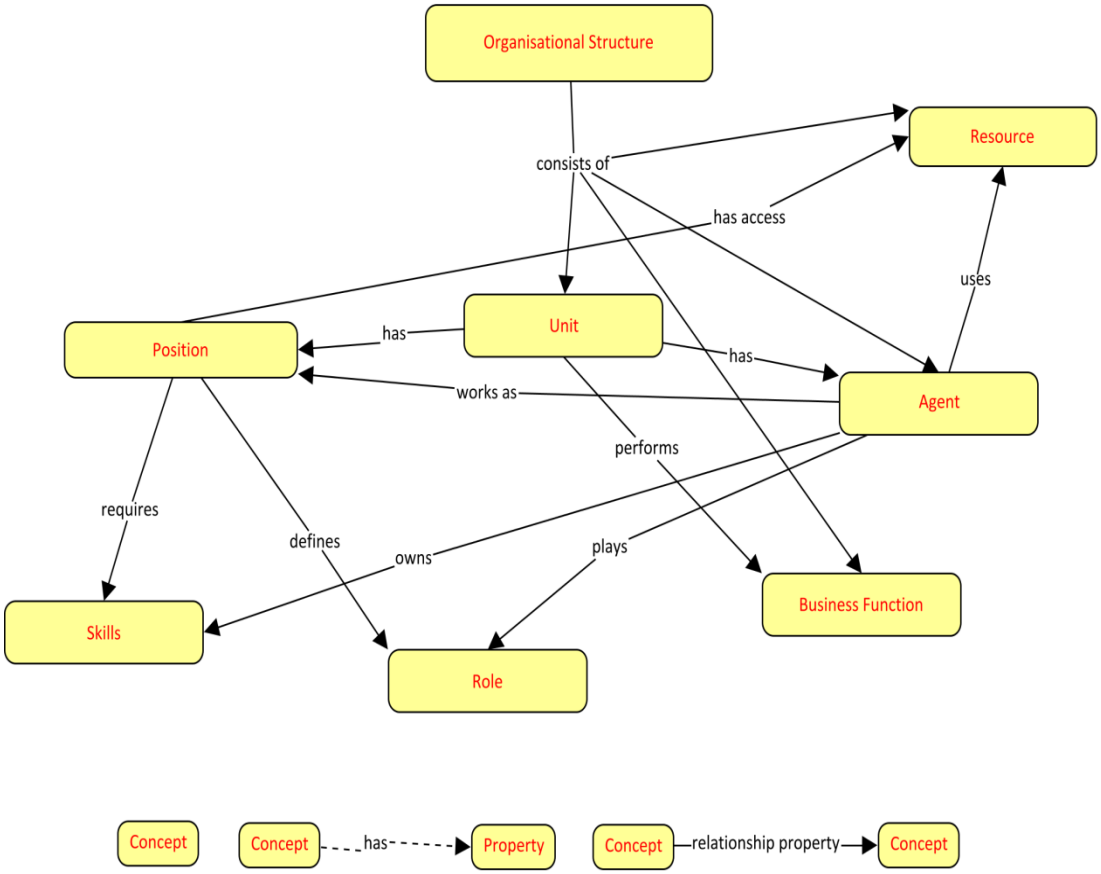


Figure 4.6: Concept Map of the Organisational Structure KME

4.2.4.5 The Business Repository KME

The business repository can be a subject or part of the integrative information technology KME, if considered as a well-structured warehouse with efficient query techniques (Weske, 2010). However, it is useful to separate it as a standalone KME in order to classify and facilitate the search for the documented explicit knowledge. In this research, the business repository KME is defined as metadata schemas, which semantically represent information about e-documents (Lee and Kunzle, 2017; Yang, Chen and Shao, 2004). Other sources of information such as transactional data are important, however, they are not essential in this research since they describe the services or the functionalities which already exist in another KME, i.e., the organisational structure. In addition, the extraction of the CEBEs which is the main purpose of these KMEs will be difficult and un-useful with the consideration of huge amount of transactional data and other KMEs that lead to the same CEBEs.

Metadata will have a few attributes which represent basic and simple information about the documents and are necessary for the development of the aKMEOnt. The attributes are type, description, division, creation date and creator (see Figure 4.7). The instances or the individuals of the e-documents are considered as the titles or the names of the e-documents. Selecting an attribute depends on the inspection of its expected relation with other KMEs. Creator and creation date can be related to leadership (leader, follower) and organisational structure (agent) KMEs. Division is related to the organisational structure (unit) KME. Type and description are related to knowledge context and organisational structure KME. The feedback of the DSRM iteration will reveal if any further attributes are suggested.

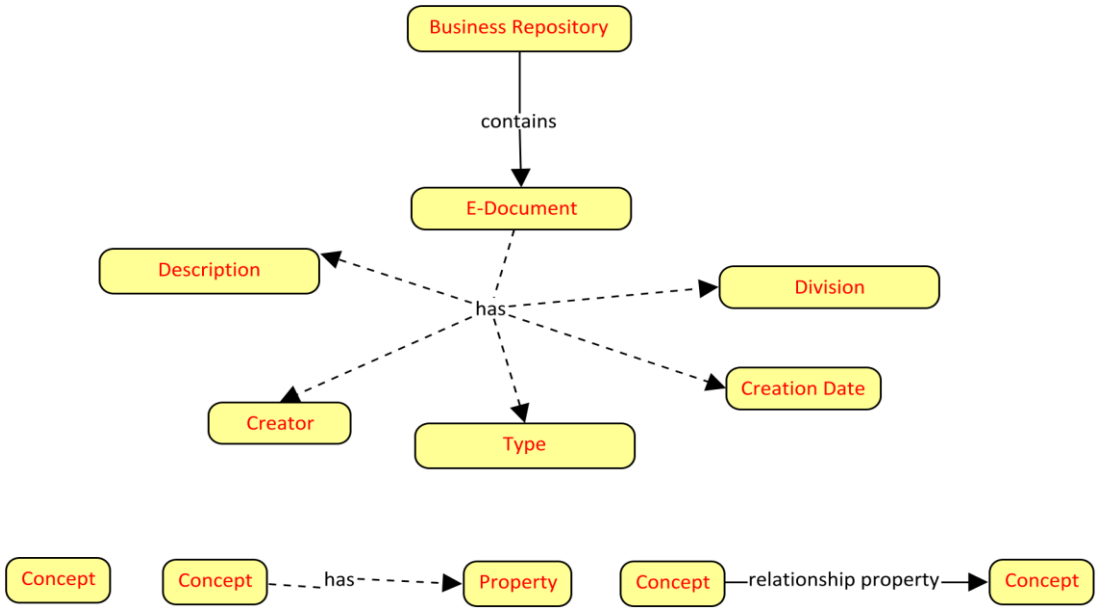


Figure 4.7: Concept Map of the Business Repository KME

4.2.4.6 The Knowledge Context KME

Knowledge context is related to the surrounding factors and relevant conditions that create a unique business situation (Brézillon and Pomerol, 2001). To address the previous definition by using the ontology, a few elements are selected to represent the factors or conditions that form a business situation. These elements, that involve context, are from the domain (Brézillon et al., 1998), and are related to other KMEs. Units or divisions, business rules, restrictions and customers are the elements that are used to build the knowledge context in the aKMEOnt (see Figure 4.8).

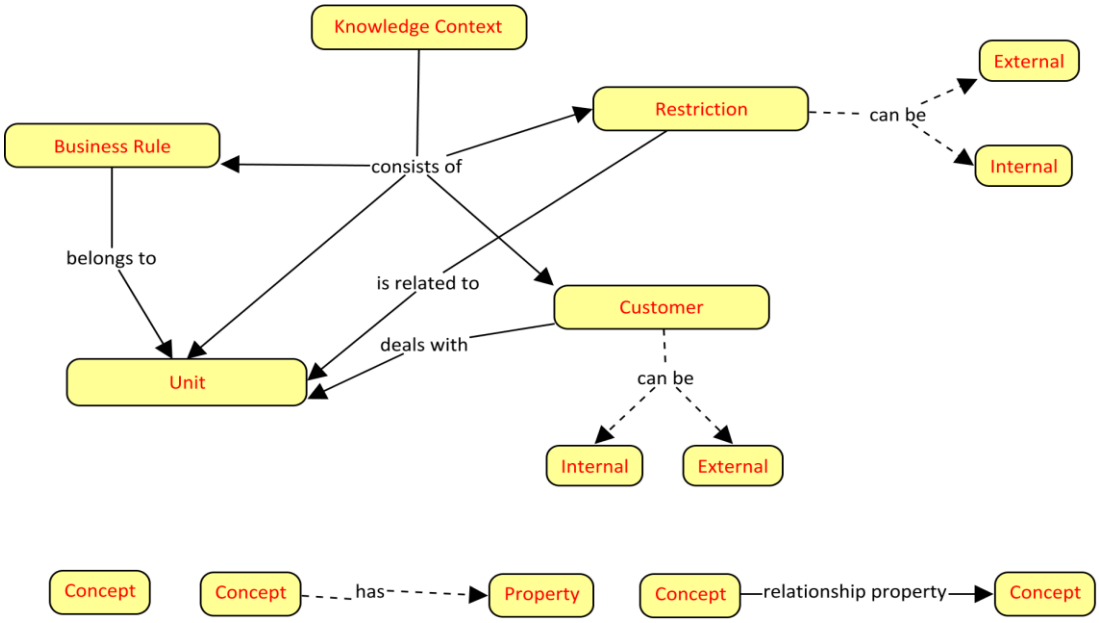


Figure 4.8: Concept Map of the Knowledge Context KME

4.2.4.7 The KMEs Concept Map

After discussing the literature relating to each KME, all KME's concepts are integrated to generate the overall concept map of the KMEs (see Figure 4.9). This map facilitates understanding the KMEs domain and developing the aKMEOnt classes, subclasses and their relationships using the OWL-DL and Protégé tool. Analysing the concept map of each KME resulted in the following changes while building the overall integrated concept map of the KMEs:

(1) *The information technology KME*: the tool concept in the concept map of the information technology KME is classified as an integrative or interactive tool using properties (review Figure 4.3). A property is an attribute that describes the values of the concept. The integration of the information technology KME with other KMEs shows that the user concept can be replaced with the agent concept in the leadership KME. Therefore, the user concept will be omitted and represented instead by the agent concept (see Figure

4.9). The agent can be any individual that has a role in the enterprise (Reynolds, 2014). These agents are supposed to be the only users in the organisation. Connecting tool and agent concepts in the aKMEOnt is accomplished using relationship properties.

(2) *The leadership KME*: every leader or follower is eventually an organisation's member holding a role and wanting to achieve a goal (review Figure 4.4). Therefore, all these members are merged into one concept while aligning all the KMEs. This concept is the agent who is originally presented in the organisational structure KME (review Figure 4.6). The agent concept is implemented in the leadership KME as the aKMEOnt is developed (see Figure 4.9). A goal is achieved by the agent. The leader or follower is presented by a property that classifies the agent. Other relationship properties are used to link the leadership KME with other KMEs.

(3) *The culture KME*: the external or internal description of the problem concept is presented as a property. The problem has a reference that informs the assumptions. The assumptions handle these problems (review Figure 4.5). A reference is the assumptions' evidence that learns from an e-document or agent, if the culture KME is integrated with other KMEs (see Figure 4.9).

(4) *The organisational structure KME*: the concepts of the organisational structure KME (review Figure 4.6) are included in the concept map with modifications to the resource and agent concepts in order for them to be integrated with other KMEs (see Figure 4.9). The agent concept is implemented in the leadership KME. A resource could be an asset that supports business activities and processes. However, it is important to define particular resources which are aligned with other KMEs. Tools and e-documents, which are defined in information technology and business repository KMEs respectively, are suitable alternatives to be classified as resources. These resources are accessed according to the positions in the organisational structure KME (see Figure 4.9). Relationship properties are used to link between different inner and outer concepts of the organisational structure KME.

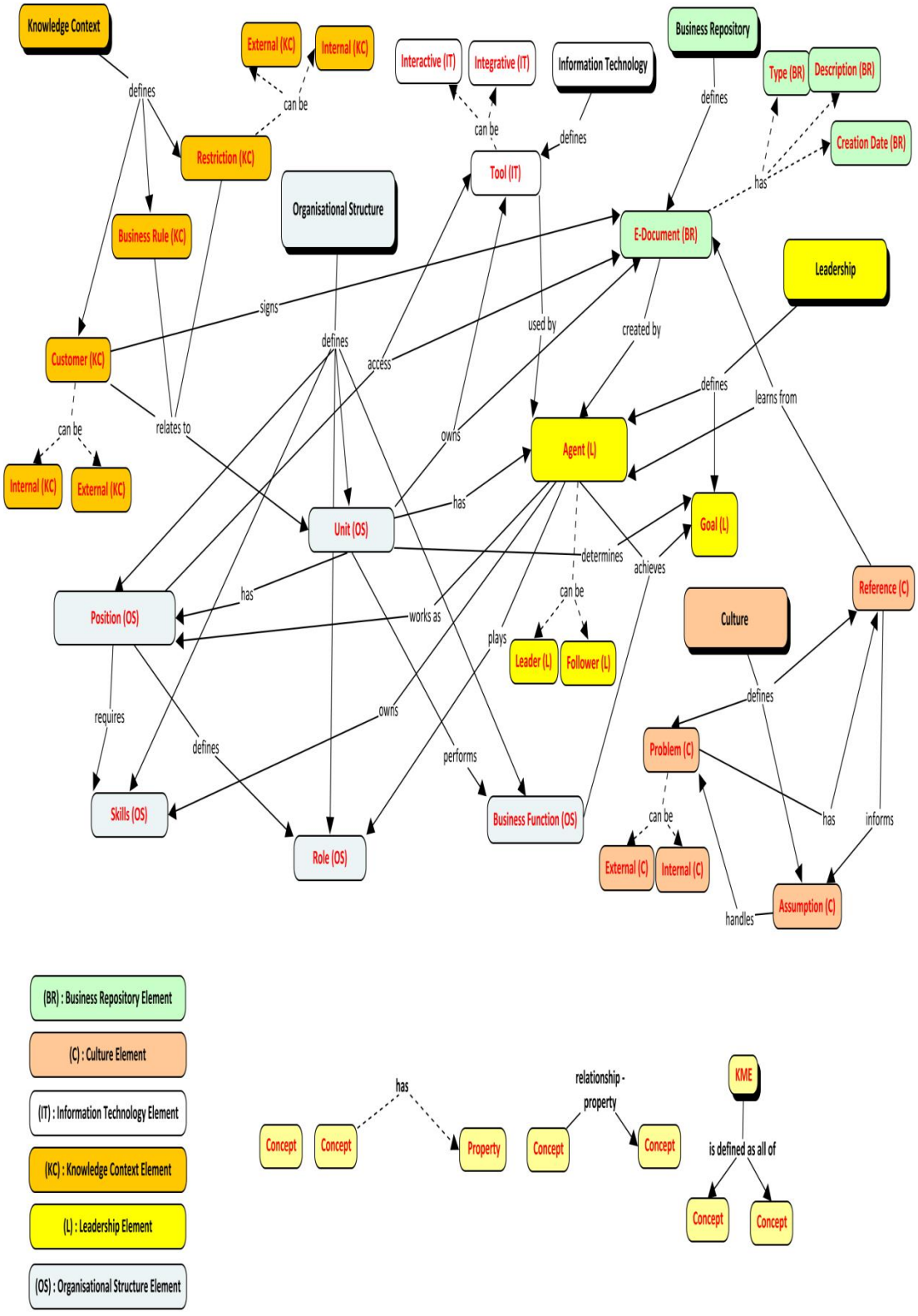


Figure 4.9: Concept Map of the Six KMEs in the aKMEOnt

(5) *The business repository KME*: the type, description and creation date attributes are properties that describe the e-document (review Figure 4.7). The creator is any organisation member; therefore, it is replaced with the agent who is implemented in the

leadership KME (see Figure 4.9). The unit is already defined in the organisational structure KME. Further relationship properties are presented in the concept map.

(6) *The knowledge context KME*: all business rules, restrictions and customers are related to a unit which is already defined in the organisational structure KME (see Figure 4.9). Customers and restrictions can be classified as external or internal using properties. Relationship properties are used to link the knowledge context KME (review Figure 4.8) with other KMEs in the concept map.

4.2.5 Development of the aKMEOnt Classes and Properties

After building the concept map of the KMEs, the KME's concepts and their relationships are mapped onto ontological elements or classes and their properties using the Protégé tool. A snapshot of aKMEOnt object and data type properties is in Figure 4.10.

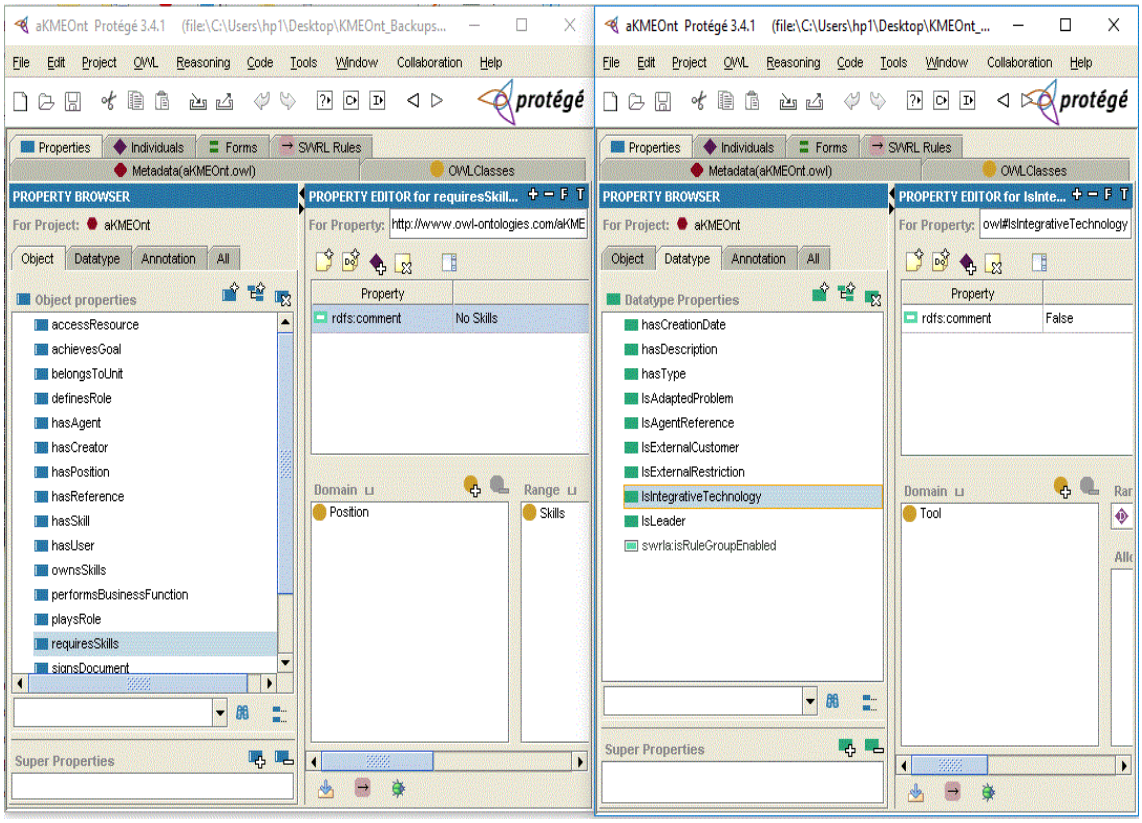


Figure 4.10: Object and Data Type Properties of the aKMEOnt using the Protégé Tool

Concepts are defined as classes in the aKMEOnt. A concept property in the concept map is a data type property in the ontology. A data type property is a description or categorisation of the concept/class individuals. It links individuals to data values. Relationship properties in the concept map are defined as object properties in the aKMEOnt. Object properties link instances of different classes. Protégé-developed classes with their object and data type properties are summarised in Table 4.1.

Table 4.1: aKMEOnt Main Concept Classes and Properties

Concept/Class	Description	Object and data type properties
Business repository		
E-Document	Main e-documents in the enterprise, which can be work procedures, contracts and manuals. These documents have creators, creation dates, types and descriptions	a. hasType of type: String b. createdBy of type Agent c. hasCreationDate of type dateTime d. hasDescription of type : String
Information technology		
Tool	Communication or storage tools to retrieve information (Interactive/Integrative)	a. IsIntegrativeTechnology : Boolean b. usedBy of type Agent
Culture		
Assumption	Solutions, processes or values for any internal or external problems	a. handlesProblem of type problem (class of the domain range)
Problem	External problems that should be adapted or internal problems that appear during the integration	a. IsAdaptedProblem of type: Boolean b. hasReference of type Reference
Reference	Documents or agents that act as a reference for the assumption or the solution	a. informsAssumption of type Assumption b. learnsFromAgent of type: Agent c. learnsFromDocument of type: E-Document
Knowledge context		
Business Rule	General principles that should be applied during work	a. relatesToUnit of type Unit
Customer	Clients from inside or outside the enterprise	a. IsExternalCustomer of type: Boolean b. relatesToUnit of type Unit c. signsDocument of type E-Document
Restriction	Limitations imposed by internal or external stakeholders	a. IsExternalRestriction of type: Boolean b. relatesToUnit of type Unit
Leadership		
Goal	Objectives that are desired to be achieved by each leader and his followers.	
Agent	Any Individual or member of the organisation who holds a managerial or non-managerial position. An agent can be a leader or follower.	a. achievesGoal of type Goal b. playsRole of type Role c. ownsSkills of type Skills d. IsLeader/Follower of type : Boolean e. worksAs of type Position
Organisational structure		
Business Function	The upper-level description of functions or work that an organisation performs such as Marketing, Sales,	a. achievesGoal of type Goal

	Research and Development, in order to achieve specific goals.	
Unit	Divisions or departments of the organisational context that deal with common activities.	a. performsBusinessFunction of type Business_Function b. hasAgent of Type Agent c. hasPosition of type Position d. ownsResource of type Tool e. ownsResource of type E-Document f. determinesGoal of type Goal
Position	Organisation positions that define the roles and their potential resources.	a. definesRole of type Role b. requiresSkills of type Skills c. accessResource of type Tool d. accessResource of type E-Document
Role	Description of the roles that are related to a position in the organisation.	
Skills	Description of capabilities that are needed to meet job requirements.	

4.2.6 Aligning the aKMEOnt with the srBPA Ontology

Developing the KMEOntoBPA framework requires some extensions to the aKMEOnt in order to align with the srBPA ontology (Yousef and Odeh, 2014). The aKMEOnt is extended by adding Candidate Essential Business Entities (CEBEs) and Semantic Web Rule Language (SWRL) rules in order to drive the instantiation of the srBPA ontology. SWRL can process ontology elements and express processing rules as well as logic. These SWRL rules can enrich the generic process of CEBEs identification. Detailed discussion about CEBEs and SWRL rules are in this section.

4.2.6.1 The Rationale behind the Extension of the aKMEOnt

The srBPA ontology is semantically enriched. However, it still needs to automate the generation of CEBEs in order to drive the development of the Riva BPA. In this regard, the aKMEOnt leads the instantiation of the srBPA ontology by identifying CEBEs, which provide new dynamic features in their automated generation and reconfiguration. The new feature will keep the semantic Riva-based BPA up-to-date in order to facilitate the self-dynamic updating of the BPA per the flow of knowledge in the organisation. Thus, the aKMEOnt is the core building block in the proposed KMEOntBPA framework.

4.2.6.2 The New Elements of the aKMEOnt

Since the KMEs are presented in different disciplines other than the BPA, the aKMEOnt requires particular customisation in relation to the Riva BPA. This customisation implies

new elements that link the two ontologies, the srBPA and aKMEOnt, while instantiating the KMEOntoBPA framework. The new elements include CEBEs and SWRL rules.

4.2.6.2.1 The CEBEs

Building the BPA using the Riva method requires brainstorming the CEBEs as an initial step. These CEBEs are major in driving the development of the BPA through identifying the EBEs, selecting the UOWs, and generating the 1st and 2nd cut process architecture diagrams. The srBPA assumes that the list of EBEs is already provided by business analysts before deriving the list of UOWs. This step in the Riva method involves a few concerns:

- Difficulty of having a team for a long duration of time from different departments to check the BPA, or brainstorm and revise the EBEs on a regular basis, especially in agile businesses;
- Lack of a dynamic BPA that reflects the changes in the business environment and keeps the BPA up-to-date;
- Missing the know-how; which means knowing how these entities are created from their sources ;
- Need of an automated system to create and track the EBEs and select the appropriate ones to build the Riva BPA.

Accordingly, the KMEs have been investigated to address these concerns since they track the flow of knowledge and explain how organisations' business entities are created. These business entities are defined as a set of capabilities and knowledge assets (Kogut and Zander, 1992) that may be considered as EBEs.

Thus, the aKMEOnt has utilised KMEs to create CEBEs. Each KME in the aKMEOnt has a formal representation of different concepts and their relationships. The overall KMEs' concepts are combined to construct the concept map of the KMEs. Instances or occurrences of each KME concept play a role in identifying potential CEBEs in relation to other KMEs. Different algorithms have been proposed in order to understand and facilitate the automatic extraction of the CEBEs in the aKMEOnt. These algorithms are translated into SWRL rules that are employed to derive CEBEs in the aKMEOnt. An overall chart that shows how these algorithms work together is in Figure 4.11.

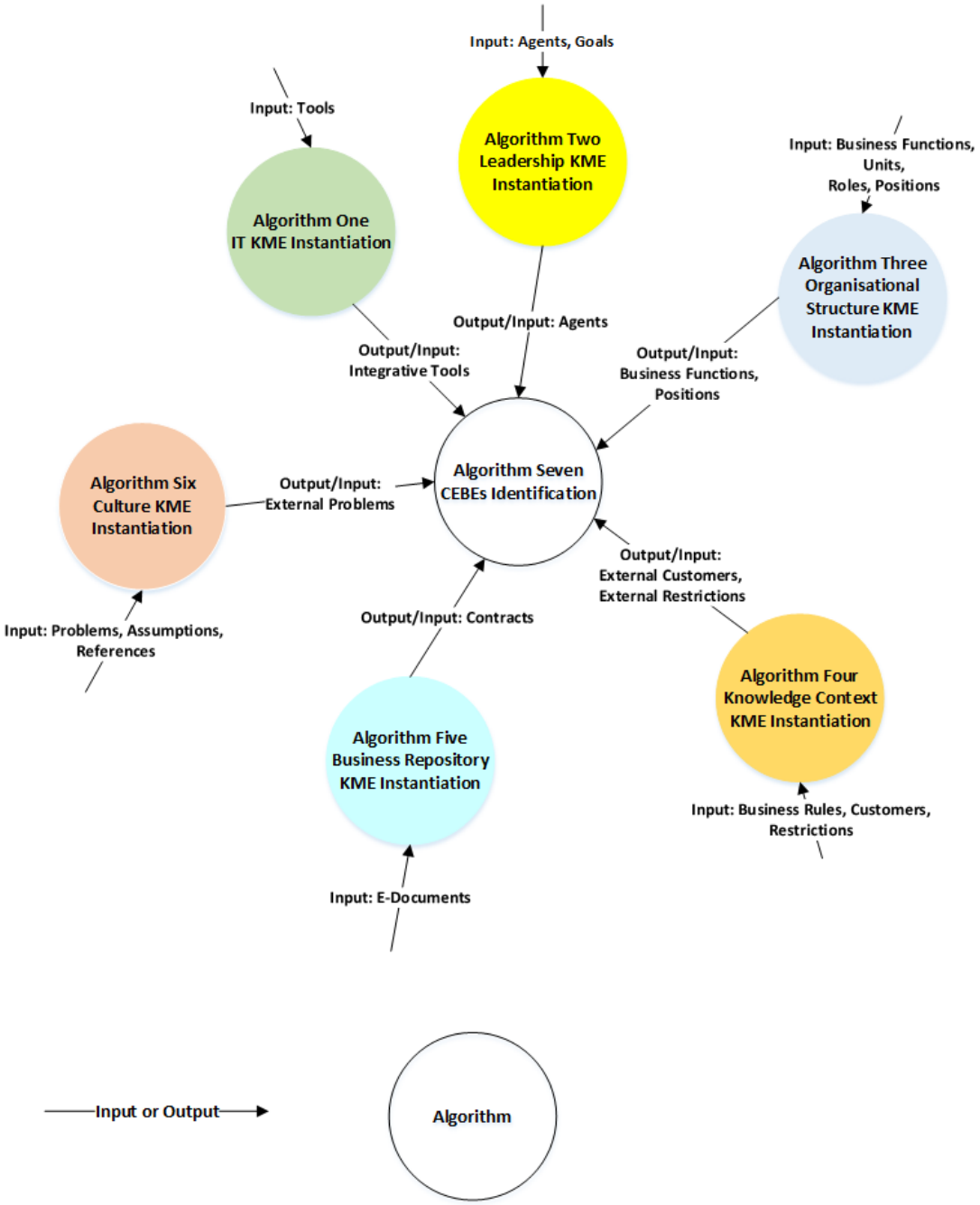


Figure 4.11: Chart of aKMEOnt Algorithms Identifying the CEBEs

The following list shows each KME and its related algorithm that supports the extraction of the CEBEs:

(1) CEBEs of the IT KME

The ontology of IT KME defines the instances of the integrative tool concept which can retrieve and access the stored knowledge in an organisation. These kinds of tools can be applications that characterise the business in different fields such as healthcare, education and the banking sectors. The IT KME tools are considered as CEBEs provided that they have an integrative type and used by agents (or employees) who are followers or leaders in the

leadership KME ontology. Accordingly, Algorithm One that extracts the CEBEs as an output from the IT KME is implemented in Figure 4.12.

Algorithm One: Information Technology KME Instantiation

Input: Information Technology = {Tool}. The set of Tool instances where Tool = {i_0... i_x}.
Output: The set of new Tools, nTool = *{$nTool_0$, $nTool_1$... $nToolj$}*
Begin
Define the new Tool List (nTool); Create instances i_t of Tool , $0 \leq t \leq x$;
For each instance i_t in Tool list
{
If (instance i_t (isIntegrative("True")))
{
Set instance i_t as new instance $nTool_v$ in the new Tool set, where $0 \leq v \leq j$; Set v++;
}
}
END

Figure 4.12: Algorithm One-IT KME Instantiation

(2) Outputs of the Leadership KME

The leadership KME doesnot have CEBEs since the individuals or the instances of this KME are the agents or the memebers in the organisation. However, the output of the leadership KME can be aligned or provided as a constraint with other KMEs such as the IT KME. Therefore, Algorithm Two is implemented in Figure 4.13 in order to extract the output of the leadership KME.

Algorithm Two: Leadership KME Instantiation

Input: Leadership = {Agent, Goal}. The set of Agent instances where Agent = {A_0,..., A_x}.
The set of Goal instances where Goal = {G_0,..., G_m}.
Output: The set of new Agents, nAgent= *{$nAgent_0$, $nAgent_1$,... ,$nAgent_j$}*
Begin
Define the new Agent List (nAgent); Create instances A_t of Agent , $0 \leq t \leq x$;
Create instances G_s of Goal, 0 $0 \leq s \leq m$;
For each instance i_t in Agent list {
If (instance A_t (AchievesGoal ()) in Goal) {
Set instance A_t as new instance $nAgent_v$ in the new Agent set, where $0 \leq v \leq j$;
Set v++; } } END

Figure 4.13: Algorithm Two-Leadership KME Instantiation

(3) CEBEs of the Organisational Structure KME

The ontology of the organisational structure KME provides instances of different concepts. Some instances can characterise the business of the organisation and are considered as CEBEs. These instances are individuals of the position and business function concepts in the ontology of organisational structure KME. Position instances are organisation positions that define the roles and their potential resources. A lecturer in a university is an example of a

position instance. Business function instances are different business functions that can characterise the business of organisation and become CEBEs. A business function such as a customer service in a telecom company is an example of a CEBE. Algorithm Three that extracts these CEBEs as an output from the organisational structure KME is implemented in Figure 4.14.

Algorithm Three: Organisational Structure KME Instantiation

Input: Organisational Structure = {Business Function, Unit, Position, Role, Skills}. The set of Business Function instances where Business Function = {BF_0... BF_x}. The set of Unit instances where Unit = {U_0... U_y}. The set of Position instances where Position = {P_0... P_k}. The set of Role instances where Role = {R_0... R_z}. The set of Skills instances where Skills = {S_0... S_r}.
Output: The set of new Business Functions, nBusinessFunction = {$nBusinessFunction_0$, $nBusinessFunction_1$... $nBusinessFunction_j$}. The set of new Positions, nPosition = {$nPosition_0$, $nPosition_1$... $nPositionj$}.

```
Begin
Define the new Business Function List (nBusinessFunction);
Define the new Position List (nPosition);
Create instances BF_i of Business Function, 0≤ i ≤ x;
Create instances U_i of Unit, 0≤ i ≤ y;
Create instances P_i of Position, 0≤ i ≤ z;
Create instances C_i of Role, 0≤ i ≤ k;
Create instances S_i of Skills, 0≤ i ≤ r;
For each instance U_i in Unit list
{
        For each instance BF_i in Business Function list {
                        If (instance U_i performsBusinessFunction(BF_i))
                        {
                        Set instance BF_i as new instance nBusinessFunction_v in the new
                        Business Function set, where 0≤ v ≤ j;
                        Set v++;
                        } }
        For each instance P_i in Position list {
                        If (instance U_i hasPosition(P_i))
                        {
                        Set instance P_i as new instance nPosition_v in the new Position set,
                        where 0≤ v ≤ j;
                        Set v++;

                        } }
        }
} END
```

Figure 4.14: Algorithm Three-Organisational Structure KME Instantiation

(4) CEBEs of the Knowledge Context KME

The ontology of the knowledge context KME has concepts that represent factors or conditions of a unique business situation. Therefore, a number of these factors can provide

CEBEs. The factors are the instances of the customer and restriction concepts in the knowledge context ontology. Customer or restriction instances are described as external ones since they are more likely to be in the essence of the business rather than the internal ones. The internal ones can be designed entities which are not essential and they are there because we have chosen to work in a particular way, or they can be roles which are not of the essence of the business. Health and safety standards and patients are sequential examples of instances of restrictions and customers that represent CEBEs which characterise the business of a hospital. Algorithm Four that derives the CEBEs from the knowledge context KME is implemented in Figure 4.15.

Algorithm Four: Knowledge Context KME Instantiation

Input: Knowledge Context = {Business Rule, Customer, Restriction}. The set of Business Rule instances where Business Rule = {BR_0... BR_x}. The set of Customer instances where Customer = {C_0... C_y}. The set of Restriction instances where Restriction = {R_0... R_z}.
Output: The set of new Customers, nCustomer= {$nCusomter_0$, $nCustomer_1$... $nCustomerj$}. The set of new Restrictions, nRestriction = {$nRestriction_0$, $nRestriction_1$... $nRestrictionj$}.

```
Begin
Define the new Customer List (nCustomer);
Define the new Restriction List (nRestriction);
Create instances BR_t of Business Rule , 0≤ t ≤ x;
Create instances C_t of Customer, 0≤ t ≤ y;
Create instances R_t of Restriction, 0≤ t ≤ z;

For each instance C_t in Customer list {
   If (instance C_t IsExternal("True"))
         {
    Set instance C_t as new instance nCustomer_v in the new Customer set, where 0≤ v ≤ j;
         Set v++;
         }
}
For each instance R_t in Restriction list {
          If (instance R_t IsExternal("True"))
         {
    Set instance R_t as new instance nRestriction_v in the new Restriction set, where 0≤ v ≤ j;
         Set v++;

         }
} END
```

Figure 4.15: Algorithm Four-Knowledge Context KME Instantiation

(5) CEBEs of the Business Repository KME

The ontology of a business repository KME is mainly related to the e-documents in an organisation. E-documents can imply descriptions of previous CEBEs such as tools, positions, services, functions and problems. However, the number of these documents can be large and extracting or identifying CEBEs through them is difficult. Moreover, e-documents

alone do not achieve a real application of knowledge management in organisations and fail to notice how these CEBEs are created or classified as a knowledge resource in an enterprise. Therefore, the e-documents will be limited to extracting only the contracts that are signed by customers. Contracts are essential object entities that can represent many of organisations' customers' related processes. They are also easy to identify and to use through their types and names in order to derive CEBEs. Different insurance forms such as auto and health insurance policies are examples of contracts that are CEBEs. Algorithm Five that derives the CEBEs from the Business Repository KME is implemented in Figure 4.16.

Algorithm Five: Business Repository KME Instantiation

Input: Business Repository = {E-Document}. The set of E-Document instances where E-Document = {D_0... D_x}.
Output: The set of new E-Documents, nE-Document= {nE-Document$_0$, nE-Document$_1$... nE-Document$_j$}
Begin
Define the new E-Document List (nE-Document);
Create instances D_t of E-Document , $0 \leq t \leq x$;
For each instance D_t in E-Document list
{
If (instance D_t (hasType("Contract"))
{
Set instance D_t as new instance nE-Document$_v$ in the new E-Document set, where $0 \leq v \leq j$;
Set v++;
}

}
END

Figure 4.16: Algorithm Five-Business Repository KME Instantiation

(6) CEBEs of the Culture KME

The ontology of a culture KME is concerned with the external adaptation problems that can be solved through a pattern of shared assumptions. External adaptation problems are related to environmental changes, new possibilities and challenging situations. The instances of an external problem concept are deemed to be CEBEs. Medical mistakes or flight delays are suggested problems that can be sequential CEBEs that characterise the business of a hospital or airline. Algorithm Six that extracts the CEBEs from the Culture KME is implemented in Figure 4.17.

Algorithm Six: Culture KME Instantiation

Input: Culture = {Problem, Assumption, Reference}.
The set of Problem instances where Problem = {P_0... P_x}.
The set of Assumption instances where Assumption = {A_0... A_y}.
The set of Reference instances where Reference = {R_0... R_z}.
Output: The set of new Problems, nProblem= {$nProblem_0$, $nProblem_1$… nProblemj}
Begin
Define the new Problem List (nProblem);
Create instances P_t of Problem, $0 \leq t \leq x$;
Create instances A_s of Assumption, $0 \leq s \leq y$;
Create instances R_u of Reference, $0 \leq u \leq z$;
For each instance A_s in Assumption list
{
For each instance P_t in Problem list
{
If (instance A_s handlesProblem(P_t) in Problem list)
{
If (instance P_t (IsExternalProblem("True")) AND (hasReference() in Reference))
{
Set instance P_t as new instance $nProblem_v$ in the new Problem set, where $0 \leq v \leq j$;
Set v++;
}
}
}
} END

Figure 4.17: Algorithm Six-Culture KME Instantiation

Previous algorithms have been developed to clarify how to automate the steps when extracting the CEBEs from the KMEs. The KMEs instantiation algorithms (one to six) represent the instantiation of the KMEs, their input(s) and necessary output(s). These output(s) will be used as inputs to identify CEBEs using Algorithm Seven in Figure 4.18.

Algorithm Seven: CEBEs Identification

Input: The set of Tool instances, nTool = {$nTool_0$, $nTool_1$... $nTool_j$}. The set of Agents instances, nAgent= {$nAgent_0$, $nAgent_1$... $nAgent_j$}. The set of Problems instances, nProblem= {$nProblem_0$, $nProblem_1$... $nProblem_j$}. The set of E-Documents instances, nE-Document= {$nE\text{-}Document_0$, $nE\text{-}Document_1$... $nE\text{-}Document_j$}. The set of Customers instances, nCustomer= {$nCustomer_0$, $nCustomer_1$... $nCustomer_j$}. The set of Restrictions instances, nRestriction = {$nRestriction_0$, $nRestriction_1$... $nRestriction_j$}. The set of Business Function instances, nBusinessFunction = {$nBusinessFunction_0$... $nBusinessFunction_j$}. The set of Position instances, nPosition = {$nPosition_0$... $nPosition_j$}.

Output: The set of candidate essential business entities (CEBEs), CEBE = {$cebe_0$, $cebe_1$... $cebe_j$}.

```
Begin
Define the new candidate EBEs List (nCEBE);
For each nTool_i  in nTool List    {
   If (nTool_i  usedby(Agent_i) in nAgent List)
          {
             Set instance  nTool_i as new instance cebe_v  in the CEBE set, where 0≤ v ≤j;
             Set v++;
          }                              }
For each nBusinessFunction_i in nBusinessFunction List   {
    Set instance nBusinessFunction_i as new instance cebe_v in the CEBE set, where 0≤ v ≤j;
    Set v++;                                                    }
For each nPosition_i in nPosition List   {
     Set instance nPosition_i as new instance cebe_v in the CEBE set, where 0≤ v ≤j;
     Set v++;
                                          }
For each nE-Document_i in nE-Document List                  // Identify SWRL No. 4,7
{
          For each nCustomer_i in nCustomer List {
            Set instance nCustomer_i as new instance cebe_v in the CEBE set, where 0≤ v ≤j;

           If (nCustomer_i signsDocument(nE-Document_i) in nE-Document List)
              {
         Set instance  nE-Document_i as new instance cebe_v  in the CEBE set, where 0≤ v ≤j;
              }
           Set v++;                                }
}
For each nRestriction_i in nRestriction List   // Identify SWRL No. 5
{
     Set instance nRestriction_i as new instance cebe_v in the CEBE set, where 0≤ v ≤j;
    Set v++;
}
For each nProblem_i in nProblem List   // Identify SWRL No. 6
{
   Set instance nProblem_i as new instance cebe_v in the CEBE set, where 0≤ v ≤j;
  Set v++;
}
END
```

Figure 4.18: Algorithm Seven- CEBEs Identification

The CEBEs represent different knowledge resources that are produced by the semantic KMEs. The Riva BPA method is an object-based approach that can embrace these knowledge resources and use them as business blocks or objects in order to build a BPA from a business perspective. Therefore, the Riva BPA and its semantic approach are aligned with semantic KMEs, which can be utilised in order to characterise the business of an organisation (or generate CEBEs) and continue remaining steps of Riva method BPA development.

Automating the extraction or generation of previous CEBEs requires using some rules associated with logic. The ontology development environment, Protégé tool, supports using Semantic Web Rule Language (SWRL) which can be used to derive the CEBEs. SWRL can process ontology elements and express processing rules as well as logic. These SWRL rules can enrich the generic process of CEBEs identification.

4.2.6.2.2 The aKMEOnt SWRL Rules

Automating the extraction or generation of previous CEBEs requires using some rules associated with logic. The ontology development environment, Protégé tool, supports using the Semantic Web Rule Language (SWRL) which can be used to derive the CEBEs. SWRL has been developed in order to resolve limited expressiveness or expressions that cannot be represented in OWL (Ontology Web Language) including DL (Description Logic) (Dean, 2004). A SWRL rule is comprised of an antecedent (body) and a consequent (head) and has the following form (Horrocks et al., 2004):

Antecedent ⇒ consequent

Example:

Person (?p) ∧ hasAge(?p, ?age) ∧ swrlb:greaterThan(?age, 70) → Old(?p)

Both the antecedent and consequent are a set of atoms that are connected with conjunctions which are comma ',' or wedge '∧'. An atom can refer to a class, data type property, object property, built-in relation, individual and a data value. If the antecedent is true then the consequent is executed or achieved. These rules will be utilised to derive the CEBEs' instances from the KMEs in the KMEOntoBPA. As mentioned, the CEBEs do not eliminate the role of business analysts who can distinguish between a CEBE and EBE.

Constructing or deriving SWRL rules is accomplished through algorithms which are identified and developed after an overview of the aKMEOnt concepts and their individuals in the previous section. Individuals are the instances of the KMEs' concepts such as units, positions and customers. The developed algorithms clarify how the steps are automated

when extracting the CEBEs from the KMEs. According to these algorithms, SWRL rules have been developed in order to automate the extraction of the CEBEs. SWRL rules are depicted in Table 4.2.

Table 4.2: KMEs Algorithms and Corresponding SWRL Rules in Deriving the CEBEs

No.	SWRL Rule Name	Description
Algorithms One,Two, Seven: IT KME Instantiation, Leadership KME Instantiation, CEBEs Identification		
1	**sRule_generate_CEBE_IntegrativeTechnology** *Tool(?T) ∧ hasUser(?T, ?A) ∧ IsIntegrativeTechnology(?T, true) → CEBE(?T)*	Integrative technologies that are used by the bank treasury are found to be CEBEs. Users or Agents are provided by leadership KME. T= Tool, A=Agent
Algorithms Three,Seven: Organisational Structure KME Instantiation,CEBEs Identification		
2	**sRule_generate_CEBE_UnitBF** *Unit(?U) ∧ performsBusinessFunction(?U,?BF) → CEBE(?BF)*	Business functions in the unit are the CEBEs. The unit represents the case study of the iteration. U=Unit, BF= Business Function.
3	**sRule_generate_CEBE_UnitPosition** *Unit(?U) ∧ hasPosition (?U,?P) → CEBE(?P)*	Positions in the unit are CEBEs. The unit represents the case study of the iteration. U=Unit, P=Position.
Algorithms Four, Seven: Knowledge Context KME Instantiation,CEBEs Identification		
4	**sRule_generate_CEBE_ExternalCustomers** *Customer(?C) ∧ IsExternalCustomer(?C,true) → CEBE(?C)*	External customers of the bank are considered CEBEs. C= customer.
5	**sRule_generate_CEBE_ExternalRestrictions** *Restriction(?R) ∧ IsExternalRestriction(?R, true) → CEBE(?R)*	Restrictions from outside the bank can be candidate EBEs. R= Restriction.
Algorithms Four, Five, Seven: Knowledge Context KME Instantiation, Business Repository KME Instantiation ,CEBEs Identification		
6	**sRule_generate_CEBE_ExternalCustomerContract** *E-Document(?D) ∧ Customer(?C) ∧ IsExternalCustomer(?C,true) ∧ signsDocument(?C, ?D) ∧ hasType(?D,"Contract") → CEBE(?D)*	Contracts that are signed by external customers can be CEBEs. External customers are provided by knowledge context KME. D= Document, C= Customer.

Algorithms Four, Five, Seven: Culture KME Instantiation, CEBEs Identification		
7	**sRule_generate_CEBE_ExternalProblemWithAssumption** *Assumption(?A) ∧ solvesProblem(?A,?P) ∧ IsExternalProblem(?P, True) → CEBE(?P)*	External problems that have assumptions to be solved can be CEBEs. A= Assumption, P = problem.

The SWRL rules in Table 4.2 semi-automate the generation of the EBEs by extracting the Candidate Essential Business Entities (CEBEs). SWRL rules from 1 to 7 provide sets of entities that can be classified as CEBEs. These sets are integrative technologies, business functions, positions, customer contracts, external customers, external restrictions and problems. The Protégé tool using SWRL rules can be used to automate and test these rules and be triggered by the user when new updates or configuration of the BPA elements are needed. The user can run these SWRL rules using the Java Expert System Shell (Jess) rule Engine in order to retrieve the latest CEBEs (see Figure 4.19). Using Jess, SWRL rules can generate new concepts of OWL and insert them in its knowledge base. In addition, Jess can enrich rule-based reasoning for the Semantic Web (O'Connor, Knublauch and Musen, 2005).

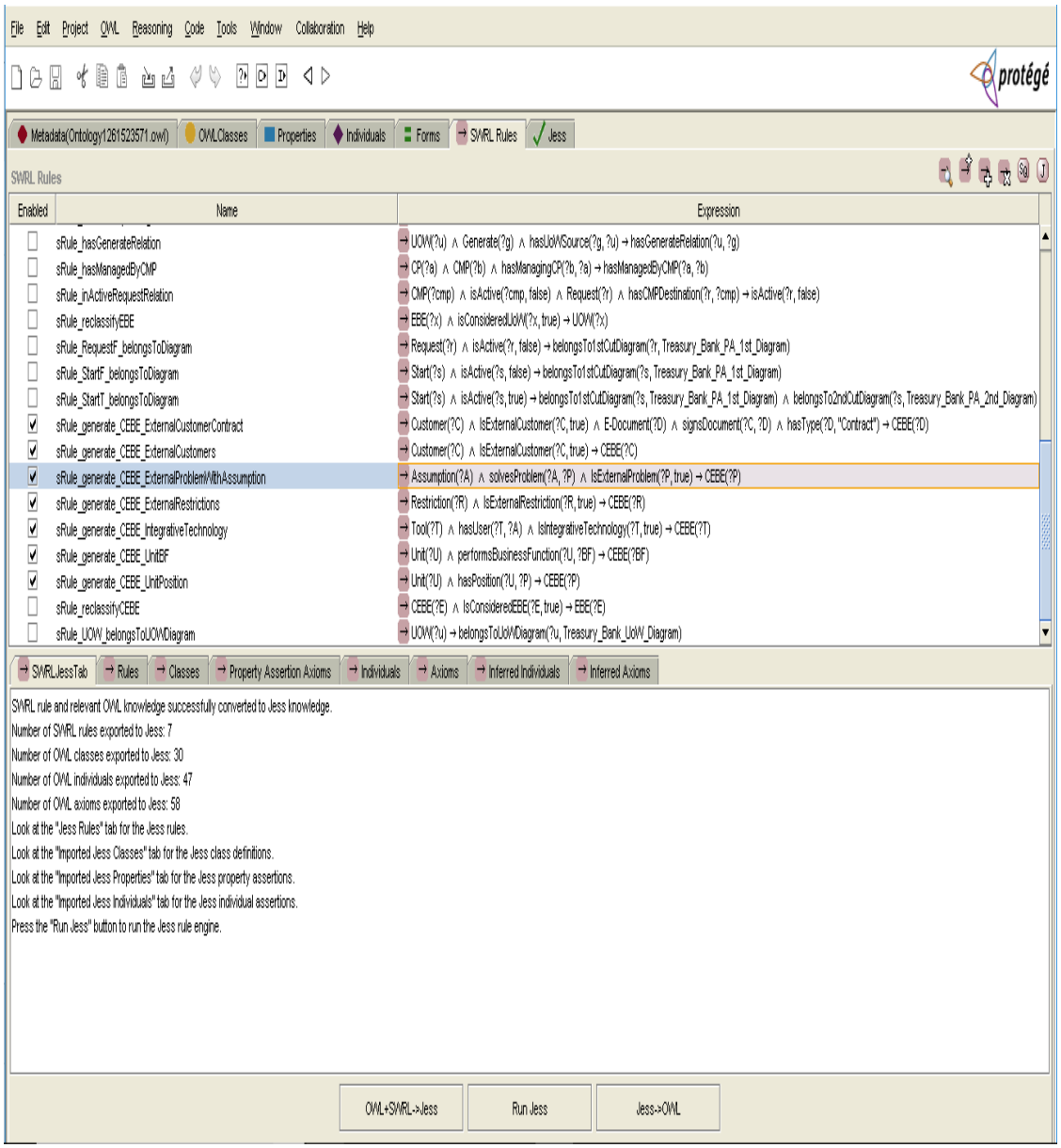


Figure 4.19: Automating SWRL Rules for extracting CEBEs using the Protégé Tool

The algorithms one to seven and their corresponding SWRL rules show how the aKMEOnt (or the abstract KMEs ontology) is instantiated in the KMEOntoBPA framework. Following the instantiation of the aKMEOnt, the second ontology of the KMEOntoBPA, i.e., the srBPA ontology is instantiated using the remaining algorithms based on Yousef (2010) work. Modifications are implemented with these algorithms in order to adopt the new CEBEs and achieve this research objective. The extracted algorithms are 'EBEs and UOWs Identification' and 'Derive Riva BPA'. The two algorithms which generate the Riva BPA elements are in Figures 4.20, 4.21.

Algorithm Eight: EBEs and UOWs Identification

Input: The set of candidate essential business entities (CEBEs), CEBE = {$cebe_0$, $cebe_1$,… ,$cebe_z$}
The set of existing (as-is) essential business entities (EBEs), exEBE = {$exebe_0$, $exebe_1$,… ,$exebe_x$}
Output: The set of new essential business entities (EBEs), nEBE = {$nebe_0$, $nebe_1$,… ,$ncebe_j$}
The set of Units of Work (UOWs), UOWs = {uow_1, uow_2,… ,uow_n}
Begin
Define the set of CEBEs in CEBE = {$cebe_0$, $cebe_1$,$cebe_u$… ,$cebe_z$} , $0 \leq u \leq z$;
Define the set of as-is EBEs in exEBE = {$exebe_0$, $exebe_1$, $exebe_b$,… ,$exebe_x$} , $0 \leq b \leq x$;
Define the set of units of work (UOWs) in UOW = {uow_0,uow_m…, uow_n} , $0 \leq m \leq n$;
Define the new essential business entities list (nEBE);

For each $cebe_u$ in CEBE do
{
If ($cebe_u$ is not qualified to be an EBE) then
{
Continue (Move to Next $cebe_u$);
}
Else
{
If ($cebe_u$ is EBE and not exist in the exEBE set)
{
Set instance i_t as new $nebe_v$ instance in nEBE set, where $0 \leq v \leq j$;
If ($cebe_u$ is UOW)
{
Set instance $cebe_u$ as new uow_m instance in UOW set, where $0 \leq m \leq n$;
Set m++;
}
Set v++;
}
}
}
END

Figure 4.20: Algorithm Eight- EBEs and UOWs Identification adapted from Yousef (2010). Used with Author's Permission

Algorithm Nine: Derive Riva BPA

Input: The set of Units of Work (UOWs), UOWs = {uow_0, uow_1,… ,uow_n}
Output: Riva-based Business Process Architecture,
relations between UOWs,
UOW_REL = {$uow\_rel_{0,\ldots,}$ uow_rel_s},
corresponding case processes, CP = {$cp_{0,\ldots,}$ cp_q} and case management processes,
CMP= {$cmp_{0\ldots}$ cmp_q} and relations between CPs and CMPs in the 2nd cut BPA Diagram,
BPA_REL = {bpa_rel_0… bpa_rel_z}.
Begin
Define the set of units of work (UOWs) in UOW = {uow_1,uow_m…, uow_n} , $0 \leq m \leq n$;

For each unit of work uow_m *in UOW do the following*
{
Add the corresponding case process cp_b *to the CP list; where* $0 \leq b \leq q$*;*
Use points of interactions between groups of activities to set relationships between CPs;
Use relationships between CPs to set the relations between UOWs

}
Generate the UOW diagram
Generate the first cut BPA
For each identified case process, cp , do the following
{
Find a group of activities that manage the flow of this cp
If such a group exists then
ADD to CMP list
End if
}
Keep points of interactions between CPs and CMPs to set relations between Riva elements;
Generate 2^{nd} *cut by modifying the* 1^{st} *cut , according to the available CMPs*
END

Figure 4.21: Algorithm Nine-Derive Riva BPA adapted from Yousef (2010). Used with Author's Permission

According to previous algorithms eight 'EBEs and UOWs Identification' and nine 'Derive Riva BPA', the alignment between the aKMEOnt and srBPA ontology in the KMEOntoBPA framework corresponds to the interaction between algorithm seven, i.e., 'CEBEs Identification' and these two algorithms (see Figure 4.22).

The interaction between previous algorithms, i.e., seven, eight and nine yields a new SWRL rule 'sRule_reclassifyCEBE' that automates the classification of CEBEs into EBEs. The execution of this new rule is preceded by asserting whether the 'isConsideredEBE' boolean property of the CEBE is true using the Protégé tool. The business analysts hold the role of this assertion. Accordingly the 'sRule_reclassifyCEBE' rule is executed in order to instantiate the srBPA ontology.

sRule_reclassifyCEBE

CEBE(?E) ∧ isExistedEBE(?E, false) ∧ isConsideredEBE(?E, true) → EBE(?E)

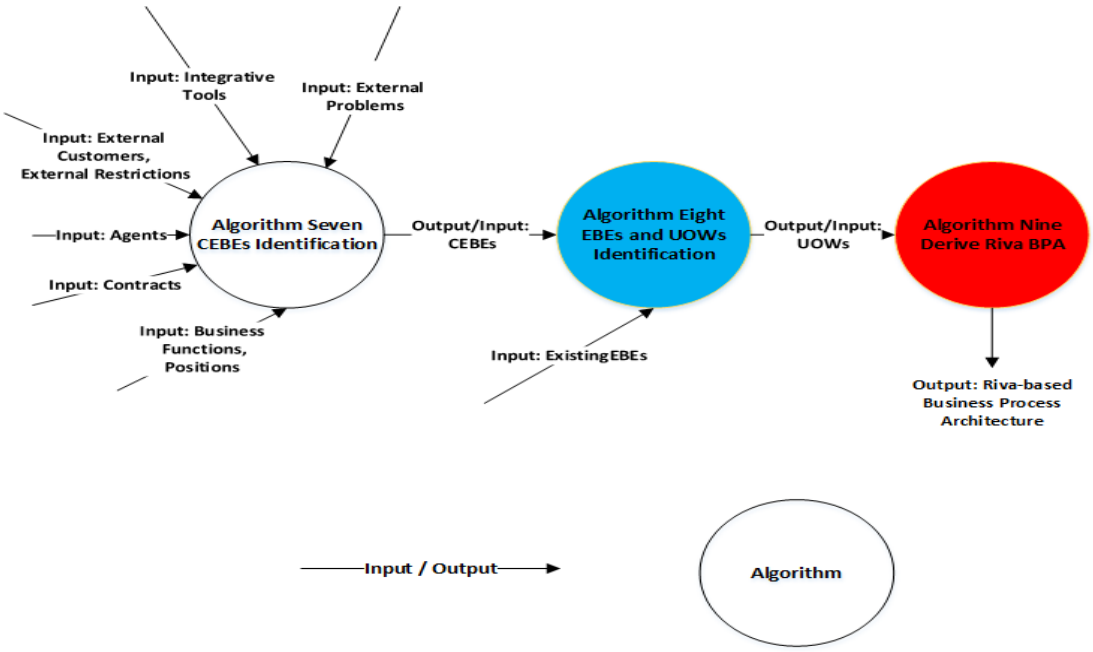


Figure 4.22: Chart of Interaction between aKMEOnt and srBPA Algorithms in the KMEOntoBPA Framework

In the completion of these algorithms and adding the new SWRL rules, we can inspect the extent to which the activities of the KMEOntoBPA framework can be automated (see Table 4.3). The automation of the KMEOntoBPA is mainly related to the automation of the interaction between the aKMEOnt and the srBPA ontologies. According to Table 4.3, the srBPA ontology indicates that approximately 75% (14 out of 19) of the activities are automatic. Manual activities are mainly related to inputs for semantic instantiation and asserting property values which need business analysts' intervention. In addition, not all heuristics have been automated in the srBPA ontology. The aKMEOnt which is aligned with the srBPA ontology has manual inputs for semantic instantiation of the KMEs. However, CEBEs are provided automatically to drive the development of the srBPA, but they still need business analysts' intervention to assert the EBEs. The total number of automatic activities in the KMEOntoBPA is 16 out of 22 activities.

Based on the previous findings, we conclude the following:

- The aKMEOnt in the KMEOntoBPA framework can be proposed to provide a form of automation for the development of a dynamic BPA.
- Object-based BPA method, specifically the Riva BPA, can be proposed as an appropriate approach to embrace the KMEs and utilise for the semi-automatic generation of its initial elements.
- The semantic ontologies can be proposed to automate the alignment between the KMEs and Riva BPA for the purpose of developing a dynamic BPA.
- There are necessary activities in the KMEOntoBPA framework, which need the decision of business analysts. These activities are manual ones.

- Not all Riva heuristics (see Section 2.2.2) are automated in the srBPA ontology and these heuristics still need to be inspected manually.

Table 4.3: Inspecting the Automation of the KMEOntoBPA Instantiation Process adapted from Yousef (2010). Used with Author's Permission

Activities of the KMEOntoBPA framework components	Inspecting the automated activities of the KMEOntoBPA components	
	Mode	**Remarks**
aKMEOnt component	**-**	**Algorithms one to seven**
Automation of Riva step two by using KMEs: extracting the CEBEs that characterise the business of an organisation and finding the EBEs		
Instantiating KMEs	**Manual**	Inputs for the semantic instantiation of information technology, leadership, organisational structure, culture, business repository and knowledge context KMEs
Instantiating CEBEs	**Automatic**	Using SWRL
Asserting CEBEs property values	**Manual**	Decisions made by business analysts
srBPA component	**-**	**Algorithms eight and nine**
Instantiating EBEs	**Automatic**	Using SWRL
Asserting EBEs property values	**Manual**	Decisions made by business analysts
Automation of Riva step three : identify the UOWs		
Instantiating UOWs	**Automatic**	Using SWRL
Asserting UOWs property values	**Automatic**	Using SWRL
Automation of Riva step four : identify dynamic relationships between UOWs		
Instantiating Generate relations	**Manual**	Inputs for the semantic instantiation
Asserting generate property values	**Automatic**	Using SWRL
Automation of Riva step five: transform the UOWs diagram into 1st cut PA		
Instantiating CPs	**Automatic**	Using Jess
Asserting CP property values	**Automatic**	Using SWRL and Jess
Instantiating CMPs	**Automatic**	Using Jess
Asserting CMP property values	**Automatic**	Using SWRL and Jess
Instantiating request relations	**Automatic**	Using Jess
Asserting request property values	**Automatic**	Using SWRL and Jess
Instantiating start relations	**Automatic**	Using Jess
Asserting start property values	**Automatic**	Using SWRL and Jess
Instantiating deliver relations	**Automatic**	Using Jess
Asserting deliver property values	**Automatic**	Using SWRL and Jess
Automation of Riva step six: transform 1st cut PA into a 2nd cut PA		
Folding CMPs into CPs	**Manual**	Decisions made by business analysts
Modifying relations related to folding CMPs	**Automatic**	Using Jess
Modifying other relations between CPs and CMPs	**Manual**	Decisions made by business analysts

4.3 DSRM First Iteration - Demonstration of the KMEOntoBPA Framework

After the design and development of the KMEOntoBPA, the demonstration phase using the *Treasury* case study is performed. The Riva "as-is" BPA of this case study is also generated

in this phase without KMEs in order to be used as a benchmark in the evaluation phase. The Riva "as-is" BPA elements are used to instantiate the srBPA ontology. Therefore, these elements which include the EBEs, UOWs and other main criteria are used to evaluate the KMEOntoBPA since they represent the elements of the Riva "as-is" BPA and its semantic approach.

4.3.1 Building the Riva "as-is" BPA

In this section, the Riva "as-is" BPA using the *Treasury* case study is generated. The elements of the Treasury BPA which include EBEs, UOWs, CPs and CMPs are presented, in addition to the Riva process architecture diagrams and dynamic relationships.

4.3.1.1 Riva "as-is" EBEs and UOWs

The second step in the Riva method, after identifying the organisation and agreeing on its domain and business boundary, is brainstorming the CEBEs that characterise the business and extracting the EBEs. The bank Treasury is the business that has been characterised in this iteration. Brainstorming the CEBEs was conducted with the Treasury team which includes the Treasury manager and five employees. Ould's (2005) questions to help identifying the CEBEs were used for the *Treasury* case study (see Appendix C). EBEs were identified by using Riva filters in step two (see Section 2.2.2). These filters include testing each one by putting the word 'a' or 'the' in front of each suggestion, removing any designed entity which is not essential and which only exists because of choosing to work in a particular way and finally, removing entities that are simply roles and not of the essence of the business. After filtering the EBEs, the third step is accomplished by determining the entities that have a lifetime to be classified as units of work (UOWs). The list of EBEs and the bracketed UOWs of the *Treasury* case study are shown in Table 4.4**.**

EBEs that are not UOWs entities were agreed with the Treasury team to be excluded due to the following filters:

(1) *Central Bank Regulations, Bank Policy, Sharia Restrictions and Central Bank Regulatory Requirements* are not considered UOWs as they do not have a lifetime that must be looked after. They are only rules or regulations to monitor and control bank processes.

(2) *SWIFT, Core Banking System, Thomson Reuters* are not considered UOWs. They are systems or technologies that are used to support or control Treasury processes.
(3) *Treasury Manager, Capital Market Trader, Forex Trader and Money Market Trader* are only roles that play a part in Treasury processes.

(4) *Currency and Sukuk* are only part of another EBE and do not have a separate lifetime of their own.

(5) *Corporate, Local Bank, Foreign Bank, Central Bank, Retail and SMEs* are all considered as a bank customer. These EBEs represent an example of heterogeneity regarding 'Synonyms' which refers to have different terms with the same meaning. All these different terms define a *Bank Customer* EBE. This type of heterogeneity can be resolved using ontologies.

Table 4.4: The Treasury Essential Business Entities, with Bracketed Units of Work

Treasury Manager	Thomson Reuters
(Asset and Liability Management)	**(Currency Purchase /Sell Order)**
(Capital Market Trading)	Forex Trader
Capital Market Trader	Money Market Trader
(Sukuk Purchase Order)	**(Letter of Credit)**
(Money Market Trading)	**(Bills for Collection)**
(Cash Analysis)	**(Managing Accounts with the Correspondent**
(Cash and Liquidity Management)	**Banks)**
(Forex Trading)	SWIFT
Sharia Restrictions	**(Money Transfer)**
(Balance Sheet Risks Control)	**(Monitoring the Centres of Foreign Currencies)**
Core Banking System	**(Treasury Operations Executive)**
Corporate	Central Bank
Local Bank	Retail
Foreign Bank	Small and Medium-Sized Enterprises (SMEs)
Currency	**(Bank Customer)**
Sukuk	Central Bank Regulatory Requirements
Central Bank Regulations	**(Short-Term Sukuk Purchase Order)**
Bank Policy	

The next step is to set the relationships between the UOWs. This will include drawing the 'generate' (g) or 'involve' relationships by the determination of the source and destination of each UOW. Each relationship is implemented by an arrow from the generating UOW to the generated UOW. The arrow is named by 'g' or 'involve' and the relationship number such as g1, g2 and g3 or involve1, involve2 and involve3. The UOWs diagram that has been approved with the Treasury team is in Figure 4.23.

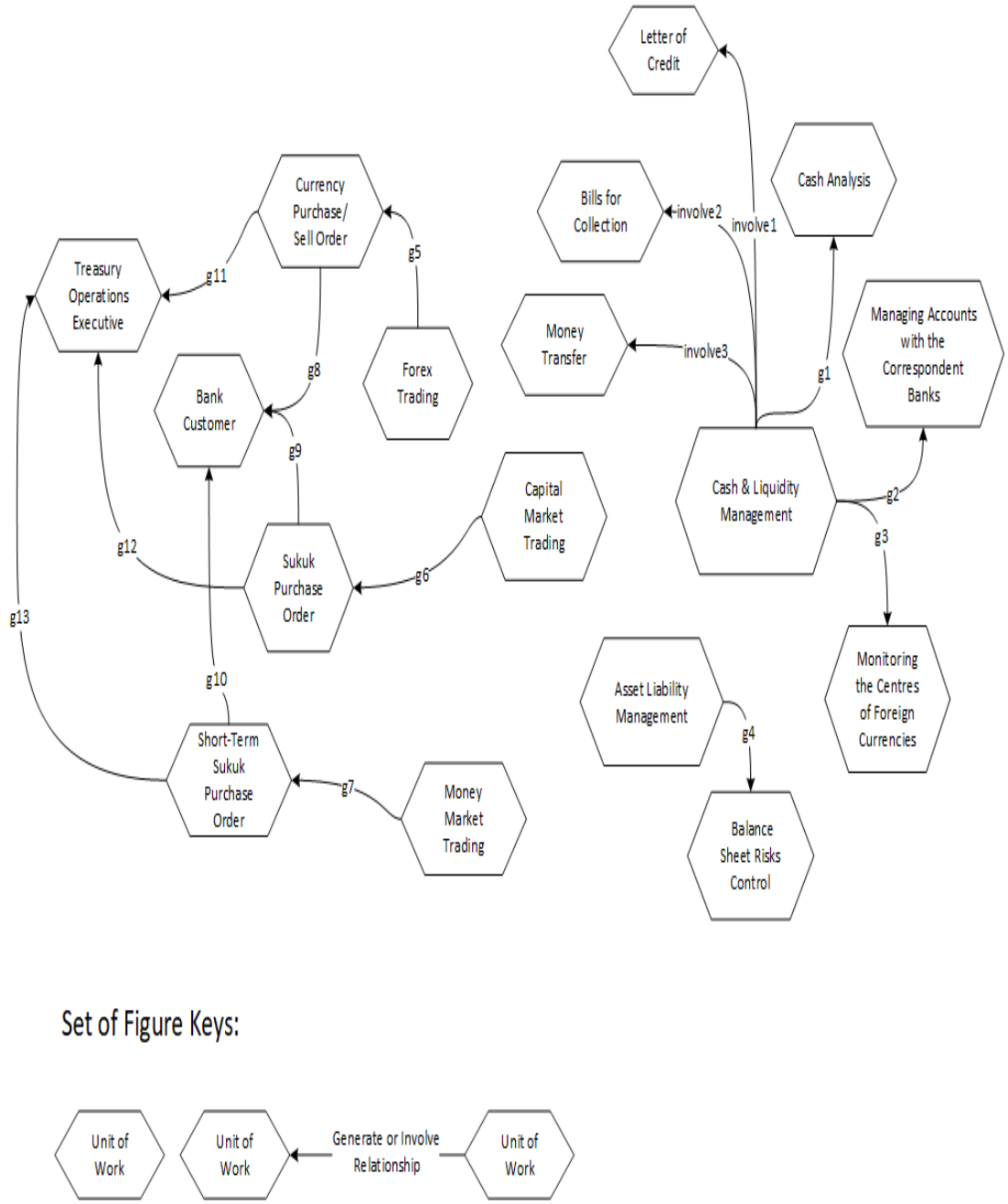
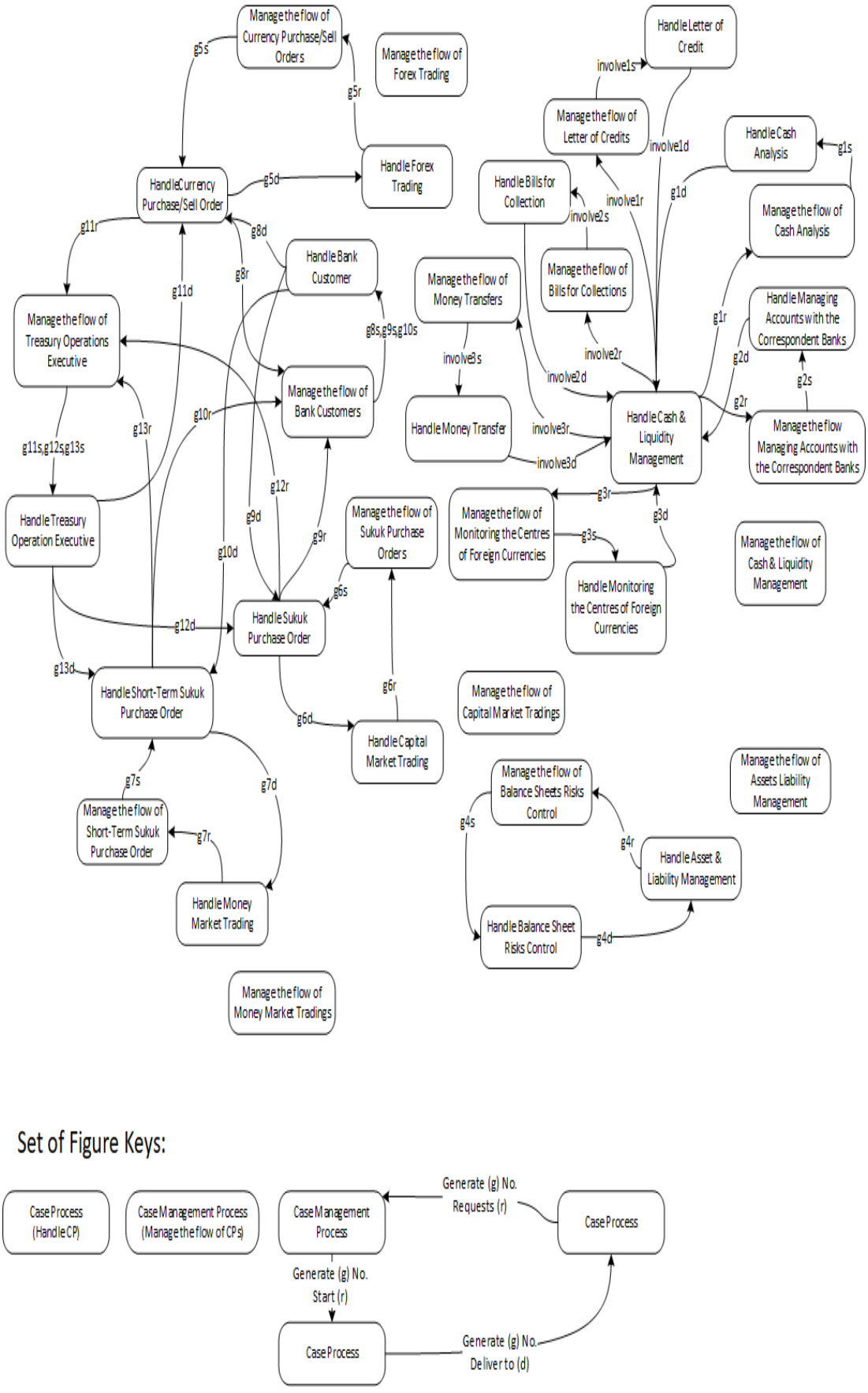


Figure 4.23: Riva BPA UOWs Diagram for the Treasury Case Study

4.3.1.2 Riva "as-is" 1st Cut PA Diagram

The fifth step in the Riva method is producing a 1st cut of the process architecture from the UOW diagram. The first cut diagram of the *Treasury* case study is produced through the case processes (CPs), case management processes (CMPs) and their relationships. For each UOW on the UOW diagram there is a CP and CMP. The 'generate' or 'involve' relationship between two UOWs of the UOWs diagram is translated into relationships between the corresponding processes. The relationships are 'request' (r), 'start' (s) and 'deliver' (d) (review Section 2.2.2). According to the UOWs diagram and the translation of its relationships, the Treasury 1st cut PA diagram can be generated. See Figure 4.24.



Set of Figure Keys:

Figure 4.24: Riva BPA 1st Cut Diagram for the Treasury Case Study

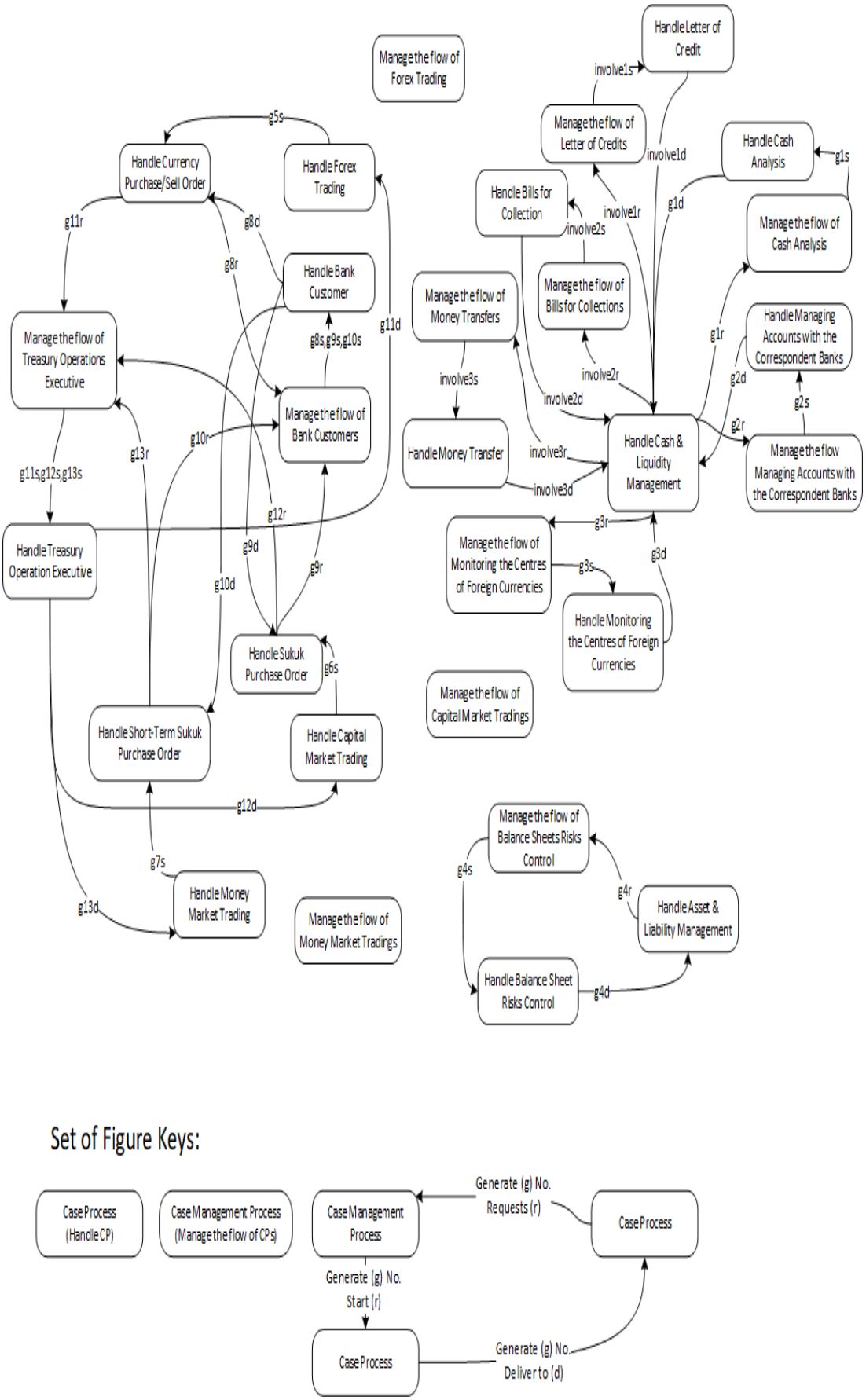
4.3.1.3 Riva "as-is" 2nd Cut PA Diagram

Producing a 2nd cut process architecture using heuristics is the sixth step in the Riva method (review Section 2.2.2). Heuristics generate a process architecture that adds more reflection to the real environment of the Treasury business. Heuristics, as mentioned in Chapter 2, include (Ould, 2005): (1) folding a task force CMP into the requesting CP; (2) dealing with 1:1 'generates' relationships; (3) dealing with delivery interactions and delivery chains; (4) dealing with collections; and finally (5) dealing with empty CMPs. These heuristics will be checked to identify whether any are applicable to the elements of the 1st cut PA diagram. The results of applying these heuristics to the 1st cut diagram are as follows:

- Folding a task force CMP into the requesting CP is a heuristic in the sixth step of Riva method. According to this heuristic, CMPs are folded in to the requesting CP. This means that the CMP is considered part or within the requesting CP. The CMPs which best considered part of the requesting CP are: *Manage the flow of Currency Purchase/Sell Orders, Manage the flow of Sukuk Purchase Orders, and Manage the flow of Short-Term Sukuk Purchase Orders*.
- Dealing with 1:1 'generates' relationships is a heuristic in the sixth step of Riva method. This heuristic states that if there is 1:1 'generates' relationships in certain (1:1) relationships and both UOWs are necessary but we cannot distinguish between the CMPs for both UOWs, one CMP can replace both. This means that the two CMPs for both UOWs can be substituted by one CMP since these UOWs are nearly the same or their cases can be handled with the same management. This heuristic was not found in the *Treasury* case study since the UOWs that have one instance such as *Manage the flow of Cash & Liquidity Management*, have a CMP that should be distinguished from other CMPs.
- Dealing with delivery interactions and delivery chains. Delivery chains which are related to *Handle Currency Purchase/Sell Order* (g11d,g5d), *Handle Sukuk Purchase Order* (g12d,g6d), *Handle Short-Term Sukuk Purchase Order* (g13d,g7d) can be short-circuited into (g11d, g12d, g13d) and delivered directly from *Handle Treasury Operation Executive* to *Handle Forex Trading*, *Handle Capital Market Trading*, *Handle Money Market Trading* sequentially. These short-circuits represent the real delivery interaction in the Treasury business.
- Dealing with collections when it is found that a UOW is a collection of another UOW and the CMP for the component is contained within the requesting CP. The CMP can be folded into the requesting CP. The *Treasury* case study has no UOW that is considered as a collection of another UOW.

- Dealing with empty CMPs in certain cases when there is only one instance of the CP and there is no calling for CMP. According to this heuristic, the following CMPs are removed since they have only one instance of the CP: *Manage the flow of Assets Liability Management* and *Manage the flow of Cash & Liquidity Management*.

The 2nd cut PA diagram is presented after applying these heuristics (see Figure 4.25).



Set of Figure Keys:

Figure 4.25: Riva BPA 2nd Cut Diagram for the Treasury Case Study

4.3.2 Building the Riva BPA using the KMEs

After building the Riva "as-is" BPA of the *Treasury* case study, the KMEOntoBPA ontologies were used to develop the Treasury BPA. The Riva "as-is" BPA clarifies the Treasury processes and provides a benchmark that assists in comparing the two BPAs, Riva "as-is" and the KMEs driven BPA. In this section, the KMEs driven BPA is developed by instantiating the KMEOntoBPA ontologies and using the algorithms along with their corresponding SWRL rules developed in the design and development DSRM phase. The ontology-based development of the BPA will support semi-automated identification of EBEs and provide flexibility to generate agile BPA.

4.3.2.1 Knowledge-based CEBEs

Brainstorming CEBEs and finding EBEs is the second step in the Riva method. By instantiating the aKMEOnt component using the *Treasury* case study, the CEBEs which are used to be brainstormed using Ould (2005) questions, are created in the KMEOntoBPA. These CEBEs are elicited for each KME by executing the SWRL rules that correspond to the developed algorithms (review Section 4.2.6.2.2 Table 4.2). The following CEBEs are identified for each KME:

Algorithm 'Information Technology KME Instantiation' is mainly concerned with extracting CEBEs from the IT KME. Identifying the CEBEs of the IT KME requires calling algorithms 'Information Technology KME Instantiation', 'Leadership KME Instantiation' and 'CEBEs Identification' (review Section 4.2.6.2.1) in order to find the integrative tools that are used by agents in the *Treasury* case study (see Table 4.5). The SWRL rule that is concerned with extracting the CEBEs from the Treasury IT KME is as follows:

'**sRule_generate_CEBE_IntegrativeTechnology'**

$Tool(?T) \wedge hasUser(?T, ?A) \wedge IsIntegrativeTechnology(?T, true) \rightarrow CEBE(?T)$

Table 4.5: Identified CEBEs using the Treasury IT KME

CEBEs	Description
Core Banking System (iMal Treasury)	The bank system technology that is used in the bank
Bank Intranet	The internal internet tool for sharing information inside the bank
Thomson Reuters Data System	Provide, integrate and manage financial information from stock exchanges and other data sources to end users such as banks. iMal Live Financial Market is a middleware that connects the bank system to Reuters system

SWIFT System	Society for Worldwide Interbank Financial Telecommunications. A messaging network for secure transmission of financial institutions information and instructions. iMal is integrated with the SWIFT Alliance System
Bloomberg Terminal	Software used to access financial information like Thomson Reuters

Algorithm 'Organisational Structure KME Instantiation' is used to derive the CEBEs from the organisational structure KME (Review Section 4.2.6.2.1). The CEBEs are identified using this algorithm and 'CEBEs Identification' algorithm which extract positions and business functions of the *Treasury* case study (see Table 4.6). The SWRL rules that extract CEBEs from the Organisational Structure KME of the *Treasury* case study are as follows:

'sRule_generate_CEBE_UnitBF'

$Unit(?U) \wedge performsBusinessFunction(?U,?BF) \rightarrow CEBE(?BF)$

'sRule_generate_CEBE_UnitPosition'

$Unit(?U) \wedge hasPosition\ (?U,?P) \rightarrow CEBE(?P)$

Table 4.6: Identified CEBEs using the Treasury Organisational Structure KME

CEBEs	Description
Cash & Liquidity Management	Collecting and managing cash and meeting financial obligations
Money Market	Money market is a segment of the financial market for trading short-term loans
Forex	Foreign exchange market refers to the global market where currencies are traded
Sukuk & Financial Securities	Shari 'a-compliant securities that are backed by tangible assets
Asset Liability Management	Managing arising risks (profit/loss and liquidity risks) due to mismatches between assets and liabilities (debts)
Treasury Operations Executive	Settlement and confirmation of Treasury transactions
Money Market Trade Officer	Bank Treasury Position
Senior Money Market Trade Officer	
Money Market Trade Supervisor	
Forex Trade Officer	
Senior Forex Trade Officer	
Forex Trade Supervisor	
Capital Market Trade Officer	
Senior Capital Market Trade Officer	
Capital Market Trade Supervisor	

Treasury Manager	Bank Position and the highest rank in Treasury
Treasury Operations Executive Officer	Bank Treasury Executive position
Senior Treasury Operations Executive Officer	
Treasury Operations Executive Supervisor	

After identifying the CEBEs of the organisational structure KME, algorithms 'Knowledge Context KME Instantiation' and 'CEBEs Identification' (Review Section 4.2.6.2.1) are called to derive the CEBEs from the knowledge context KME (see Table 4.7*)*. These algorithms will identify the *Treasury* case study external customers and restrictions. The SWRL rules that extract CEBEs from the Treasury Knowledge Context KME are below:

'sRule_generate_CEBE_ExternalCustomers'

$Customer(?C) \wedge IsExternalCustomer(?C,true) \rightarrow CEBE(?C)$

'sRule_generate_CEBE_ExternalRestrictions'

$Restriction(?R) \wedge IsExternalRestriction(?R, true) \rightarrow CEBE(?R)$

Table 4.7: Identified CEBEs using the Treasury Knowledge Context KME

CEBEs	Description
Jordan Central Bank Instructions	Instructions issued by the central bank to all local banks
Central bank law	Rules imposed by the central bank on all local banks
Trade Law	Law in Jordan
Investment Promotion Law	
Law Regulating the Exchange	
Public Debt Law	
Banking Law	
Income Tax Act	
Electronic Transactions Act	
Sharia Restrictions	It is the Shari 'a law from a combination of sources. First 'Quran' then 'Sunnah' (sayings of prophet Mohammad) and finally 'Fatawas' (Scholars opinions and explanations in relation to the Quran and Sunnah)
Bank Policy	Principles that rule the bank procedures
Bank Customer	Any individual or party that makes benefits of bank services
Corporate	Large organisations or companies
Local Bank	Other banks locally operated
Foreign Bank	External bank
Central Bank	National bank that provides financial services for the country and it is considered also as a customer for the local banks
Retail	Individual customers
SMEs	Small and medium-sized enterprises

Algorithm ‘Business Repository KME Instantiation’ is used to identify the CEBEs from the business repository KME (Review Section 4.2.6.2.1). This identification requires calling this algorithm in addition to ‘Knowledge Context KME Instantiation’ and ‘CEBEs Identification’ algorithms. ‘Knowledge Context KME Instantiation’ provides the external customers that are required to sign the contract documents. ‘CEBEs Identification’ extracts or generates these CEBEs (see Table 4.8). The SWRL rule deriving CEBEs from the Treasury Business Repository KME is as follows:

‘sRule_generate_CEBE_ExternalCustomer Contract’

E-Document(?D) ∧ Customer(?C) ∧ IsExternalCustomer(?C,true) ∧ signsDocument(?C, ?D) ∧ hasType(?D,"Contract") → CEBE(?D)

Table 4.8: Identified CEBEs using the Treasury Business Repository KME

CEBEs	Description
Currency Invoice of Sale	Exchange currencies on the spot (certain amount within the same day)
Commodity Murabaha Confirmation	Sukuk use murabaha contracts

Finally the CEBs are derived from the culture KME. Algorithms ‘Culture KME Instantiation’ and ‘CEBEs Identification’ (Review Section 4.2.6.2.1) are used to identify CEBEs from the external problems of the culture KME (see Table 4.9). The following SWRL rule derives the CEBEs from the Treasury culture KME:

‘sRule_generate_CEBE_ExternalProblem_ WithAssumption’

Assumption(?A) ∧ solvesProblem(?A,?P) ∧ IsExternalProblem(?P, True) → CEBE(?P)

Table 4.9: Identified CEBEs using the Treasury Culture KME

CEBEs	Description
Forex Price	The price of curriencies can introduce a problem while exchanging between trading banks. This problem requires values and traditions (mainly trust value) to handle between banks.

4.3.2.2 Knowledge-based EBEs and UOWs

After the identification of the CEBEs using the aKMEOnt component, algorithm ‘EBEs and UOWs Identification’ is used to instantiate the srBPA ontology component in order to identify the KMEs driven EBEs and UOWs. All the KMEs driven CEBEs are checked with the Treasury team and filters of the Riva second step were used to assure that all these CEBEs are EBEs that characterise the Treasury business. The EBEs that have a lifetime are classified as UOWs. The list of KMEOntoBPA EBEs and UOWs of the *Treasury* case study are shown in Table 4.10.

Table 4.10: The CEBEs/EBEs and Bracketed UOWs for the Treasury Case Study

Core Banking System-iMal Treasury	***Senior Treasury Operations Executive Officer***
Bank Intranet	***Jordan Central Bank Instructions***
Thomson Reuters Data System	***Central bank Law***
SWIFT System	***Trade Law***
Bloomberg Terminal	***Investment Promotion Law***
(Cash & Liquidity Management)	***Law Regulating the Exchange***
(Money Market)	***Public Debt Law***
(Forex)	***Banking Law***
(Sukuk & Financial Securities)	***Sharia Restrictions***
(Asset Liability Management)	***Income Tax Act***
(Treasury Operations Executive)	***Electronic Transactions Act***
Money Market Trade Officer	***Bank Policy***
Senior Money Market Trade Officer	***(Bank Customer)***
Money Market Trade Supervisor	***Corporate***
Treasury Manager	***Local Bank***
Forex Trade Officer	***Foreign Bank***
Senior Forex Trade Officer	***Central Bank***
Forex Trade Supervisor	***Retail***
Capital Market Trade Officer	***SMEs***
Senior Capital Market Trade Officer	***(Currency Invoice of Sale)***
Capital Market Trade Supervisor	***(Sukuk - Commodity Murabaha Confirmation)***
Treasury Operations Executive Officer	***Forex Price***
Treasury Operations Executive Supervisor	
IT, Organisational Structure, Knowledge Context, Business Repository, Culture KMEs CEBEs	

EBEs that are not UOWs entities are excluded due to the followings filters:

(1) *Jordan Central Bank Instructions, Central bank law, Trade Law, Investment Promotion Law, Law Regulating the Exchange, Public Debt Law, Banking Law, Sharia Restrictions, Income Tax Act, Electronic Transactions Act and Bank Policy* are regulations and restrictions which are used to control the bank processes and do not have a lifetime that must be looked after.

(2) *Core Banking System-iMal Treasury, Bank Intranet, Thomson Reuters Data System, SWIFT System and Bloomberg Terminal* are clearly not UOWs. They are only systems and technologies that support or control the Treasury processes.

(3) *Money Market Trade Officer, Senior Money Market Trade Officer, Money Market Trade Supervisor* and other positions are considered as roles that play a part in the processes.

(4) The *Forex Price* problem is part of another EBE which is Forex and does not have a separate lifetime of its own.

(5) *Corporate, Local Bank, Foreign Bank, Central Bank, Retail and SMEs* as mentioned in Section 4.3.1.1, define a *Bank Customer* and represent the example of 'Synonyms' heterogeneity that are resolved by using ontologies. The built-in property in OWL

owl:sameAs is used to define these EBEs as a *Bank Customer* EBE in the KMEOntoBPA using the Protégé Tool.

According to the KMEOntoBPA components activities in Section 4.2.6 Table 4.3, asserting which CEBEs are EBEs, are done by business analysts using the ontology data type property. This data type property is 'isConsideredEBE'. On the other hand, generating EBEs are performed by the following SWRL rule:

$CEBE(?E) \wedge isExistedEBE(?E, false) \wedge isConsideredEBE(?E, true) \rightarrow EBE(?E)$

Same assertion is done for EBEs after calling algorithm 'EBEs and UOWs Identification' and using data type property 'isConsideredUoW'. The assertion is followed by generating UOWs instances by the SWRL rule below:

$EBE(?x) \wedge isConsideredUoW(?x, true) \rightarrow UOW(?x)$

The next step in the KMEOntoBPA framework is to identify the relationships between the UOWs. This step is performed by 'Derive Riva BPA' algorithm and its corresponding SWRL rules based on Yousef (2010) work (see also Appendix A). It also includes the determination of the source and destination of each UOW, in addition to the Treasury UOW diagram they belong to.

By identifying these relationships with the Treasury team using the srBPA ontology component, the knowledge-based UOWs diagram can be implemented (see Figure 4.26).

Figure 4.26: Knowledge-based Riva UOWs Diagram for the Treasury Case Study

4.3.2.3 Knowledge-based Riva 1st and 2nd Cut PA Diagrams

After the generation of the knowledge-based Riva UOWs diagram, algorithm 'Derive Riva BPA' generates the knowledge-based Riva 1st and 2nd cut diagrams of the *Treasury* case study. The 1st cut diagram of the Treasury can be produced through the CPs, CMPs and their relationships. All CP and CMP instances are generated programmatically using the Jess Engine. The Jess Engine is already integrated with Protégé 3.4.1 through the Jess Tab.

As it was mentioned, the fifth step in Riva method is transforming UOWs diagram into 1st cut PA (or process architecture) diagram. This transformation requires translating each UOW into CP (or case process), CMP (or case management process) and the relationships between them. Using the Jess Tab engine in Protégé Tool, the following rules or commands are used to create the corresponding CP and CMP of each UOW in the KMEOntoBPA applied to the *Treasury* case study:

1) Generating automatically corresponding CP of each UOW using Jess Tab:
   *(mapclass **Ontology_URI**#UOW)*
   *(defrule create_CP ?f <- (object(is-a **Ontology_URI** #UOW)) => (make-instance (str-cat(instance-name ?f) "_Handling") of **Ontology_URI** #CP **Ontology_URI** #hasCorrespondingUoW ?f)))*
2) Generating automatically corresponding CMP of each UOW using Jess Tab:
   *(mapclass **Ontology_URI**#UOW)*
   *(defrule create_CMP ?g <- (object(is-a **Ontology_URI**#UOW)*
   *(**Ontology_URI**#hasCorrespondingCP ?cp)) => (make-instance (str-cat(instance-name ?g) "_flowManaging") of **Ontology_URI**#CMP*
   *(**Ontology_URI**#hasManagingCP ?cp)))*

The next step is to automatically generate the relationships between the CPs and CMPs. Three relationships which include request, start and deliver are created between the corresponding CPs and CMPs. The following rule or command in Jess translates the relationships between the UOWs into relationships between the corresponding CPs and CMPs in the KMEOntoBPA applied to the *Treasury* case study:

*(mapclass **Ontology_URI**#Generate)*
*(mapclass **Ontology_URI**#UOW)*
*(mapclass **Ontology_URI**#CMP)*
*(mapclass **Ontology_URI**#CP)*
*(defrule translate_relations (object(is-a **Ontology_URI**#Generate) (OBJECT ?f)*
*(**Ontology_URI**#hasUoWSource ?a) (**Ontology_URI**#hasUoWDestination ?b))*
*(object(is-a **Ontology_URI**#CP) (OBJECT ?acp)*

*(**Ontology_URI**#hasCorrespondingUoW ?a)) (object(is-a **Ontology_URI**#CP) (OBJECT ?bcp) (**Ontology_URI**#hasCorrespondingUoW ?b)) (object(is-a **Ontology_URI**#CMP) (OBJECT ?bcmp) (**Ontology_URI**#hasManagingCP ?bcp)) => (make-instance (str-cat(instance-name ?f) "_d") of **Ontology_URI**#Deliver (**Ontology_URI**#hasCPSource ?bcp) (**Ontology_URI**#hasCPDestination ?acp)) (make-instance (str-cat(instance-name ?f) "_r") of **Ontology_URI**#Request (**Ontology_URI**#hasCPSource ?acp) (**Ontology_URI**#hasCMPDestination ?bcmp)) (make-instance (str-cat(instance-name ?f) "_s") of **Ontology_URI**#Start (**Ontology_URI**#hasCMPSource ?bcmp) (**Ontology_URI**#hasCPDestination ?bcp)))*

Executing the above rule using the Jess engine would create three types of relations for each 'generate' relation. These relations are request, start and deliver. Using the produced relationships by the Protégé tool, the Treasury 1st cut PA diagram can be extracted after generating the UOW diagram (see Figure 4.27).

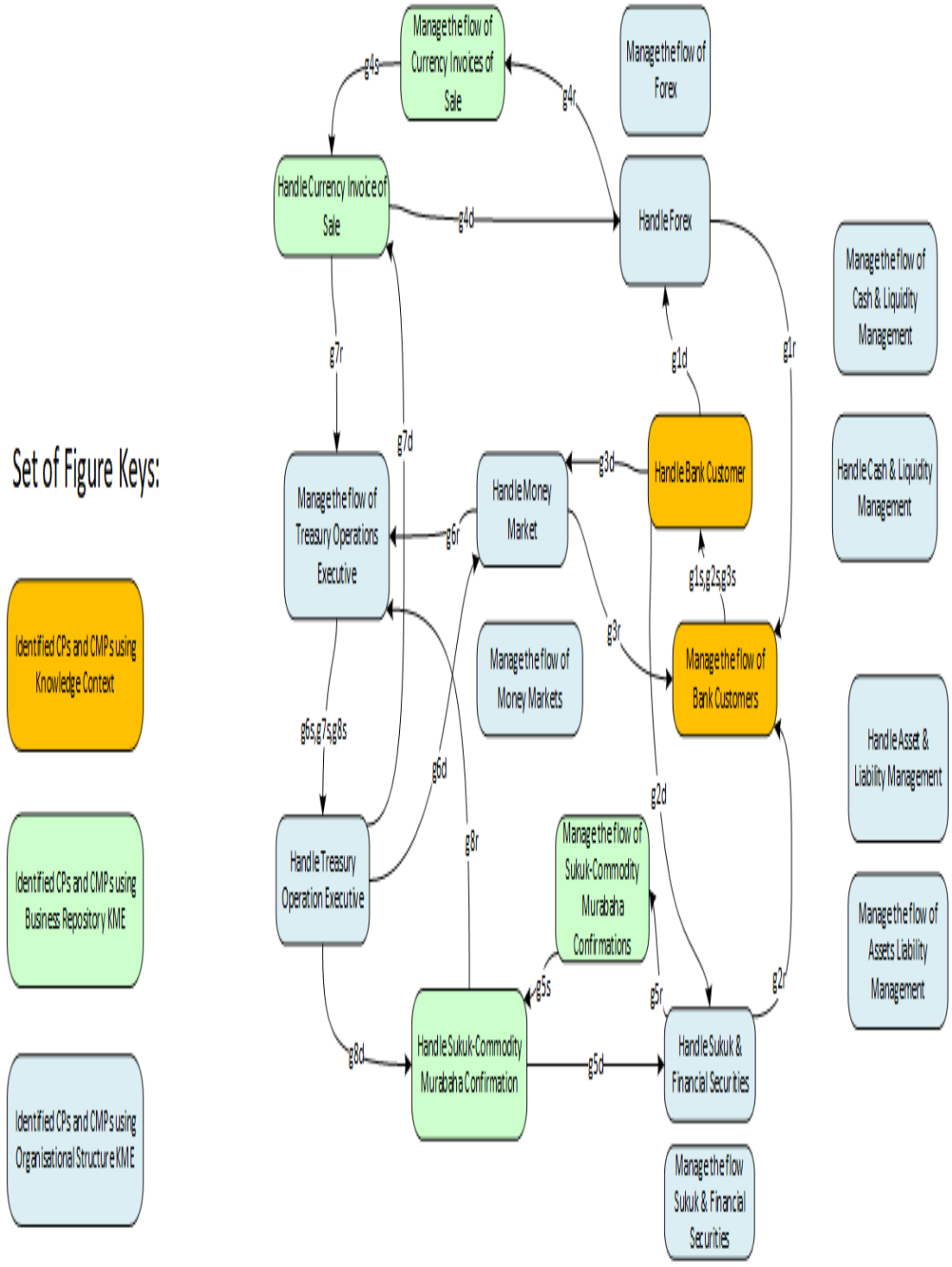


Figure 4.27: Knowledge-Based Riva 1st Cut PA Diagram for the Treasury Case Study

Generating Riva 1st cut PA involves applying heuristics in order to generate the 2nd cut PA (review Section 2.2.2). These heuristic are as follows:

- Folding a task force CMP into the requesting CP. According to this heuristic, CMPs can be folded in to the requesting CP. The CMPs are *Manage the flow of Currency Invoices of Sale and Manage the flow of Sukuk-Commodity Murabaha Confirmations*.
- Dealing with 1:1 'generates' relationships. This heuristic was not found in the Treasury KMEs driven 1st cut PA diagram since the UOWs that have one instance such as *Manage the flow of Cash & Liquidity Management* do not have relationships with other UOWs.
- Dealing with delivery interactions and delivery chains. Delivery chains which are related to *Handle Currency Invoice of Sale* (g7d, g4d) and *Handle Sukuk-Commodity Murabaha Confirmation* (g8d, g5d) can be short-circuited into (g7d, g8d) and delivered directly from *Handle Treasury Operation Executive* to *Handle Forex* and *Handle Sukuk & Financial Securities* sequentially.
- Dealing with collections when it is found that a UOW is a collection of another UOW and the CMP for the component is contained within the requesting CP. The CMP can be folded into the requesting CP. No dealing with collections was found since folded CMPs were considered as a task force rather than a component within the requesting CP.
- Dealing with empty CMPs in certain cases when there is only one instance of the CP and there is no calling for CMP. According to this heuristic, the following CMPs are removed: *Manage the flow of Assets Liability Management* and *Manage the flow of Cash & Liquidity Management*.

Deleting or folding CMPs is implemented in the srBPA ontology using the data type property 'isActive' for the CMP. For each CMP deleted, all relevant existing 'request' (r) relations will be deleted. The following SWRL rule can be used to delete all 'request' (r) relations that are related to the deleted CMPs:

$$CMP(?cmp) \wedge isActive(?cmp, false) \wedge Request(?r) \wedge hasCMPDestination(?r, ?cmp) \rightarrow isActive(?r, false)$$

The 'Start' (s) relationships which are connected to the CPs can be updated by changing the source from CMP to the CP that is requested. The 2nd cut PA diagram can be presented after applying the Riva heuristics (see Figure 4.28).

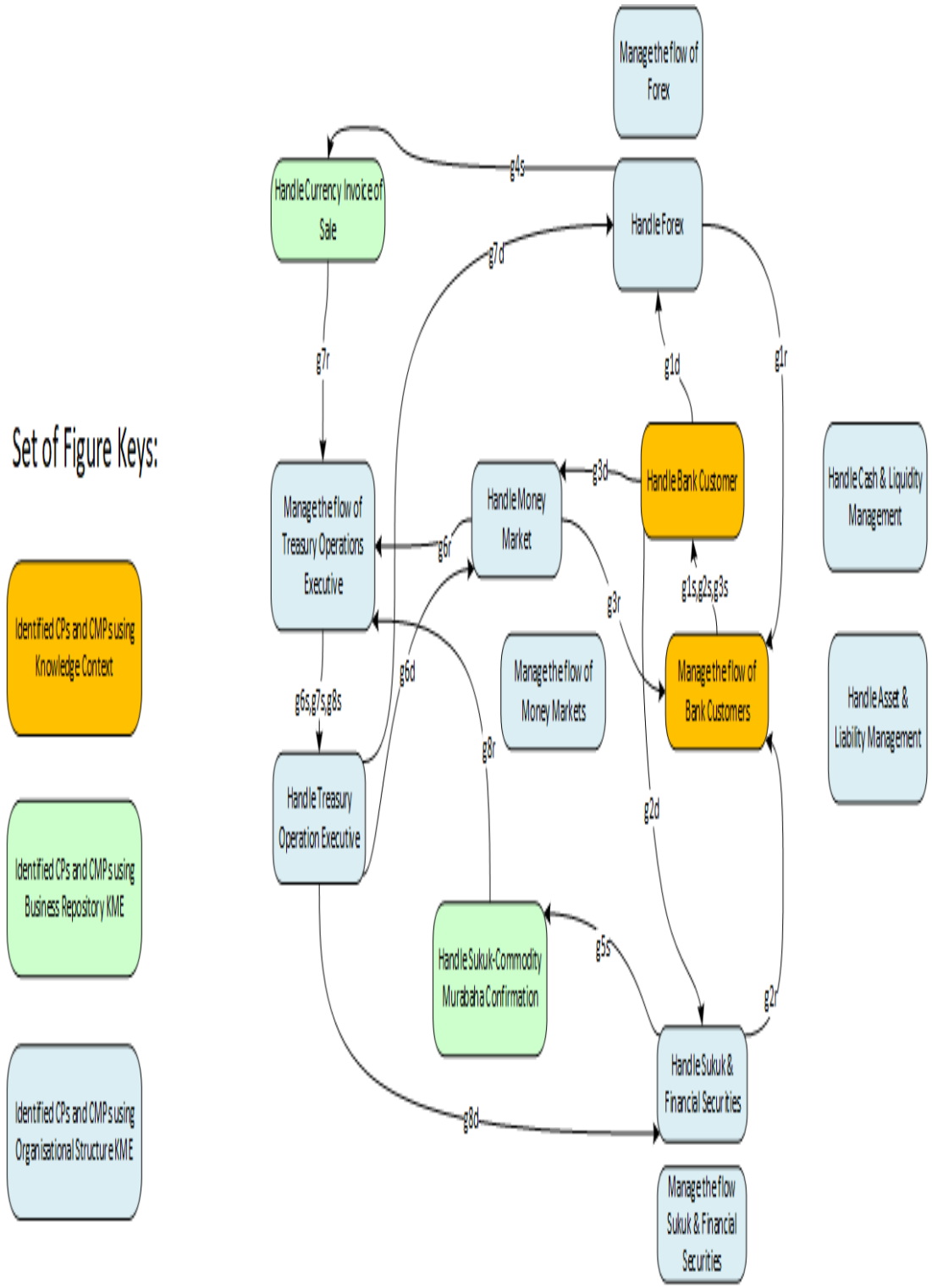


Figure 4.28: Knowledge-Based Riva 2nd Cut PA Diagram for the Treasury Case Study

The following created copies of the 'Start' (s) relationships are added with changing the source to CPs handlers for the Treasury knowledge-based 2nd cut PA diagram: g4s and g5s.

Now the following SWRL rule is executed in order to determine the CMPs that belong to the Treasury 2nd cut diagram:

CMP(?cmp) ∧ isActive(?cmp, true) ∧ belongsTo1stCutDiagram(?cmp, PA_1st_Diagram) → belongsTo2ndCutDiagram(?cmp, PA_2nd_Diagram)

Dealing with empty CMPs when there is only one instance of the CP by removing the CMPs is performed by using the data type property 'isActive' for the CMP in the srBPA ontology. Dealing with delivery interactions and delivery chains is not supported in the srBPA ontology.

4.4 DSRM First Iteration - Evaluation of the KMEOntoBPA Framework

After the demonstration of the KMEOntoBPA using the *Treasury* case study, an evaluation is conducted based on the research evaluation framework. The evaluation framework includes testing the verification and validation of the KMOntoBPA Framework (see Chapter 3 Section 3.4.2).

4.4.1 Verification of the aKMEOnt

Informing the verification of the aKMEOnt requires evaluating the correctness of the semantic representation of the KMEs, i.e, the aKMEOnt, according to the KMEs of the case study of the DSRM iteration. Figure 4.29 shows the verification of the aKMEOnt using the research primary concerns and sub-questions. Each sub-question presents a criterion that Juristo and Morant (1998) defined to address part of the correctness. These criteria are completeness, consistency and redundancy. Any failure in meeting any of these criteria means missing or surplus, inconsistency or redundancy in the aKMEOnt elements which results in incorrectness. Thus, all these criteria in the sub-questions are checked collectively in order to inform the correctness of the aKMEOnt.

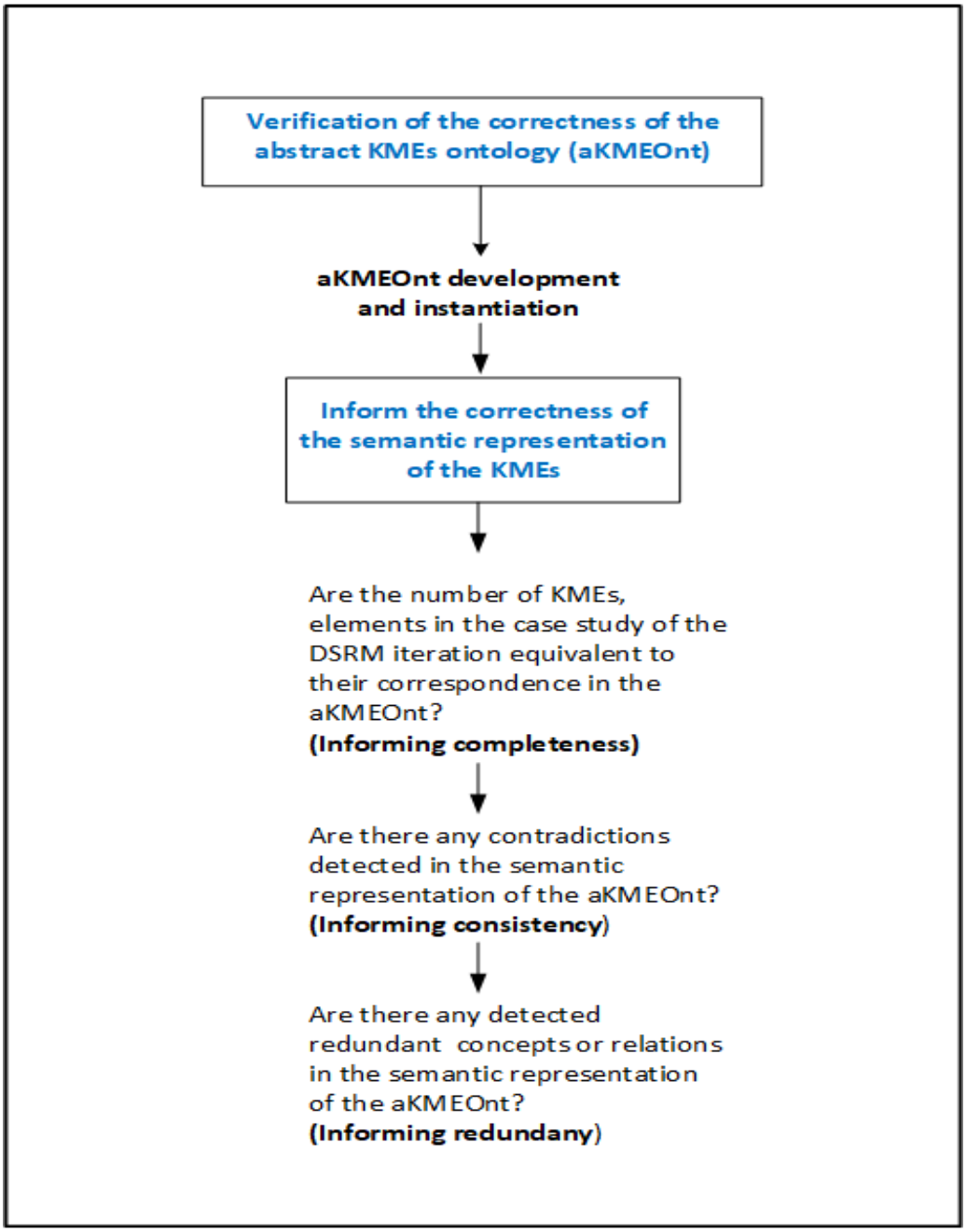


Figure 4.29: Verification of the aKMEOnt using Research Concerns and Sub-Questions

Table 4.11 compares the KMEs elements of the *Treasury* case study with their semantic representation, the aKMEOnt, in order to inspect the consistent representation of the instantiated aKMEOnt. This inspection is important to ensure that results are not affected by any contradiction that exists among the components of the ontology system (the aKMEOnt) and the business domain. The Treasury team inspected with researcher the consistent representation of the KMEs' elements using the aKMEOnt.

Table 4.11: Comparing KMEs Elements of the Treasury Case Study with their Semantic Representation in the aKMEOnt

aKMEOnt elements	KMEs of Treasury case study	aKMEOnt using Treasury (Protégé ontology editor)	Remarks
Tools (integrative)	5 tools were identified as integrative by Treasury case study	5 input instances of class 'Tool' were created and classified as integrative using data-type property and asserted to belong to the information technology KME	Consistent representation of tools in terms of number and semantics through the tool data-type property 'IsIntegrativeTechnology'
Business functions	6 business functions were identified by the Treasury case study	6 input instances of class 'Business function' were created and asserted to belong to the organisational structure KME	Consistent representation of business functions in terms of number and semantics
Positions	13 positions of Treasury case study were identified	13 input instances of the class 'Position' were created and asserted to organisational structure KME	Consistent representation of positions in terms of number and semantics
Customers (external)	7 customers were identified as external ones and are in relation to the Treasury case study	7 input instances of the class 'Customer' were created and asserted to belong to the knowledge context KME	Consistent representation of customers in terms of number and semantics through the customer data-type property 'IsExternal Customer'
Restrictions (external)	11 restrictions were identified as external ones and are related to the Treasury case study	11 input instances of class 'Restriction' were created and asserted to belong to the knowledge context KME	Consistent representation of restrictions in terms of number and semantics through the restriction data-type property 'IsExternal Restriction'
(E-Documents) (type: contracts)	2 documents were found to be contracts in the documents that are accessed in the Treasury case study	2 input instances of class 'E-document' were created and asserted to belong to business repository KME	Consistent representation of restrictions in terms of number and semantics through the restriction data-type property 'hasType'
Problem (type: external)	1 problem was mentioned as a solved problem according to culture values	1 instance of class 'Problem' was created and asserted to belong to the culture KME	Consistent representation of restrictions in terms of number and semantics through the restriction data-type property 'IsAdapted Problem'

Based on the verification of the Treasury KMEs, the following results are concluded and approved by the Treasury team:

(1) Inspecting the semantic representation of the aKMEOnt shows that the KMEs elements of the *Treasury* case study were correctly captured, where the instantiation of the aKMEOnt resulted in the same number and semantics of the KMEs elements of the Treasury.

(2) The aKMEOnt representation of the Treasury KMEs elements is structurally and logically consistent which means that the ontology considers the constructs of the ontology language and does not have contradicting information. Thus, no errors were generated after performing consistency checking using the protégé development editor (see Figure 4.30).

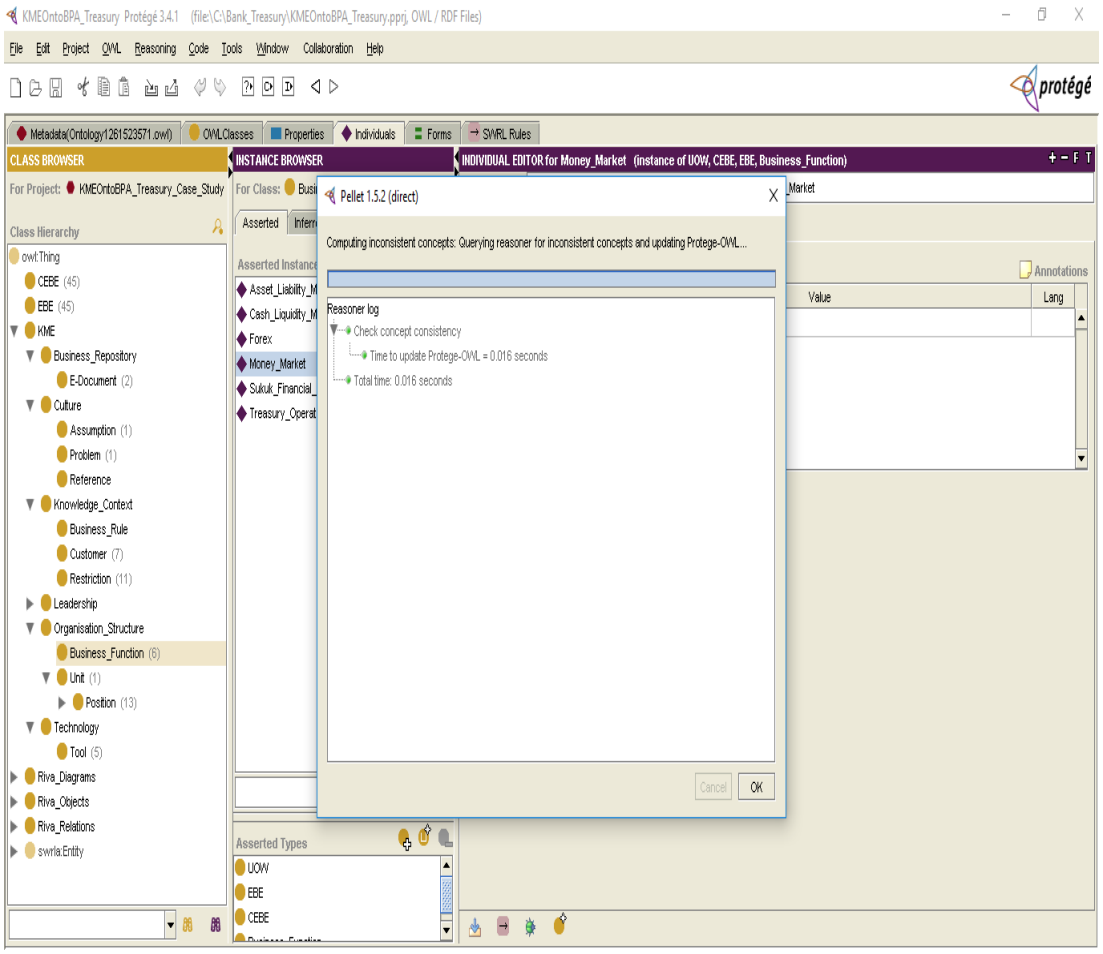


Figure 4.30: Checking Consistency of the aKMEOnt Elements in Treasury Case Study using Pellet 1.5.2 Reasoner in Protégé Tool

4.4.2 Validation of the Riva "as-is" BPA

The Riva "as-is" BPA of the *Treasury* case study is developed and validated with the support of the Treasury team. Informing the validation of the Riva "as-is" BPA requires checking the

validity of the Riva BPA elements including, EBEs, UOWs , generate/involve relationships, CPs, CMPs, first cut PA diagram relationship, applied heuristics and the 2nd cut PA diagram. Table 4.12 shows the elements that have been validated with the Treasury team.

Table 4.12: Validated Riva "as-is" BPA Elements of the Treasury Case Study

Riva BPA elements	Treasury Riva-based BPA	Remarks
EBEs	36 entities were identified as EBEs during a brainstorming meeting with the Treasury team	*Are these the right EBEs that characterise the Treasury business?* ***Yes***
UOWs	17 EBEs were selected and considered as UOWs	*Are these the right UOWs?* ***Yes***
Generate and involve Relationships	13 Generate and 3 involve relationships were identified between UOWs	*Are these the right relationships between UOWs?* ***Yes***
CPs	17 CPs corresponding to UOWs belong to 1st and 2nd cut diagrams	*Are these the right CPs that correspond to their UOWs?* ***Yes***
CMPs	17 CMPs corresponding to UOWs belong to the 1st cut diagram and 12 out of 17 belong to the 2nd cut diagram	*Are these the right CMPs that correspond to their UOWs?* ***Yes***
Request relationships in the 1st cut diagram	13 request relationships were identified in the 1st cut diagram	*Are these the right identified request relationships?* ***Yes***
Deliver relationships in the 1st cut diagram	13 deliver relationships were identified in the 1st cut diagram	*Are these the right identified deliver relationships?* ***Yes***
Start relationships in the 1st cut diagram	13 start relationships were identified in the 1st cut diagram	*Are these the right identified start relationships?* ***Yes***
Applying heuristics and 2nd cut diagram	3 CMPs were folded in CPs , 2 empty CMPs were and 6 delivery chain relationships were short-circuited into 3 delivery relationships resulting in the Riva 2nd cut diagram in Figure 4.25	*Are these the right folded, omitted and short-circuited CMPs in Riva 2nd Cut diagram?* ***Yes***

4.4.3 Validation of the KMEOntoBPA Framework

After verifying the aKMEOnt component, the KMEOntBPA is validated with the Treasury team by checking the validity of the CEBEs according to Riva BPA EBEs description and comparing the knowledge-based BPA to the Riva "as-is" BPA.

4.4.3.1 Validity of CEBEs

The Riva method EBEs characterise the business that the organisation is in; they are called essential because they are part of the essence of business (Ould, 2005). Accordingly, CEBEs were checked by the Treasury team to see whether they correspond to that description and no

missing is in these CEBEs. Ould (2005) has considered EBEs and their extracted UOWs central to constructing the Riva process architecture and while brainstorming has suggested some prompt questions to output candidates for EBEs. These prompt questions can support checking and assuring that these entities can be candidates for EBEs. Table 4.13 shows the validation of the extracted CEBEs and Ould corresponding question that can belong to.

Table 4.13: Validated Treasury CEBEs corresponding to Ould Suggested Questions

Candidate Essential Business Entities (CEBEs)	Riva Ould Suggested Question (Ould,2005)	Validated as EBEs
Cash & Liquidity Management ,Money Market, Forex, Sukuk & Financial Securities , Asset Liability Management , Treasury Operations Executive	What do we make? Or What do we care for?	Validated
Core Banking System-iMal Treasury, Bank Intranet, Thomson Reuters Data System, SWIFT System, Bloomberg Terminal, Money Market Trade Officer, Senior Money Market Trade Officer,Money Market Trade Supervisor, Treasury Manager, Forex Trade Officer,Senior Forex Trade Officer, Forex Trade Supervisor, Capital Market Trade Officer,Senior Capital Market Trade Officer,Capital Market Trade Supervisor, Treasury Operations Executive Officer, Senior Treasury Operations Executive Officer, Treasury Operations Executive Supervisor	What sort of things do we deal with day in, day out?	Validated
Currency Invoice of Sale, Commodity Murabaha Confirmation	Are there things that our customers have, or want, or do, that might be EBEs for us?	Validated
Jordan Central Bank Instructions, Central bank law, Trade Law, Investment Promotion Law, Law Regulating the Exchange, Public Debt Law, Banking Law, Sharia Restrictions, Income Tax Act, Electronic Transactions Act, Bank Policy	What things can we simply not get away from?	Validated
Bank Customer, Corporate, Local Bank, Foreign Bank, Central Bank, Retail, SMEs	Who are our external customers?	Validated

4.4.3.2 Comparing the Knowledge-based BPA to the Riva "as-is" BPA

The Riva "as-is" BPA (pre using KMEs) as mentioned provides a benchmark that is utilised to compare the Riva "as-is" BPA with knowledge-based BPA. This comparison is performed

by checking the difference between both business process architectures using Riva-based quantitative criteria such as the number of elements (EBEs, UOWs and CPs) and other qualitative criteria such as identification, support of robustness and learning capability and traceability. In addition to this comparison, the quality of the elements of the knowledge-based BPA is discussed in relation to their importance, defects, representativeness and reflection of real Treasury business. Table 4.14 compares the two BPAs using the *Treasury* case study. The number of both BPAs elements including (EBEs, UOWs, CPs, CMPs) were derived from the Riva "as-is" BPA (review Section 4.3.1) and the knowledge-based BPA (review Section 4.3.2). The Treasury team reviewed and agreed on the results that were concluded through this comparison.

Table 4.14: Comparing the Knowledge-Based BPA with the Riva "as-is" BPA using the Treasury Case Study

Criteria	Riva "as-is" BPA	Knowledge-based BPA	Remarks
No. of EBEs	36	45	EBEs number of knowledge-based BPA exceeds the Riva as-is BPA
No. of UOWs	17	9	Missing UOWs in the knowledge-based BPA are mainly in entities that can be characterised as services
No. of CPs in the Riva 2nd cut PA diagram	17	9	The missing UOWs reflects the number of corresponding CPs in Riva process architecture
No. of 2nd cut omitted/folded CMPs	5	4	The missing UOWs reflects the number of folded CMPs in the knowledge-based BPA
Is traceability of the sources of the BPA elements supported?	No	Yes	Semantic Riva "as-is" BPA tracks BPA elements but not the original source of each element
Identification (Is it a knowledge-based BPA?)	Brainstorming (not knowledge-based)	Treasury KMEs or resources (knowledge-based)	First step of CEBEs/EBEs creation
Support of Robustness and learning capability criteria	No	Yes	Responding to business changes and learning from environment

Comparing the two business process architectures using the *Treasury* case study reveals a difference in the extracted EBEs. This can be explained due to the identification criterion in

each approach. Identifying EBEs in the Riva "as-is" BPA depends on brainstorming using Ould (2005) suggested questions. Brainstorming EBEs was not an approach that used formal documents or information in the *Treasury* case study. It was also limited by time and the available space and was difficult to repeat. On the other hand, identifying EBEs using KMEs was more flexible and had fewer constraints than brainstorming. It was also more formal and structured by gathering and entering specific input data from documents in order to instantiate the KMEOntoBPA ontologies. Therefore, eliciting EBEs using KMEs resulted in a higher number of EBEs. However, the number of UOWs in the Riva "as-is" BPA is higher than the ones in the knowledge-based BPA. This shortcoming is mainly related to the absence of the Treasury service EBEs that characterise the *Treasury* case study and meet a business need for external or internal customers. These business services are *Letters of Credit, Bills for Collection, Money Transfers, Managing Accounts with the Correspondent Banks, Monitoring the Centres of Foreign Currencies, Cash Analysis, Short-term Sukuk Purchase Orders* and *Balance Sheet Risk Controls.* Other business services, *Currency Purchases /Sell Orders and Sukuk Purchase Order*, were substituted by E-documents UOWs that were found in the *Treasury* case study as alternatives that can characterise these business services. Thus, the absence of business service representation can be considered the main disadvantage of the KMEOntoBPA design. A fine-grained concept that represents services can deliver better and complete UOWs.

The KMEOntoBPA has a traceability feature to the sources of the BPA elements. This feature provides an explanation and understanding of these elements. It contributes to answering how BPA elements are created and who knows about these elements which support knowledge management practices and implementation in the *Treasury* case study.

Figure 4.31 shows the distribution of the EBEs according to the KMEs of the *Treasury* case study. The organisational structure KME provides the highest number of EBEs followed by the knowledge context KME. This distribution shows that organisational structure KME is the most critical KME in generating EBEs of the Treasury BPA. It provides around 42% of the EBEs and creates up to 6 UOWs out of 9, which will be also recognised with their corresponding CPs and CMPs.

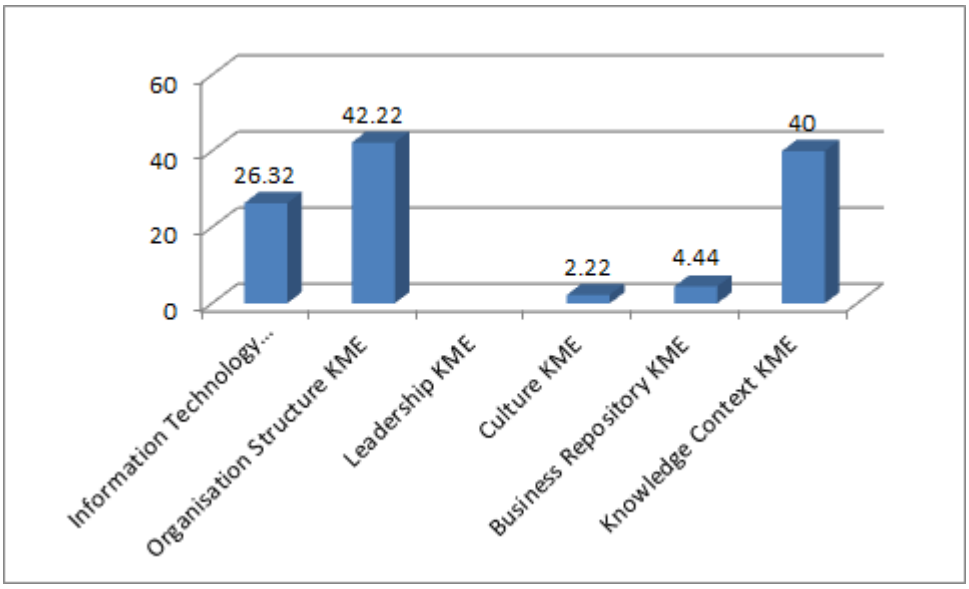


Figure 4.31: Distribution of EBEs Percentages according to the KMEs of Treasury Case Study

The knowledge context KME has the second highest number of EBEs. However, the business repository KME provides two UOWs while the knowledge context KME provides only one. This difference in the number of UOWs and their corresponding CPs and CMPs shows that business repository KME has more impact on the development of the BPA UOWs, 1st and 2nd cut PA diagrams than the knowledge context KME in the *Treasury* case study. Figure 4.32 shows the distribution of the UOWs and their corresponding CPs and CMPs according to the KMEs of the *Treasury* case study. Accordingly, it can be concluded that the organisational structure KME is the most critical KME in the development of Treasury BPA followed by business repository and knowledge context KMEs.

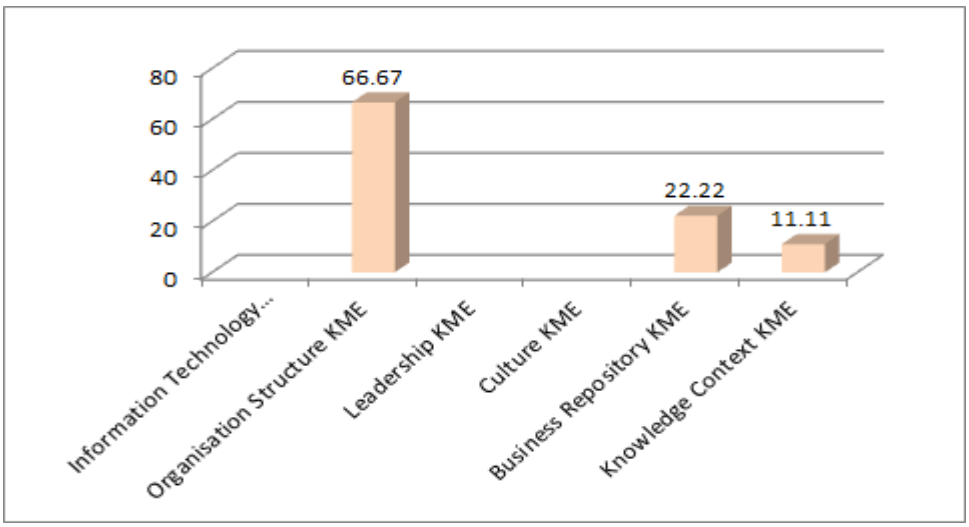


Figure 4.32: Distribution of UOWs, Corresponding CPs and CMPs Percentages According to the KMEs of Treasury Case Study

Reflecting on Table 4.14, this research presents a semantic knowledge-based identification for developing BPA, driven by KMEs in relation to business processes in the *Treasury* case study. Moreover, it provides robustness and learning capability for the Treasury BPA according to Treasury team who ensured the following:

- The new knowledge-based BPA can respond to changes in the Treasury department and environment.
- The knowledge-based BPA has learning capabilities through acquiring and providing different knowledge resources in Treasury business.
- The absence of services is impacting the responding to changes in the BPA and it affects its learning capabilities.

Thus, these criteria of robustness and learning capability add a new evolutionary dimension to this BPA (Prat et al., 2014) and enables it to be more dynamic and competitive. These criteria are not fulfilled by the Riva "as-is" BPA and its semantic approach. However, these criteria are affected by the shortcomings that have been revealed in the KMEOntoBPA design in relation to the business services representation which reduces the response to changes and learning experience.

Finally, the importance of the elements of the knowledge-based BPA for the *Treasury* case study stems from the abilities to adopt new resources and being representative to Treasury knowledge resources. The EBEs, UOWs and their corresponding CP and CMPs show main functionalities, positions, processes in Treasury business. However, these elements still have defects. They are not complete and they do not show all the real flow of business in the *Treasury* case study.

4.5 Feedback on the DSRM First Iteration

The feedback on this iteration depends on both the verification and validation of the KMEOntoBPA. The validation of the KMEOntoBPA shows that shortcomings are still found after comparing the knowledge-based BPA of the KMEOntoBPA with the Riva "as-is" BPA. These shortcomings involve the absence of representing services in the *Treasury* case study, which makes the EBEs, UOWs, CPs and CMPs elements less representative of the real business of the *Treasury* case study. In addition, it impacts the response to changes and the learning capabilities of the BPA. A summary of this feedback is found in Table 4.15.

Therefore, it is recommended that there be an iteration back to the design and development phase and consider services representation in the KMEOntoBPA framework. This new iteration should resolve this disadvantage and support an agile generation and

reconfiguration for all the BPA elements. It also continues testing the KMEOntoBPA on different bank functionality.

Table 4.15: Summary of the Feedback of the DSRM First Iteration

No.	Outcomes
1	Knowledge-based EBEs, UOWs, CPs and CMPs are not complete in relation to real Treasury business workflow
2	Absence of Treasury services which impact the whole BPA elements
3	Knowledge-based BPA does not well reflect the real Treasury business
4	Knowledge-based BPA is not complete in responding to changes and learning capabilities

4.6 Chapter Summary

This chapter is the first iteration of the DSRM. It involves addressing research questions RQ3 and RQ4. These research questions are fully or partly answered by the fulfilment of two objectives: (i) aligning the BPA method with the KMEs and (ii) undertaking a critical evaluation of the effectiveness of the use of KMEs in the development of BPA using the case study method. The two objectives are achieved by the utilisation of DSRM phases in order to design and develop, demonstrate and evaluate the KMEOntoBPA using the *Treasury* case study. The aKMEOnt component was developed and aligned with the srBPA ontology component in order to generate the KMEOntoBPA. The knowledge-based BPA diagrams are generated by the KMEOntoBPA demonstration. The Riva "as-is" BPA diagrams of the *Treasury* case study are also generated in this phase as a benchmark for the evaluation phase. Verification and validation tests are applied in the evaluation phase. The validation has revealed some disadvantages of the KMEOntoBPA in this iteration. These disadvantages include shortcomings in the EBEs, UOWs, CPs and CMP elements which impact the KMEOntoBPA responding to the real workflow of Treasury business and changes in environment. This is in addition to its learning capabilities. A DSRM second iteration is important to ensure the positive results of the first iteration and to support addressing the disadvantages after the modifications on the KMEOntoBPA design and demonstrating a new case study.

Chapter 5

DSRM Second Iteration: KMEOntoBPA Application to the Deposits Case Study

5.1 Introduction

In the previous chapter, the first iteration of the DSRM was completed using the *Treasury* case study. In this chapter, a new iteration aims to address the previous iteration shortcomings and continue evolving the KMEOntoBPA framework (review Figure 3.4 Chapter 3) using the *Deposits* case study. The second iteration of the DSRM is carried out with modifications implemented on the KMEOntoBPA design following the feedback of the DSRM first iteration. The *Deposits* case study will be used in this chapter in order to evaluate the KMEOntoBPA framework after the new modifications. The demonstration phase of the DSRM second iteration will include the development of the Riva "as-is" BPA and the instantiation of the KMEOntoBPA ontologies using the latter case study. Finally, the evaluation is performed by following the verification and validation approach discussed in Chapter 3, and assessing the dynamism and sustainable competitive advantage of the KMEOntoBPA.

5.2 DSRM Second Iteration - Design and Development of the KMEOntoBPA Framework

The evaluation of the DSRM first iteration revealed some shortcomings in the design of the KMEOntoBPA. Shortcomings are mainly related to the UOWs and their corresponding CPs, CMPs and their relationships, while comparing the KMEs driven BPA approach to the Riva "as-is" BPA. The Riva "as-is" BPA has revealed the absence of business services in the KMEs driven BPA. The design of KMEOntoBPA ontologies have been revisited in order to attend to these shortcomings.

In the aKMEOnt, the business behavioural concept/class replaces the business function concept/class (see Figure 5.1). The business function concept that was used in the first iteration design is only limited to the description of the upper-level function or work that the bank performs. This concept is adopted from the organisational structure ontology (Abramowicz et al., 2008). The business behavioural concept is a more comprehensive concept that can imply business functions and services and address the disadvantage of the previous KMEOntoBPA design in the first iteration of the DSRM. This concept does not only include concepts of business functions and services, but it extends to cover business processes, interactions and events according to the Open Group Standard ArchiMate (Iacob, et al., 2009). The implications of this modification will be explained in the demonstration and evaluation of the second iteration in Sections 5.3 and 5.4.

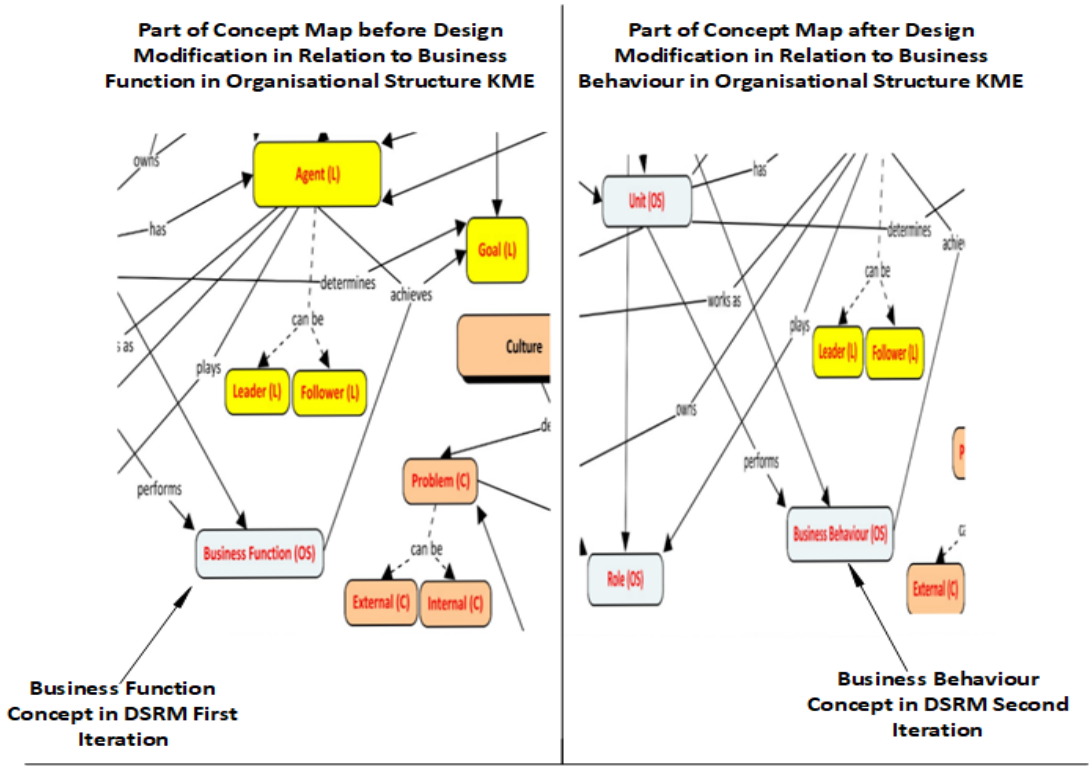


Figure 5.1: Changing Business Function to Business Behaviour in the Concept Map of the KMEs

The new modification requires some changes to the KMEOntoBPA ontologies. These changes involve (re)defining concepts, properties and SWRL rules in the KMEOntoBPA (see Table 5.1), in addition to 'Organisational Structure KME Instantiation' and 'CEBEs Identification' algorithms.

Table 5.1: Redefined SWRL Rules and Properties according to the Second Iteration

First iteration		**Second iteration**	
Concept	**Properties**	**Concept**	**Properties**
Unit	performsBusinessFunction of type Business_Function	Unit	performsBusinessBehaviour of type Business_Behaviour
Business Function	a. achievesGoal of type Goal	Business Behaviour	a. hasType of type: String b. achievesGoal of type Goal
SWRL Rules			
sRule_generate_CEBE_BusinessFunctions *Unit(?u) ∧ performsBusinessFunction(?u,?BF) → CEBE(?BF)*		**sRule_generate_CEBE_BusinessBehaviour** *Unit(?u) ∧ performsBusinessBehaviour(?u,?BB) → CEBE(?BB)*	

The new data type property 'hasType' of the business behaviour concept in the aKMEOnt will determine the behavioural types that are needed in this iteration in order to address the

feedback of the first iteration. Business functions which already exist in the previous iteration and business services are the behavioural types that are required.

Algorithms 'Organisational Structure KME Instantiation' and 'CEBEs Identification' have also been revisited to address the changes of the KMEOntoBPA ontologies (see Figure 5.2).

Algorithm Three: Organisational Structure KME Instantiation

Input: Organisational Structure = {Business Behaviour, Unit, Position, Role, Skills}. The set of Business Behaviour instances where Business Behaviour = {BB_0... BB_x}. The set of Unit instances where Unit = {U_0... U_y}. The set of Position instances where Position = {P_0... P_k}. The set of Role instances where Role = {R_0... R_z}. The set of Skills instances where Skills = {S_0... S_r}.
Output: The set of new Business Behaviours, nBusinessBehaviour = {$nBusinessBehaviour_0$, $nBusinessBehaviour_1$... $nBusinessBehaviour_j$}. The set of new Positions, nPosition = *{$nPosition_0$, $nPosition_1$... $nPositionj$}.*

```
Begin
Define the new Business Behaviour List (nBusinessBehaviour);
Define the new Position List (nPosition);
Create instances BBi of Business Behaviour, 0≤ i ≤x;
Create instances Ui of Unit, 0≤ i ≤y;
Create instances Pi of Position, 0≤ i ≤z;
Create instances Ci of Role, 0≤ i ≤k;
Create instances Si of Skills, 0≤ i ≤r;
For each instance Ui in Unit list
{
        For each instance BBi in Business Behaviour list
        {
            If (instance Ui performsBusinessBehaviour(BBi))
                        {
                            if (BBi hasType("Function") ) OR (BBi
                            hasType("Service") ) {
                            Set instance BBi as new instance nBusinessBehaviour v in
                            the new Business Behaviour set, where 0≤ v ≤j;
                            Set v++;                    }
                        }
        }
        For each instance Pi in Position list
        {
                            If (instance Ui hasPosition(Pi)) {
                            Set instance Pi as new instance nPositionv in the new Position set,
                            where 0≤ v ≤j;
                            Set v++;                    }
        }
}
END
```

Figure 5.2: Algorithm Three-Organisational Structure KME Instantiation after Design Changes of the KMEOntoBPA Framework

Algorithm 'CEBEs Identification' will be the same with changes to the parts related to the business function which is now redefined to business behaviour (see Figure 5.3).

Algorithm Seven: CEBEs Identification

Input: ……. The set of Business Behaviour instances, nBusinessBehaviour = {nBusinessBehaviour$_0$... nBusinessBehaviour$_j$}. .....
Output: The set of candidate essential business entities (CEBEs), *CEBE = {cebe$_0$, cebe$_1$... cebej}.*
Begin
Define the new candidate EBEs List (nCEBE);
……
.....
.....
For each nBusinessBehaviour$_i$ in nBusinessBehaviourList {
Set instance nBusinessBehaviour$_i$ as new instance cebe$_v$ in the CEBE set, where 0≤ v ≤j;
Set v++;
}
…….
…….
…….
END

Figure 5.3: Algorithm Seven - CEBEs Identification after Design Changes of the KMEOntoBPA Framework

5.3 DSRM Second Iteration - Demonstration of the KMEOntoBPA Framework

5.3.1 Building the Riva "as-is" BPA

In this section, the Riva "as-is" BPA is developed using the *Deposits* case study. The Deposits BPA EBEs, UOWs, CPs and CMPs are identified, in addition to the Riva BPA diagrams and dynamic relationships which are generated through the application of Riva method. The Riva "as-is" BPA of the *Deposits* case study is used as a benchmark in the evaluation phase. EBEs, UOWs, CPs, CMPs and their corresponding relationships which are used in the Riva "as-is" BPA and its semantic approach, are the main criteria for the KMEOntoBPA evaluation.

5.3.1.1 Riva "as-is" EBEs and UOWs

After a brainstorming session with the branch manager and two senior employees in the *Deposits* case study, CEBEs were extracted using Ould's (2005) suggested questions (see Appendix C). Following CEBEs extraction, EBEs and bracketed UOWs list was identified in Table 5.2 using Riva filters to output EBEs and UOWs**.** Riva filters to identify EBEs include testing by placing 'a' or 'the' in front of each entity, removing any designed entity which is not essential and removing entities that are simply roles and not of the

essence of the business. Excluded CEBEs using these filters are referred to in Appendix C. The UOWs are determined by inspecting the lifetime of each entity.

Table 5.2: The Deposits Essential Business Entities with Bracketed Units of Work

Automated Teller Machine -ATM	*Bank Manager*
Account	*Corporate*
(Account Form)	***(Deposit Services Request)***
(Accounts Executive)	***(Current Account)***
(Bank Statement)	***(Customer Information File – CIF)***
(Bills Payment)	***(Customer Verification)***
(Blacklisted People)	*Customer Relationship Officer*
Bank Policy	*Deposits*
(Cash and Teller Services Request)	***(E-Card)***
(Cash Deposit)	***(Fixed Account)***
(Cash Withdrawal)	*Joint Account*
Central Bank Regulations	***(Money transfer)***
Central Bank	*Retail*
Cheque	***(Safe Box Deposit)***
(Cheque Book Ordering)	***(Safe Box Form)***
(Cheque Cashing)	***(Salary Transfer)***
(Cheque Clearing)	***(Saving Account)***
(Cheque Deposit)	*SMEs*
(Currency Exchange)	*Local Bank*
Foreign Bank	*Teller*
Bank Branch	*Banking System*
(Bank Customer)	*Sharia Restrictions*
Central Bank Regulatory Requirements	*Cash*
Currency	*Internet Banking*

A discussion with the bank's branch team has resulted in an agreement to exclude the following EBEs from the UOWs list according to Riva UOWs filters:

(1) *Central Bank Regulations, Bank Policy, Sharia Restrictions and Central Bank Regulatory Requirements* are not UOWs as they are only rules or regulations for controlling bank processes and they do not have a lifetime that must be looked after.

(2) *Banking System and Automated Teller Machine –ATM* are only systems or technologies that are used to support the Deposits processes.

(3) *Account, Cheque, Deposits, Cash, Currency, Joint Accounts and Internet Banking* are EBEs that are only part of another EBE and they do not have a separate lifetime of their own.

(4) *Customer Relationship Officer, Bank Manager,Bank Branch and Teller* are only roles that play a part in Deposits processes.

(5) *Central Bank, Local Bank, Foreign Bank, Corporate Customers, Retail Customers* and *SMEs*. These EBEs as it was mentioned in Chapter 4, are equivalent to the *Bank Customer* EBE. This is a type of 'Synonyms' heterogeneity which can be resolved using ontologies.

By determining the UOWs, the relationship between these UOWs can be generated. 'Generate' (g) relationships are drawn after setting each UOW source and destination. A final UOWs diagram is presented after discussion with the bank's branch manager and senior employees. Figure 5.4 presents the UOW diagram of the *Deposits* case study and its dynamic relationships.

Figure 5.4: Riva BPA UOWs Diagram for the Deposits Case Study

5.3.1.2 Riva "as-is" 1st Cut PA Diagram

The Riva 1st cut diagram of the bank's Deposits is produced through the CPs, CMPs and their relationships. CPs and CMPs are generated by translating each UOW into CP, CMP and their relationships. Relationships are created by translating each 'generate' (g)

relationship into ‘request’ (r), ‘start’ (s) and ‘deliver’ (d) relationships (review Section 4.3.2.1). Accordingly, the 1st cut diagram of the Deposits is generated (see Figure 5.5).

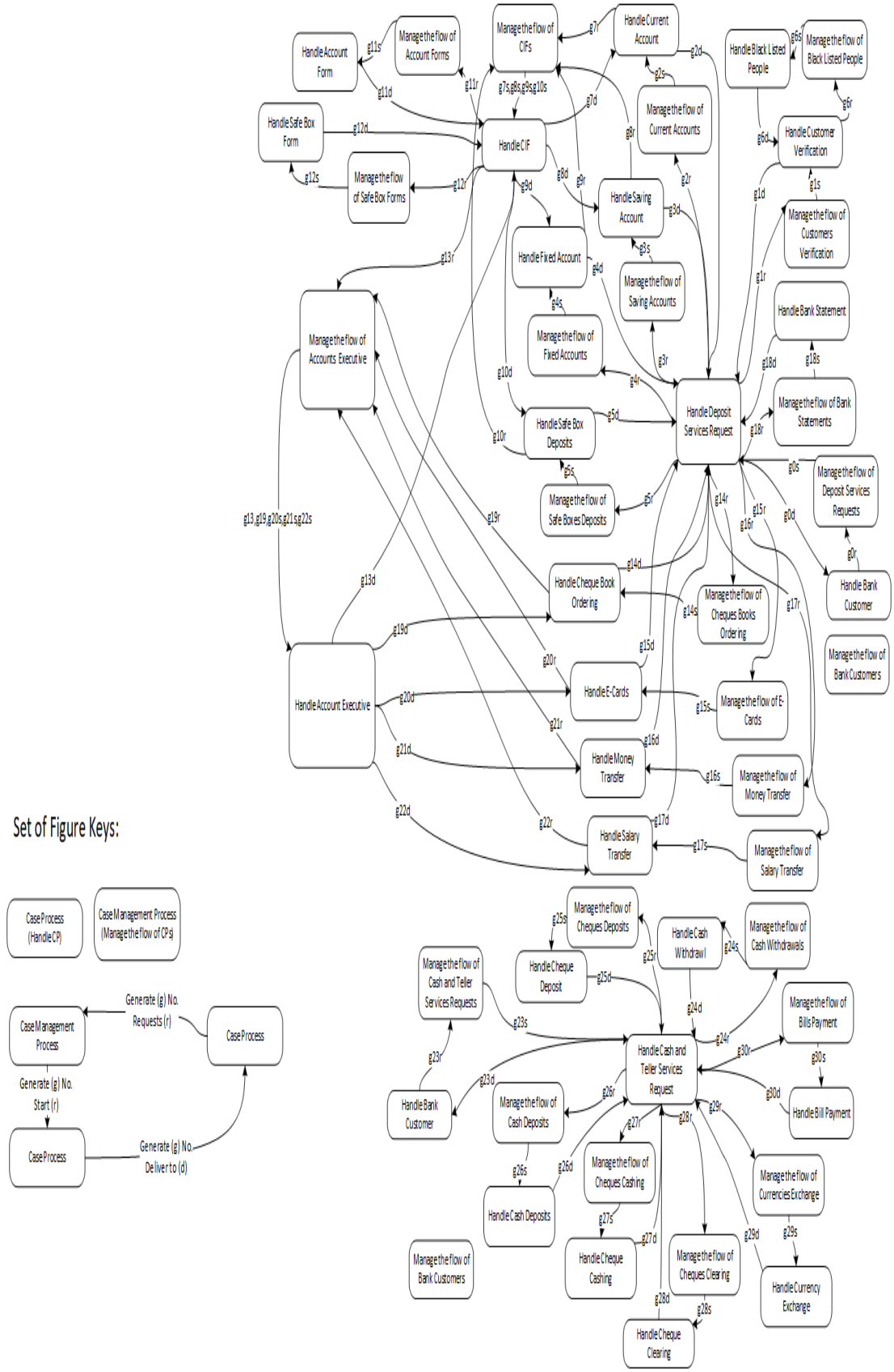


Figure 5.5: Riva BPA 1st Cut Diagram for the Deposits Case Study

5.3.1.3 Riva "as-is" 2nd Cut PA Diagram

After generating the Riva 1st cut PA (or process architecture) diagram, a set of heuristics is applied in order to create the 2nd cut PA diagram (review Section 2.2.2). Heuristics are expected to provide a more realistic reflection on the Deposits business of the bank branch.

The following heuristics are found appropriate to apply on the first cut diagram:

- Folding a task force CMP into the requesting CP. CMPs can be folded into the requesting CP. The CMPs are *Manage the flow of Safe Box Forms, Manage the flow of Account Forms , Manage the flow of Blacklisted People , Manage the flow of Current Accounts, Manage the flow of Saving Accounts, Manage the flow of Fixed Accounts, Manage the flow of Safe Boxes Deposits, Manage the flow of Cheque Books Ordering, Manage the flow of E-Cards, Manage the flow of Money Transfer, Manage the flow of Salary Transfer, Manage the flow of Bank Statements ,Manage the flow of Cash Withdrawals, Manage the flow of Cheque Deposits, Manage the flow of Cash Deposits, Manage the flow of Cheque Cashing, Manage the flow of Cheque Clearing, Manage the flow of Currencies Exchange* and *Manage the flow of Bills Payment*. These CMPs are considered part of the requesting CPs in the *Deposits* case study.
- Dealing with 1:1 'generates' relationships. There are no 1:1 'generates' relationships in the *Deposits* case study. All UOWs have more than one instance and generate instances of another UOW.
- Dealing with delivery interactions and delivery chains. Delivery chains which are related to *Handle Current Account* (g7d, g2d), *Handle Savings Account* (g8d, g3d), *Handle Fixed Account* (g9d, g4d), *Handle Safe Box Deposits* (g10d, g5d) can be short-circuited into (g7d, g8d, g9d, g10d) and delivered directly from *Handle CIF* to *Handle Deposit Services Request*.

  Delivery chains which are related to *Handle Cheque Book Ordering* (g19d, g14d), *Handle E-Cards* (g20d, g15d), *Handle Money Transfer* (g21d, g16d) and *Handle Salary Transfer* (g22d, g17d) can be short-circuited into (g19d, g20d, g21d, g22d) and delivered directly from *Handle Account Executive* to *Handle Deposit Services Request*. These short-circuits are the real delivery interaction in the *Deposits* case study.
- Dealing with collections. The *Deposits* case study has no UOWs that are considered as a collection of another UOW. Folded CMPs in the Deposits are considered task force that are folded in to the requesting CPs but not a component or a collection of another UOW.
- Dealing with empty CMPs in specific cases when only one instance of the CP exists and there is no CMP. No empty CMPs were found since there is no handle for only one instance or occurrence of the CP in the Deposits.

After applying the Riva heuristics, the Riva second cut PA diagram is presented (see Figure 5.6).

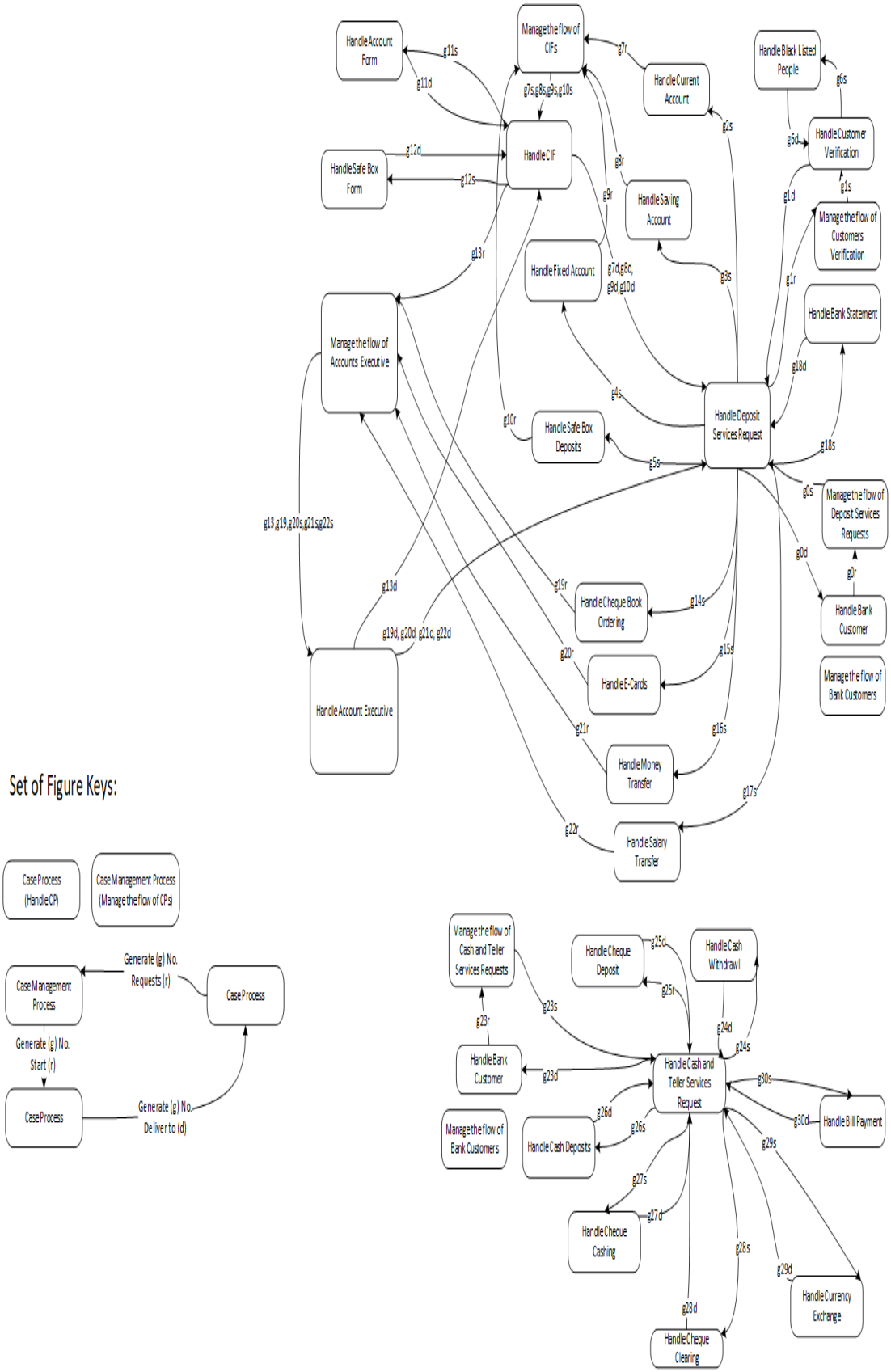


Figure 5.6: Riva BPA 2nd Cut Diagram for the Deposits Case Study

5.3.2 Building the Riva BPA using the KMEs

The BPA of the *Deposits* case study is developed in this stage using the KMEOntoBPA. The KMEOntoBPA ontologies and the introduced algorithms after modifications are used to generate the knowledge-based BPA. The necessary input data will be provided by the Deposits part of the bank's branch in order to instantiate the KMEOntoBPA ontologies.

5.3.2.1 Knowledge-based CEBEs

As it was mentioned, the second step in the Riva method is brainstorming CEBEs and finding the EBEs. This step is fundamental in building the other Riva steps. By instantiating the KMEOntoBPA ontologies using the Deposits of the bank's branch, the CEBEs can be extracted. Providing the CEBEs does not eliminate the role of business analysts in deciding whether a CEBE is an EBE or not. According to the algorithms one to seven and their corresponding SWRL rules, the output CEBEs are as follows:

Algorithms 'Information Technology KME Instantiation', 'Leadership KME Instantiation' and 'CEBEs Identification' provide the CEBEs of the IT KME in the *Deposits* case study that are used in the BPA development. The extracted CEBEs are in Table 5.3. The same SWRL in the first iteration is used to extract CEBEs.

Table 5.3: Identified CEBEs using the Deposits IT KME

CEBEs	Description
Core Banking System (iMAL Customer Service Management)	The bank system technology that is used in the bank.
Bank Intranet	The internal internet tool for sharing information inside the bank.
Internet Banking / Web Access	Allowing user to conduct financial transactions via the internet. The bank has r*etail and corporate online services (iMAL 2RetailPortal / 2CorporatePortal).*
ATM	Automated teller machine.
iMAL ATMBroker	Supports all transactions processed through ATM machines and enables interfacing between the bank ATM switch or national switch and iMAL core banking system.
Exchange Rate Board	System that provides the capability of linking the display rate board to core banking system.
Companies Control System	Retrieving data related to the corporate customers.

Algorithms 'Organisational Structure KME Instantiation' and 'CEBEs Identification' are called to derive the CEBEs from the organisational structure KME. The CEBEs of the *Deposits* case study which are extracted using these algorithms are in Table 5.4.

Table 5.4: Identified CEBEs using the Deposits Organisational Structure KME

CEBEs	Description
Customer Service Management	Deposits business functions.
Incoming, local and International Transfers	
Customer Identification and Verification	
Cheque Book Management	
CIF Management	
Card Management	
Management of Deposits	
Blacklist Management	
Cash and Teller Management	
Accounts Executive	
Amana (Safe Box)	Deposits business services.
Current Account	
Fixed Account	
Savings Account	
Joint Account	
Cheque Book Issuing	
E-Cards Issuing	
Cash Withdrawing	
Cheque Depositing	
Cash Depositing	
Cheque Cashing	
Cheque Clearing	
Currency Exchanging	
Money Transferring	
Salary Transferring	
Bank Statement Issuing	
Bills Paying	
Customer Relationship Officer	Bank front office position.
Senior Customer Relationship Officer	
Customer Relationship Supervisor	
Teller/Customer Service Representative	
Bank Manager	Bank Position and the highest rank in branch location.
Accounts Executive Officer	Deposits executive position.
Accounts Executive Supervisor	
Senior Accounts Executive Officer	
Head of Accounts Executive Department	

One of the SWRL rules that are used to derive CEBEs from the organisational structure KME is modified. The SWRL rules with the new modified one are as follows:

'sRule_generate_CEBE_BusinessBehavior' (New SWRL rule)

$Unit(?u) \wedge performsBusinessBehavior(?u,?BB) \rightarrow CEBE(?BB)$

'sRule_generate_CEBE_UnitPosition'

Unit(?U) ∧ hasPosition (?U,?P) → CEBE(?P)

Algorithms 'Knowledge Context KME Instantiation' and 'CEBEs Identification' are called to identify the CEBEs of the knowledge context KME in the Deposits of the bank's branch. Table 5.5 includes these CEBEs, which represent the external customers and restrictions of the *Deposits* case study. Same SWRL rules in the first iteration are used to derive CEBEs from the knowledge context KME.

Table 5.5: Identified CEBEs using the Deposits Knowledge Context KME

CEBEs	Description
Jordan Central Bank Instructions	Instructions issued by the central bank to all local banks
Central bank Law	Rules imposed by the central bank on all local banks
Deposits Guarantee Act	Laws in Jordan in relation to deposits business and department
Law Regulating the Exchange	
Public Debt Law	
Banking Law	
Income Tax Act	
Electronic Transactions Act	
Sharia Restrictions	It is the Shari 'a law from a combination of sources. First "Quran" then "Sunnah" (sayings of prophet Mohammad) and finally "Fatawas" (Scholars opinions and explanations in relation to Quran and Sunnah)
Instructions Unit Bounced Cheques No. 22-2005	Instructions related to cheques that cannot be processed
Bank Policy	Principles that rule the bank procedures
Bank Customer	Any individual or party that benefits from bank services
Corporate	Large organisations or companies
Local Bank	Other banks locally operated
Foreign Bank	External bank
Central Bank	National bank that provides financial services for the country and it is considered also as a customer for the local banks
Retail	Individual customers
SMEs	Small and medium-sized enterprises

Again in this iteration algorithm 'Business Repository KME Instantiation' apart from algorithms 'Knowledge Context KME Instantiation' and 'CEBEs Identification' are called in order to extract the contract documents that are signed by external customers. Calling these algorithms has shown two main forms that are represented in Table 5.6. These forms are considered contracts to the *Deposits* case study since they contain conditions and must be

signed by the customer. The SWRL rule that is used to extract CEBEs from the Deposits business repository KME remains the same as the first iteration.

Table 5.6: Identified CEBEs using the Deposits Business Repository KME

CEBEs	Description
Account Opening Form	A contract signed by customer to open any account
Amana-Safe Deposit Form	A contract that gives the customer a service of keeping his/her belongings in a safe place

Algorithms 'Culture KME Instantiation' and 'CEBEs Identification' are finally called in order to extract the CEBEs which are identified in Table 5.7. Same SWRL rule is used to derive CEBEs from Deposits culture KME.

Table 5.7: Identified CEBEs using the Deposits Culture KME

CEBEs	Description
Customer Identification and Verification Problems	Bank employee finds problems with identifying and verifying customers who need certain values rooted in bank such as customer satisfaction and trust
Customers Special Cases	There are certain special customers' cases in cash and deposits transactions such as customers' disabilities. These cases require handling through a set of values or assumptions
Wrong Money Transfers	Problems in transferring money to other banks or individuals might happen and need certain values such as trust and collaboration to handle

5.3.2.2 Knowledge-based EBEs and UOWs

The execution of algorithm 'EBEs and UOWs Identification' can identify the EBEs and UOWs that will instantiate the srBPA ontology component of the KMEOntoBPA (see Table 5.8). The identified CEBEs are checked with the bank's branch team in order to ensure that these CEBEs are EBEs that characterise the Deposits business. The non-bracketed EBEs are not considered UOWs for one of the following filters which are in previous sections:

(1) They are not considered UOWs and do not have a lifetime that must be looked after such as *Central Bank Law, Deposits Guarantee Act, Law Regulating the Exchange, Public Debt Law* and other mentioned laws and regulations. These are only regulations or restrictions that control processes and do not handle a case.

Table 5.8: The CEBEs/EBEs and Bracketed UOWs for the Deposits Case Study

Core Banking System (iMAL)	***(Bills Paying)***
Bank Intranet	***Customer Relationship Officer***
Internet Banking / Web Access	***Senior Customer Relationship Officer***
ATM	***Customer Relationship Supervisor***
iMAL ATMBroker	***Bank Manager***
Exchange Rate Board	***Teller/Customer Service Representative***
Companies Control System	***Accounts Executive Officer***
(Incoming, local and International Transfers)	***Accounts Executive Supervisor***
	Senior Accounts Executive Officer
(Customer Identification and Verification)	***Head of Accounts Executive Department***
	Jordan Central Bank Instructions
(Cheque Book Management)	***Central Bank Law***
(CIF Management)	***Deposits Guarantee Act***
(Card Management)	***Law Regulating the Exchange***
(Management of Deposits)	***Public Debt Law***
(Blacklist Management)	***Banking Law***
(Cash and Teller Management)	***Sharia Restrictions***
(Accounts Executive)	***Income Tax Act***
(Amana Safe Box)	***Electronic Transactions Act***
(Current Account)	***Instructions Unit Bounced Cheques No. 22-2005***
(Fixed Account)	***Bank Policy***
(Savings Account)	***(Bank Customer)***
(Cheque Book Issuing)	***Corporate***
(E-Card Issuing)	***Local Bank***
(Cash Withdrawing)	***Foreign Bank***
(Cheque Depositing)	***Central Bank***
(Cash Depositing)	***Retail***
(Cheque Cashing)	***SMEs***
(Cheque Clearing)	***(Account Opening Form)***
(Currency Exchanging)	***(Amana-Safe Box Form)***
(Money Transferring)	***Customer Identification and Verification Problems***
(Salary Transferring)	
Joint Account	***Customers Special Cases***
(Bank Statement Issuing)	***Wrong Money Transfers***
(Customer Service Management)	
IT, Organisational Structure, Knowledge Context, Business Repository, Culture KMEs CEBEs	

(2) They are clearly not UOWs. *ATM*, *iMAL ATMBroker*, *Core Banking System (iMAL)*, *Exchange Rate Board*, *Companies Control System and Bank Intranet* are systems or technologies that are used to support Deposits processes in the bank.

(3) They are only roles that play a part in Deposits processes such as *Accounts Executive Supervisor*, *Senior Accounts Executive Officer*, *Teller/Customer Service Representative*, *Customer Relationship Officer* and other remaining positions.

(4) They are only part of another EBEs and do not have a separate lifetime such as *Joint Account, Customer Identification and Verification Problems, Customer Special Cases , Wrong Money Transfers*.

(5) *Corporate, Local Bank, Foreign Bank, Central Bank, Retail* and *SMEs* are all Bank Customers as mentioned in demonstrating the Riva "as-is" BPA and the first iteration.

After the assertion of EBEs by Deposits team, EBEs instances are generated automatically by the following SWRL rule which was used in previous iteration:

$CEBE(?E) \wedge isExistedEBE(?E, false) \wedge isConsideredEBE(?E, true) \rightarrow EBE(?E)$

The assertion of UOWs by the Deposits team is followed by generating the UOWs instances using the SWRL rule below:

$EBE(?x) \wedge isConsideredUoW(?x, true) \rightarrow UOW(?x)$

The next step is to identify the relationships between UOWs using algorithm 'Derive Riva BPA'. This step also includes setting the source and destination of each UOW, in addition to the Deposits UOW diagram they belong to (review section 4.3.2.2). Figure 5.7 presents the knowledge-based UOWs diagram of the *Deposits* case study and their dynamic relationships.

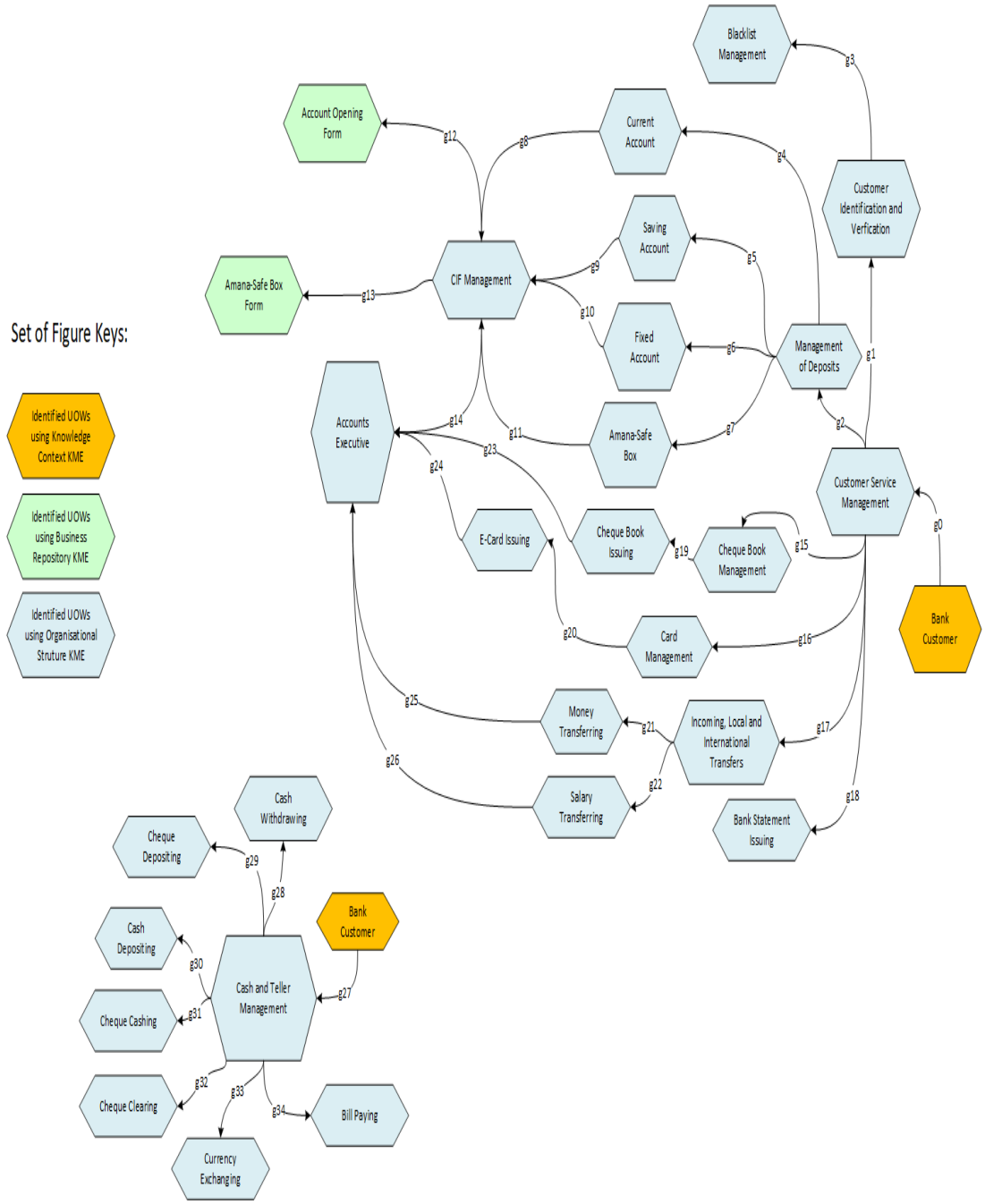


Figure 5.7: Knowledge-based Riva UOWs Diagram for the Deposits Case Study

5.3.2.3 Knowledge-based Riva 1st and 2nd Cut PA Diagrams

'Derive Riva BPA' algorithm generates the knowledge-based Riva 1st and 2nd cut PA diagrams after the generation of the knowledge-based Riva UOW diagram. The same steps which are used in developing the knowledge-based BPA of the Treasury are applied to the Deposits (see Section 4.3.2.3). The knowledge-based Riva 1st cut PA diagram of the *Deposits* case study is introduced through the CPs, CMPs and their relationships (see Figure 5.8). The CP and CMP instances as mentioned before are generated programmatically using the Jess Engine of the Protégé tool.

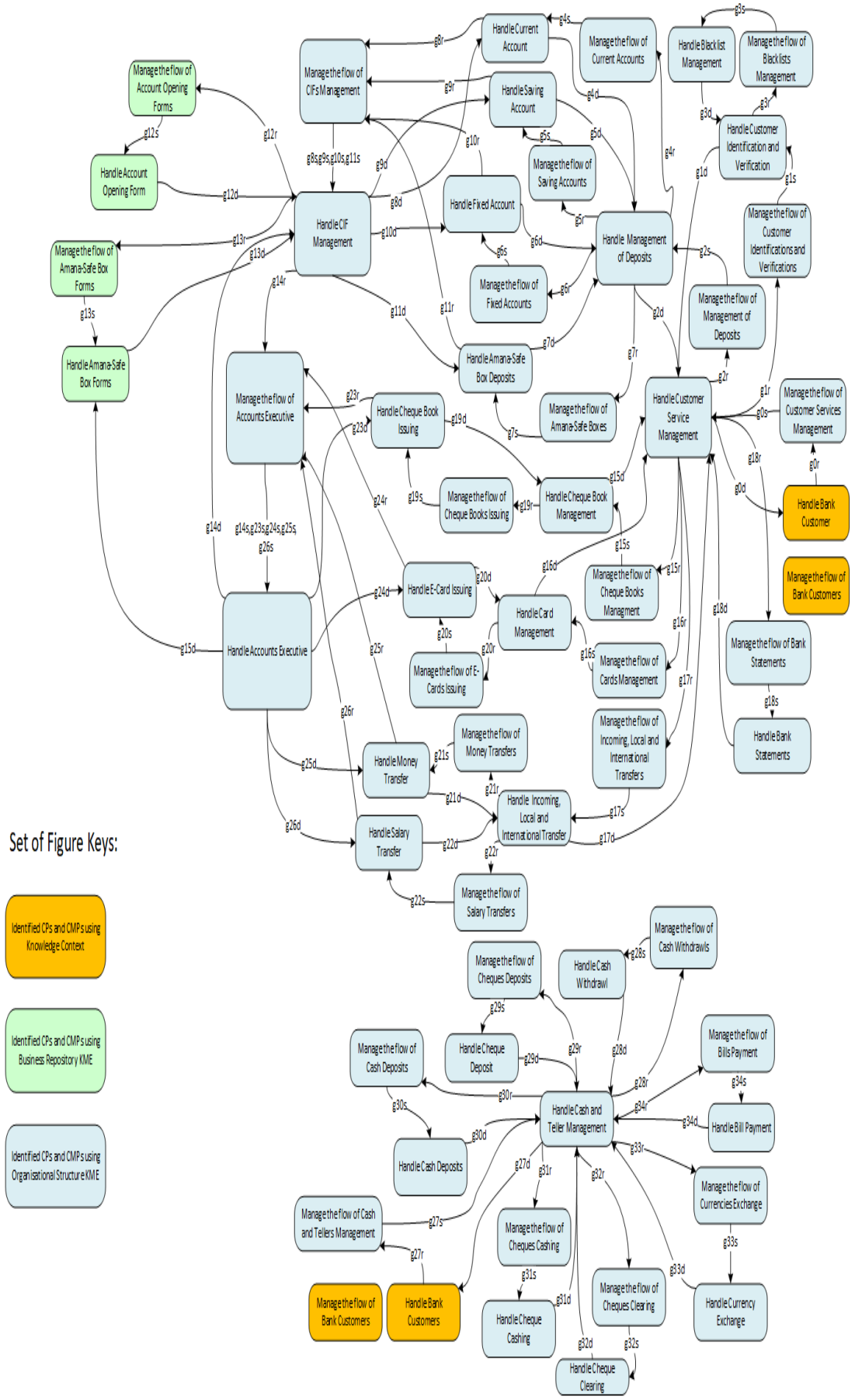


Figure 5.8: Knowledge-based Riva 1st Cut PA Diagram for the Deposits Case Study

After generating the Riva 1st cut PA diagram, a set of Riva heuristics are applied (review Section 2.2.2) and the knowledge-based 2nd cut PA diagram of the *Deposits* case study is generated (see Figure 5.9). Some of the CMPs and their relationships are removed and new relationships are added. The following CMPs and their relationships are removed from the knowledge-based 2nd cut PA diagram according to the following heuristics:

- Folding a task force CMP into the requesting CP. The following CMPs are removed: *Manage the flow of Blacklists Management, Manage the flow of Current Accounts, Manage the flow of Saving Accounts, Manage the flow of Fixed Accounts, Manage the flow of Amana-Safe Boxes, Manage the flow of Account Opening Forms, Manage the flow of Amana-Safe Box Forms, Manage the flow of Cheque Books Issuing, Manage the flow of Bank Statements, Manage the flow of E-Cards Issuing, Manage the flow of Money Transfers, Manage the flow of Salary Transfers, Manage the flow of Cash Withdrawals, Manage the flow of Cheque Deposits, Manage the flow of Cash Deposits, Manage the flow of Cheque Cashing, Manage the flow of Cheque Clearing, Manage the flow of Currencies Exchange* and *Manage the flow of Bill Payments*. All these CMPs are task force ones and can be folded into their requesting CPs.
- Dealing with 1:1 'generates' relationships. The knowledge-based BPA reveals that the UOWs have more than one instance similar to the Riva "as-is" BPA of the Deposits. Thus, there is no 1:1 'generates' relationships.
- Dealing with delivery interactions and delivery chains. Some delivery chains which are related to *Handle Cheque Book Issuing* and *Handle Cheque Book Management* (g23d, g19d,g15d), *Handle E-Cards Issuing* and *Handle Card Management* (g24d, g20d,g16d), *Handle Money Transfer and Handle Incoming, Local and International Transfer* (g25d, g21d,g17d) , *Handle Salary Transfer and Handle Incoming, Local and International Transfer* (g26d, g22d,g17d), can be short-circuited into (g23, g24d, g25d, g26d) and delivered directly from *Handle Account Executive* to *Handle Customer Service Management*.

  Delivery chain which is also related to *Handle Current Account* (g8d,g4d,g2d), *Handle Saving Account* (g9d, g5d,g2d), *Handle Fixed Account* (g10d,g6d,g2d), *Handle Amana-Safe Deposits* (g11d,g7d,g2d), can be short-circuited into (g8d,g9d,g10d,g11d) and delivered directly from *Handle Customer Information File (CIF)* to *Handle Customer Service Management*.
- Dealing with collections. The knowledge-based BPA of the *Deposits* case study doesnot have a UOW that is a collection of another UOW. Folded CMPs are considered tasks force rather than collection of another UOW, similar to the Riva "as-is" BPA.
- Dealing with empty CMPs. No empty CMPs were found since several instances of CP are managed by the each CMP in the *Deposits* case study.

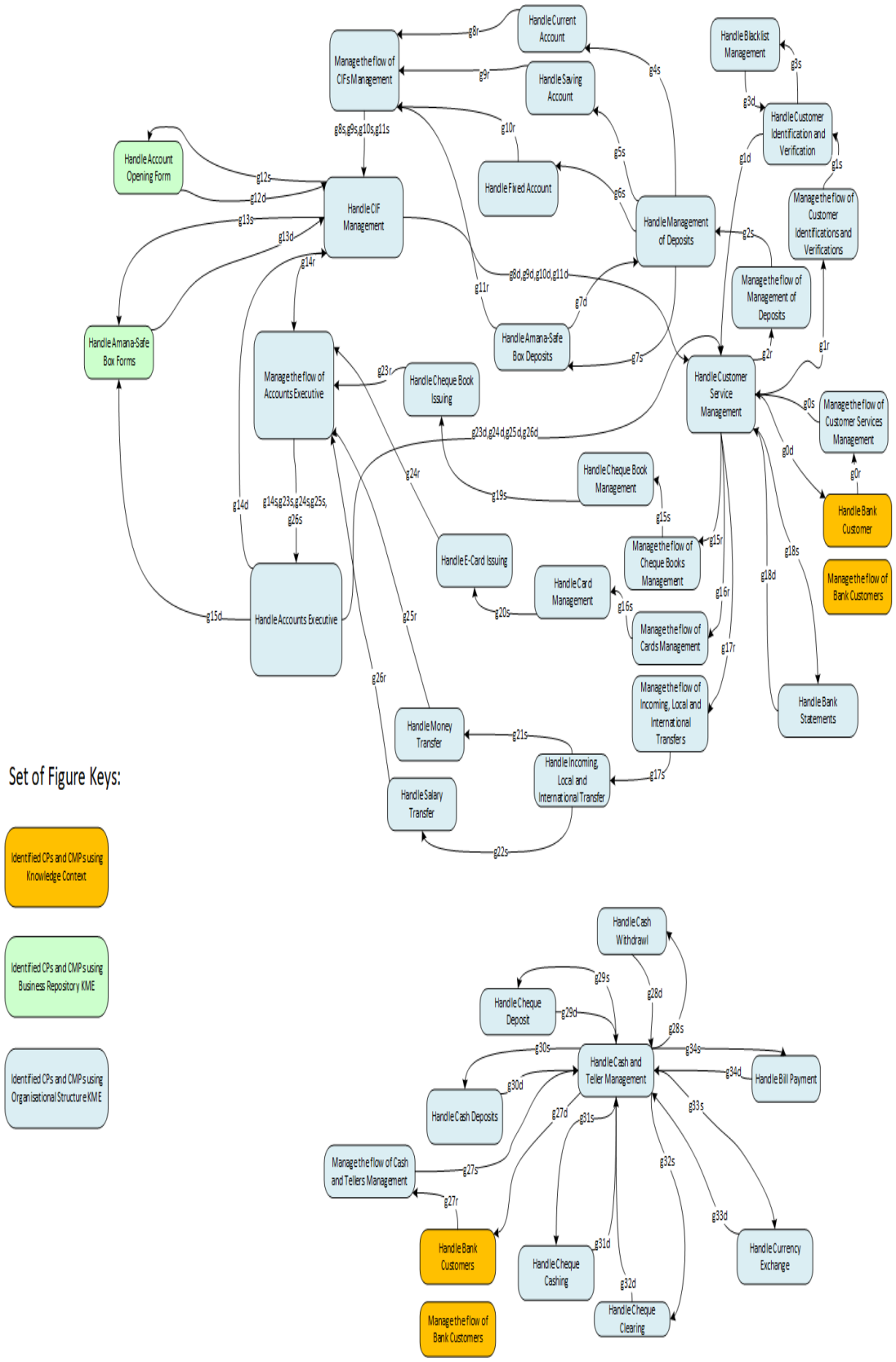


Figure 5.9: Knowledge-based Riva 2nd Cut PA Diagram for the Deposits Case Study

Deleting or folding CMPs in Riva heuristics are followed by: (1) redefining 'Start' (s) relationships by changing the source to CPs, these new 'Start' (s) relationships in the

previous 2nd cut PA diagram are g3s, g4s, g5s, g6s, g7s, g18s, g19s, g20s, g21s, g22s, g28s, g29s, g30s, g31s, g32s, g33s, g34s; and (2) determining the CMPs that belong to the Deposits knowledge-based 2nd cut PA diagram (see Section 4.3.2.3).

Dealing with empty CMPs by the removal of the CMPs is performed using the data type property 'isActive' as it was mentioned in Chapter 4.

5.4 DSRM Second Iteration - Evaluation of the KMEOntoBPA Framework

The KMEOntoBPA framework is further evaluated in the second iteration of the DSRM using the *Deposits* case study. Verification, validation, dynamism and sustainable competitive advantage have been carried during this iteration. Verification is related to verifying the aKMEOnt using the Deposits part of the bank's branch. The validation is concerned with the Riva "as-is" BPA and the KMEOntoBPA. Finally, dynamism and sustainable competitive advantage are evaluated using the same case study.

5.4.1 Verification of the aKMEOnt

In the first iteration, the aKMEOnt was verified using the primary concerns and sub-questions which informs the correctness of the aKMEOnt (see Section 4.4.1). The same concerns and sub-questions will be applied in order to verify the aKMEOnt using the Deposits case study. A comparison is conducted in Table 5.9 between the KMEs elements of the *Deposits* case study and its semantic representation, the aKMEOnt in order to ensure consistency of representation as the aKMEOnt is instantiated. This consistency assures that no contradiction among the components of the ontology and the Deposits case study domain will impact the results. The bank's branch manager and the associated team inspected with researcher the consistent representation of the KMEs' elements using the aKMEOnt.

Table 5.9: Comparing KMEs Elements of the Deposits Case Study with their Semantic Representation in the aKMEOnt

aKMEOnt elements	KMEs of Deposits case study	aKMEOnt using Deposits (Protégé ontology editor)	Remarks
Tools (integrative)	7 tools were identified as integrative by the *Deposits* case study of the bank's branch	7 input instances of class 'Tool' were created and classified as integrative using data-type property and asserted to belong to the information technology KME	Consistent representation of tools in terms of number and semantics through the tool data-type property 'IsIntegrative Technology'

Business Behaviour	27 business behaviour elements (10 business functions, 17 services) were identified by the *Deposits* case study	27 input instances of class 'Business Behaviour' were created and classified into functions and services using 'hasType' property and asserted to belong to the organisational structure KME	Consistent representation of business behaviour in terms of number and semantics
Positions	9 positions of Deposits case study were identified	9 input instances of the class 'Position' were created and asserted to organisational structure KME	Consistent representation of positions in terms of number and semantics
Customers (external)	7 customers were identified as external ones and are in relation to the *Deposits* case study	7 input instances of the class 'Customer' were created and asserted to belong to the knowledge context KME	Consistent representation of customers in terms of number and semantics through the customer data-type property 'IsExternal Customer'
Restrictions (external)	11 restrictions were identified as external ones and are related to the *Deposits* case study	11 input instances of class 'Restriction' were created and asserted to belong to the knowledge context KME	Consistent representation of restrictions in terms of number and semantics through the restriction data-type property 'IsExternal Restriction'
(E-Documents) (type: contracts)	2 documents were found to be contracts in the documents that are accessed in the *Deposits* case study	2 input instances of class 'E-document' were created and asserted to belong to business repository KME	Consistent representation of restrictions in terms of number and semantics through the restriction data-type property 'hasType'
Problem (type: external)	3 problems were mentioned as a solved problem related to culture values	3 instances of class 'Problem' were created and asserted to belong to the culture KME	Consistent representation of restrictions in terms of number and semantics through the restriction data-type property 'IsAdapted Problem'

The verification of the aKMEOnt using the *Deposits* case study has shown the following results which are identified by the bank's branch manager and the associated team:

(1) The KMEs elements of the *Deposits* case study were elicited correctly and the instantiation of the aKMEOnt indicates the same number and semantics of the Deposits KMEs elements.

(2) The Protégé development editor has shown no detected errors after conducting consistency checking of the instantiated aKMEOnt using the KMEs of the Deposits (see Figure 5.10). This means that the aKMEOnt developed using the Deposits KMEs is structurally and logically consistent and considers the constructs of the ontology language and have no contradiction.

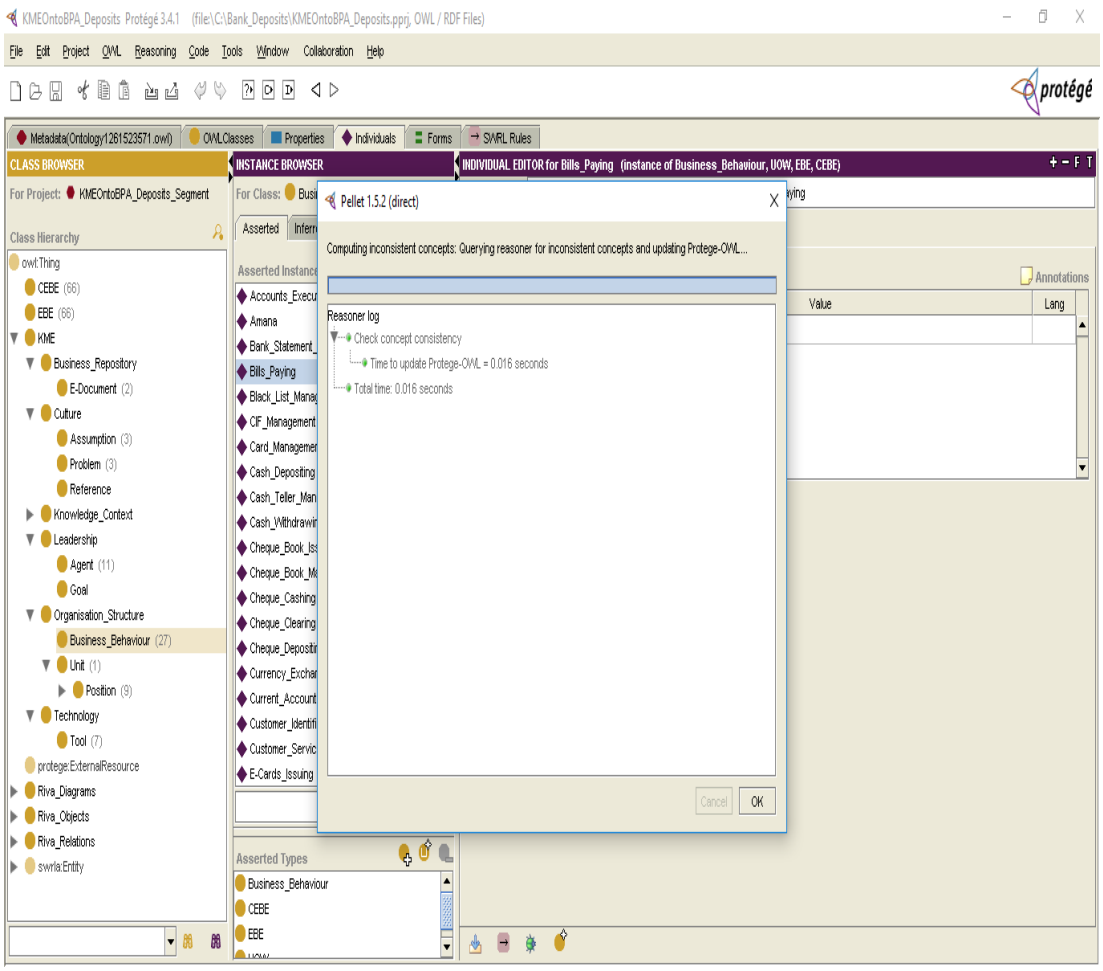


Figure 5.10: Checking Consistency of aKMEOnt Elements in Deposits Case Study using Pellet 1.5.2 Reasoner in Protégé Tool

5.4.2 Validation of the Riva "as-is" BPA

In this section, the Riva "as-is" BPA of the *Deposits* case study is validated with the bank's branch manager and the associated team. The validation was performed by a final validity check of the Riva BPA elements and their relationships in addition to the Riva "as-is" BPA diagrams and the applied heuristics to the 2nd cut PA diagram. Table 5.10 shows the Riva "as-is" BPA elements that have been validated with the bank's branch manager and the associated team of the *Deposits* case study.

Table 5.10: Validated Riva as-is BPA Elements of the Deposits Case Study

Riva BPA elements	Deposits Riva-based BPA	Remarks
EBEs	48 entities were identified as EBEs during a brainstorming meeting with the branch manager and senior employees of the *Deposits* case study	*Are these the right EBEs that characterise the Deposits business?* ***Yes***
UOWs	25 EBEs were selected and considered as UOWs	*Are these the right UOWs?* ***Yes***
Generate Relationships	31 Generate relationships were identified between UOWs	*Are these the right relationships between UOWs?* ***Yes***
CPs	25 CPs corresponding to UOWs belong to 1st and 2nd cut diagrams	*Are these the right CPs that correspond to their UOWs?* ***Yes***
CMPs	25 CMPs corresponding to UOWs belong to the 1st cut diagram and 6 out of 25 belong to the 2nd cut diagram	*Are these the right CMPs that correspond to their UOWs?* ***Yes***
Request relationships in the 1st cut diagram	31 request relationships were identified in the 1st cut diagram	*Are these the right identified request relationships?* ***Yes***
Deliver relationships in the 1st cut diagram	31 deliver relationships were identified in the 1st cut diagram	*Are these the right identified deliver relationships?* ***Yes***
Start relationships in the 1st cut diagram	31 start relationships were identified in the 1st cut diagram	*Are these the right identified start relationships?* ***Yes***
Applying heuristics and 2nd cut diagram	19 CMPs were folded in CPs and 16 delivery chain relationships were short-circuited into 8 delivery relationships resulting in the Riva 2nd cut diagram in Figure 5.6	*Are these the right folded and short-circuited CMPs in Riva 2nd Cut diagram?* ***Yes***

5.4.3 Validation of the KMEOntoBPA Framework

In this section, the KMEOntoBPA approach is validated with the bank's branch manager and the associated team. The validation includes checking the validity of the CEBEs according to Riva EBEs definition and comparing the Riva "as-is" BPA to the KMEOntoBPA output knowledge-based BPA.

5.4.3.1 Validity of CEBEs

Identification of the EBEs is the cornerstone of the Riva BPA method. Checking the validity of CEBEs according to their characterisation of the business of banking Deposits is essential

in the validation of the KMEOntoBPA approach. Thus, the CEBEs were checked and assured by the bank's branch manager and the Deposits team that they characterise the Deposits business in the bank with no missing in these CEBEs. The CEBEs are also supported by Ould's (2005) suggested questions that are recommended for use to brainstorm candidate EBEs. Table 5.11 shows these CEBEs and Ould's corresponding questions.

Table 5.11: Validated Deposits CEBEs corresponding to Ould's Suggested Questions

Candidate Essential Business Entities (CEBEs)	Riva Ould Suggested Question (Ould,2005)	Validated as EBEs
Incoming, local and International Transfers, Customer Identification and Verification, Cheque Book Management, Customer Service Management, CIF Management, Card Management, Management of Deposits, Blacklist Management, Cash and Teller Management, Accounts Executive, Customer	What do we make? Or What do we care for?	Validated
Amana -Safe Box, Current Account, Fixed Account, Savings Account, Cheque Book Issuing, E-Card Issuing, Cash Withdrawing, Cheque Depositing, Cash Depositing, Cheque Cashing, Cheque Clearing, Currency Exchanging, Money Transferring, Salary Transferring, Bank Statement Issuing, Bills Paying	What do we sell or provide? What product lines do we have? What services do we offer? What service lines do we have?	Validated
Core Banking System (iMAL), Bank Intranet, Internet Banking / Web Access, ATM, iMAL ATMBroker, Exchange Rate Board, Companies Control System, Customer Relationship Officer, Senior Customer Relationship Officer, Customer Relationship Supervisor, Bank Manager, Teller/Customer Service Representative, Accounts Executive Officer, Accounts Executive Supervisor, Senior Accounts Executive Officer, Head of Accounts Executive Department	What sort of things do we deal with day in and day out?	Validated
Identification and Verification Problems, Customers Special Cases, Wrong Money Transfers. Further Answers are also included in previous questions	Are there things that our customers have, or want, or do, that might be EBEs for us?	Validated
Jordan Central Bank Instructions, Central Bank Law, Deposits Guarantee Act, Law Regulating the Exchange, Public Debt Law, Banking Law, Sharia Restrictions, Income Tax Act, Electronic Transactions Act, Instructions Unit Bounced Checks No. 22-2005,*Bank Policy*	What things can we simply not get away from?	Validated
Bank Customer, Corporate, Local Bank, Foreign Bank, Central Bank, Retail, SMEs	Who are our external customers?	Validated

5.4.3.2 Comparing the Knowledge-based BPA to the Riva "as-is" BPA

In this section, the Riva "as-is" BPA is compared to the knowledge-based BPA in order to inform the effectiveness of the KMEOntoBPA. The same criteria used in the DSRM first iteration are also used to compare both BPAs. These criteria include quantitative and qualitative comparisons such as the number of elements (EBEs, UOWs, CPs), identification, support of robustness and learning capability and traceability. Table 5.12 shows this comparison using the *Deposits* case study. A discussion is also carried out regarding the elements of the knowledge-based BPA importance, defects, representativeness and reflecting to real business. The number of both BPAs elements including (EBEs, UOWs, CPs, CMPs) were derived from the Riva "as-is" BPA (review Section 5.3.1) and the knowledge-based BPA (review Section 5.3.2). The Deposits team checked and agreed on the findings that were concluded through this comparison.

Table 5.12: Comparing the Knowledge-based BPA with the Riva "as-is" BPA using the Deposits Case Study

Criteria	Riva "as-is" BPA	Knowledge-based BPA	Remarks
No. of EBEs	48	66	EBEs number of knowledge-based BPA exceeds the Riva "as-is" BPA
No. of UOWs	25	29	Missing UOWs in the Riva "as-is" BPA are mainly in entities that can be characterised as business functions
No. of CPs in the Riva 2nd cut PA diagram	25	29	The missing UOWs reflects the number of corresponding CPs in Riva "as-is" BPA
No. of 2nd cut folded CMPs	19	19	Same number of folded CMPs in both approaches
Is traceability of the sources of the BPA elements supported?	No	Yes	Semantic Riva "as-is" BPA tracks BPA elements but not the original source of each element
Identification (Is it a knowledge-based BPA?)	Brainstorming (not knowledge-based)	Deposits KMEs or resources (knowledge-based)	The approach of identifying the CEBEs/EBEs
Support of robustness and learning capability criteria	No	Yes	Responding to business changes and learning from environment

The comparison between the two approaches using the *Deposits* case study of the bank shows a difference in the number of EBEs. As it is mentioned in the previous iteration, this is due to the identification criterion in each approach. Using KMEOntoBPA framework provides more flexibility with fewer constraints compared to meeting domain experts in *Deposits* case study with limited time and available space. It also supports a formal and structured elicitation of knowledge through determining the necessary inputs in order to instantiate the KMEOntoBPA ontologies. The EBEs in the knowledge-based BPA reveal a more comprehensive representation of the entities that characterise the Deposits business. They also indicate problems that might appear during executing processes in relation to the Deposits in the bank through the culture KME. These problems are such as *Customers Special Cases* and *Wrong Money Transfers*.

The number of UOWs and corresponding CPs in the knowledge-based BPA diagrams are higher than the Riva "as-is" BPA. The knowledge-based BPA captured a few extra high-level functionalities that were missed in brainstorming but found in the documents specification of the banking system. The missing of these functionalities results in missing in understanding the workflow of the Deposits in the bank. The functionalities are *Management of Deposits, Cheque Book Management, Card Management and Incoming, local and International Transfers*. Accordingly, the corresponding CPs of the UOWs have shown a higher number in the knowledge-based BPA 2nd cut PA diagram and provide more reflection on the real business and workflow of the *Deposits* case study.

The two BPA approaches have a clear difference in CEBEs/EBEs but not in UOWs, CPs, CMPs and their relationships, which is expected since both approaches are Riva-based and define the key or core processes for the same case study. Core processes of a BPA are usually consistent for the same organisation. Furthermore, Ould (2005) claims that the Riva BPA is invariant for an organisation that remains in the same business. One of the changes in both approaches is found in the naming of the EBEs and their corresponding UOWs, CPs and CMPs. This difference can be justified by the formal identification that is provided by the KMEs, since the data inputs (or the instances) of the KMEOntoBPA ontologies were elicited from its formal document resources in relation to Deposits business in the bank. The use of ontologies supported organising and sharing the documented names of these EBEs and their corresponding BPA elements and representing them formally in the *Deposits* case study of the bank.

The KMEOntoBPA adds a traceability feature to the original sources of the BPA elements. This feature provides clarification and an understanding of how Deposits processes or elements are created. It also contributes to the answers of know-how and who-knows

questions in the *Deposits* case study. Figure 5.11 shows the distribution of the EBEs according to the KMEs in the *Deposits* case study.

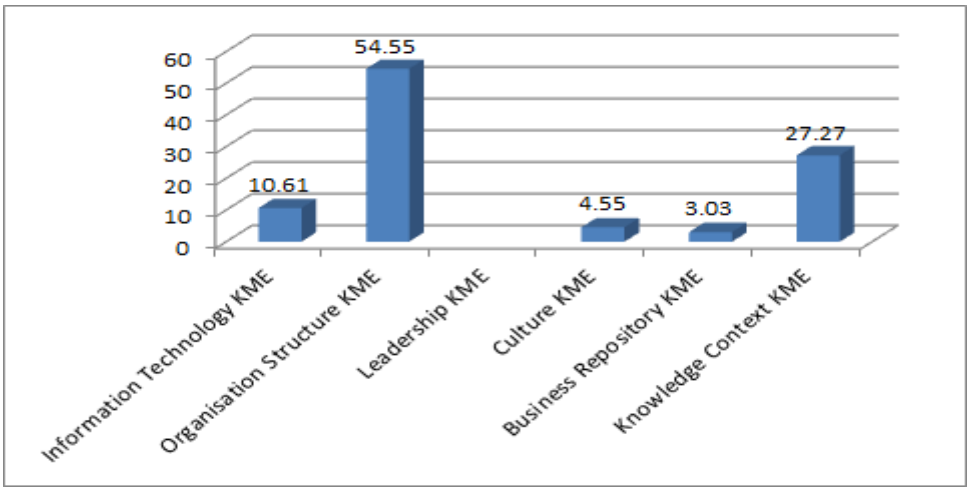


Figure 5.11: Distribution of EBEs Percentages according to the KMEs of the Deposits Case Study

The organisational structure KME has the highest percentage of EBEs followed by the knowledge context KME. This distribution clarifies that the organisational structure KME is the most critical KME in the *Deposits* case study. It generates more than 54% of the EBEs. The knowledge context is the second KME in providing the highest number of EBEs. Nevertheless, one UOW is only identified through this KME, while two UOWs are identified by the business repository KME. This difference shows that the business repository KME has more effect on the development of the BPA UOWs and their corresponding CPs and CMPs in the *Deposits* case study. Figure 5.12 shows the distribution of the UOWs and their corresponding CPs and CMPs according to the KMEs of the *Deposits* case study. Accordingly, it is concluded that the organisational structure KME is the most critical KME in the development of Deposits BPA followed by business repository and knowledge context KME.

Semantic KMEs identify different knowledge resources in order to drive the development of the BPA. This identification is significant in applying KM in the development of the BPA of the *Deposits* case study. It also supports robustness and learning capability for the BPA according to the Deposits team for the following:

(1) The knowledge-based BPA is flexible in showing potential responses to changes that occur in the Deposits business.
(2) The knowledge-based is able to learn and provide new knowledge resources in bank Deposits.

These criteria as mentioned in the first iteration, add an evolutionary dimension to BPA (Prat et al., 2014) and supports it dynamism and competitiveness.

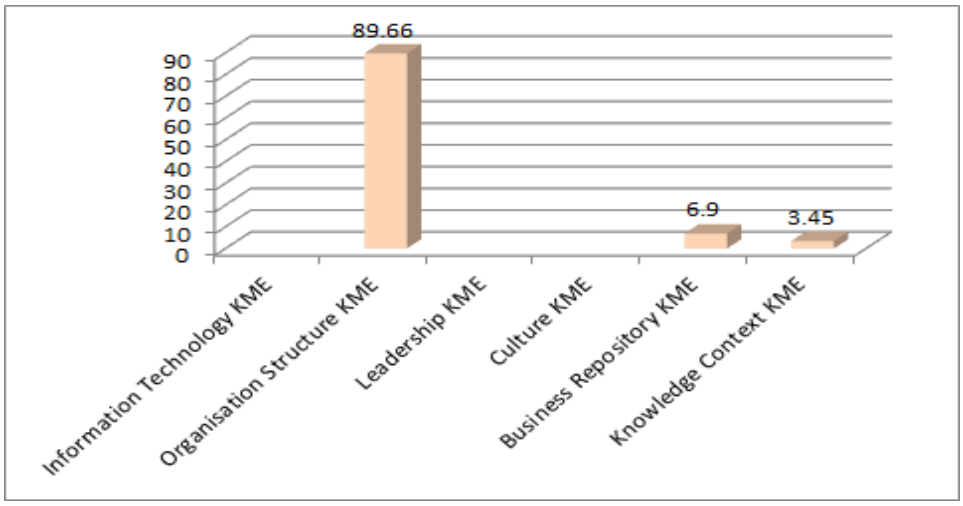


Figure 5.12: Distribution of UOWs, corresponding CPs and CMPs Percentages according to the KMEs of the Deposits Case Study

Finally, the elements of the knowledge-based BPA show how important they are in identifying the Deposits knowledge resources and reflecting the Deposits real business. The EBEs, UOWs and their corresponding CP and CMPs were considered representative to the Deposits branch manager and the associated team. Moreover, they implement the real business and complete missing functionalities that were found in the Riva "as-is" BPA. They also ensure the use of formal naming of knowledge resources in the bank.

5.4.4 A Dynamic and Competitive BPA

After the validation of the knowledge-based BPA and comparing it to the Riva "as-is" benchmark, the way is paved to assess the effectiveness of the KMEOntoBPA framework in developing an effective BPA that is dynamic and provides a sustainable competitive advantage (SCA) to the organisation. This objective requires a holistic or socio-technical approach that evaluates the KMEOntoBPA framework using the *Deposits* case study. The holistic approach will apply the following evaluation types: (1) inspecting the EBEs automation and the potential of agile generation and re-configuration of the knowledge-based BPA elements; and (2) conducting a mixed methods approach that evaluates the advantages of the KMEOntoBPA and its support to sources of sustainable competitive advantage on the organisational level.

5.4.4.1 Automation and BPA Agility

The automation defines the extent to which the steps of the KMEOntoBPA framework can be automated. Automation of the KMEOntoBPA is mainly related to the automation of the

aKMEOnt and its generated CEBEs which instantiate the srBPA ontology component of the KMEOntoBPA. Input knowledge resources of the *Deposits* case study are entered into the aKMEOnt as a prerequisite. Identification of the EBEs from these knowledge resources is automated through the algorithms and their corresponding SWRL rules using the Protégé tool in order to drive the development of the BPA. A business analyst intervention is still necessary as a manual activity to assert these EBEs and distinguish from the CEBEs.

Instantiation of the KMEOntoBPA ontologies using the Protégé ontology editor shows that generating Deposits CEBEs/EBEs can be automated and performed using the KMEOntoBPA ontologies. Moreover, the CEBEs construct the core elements of the Deposits knowledge-based BPA and are then classified into EBEs and then to UOWs. The KMEOntoBPA ontologies are also able to identify and adopt new knowledge resources that are configured by the KMEs such as roles and skills in organisation structure KME, business rules in knowledge context KME, and goals and agents in leadership KME. This feature achieves the potential of continuous and real-time generation or re-configuration of the Deposits knowledge-based BPA elements by extracting new CEBEs from new knowledge resources.

5.4.4.2 The KMEOntoBPA: Advantages and Supporting Sources of Sustainable Competitive Advantage

In this section, mixed or triangulation methods (quantitative and qualitative) are used to assess the sustainable competitive advantage (SCA) of instantiating the KMEOntoBPA framework using the *Deposits* case study. Nine questionnaires were hand-delivered to senior staff who are involved with Deposits transactions and the manager of the bank's branch. An interview was conducted with the branch manager in order to enrich and support the findings of these questionnaires (see interview responses Appendix D). The interview questions are about the driving factors for developing a dynamic and competitive BPA, the existing problems and the defects of business processes, the main expected benefits of using semantic KMEs in BPA development, the KMEOntoBPA support to the case study regarding: (1) accuracy and completeness in achieving the *Deposits* case study goals; (2) traceability and tracking changes in processes ; (3) adaptability to dynamic environment changes; (4) supporting technical capabilities, core competences and social capital (or sources of sustainable competitive advantage) (review Chapter 3 Section 3.5). Each question of the interview has been labelled to facilitate referencing or adding part of the interview responses within the questionnaires results discussion. The questionnaire's reliability has been tested using Cronbach's alpha test. Reliability is "the ability of the questionnaire to consistently measure the topic under study at different times and across different populations" (Hinton,

McMurray and Brownlow, 2014, p. 351). It evaluates the internal consistency of the instrument items. Cronbach's alpha is the most common method in testing reliability (Hinton, McMurray and Brownlow, 2014) .The value calculated using Cronbach's Alpha coefficient using 29 items is 0.914, which is very high and within an excellent range (see Appendix E).

The normal distribution analysis of the study's variables emphasises that variables are normally distributed. A graphical assessment of data plots (histograms) and numerical statistics are used for normality tests (see Appendix F). Shapiro-Wilk is a numerical test that is recommended for a sample size of less than 50 (Elliott and Woodward, 2007), which suits the sample size of the *Deposits* case study. The data distribution of the study variables is normal if the significance levels of the variables (p-values) using Shapiro-Wilk test are more than 0.05. According to the Shapiro-Wilk tests, the significance levels of the independent variable, the KMEOntoBPA advantages, and the dependent variable, KMEOntoBPA impact on the sources of SCA, are p-values=.405, .809, .772, .314 > 0.05, which means that the data distribution of the study's variables is normal.

The correlation between the independent variable, the KMEOntoBPA advantages, and the dependent variable, the impact of KMEOntoBPA on sources of SCA, will be examined using scatterplot graph and Pearson's correlation coefficient. This correlation indicates whether the simple linear regression (SLR) analysis can be conducted in order to predict the relationship between KMEOntoBPA advantages and the impact of KMEOntoBPA on sources of the SCA variables.

5.4.4.2.1 Advantages of the KMEOntoBPA

In the first section of the questionnaire in Appendix B.1, question one (Q1) examines twelve possible advantages that may result of implementing the KMEOntoBPA in the Deposits part of the bank's branch. The advantages have been analysed using frequency distribution analysis and descriptive statistics (see Appendix G.1). The key findings are the following:

I. More than half of the sample (n = 5) in the *Deposits* case study (55.0%) expressed their strongly agreement for each of the following advantages: (Q1.7) increasing the accuracy of service delivery and improving the financial control (mean = 4.56, significance = 1, rate = high), (Q1.3) reducing cycle time of processes and services (mean = 4.56, significance = 2, rate = high).

   These advantages are supported by interviewee responses who mentioned that using semantic KMEs such as business repository 'is a reference to a quick decision making'. It also 'reduces cost and communication, and facilitates quick processes

achievement'. Furthermore, the semantic knowledge context can 'reduce risks and costs on processes' (label 5/ Appendix D.1/ Branch Manager).

II. The entire sample agreed on five advantages of the KMEOntoBPA (see Table 5.13). These advantages overlap with the interviewee responses that the semantic implementation of the business repository and knowledge context KMEs 'reduce risks and costs on processes, achieve the required quality and support quick decision making'. Culture also 'solves problems' which decreases bottlenecks in the work system. Information technology 'supports identifying the tools that are used to perform processes' and 'develop the performance of the organisation and employees' (label 5/ Appendix D.1/ Branch Manager).

Table 5.13: Frequency Distribution Analysis and Descriptive Statistics of the KMEOntoBPA Advantages for the Deposits Case Study (with Agreement 100%)

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
2	Simplifying work procedures and decreasing bottlenecks in the work system **(significance = 3, mean = 4.44)**	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (55.6%)	4 (44.4%)
3	Reducing cycle time of processes and services **(significance = 2, mean = 4.56)**	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (44.4%)	5 (55.6%)
5	Automating processes and services **(significance = 4, mean = 4.44)**	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (55.6%)	4 (44.4%)
7	Increasing the accuracy of service delivery and improving the financial control **(significance = 1, mean = 4.56)**	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (44.4%)	5 (55.6%)
9	Making fast and rational decisions **(significance = 5, mean = 4.33)**	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (66.7%)	3 (33.3%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.						

III. No respondents expressed their strong disagreement with any of the advantages of the KMEOntoBPA, and only two respondents expressed their disagreement with two advantages.

5.4.4.2.2 KMEOntoBPA Support to Sources of Sustainable Competitive Advantage

In this section, the KMEOntoBPA impact on the sources of SCA using Frequency distribution analysis and descriptive statistics is evaluated (see Appendix H). 17 paragraphs of the questionnaire in section two Appendix B.1, are distributed through 3 questions to examine the impact of KMEOntoBPA on the three main sources of SCA; (Q2) technical capabilities (6 paragraphs), (Q3) core competences (5 paragraphs) and (Q4) social capital (6 paragraphs). The key results are the following:

1) **Technical Capabilities**:

- (Q2.1) Knowledge building and unifying of information resources is the most significant impact of the KMEOntoBPA on technical capabilities (mean = 4.33).
- More than (85%) of the sample has strongly agreed or agreed on two statements regarding KMEOntoBPA support for technical capabilities (see Table 5.14).

Table 5.14: Frequency Distribution Analysis and Descriptive Statistics of KMEOntoBPA Impacts on Technical Capabilities for the Deposits Case Study (with Agreement > 85%)

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
1	There is knowledge building and the unifying of information resources **(significance = 1, mean = 4.33)**	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (66.7%)	3 (33.3%)
2	Tracking and maintenance of the processes and services are regular **(significance = 4, mean = 4.00)**	0 (0.0%)	0 (0.0%)	1 (11.1%)	7 (77.8%)	1 (11.1%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.						

- No disagreement is recorded on any of the statements that represent the impact of KMEOntoBPA on technical capabilities.

2) **Core Competences**

- (Q3.5) The ability of the bank to cope with a changeable business environment is the most significant impact of the KMOntoBPA on core competences (mean = 4.33).
- More than 85% of the sample has strongly agreed or agreed on three statements regarding the KMEOntoBPA support for core competences (see Table 5.15).

Table 5.15: Frequency Distribution Analysis and Descriptive Statistics of KMEOntoBPA Impacts on Core Competences for the Deposits Case Study (with Agreement > 85%)

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
1	New knowledge and experiences are provided **(significance = 4, mean = 4.11)**	0 (0.0%)	0 (0.0%)	1 (11.1%)	6 (66,7%)	2 (22.2%)
2	There is an improvement of 'value-added' in the services and processes **(significance = 3, mean = 4.11)**	0 (0.0%)	0 (0.0%)	1 (11.1%)	6 (66.7%)	2 (22.2%)
4	Services and processes are provided competently **(significance = 2, mean = 4.22)**	0 (0.0%)	0 (0.0%)	1 (11.1%)	5 (55.6%)	3 (33.3%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.						

- No disagreement is responded on any of the statements that represent the impact of KMEOntoBPA on core competences.

3) **Social Capital**

- (Q4.6) The ability of the bank to access complementary sources of expertise is the most significant impact of the KMEOntoBPA on social capital (mean = 4.33).
- A consensus on two impacts as the most significant ones is concluded after a combination of the percentages on 'agree' and 'strongly agree' (see Table 5.16).

Table 5.16: Frequency Distribution Analysis and Descriptive Statistics of KMEOntoBPA Impacts on Social Capital for the Deposits Case Study (with Agreement 100%)

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
4	Knowledge is exchanged across the bank **(significance = 2, mean = 4.22)**	0 (0.0%)	0 (0.0%)	0 (0.0%)	7 (77.8%)	2 (22.2%)
6	The bank is able to access complementary sources of expertise **(significance = 1, mean = 4.33)**	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (66.7%)	3 (33.3%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.						

- No disagreement is provided as a response on any of the impact of KMEOntoBPA on social capital.

'Dynamic business environment' and 'Changing the organisation environment such as knowledge building, exploitation of resources and competences' have 'high value' as the

main driving factors behind the development of a dynamic and competitive BPA (label 1/ Appendix D.1). Therefore, it is reasonable to conclude that the most significant impact of the KMEOntoBPA includes 'knowledge building and unifying of information resources' or 'bank ability to cope with changeable business environment'. Moreover, the KMEOntoBPA 'adapt dynamic changes to environment', 'track changes and add traceability feature to processes' (label 6/ Appendix D.1). Excluding disagreement by the respondents in the questionnaires is compatible with the interviewee responses who confirm the role of KMEOntoBPA in supporting the sources of SCA: technical capabilities, core competences and social capital (label 6/ Appendix D.1).

5.4.4.2.3 Correlation between Advantages and Impact on Sources of Sustainable Competitive Advantage

Regression analysis predicts the response of a dependent variable on the basis of knowledge about an independent variable. However, producing this analysis requires testing the degree of relationship between these two variables by identifying whether there is a correlation. The correlation between the independent variable, the KMEOntoBPA advantages, and the dependent variable, KMEOntoBPA impact on the sources of SCA can be examined using the scatterplot graph and Pearson's correlation coefficient. The regression line of the scatterplot graph indicates the relationship between the dependent and independent variables (see Figure 5.13).

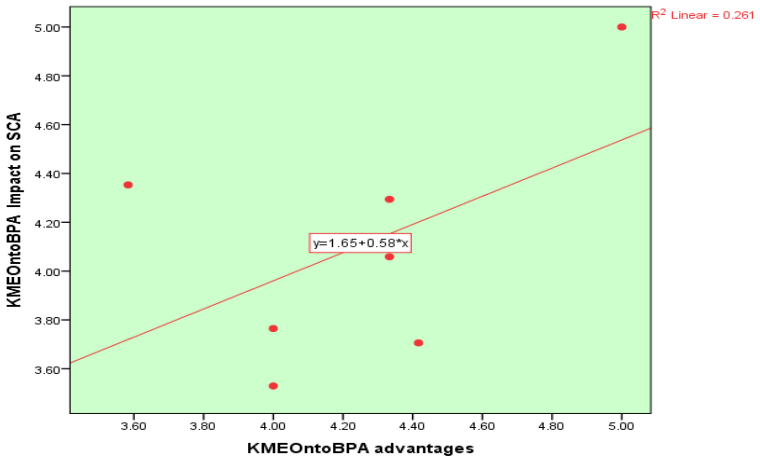


Figure 5.13: The Scatterplot Graph for Correlation Analysis

However, Pearson's correlation p-value value (.160) in Table 5.17 shows no significant positive relationship between the KMEOntoBPA advantages and the KMEOntoBPA impact on the sources of the SCA ($r = .511$, $p < .005$). Therefore, the null hypothesis is accepted, where H_0 indicates that there is no correlation between the KMEOntoBPA advantages and the KMEOntoBPA impact on sources of competitive advantage. Accordingly, there is no

need to conduct the simple linear regression analysis, if there is no statistically significant relationship between both variables.

Table 5.17: Pearson's Correlations - The Deposits Case Study

		KMEOntoBPA Advantages	KMEOntoBPA Impact on SCA
KMEOntoBPA Advantages	Pearson Correlation	1	.511
	Sig. (2-tailed)		.160
	N	9	9
KMEOntoBPA Impact on SCA	Pearson Correlation	.511	1
	Sig. (2-tailed)	.160	
	N	9	9

5.5 Feedback on the DSRM Second Iteration

The evaluation of the KMEOntoBPA shows that the design of the KMEOntoBPA framework is correct, complete and valid regarding verification and validation. These were both tested in relation to the *Deposits* case study. The validation shows that the knowledge-based BPA is more representative compared to the Riva "as-is" BPA after re-visiting the feedback of the first iteration of the DSRM and applying changes to the aKMEOnt. It also shows that the organisational structure KME has the highest contribution in generating CEBEs, EBEs and UOWs. In addition, the generated CEBEs, EBEs, UOWs and other Riva BPA elements using the KMEOntoBPA are more formal and reflective of real Deposits business compared to the Riva "as-is" BPA. Finally, this framework adds learning capabilities and robustness to the BPA which enables the BPA to be flexible in adopting changes and learning from the surrounding environment.

The objective achievement of the KMEOntoBPA was evaluated by dynamism and sources of SCA (or sustainable competitive advantage) which were also demonstrated and evaluated using the *Deposits* case study. The KMEOntoBPA has shown dynamism by automating the generation of CEBEs using different algorithms and their corresponding SWRL rules. It also re-configures BPA elements by providing up-to-date naming or elimination of EBEs which can be presented with different names after SWRL rules execution (For example: *Invoice Paying* instead of *Bills Paying*) or removed at all from the KMEOntoBPA. The evaluation of the KMEOntoBPA has also provided several advantages such as increasing the accuracy of service delivery, improving the financial control and reducing the cycle time of processes and services. Moreover, the KMEOntoBPA provides support to the sources of SCA and no disagreements were recorded regarding any of the impacts of KMEOntoBPA on technical capabilities, core competences and social capital. However, there was no significant positive relationship between the KMEOntoBPA advantages and the KMEOntoBPA impact on the

sources of SCA. This can be justified by the sample size of the Deposits bank's branch. A summary of this feedback follows in Table 5.18.

Table 5.18: Summary of the Feedback of the DSRM Second Iteration using the Deposits Case Study

No.	Outcomes
1	The knowledge-based EBEs, UOWs, CPs and CMPs are more representative, formal and reflective to real Deposits business compared to Riva "as-is" BPA
2	The KMEOntoBPA adds robustness and learning capabilities to the BPA
3	The KMEOntoBPA shows dynamism and automates the generation of CEBEs. It is also agile in adapting changes and reflecting on different BPA elements
4	The KMEOntoBPA has informed several advantages and support sources of SCA
5	There is no positive relationship detected between the KMEOntoBPA advantages and the KMEOntoBPA impact on the sources of SCA
6	The KMEOntBPA with new modifications has revealed positive feedback after demonstrating and evaluating using the Deposits case study

After the previous feedback, the KMEOntoBPA with new modifications has proved that it can have positive results using the *Deposits* case study of the bank. Nevertheless, the KMEOntoBPA with new modifications requires to be evaluated with the new business functionalities of the bank in order to ensure that these modifications address the role of the KMEs in BPA development and inform the aim of the research. In addition, the KMEs contribution in the generation of the different BPA elements needs to be inspected using different case studies in order to assert which KME is the most critical.

Thus, a new iteration with the same KMEOntoBPA design of the second iteration can be conducted using the *Financing* case study of the bank. This iteration will complete the core functionalities of the bank and form its whole BPA. It will also provide the research with a more consistent result regarding the design and the development of the KMEOntoBPA, in addition to a larger case study and participants.

5.6 Chapter Summary

This chapter presents the second iteration of the DSRM, which is related to the research questions RQ3 and RQ4. The objectives that fully or partly fulfil these research questions are addressed by applying the DSRM phases to the KMEOntoBPA using the *Deposits* case study. The design and development phase has a modification to the business function concept and its corresponding algorithms, SWRL rules and properties. The business behavioural concept is used instead in order to resolve the shortcomings that are found in the first iteration. These shortcomings are mainly related to the missing EBEs, UOWs and their corresponding BPA elements that represent the services in the *Treasury* case study. The business behavioural concept is more comprehensive and results in business functions and

services which appeared to meet the disadvantages of the KMEOntoBPA design in the first iteration. After the new modifications, the KMEOntoBPA is demonstrated and the knowledge-based BPA is generated after the instantiation of the KMEOntoBPA using the *Deposits* case study. The Riva "as-is" BPA of the *Deposits* case study is also developed as a benchmark in order to evaluate the knowledge-based BPA. The demonstration phase is followed by accomplishing different evaluation types which include verification, validation, dynamism and support to sources of sustainable competitive advantage. Accordingly, feedback on the DSRM second iteration is presented. The feedback of the second iteration shows that the knowledge-based BPA elements are more representative compared to the Riva "as-is" BPA and reflects the real workflow of the Deposits business. It also shows that the knowledge-based BPA is dynamic and supports the adaption of changes in the Deposits business environment with robustness and learning capabilities. Furthermore, it has several advantages and supports the sources of SCA including technical capabilities, core competences and social capital. However, the impacts of KMEOntoBPA with new modifications require a new evaluation of the KMEOntoBPA using a different bank functionality in order to ensure these impacts and inspect the KMEs using a different case study. The overall BPA of the bank then needs to be completed. Thus a recommendation to finalise the research with a third iteration is concluded.

Chapter 6

DSRM Third Iteration: KMOntoBPA Application to the Financing Case Study

6.1 Introduction

This chapter completes the iterations of the DSRM and hence provides a development of comprehensive knowledge-based BPA to the bank with a final evaluation for the KMEOntoBPA framework (review Figure 3.4 Chapter 3). The KMEOntoBPA is demonstrated and evaluated using the *Financing* case study. The Riva "as-is" BPA of the *Financing* case study is also developed and validated as a benchmark and is compared with the knowledge-based BPA. Different evaluation types are also performed including verification and validation, dynamism and the sustainable competitive advantage of the KMEOntoBPA. Finally, feedback of this iteration concludes the chapter.

6.2 DSRM Third Iteration - Demonstration of the KMEOntoBPA Framework

6.2.1 Building the Riva "as-is" BPA

In this part, the Riva "as-is" BPA is generated using the *Financing* case study. The CEBEs, EBEs, UOWs, CPs and CMPs are generated through the Riva steps, in addition to the Riva BPA diagrams. The Riva "as-is" BPA will be used to evaluate the knowledge-based BPA of this iteration.

6.2.1.1 Riva "as-is" EBEs and UOWs

After meetings and discussions with the Financing team which includes the credit and trade managers as well as two senior employees of the Financing in the bank headquarters, the following EBEs and bracketed UOWs in Table 6.1 are extracted after applying Riva suggested questions and filters to identify EBEs and UOWs (see Appendix C). EBEs are tested using 'a' or 'the' in front of each one and designed entities or roles that are not of the essence of the business are removed. The UOWs that have a lifetime are also determined and non-bracketed EBEs are excluded according to the Riva UOWs filters.

The Riva UOWs filters were checked with the Financing team and resulted in the exclusion of the following EBEs from the UOWs list as follows:

(1) *Central Bank Regulations, Bank Policy , Sharia Restrictions and Central Bank Regulatory Requirements* are not UOWs since they are regulations and rules and do not have a lifetime that must be looked after.
(2) *Financing Services Diversification and Banking System* are considered not UOWs. *Banking System* is used to control processes and *Financing Services Diversification* is clearly not UOW.

(3) *Financing Service, Financing Report and Internet Banking* are EBEs that are only part of another EBEs and do not have a separate lifetime of their own.

(4) *Bank Branch, Bank Manager, Financing Manager, Financing Supervisor, Customer Relationship Officer* are only roles that play a part in the Financing processes.

(5) *Central Bank, Local Bank, Foreign Bank, Corporate, Retail, SMEs* are considered synonyms to the *Bank Customer* EBE since they all define a bank customer.

Table 6.1: The Financing Essential Business Entities, with Bracketed Units of Work

Bank Branch	***(Utility Financing)***
(Bills for Collection)	***(Ijarah_Contract)***
(Black Listed People)	*Internet Banking*
Bank Policy	***(Istisna Contract)***
Central Bank Regulations	***(Ju'alah Contract)***
(Commodity Financing)	***(Letter of Credit)***
(Bank Customer)	*Financing Manager*
Corporate	***(Murabaha Contract)***
Customer Relationship Officer	***(Credit Approval)***
(Described Commodity Financing)	***(Qard Hassan Financing)***
(Financing Executive)	***(Real Estate Financing)***
Financing Report	*Retail*
Bank Manager	*SMEs*
Financing Supervisor	*Local Bank*
Banking System	*Foreign Bank*
(Financing Request)	*Central Bank*
Financing Service	*Sharia Restrictions*
Financing Services Diversification	*Central Bank Regulatory Requirements*
(Customer Verification)	

After excluding non UOWs' EBEs, 'generate' (g) relationships were identified between the UOWs. This step includes determining the source and destination of each UOW. Accordingly, the final Riva BPA UOW diagram of the *Financing* case study was agreed by the Financing team and is presented in Figure 6.1

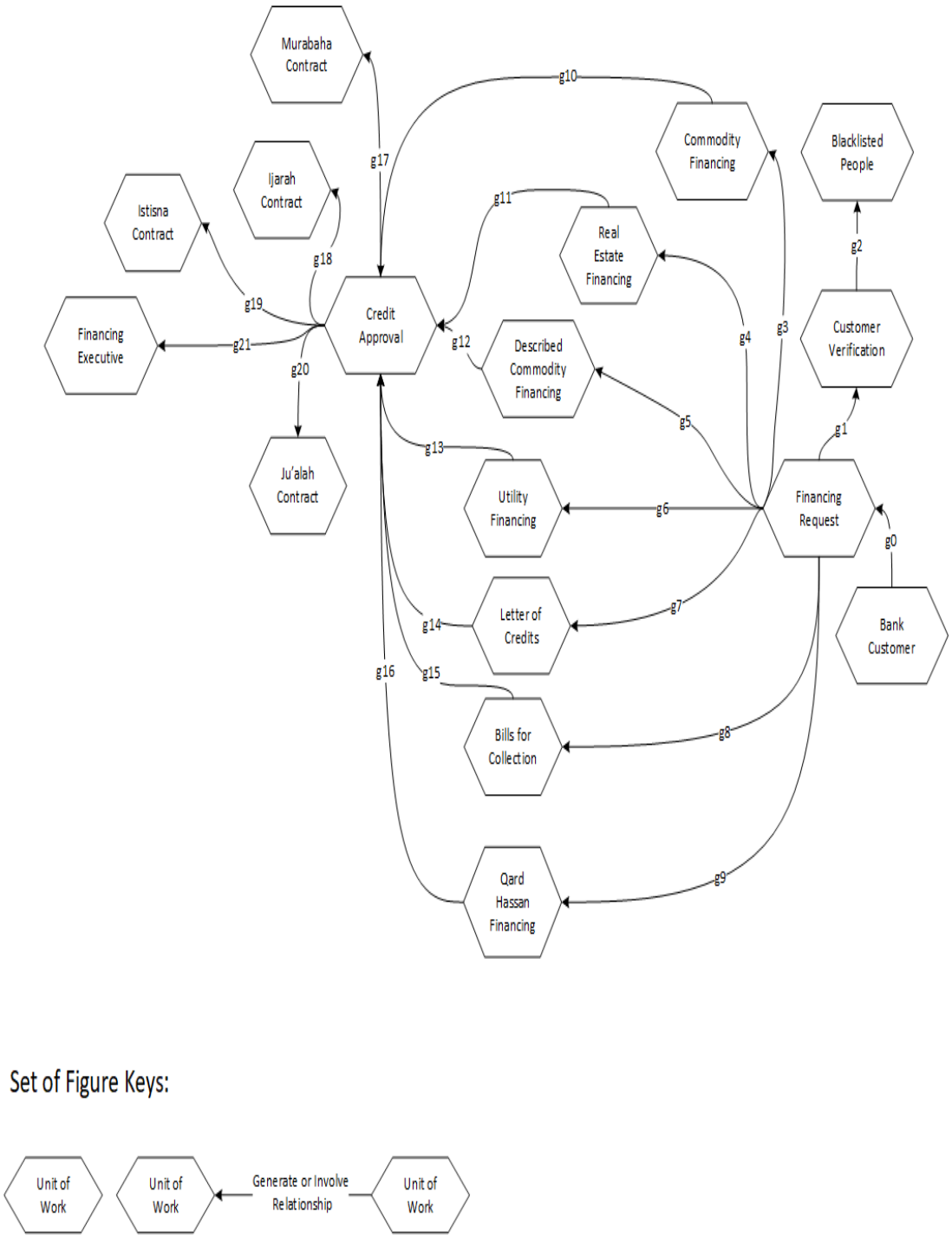


Figure 6.1: Riva BPA UOWs Diagram for the Financing Case Study

6.2.1.2 Riva "as-is" 1st Cut PA Diagram

The Riva 1st cut PA diagram of the *Financing* case study is generated after the UOW diagram. The 1st cut PA includes CPs, CMPs and their relationships. These elements correspond to the UOWs elements and their generate relationships. Each 'generate' (g) relationship is translated into 'request' (r), 'start' (s) and 'deliver' (d) relationships (review Section 4.3.1.2). Hence, the first cut diagram of the *Financing* case study is generated (see Figure 6.2).

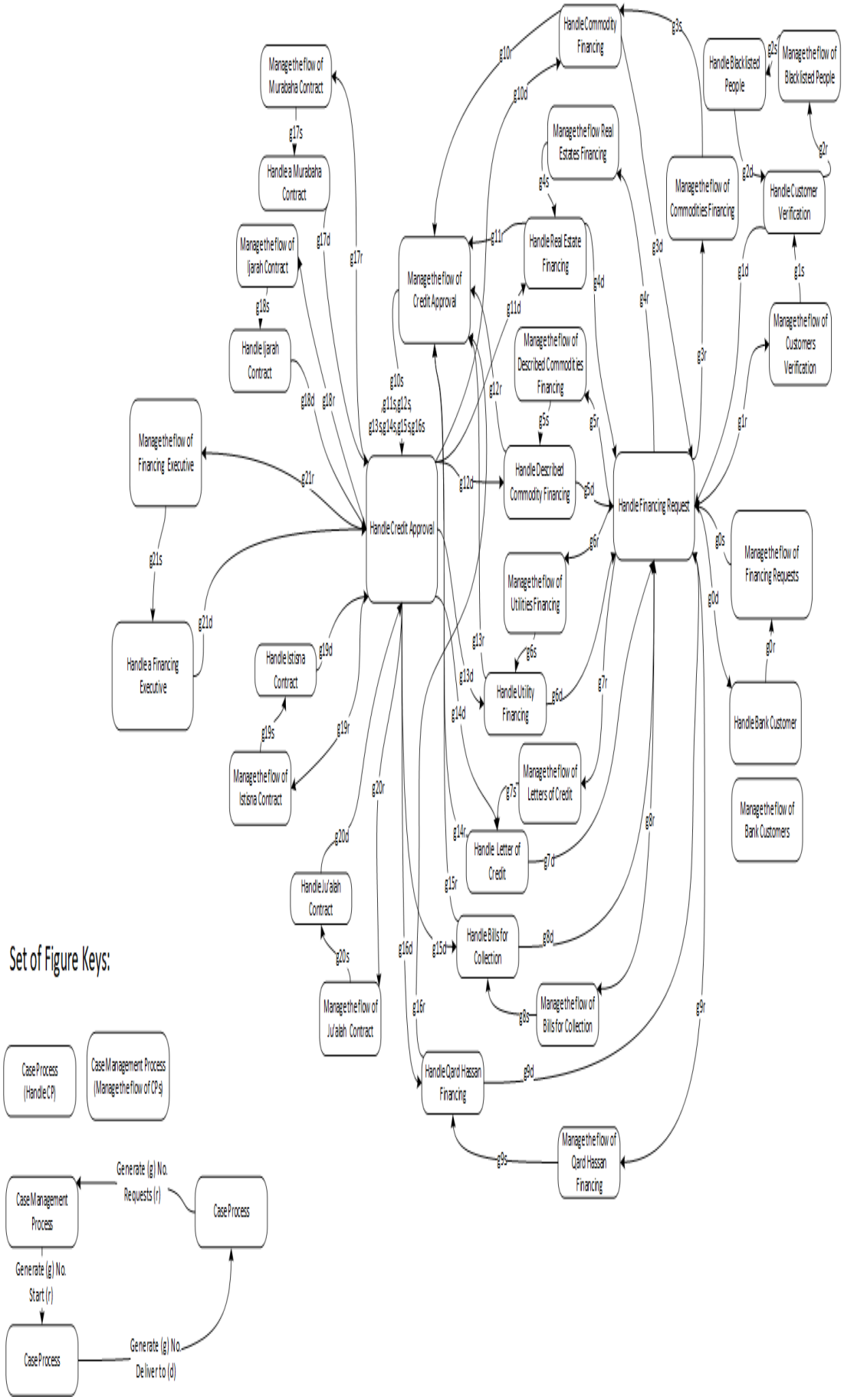


Figure 6.2: Riva BPA 1st Cut Diagram for the Financing Case Study

6.2.1.3 Riva “as-is" 2nd Cut PA Diagram

A set of heuristics are implemented after the generation of the Riva 1st cut PA diagram (review Section 2.2.2). These heuristics are important to reflect the real business environment of the *Financing* case study of the bank. The heuristics that were found in relation to the Financing team are the following:

- Folding a task force CMP into the requesting CP. CMPs are folded into the requesting CP. The CMPs that can be folded are *Manage the flow of Blacklisted People*, *Manage the flow of Murabaha Contract, Manage the flow of Ijarah Contract, Manage the flow of Istisna Contract, Manage the flow of Ju'alah Contract, Manage the flow of Commodities Financing, Manage the flow of Real Estates Financing, Manage the flow of Described Commodities Financing, Manage the flow of Utilities Financing, Manage the flow of Qard Hassan Financing, Manage the flow of Letters of Credit and Manage the flow of Bills for Collection*. Each CMP is considered part of another requesting CP in the Financing case study.
- Dealing with 1:1 ‘generates’ relationships. 1:1 ‘generates’ relationships were not found in the *Financing* case study. The defined UOWs have more than one instance or case to handle.
- Dealing with delivery interactions and delivery chains. Some delivery chains which are related to *Handle Commodity Financing* (g10d,g3d), *Handle Real Estate Financing* (g11d, g4d), *Handle Described Commodity Financing* (g12d,g5d) , *Handle Utility Financing* (g13d,g6d), *Handle Letter of Credit* (g14d,g7d) , *Handle Bills for Collection* (g15d,g8d), *Handle Qard Hassan Financing* (g16d, g9d), are short-circuited into (g10d,g11d,g12d,g13d,g14d,g15d,g16d) and delivered directly from *Handle Credit Approval* to *Handle Financing Request*.
- Dealing with collections. The Financing team did not consider any UOW as a collection of another UOW. Every UOW has its own CMP that is distinguished from other CMPs. However, there are CMPs which are folded into the requesting CPs as tasks force.
- Dealing with empty CMPs in specific cases when only one instance of the CP exists and there is no CMP. There is no case with one instance of CP in order to have an empty CMP and remove it accordingly.

The Riva 2nd cut PA diagram is presented after applying the Riva heuristics (see Figure 6.3).

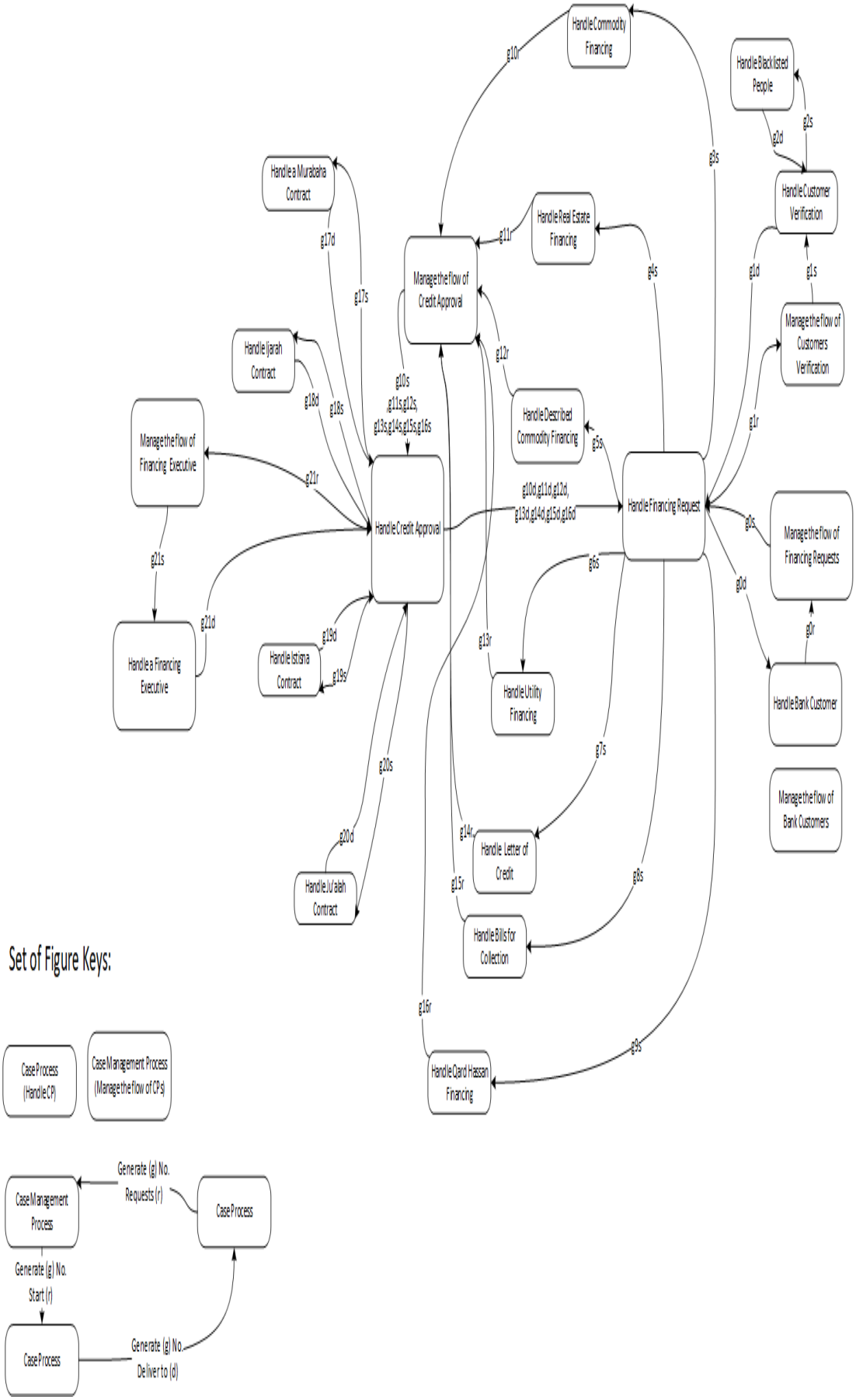


Figure 6.3: Riva BPA 2nd Cut Diagram for the Financing Case Study

6.3.2 Building the Riva BPA using the KMEs

After developing the Riva "as-is" BPA using the *Financing* case study, the BPA for the same case study is developed using the KMEOntoBPA. The same algorithms and their corresponding SWRL rules which were implemented and used in previous iterations, in addition to KMEOntoBPA ontologies, are utilised to develop the knowledge-based BPA of the *Financing* case study. Inputs of the KMEOntoBPA ontologies are provided by the Financing team of the bank in order to instantiate the KMEOntoBPA ontologies.

6.3.2.1 Knowledge-based CEBEs

Algorithms and SWRL rules instantiating the KMEntoBPA ontologies have been used to extract different CEBEs in order to develop the knowledge-based BPA. The execution of algorithms and SWRL rules results in the identification of the CEBEs as follows:

Algorithms 'Information Technology KME Instantiation', 'Leadership KME Instantiation' and 'CEBEs Identification' can identify the CEBEs of the IT KME. The same SWRL rule in the first and second iterations is used to extract the CEBEs. Table 6.2 shows these CEBEs.

Table 6.2: Identified CEBEs using the Financing IT KME

CEBEs	Description
Core Banking System (iMAL Facility Management)	The bank system technology that is used in the bank.
iMal Islamic Invest	Handles different types of Islamic instruments such as Murabaha, Ijara and Ististna'a
iMal Trade Finance	Handles commercial activities and provides letters of credit and bills for collection
Bank Intranet	The internal internet tool for sharing information inside the bank.
Internet Banking / Web Access	Allowing user to conduct financial transactions via the internet. The bank has *retail and corporate online services (iMAL* 2RetailPortal / 2CorporatePortal*)*
Funded Customers System	Reports any Jordanian bank customer who already was funded by a specific amount of money (around thirty thousand JODs) that the central bank decides

Algorithms 'Organisational Structure KME Instantiation' and 'CEBEs Identification' derive the CEBEs from the organisational structure KME. The same SWRL rules after modification in the second iteration are used to extract the CEBEs. The CEBEs of the *Financing* case study which are identified using these algorithms and rules are in Table 6.3.

Table 6.3: Identified CEBEs using the Financing Organisational Structure KME

CEBEs	Description
Consumer & Corporate Financing Requests	Financing business function
Customer Identification and Verification	
Trade Finance	
Credit Operations	
Islamic Investment	
Black List Management	
Credit Executive	
Commodity Financing	Financing business service
Described Commodity Financing	
Utility Financing	
Real State Financing	
Qard Hassan Financing	
Letter of Credit issuance	
Bills for Collection	
Customer Relationship Officer	Bank front office position
Senior Customer Relationship Officer	
Customer Relationship Supervisor	
Bank Manager	Bank Position and the highest rank in branch location
Credit Manager	Financing managerial position
Credit Review Manager	
Credit Operations Manager	
Credit Supervisor	Financing position
Senior Credit Officer	
Credit Officer	
Credit Review Supervisor	
Senior Credit Review Officer	
Credit Review officer	
Credit Operations Supervisor	
Senior Credit Operations Officer	
Credit Operations Officer	
Credit Executive Supervisor	Financing executive position
Senior Credit Executive Officer	
Credit Executive Officer	
Credit Executive Manager	Financing managerial executive position
Trade Finance Manager	Trade finance managerial position
LC Supervisor	Trade finance position
Senior LC Officer	
LC Officer	

Algorithms ‘Knowledge Context KME Instantiation’ and ‘CEBEs Identification’ and SWRL rules are executed to identify the CEBEs of the knowledge context KME. Table 6.4 presents these CEBEs, which include the external customers and restrictions of the *Financing* case study.

Table 6.4: Identified CEBEs using the Financing Knowledge Context KME

CEBEs	Description
Jordan Central Bank Instructions	Instructions issued by the central bank to all local banks.
Central bank Law	Rules imposed by the central bank on all local banks
Trade Law	Law in Jordan in relation to financing business and department
Investment Promotion Law	
Law Regulating the Exchange	
Public Debt Law	
Banking Law	
Income Tax Act	
Leasing Act	
Electronic Transactions Act	
Sharia Restrictions	It is the Sharia law from a combination of sources. First “Quran” then “Sunnah” (sayings of prophet Mohammad) and finally “Fatawas” (Scholars opinions and explanations in relation to the Quran and Sunnah)
Bank Policy	Principles that rule the bank procedures
Bank Customer	Any individual or party that benefits from bank services
Corporate	Large organisations or companies
Local Bank	Other banks locally operated
Foreign Bank	External bank
Central Bank	National bank that provides financial services for the country and is also considered as a customer for the local banks
Retail	Individual customers
SMEs	Small and medium-sized enterprises

Algorithms ‘Business Repository KME Instantiation’, ‘Knowledge Context KME Instantiation’ and ‘CEBEs Identification’ and SWRL rules are executed in order to extract the contract documents that are signed by external customers. Table 6.5 presents the available contracts that were found in the *Financing* case study.

Table 6.5: Identified CEBEs using the Financing Business Repository KME

CEBEs	Description
Ijarah Contract	Lease Islamic contract
Istisna Contract	Islamic contract to manufacture goods, assemble or process them according to exact specifications and a fixed timeline
Ju'alah Contract	A service Islamic contract (mainly brokerage contract in our bank case)
Murabaha Contract	A sale Islamic contract

The final group of CEBEs in Table 6.6 are derived using algorithms 'Culture KME Instantiation' and 'CEBEs Identification' and same SWRL rules in the first and second iterations.

Table 6.6: Identified CEBEs using the Financing Culture KME

CEBEs	Description
Customers' Special Cases	There are certain special customers' cases in financing transactions such as customers' disabilities. These cases require handling through a set of values or assumptions
Customer Identification and Verification Problems	Bank employee finds problems with identifying and verifying customers who need certain values rooted in banks such as customer satisfaction and trust.
Commodity Delivery	Problems in the process of delivering a commodity that the bank agreed to finance

6.3.2.2 Knowledge-based EBEs and UOWs

After the CEBEs identification, algorithm 'EBEs and UOWs Identification' identifies the EBEs and UOWs that instantiates the srBPA ontology component of the KMEOntoBPA (see Table 6.7). The CEBEs were checked with the Financing team of the bank and were ensured as being EBEs that characterise the Financing business using Riva EBEs filters testing. Filters as mentioned in previous iterations, include putting an 'a' or 'the' in front of each entity, removing any designed entities and removing entities that are simply roles and not of the essence of the business.

The EBEs are not considered UOWs for one of the following filters:

(1) They are not considered UOWs and do not have a lifetime that must be looked after such as *Central bank Law , Trade Law, Investment Promotion Law, Law Regulating the Exchange, Public Debt Law, Banking Law, Sharia Restrictions, Bank Policy, Income Tax Act, Leasing Act, Electronic Transactions Act* and *Jordan Central Bank Instructions*. These are rules or regulations that control the Financing bank processes.

Table 6.7: The CEBEs/EBEs and Bracketed UOWs for the Financing Case Study

Core Banking System *iMal Islamic Invest* *IMal Trade Finance* *Bank Intranet* *Internet Banking / Web Access* *Funded Customers System* *(Consumer & Corporate Financing Requests)* *(Customer Identification and Verification)* *(Trade Finance)* *(Credit Operations)* *(Islamic Investment)* *(Black List Management)* *(Credit Executive)* *(Commodity Financing)* *(Described Commodity Financing)* *(Utility Financing)* *(Real Estate Financing)* *(Qard Hassan Financing)* *(Letter of Credit issuance)* *(Bills for Collection)* *Customer Relationship Officer* *Senior Customer Relationship Officer* *Customer Relationship Supervisor* *Bank Manager* *Credit Manager* *Credit Supervisor* *Senior Credit Officer* *Credit Officer* *Credit Review Manager* *Credit Review Supervisor* *Senior Credit Review Officer* *Credit Review officer* *Credit Executive Manager* *Credit Executive Supervisor* *Senior Credit Executive Officer*	*Credit Executive Officer* *Credit Operations Manager* *Credit Operations Supervisor* *Senior Credit Operations Officer* *Credit Operations Officer* *Trade Finance Manager* *LC Supervisor* *Senior LC Officer* *LC Officer* *Jordan Central Bank Instructions* *Central bank Law* *Trade Law* *Investment Promotion Law* *Law Regulating the Exchange* *Public Debt Law* *Banking Law* *Sharia Restrictions* *Bank Policy* *Income Tax Act* *Leasing Act* *Electronic Transactions Act* *(Bank Customer)* *Corporate* *Local Bank* *Foreign Bank* *Central Bank* *Retail* *SMEs* *(Ijarah Contract)* *(Istisna Contract)* *(Ju'alah Contract)* *(Murabaha Contract)* *Customers' Special Cases* *(Commodity Delivery)* *Customer Identification and Verification Problems*
IT**, Organisational Structure, Knowledge Context, Business Repository, Culture **KMEs** **CEBEs	

(2) *Core Banking System, iMAL Facility Management, iMal Islamic Invest, iMal Trade Finance, Bank Intranet, Funded Customers System* are not considered UOWs. These are systems which are used to control and monitor the Financing processes.

(3) They are only roles that play a part in Financing processes such *Senior Customer Relationship Officer, Customer Relationship Supervisor, Bank Manager, Credit Manager, Credit Supervisor, Senior Credit Officer, Credit Officer, Credit Review*

Manager, Credit Review Supervisor, Senior Credit Review Officer, Credit Review officer, Credit Executive Manager, Credit Executive Supervisor, Senior Credit Executive Officer, Credit Executive Officer, Credit Operations Manager, Credit Operations Supervisor, Senior Credit Operations Officer, Credit Operations Officer, Trade Finance Manager, LC Supervisor , Senior LC Officer and LC Officer.

(4) They are only part of other EBEs and do not have a separate lifetime such as *Internet Banking, Customer Identification and Verification Problems, Customer Special Cases*

(5) *Corporate, Local Bank, Foreign Bank, Central Bank, Retail* and *SMEs* are banks customers that represent the *Bank Customer* EBE.

The EBEs are ensured by the Financing team and the EBEs instances are generated automatically in the srBPA ontology using the same SWRL rule in the first and second iterations (review section 4.3.2.2).

The UOWs are also asserted by the Financing team and the UOWs instances are generated automatically in the srBPA ontology using the SWRL rule that is used in the first the second iteration (review section 4.3.2.2).

After the generation of EBEs and UOWs instances, the UOWs relationships are identified by the 'Derive Riva BPA' algorithm. By this identification, the UOW diagram of the *Financing* case study is presented (see Figure 6.4).

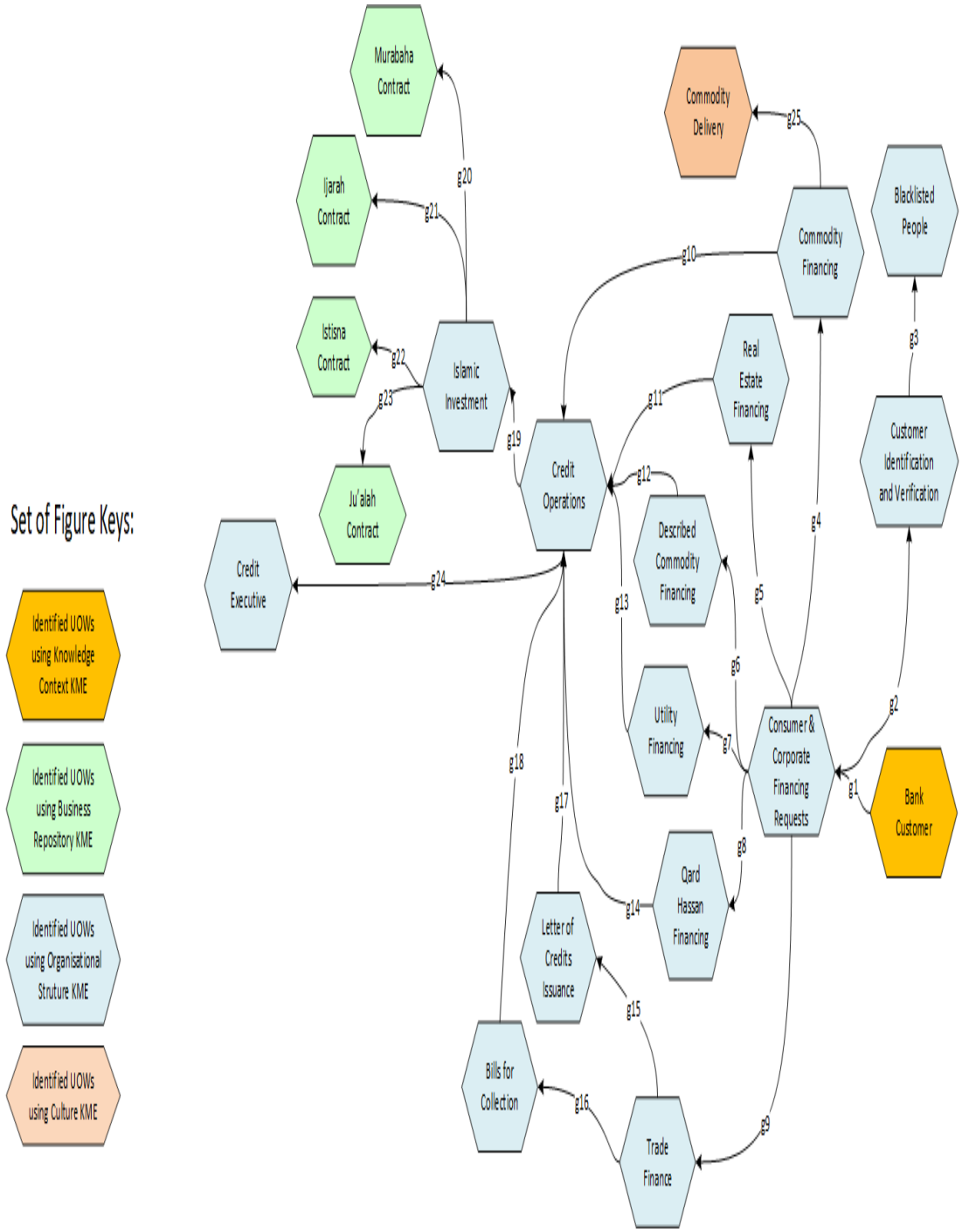


Figure 6.4: Knowledge-based Riva UOW Diagram for the Financing Case Study

6.3.2.3 Knowledge-based Riva 1st and 2nd Cut PA Diagrams

Algorithm 'Derive Riva BPA' carries out to generate knowledge-based Riva 1st and 2nd cut PA diagrams. The same steps which are used in developing the knowledge-based BPA in previous iterations are re-applied to the *Financing* case study (see Section 4.3.2.3). The knowledge-based Riva 1st cut PA diagram of the *Financing* case study is generated through the CPs, CMPs and their relationships (see Figure 6.5).

Figure 6.5: Knowledge-based Riva 1st cut PA Diagram for the Financing Case Study

Riva heuristics are applied after the generation of the Riva 1st cut PA diagram (review Section 2.2.2). Accordingly, the knowledge-based 2nd cut PA diagram of the *Financing* case study is generated (see Figure 6.6). The heuristics that have been found are the following:

- Folding a task force CMP into the requesting CP. CMPs are folded into the requesting CP. The CMPs which are folded: *Manage the flow of Blacklisted People, Manage the flow of Murabaha Contract, Manage the flow of Ijarah Contract, Manage the flow of Istisna Contract, Manage the flow of Ju'alah Contract, Manage the flow of Commodities Financing, Manage the flow Real Estates Financing, Manage the flow of Described Commodities Financing, Manage the flow of Utilities Financing, Manage the flow of Qard Hassan Financing, Manage the flow of Letters of Credit Issuance and Manage the flow of Bills for Collection*.
- Dealing with 1:1 'generates' relationships. Same as the Riva "as-is" BPA, 1:1 'generates' relationships were not discovered in the *Financing* case study since UOWs have more than one case process to manage.
- Dealing with delivery interactions and delivery chains. Some delivery chains which are related to *Handle Commodity Financing* (g10d,g4d), *Handle Real Estate Financing* (g11d, g5d), *Handle Described Commodity Financing* (g12d,g6d) , *Handle Utility Financing* (g13d,g7d), *Handle Letter of Credit Issuance* and *Handle Trade Finance* (g17d,g15d,g9d) , *Handle Bills for Collection* and *Handle Trade Finance* (g18d,g6d,g9d), *Handle Qard Hassan Financing* (g14d, ,g8d), are short-circuited into (g10,g11d,g12d,g13d,g14d,g17d,g18d) and delivered directly from *Handle Credit Operations* to *Handle Consumer & Corporate Financing Requests*. The delivery chain that is related to *Handle Commodity Delivery* and *Handle Commodity Financing* (g25d, g4d) can also be short-circuited into (g25d) and delivered directly from *Handle Commodity Delivery* to *Handle Consumer & Corporate Financing Requests*.
- Dealing with collections. There is no UOW that is considered a collection of another UOW in *Financing* case study. The Financing team considered Folded CMPs are as tasks force, same as the Riva "as-is" BPA.
- Dealing with empty CMPs in specific cases when only one instance of the CP exists and there is no CMP. CMPs have more than one instance or case process to manage and there is no empty CMP.

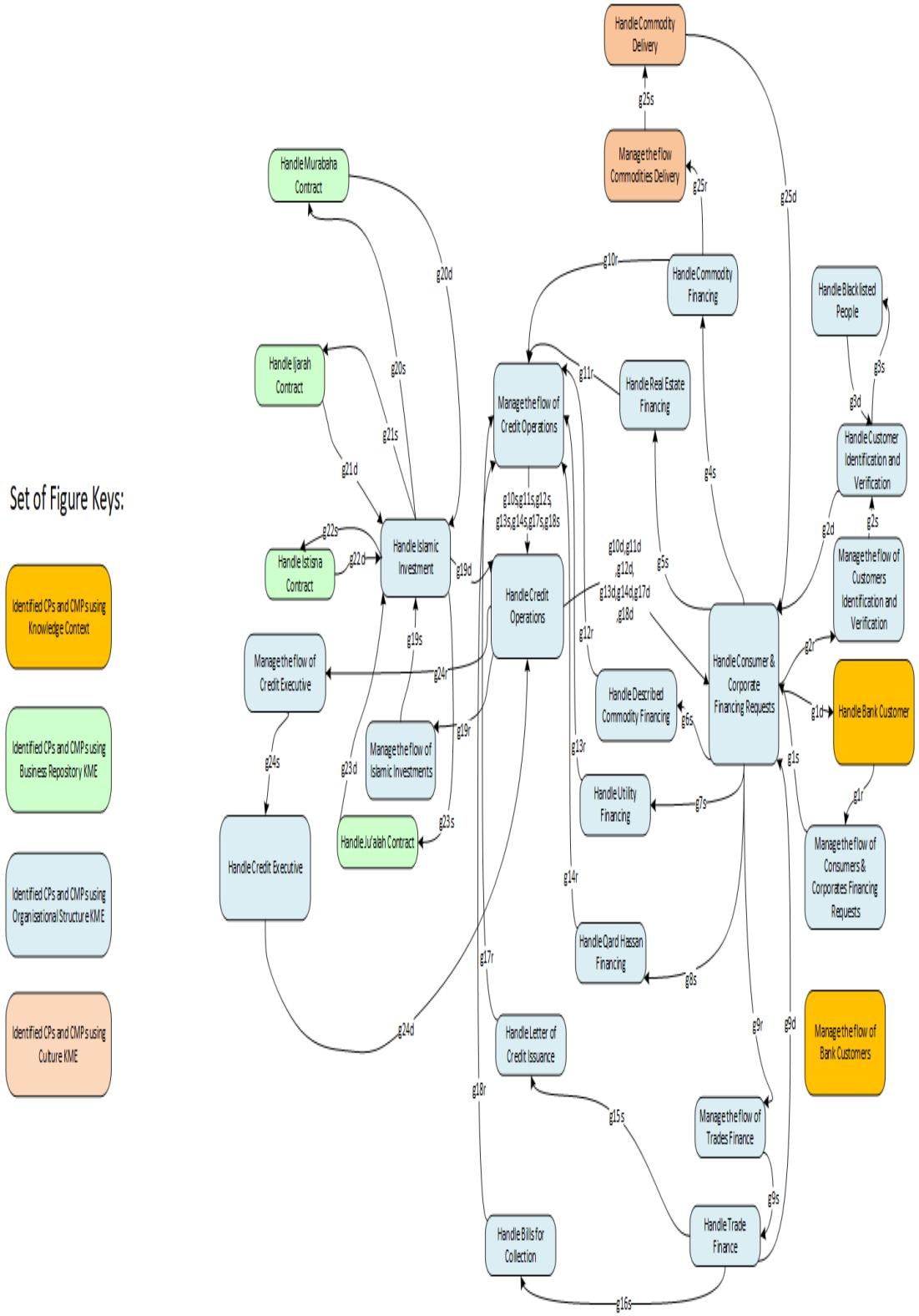


Figure 6.6: Knowledge-based Riva 2nd cut PA Diagram for the Financing Case Study

Folding CMPs in Riva heuristics requires the following:
(1) re-configuration of 'Start' (s) relationships by changing the source to CPs. These new 'Start' (s) relationships in the 2nd cut PA diagram are g3s, g4s, g5s, g6s, g7s, g8s, g15s, g16s , g20s, g21s, g22s,g23s; (2) determination of the CMPs that belong to the Financing knowledge-based 2nd cut PA diagram; and (3) assertion to which of the Riva diagrams the relations belong to using the SWRL rules (see Section 4.3.2.3).

Finally, empty CMPs is handled or removed in the srBPA ontology by using the data type property 'isActive' for the CMP in the srBPA ontology.

6.4 DSRM Third Iteration - Evaluation of the KMEOntoBPA Framework

An evaluation is conducted based on the components and evaluation types of the research evaluation framework (see Chapter 3, Table 3.1). The same evaluation tests that were used in the second iteration are applied to the third one. The evaluation includes verification of the aKMEOnt, validation of the Riva "as-is" BPA and KMEOntoBPA, dynamism and sustainable competitive advantage.

6.4.1 Verification of the aKMEOnt

Verification of the aKMEOnt involves the same criteria of the first and second iteration that were used to inform the correctness and verify the aKMOnt (see Section 4.4.1). These criteria include redundancy, completeness and consistency, which have been applied to the aKMEOnt using the *Financing* case study. Table 6.8 indicates the consistent representation of the instantiated aKMEOnt and compares the KMEs' elements of the *Financing* case study with its semantic representation, the aKMEOnt. Consistent representation ensures that there is no contradiction among the components of the ontology and the Financing case study domain that can impact the results. The Financing team has inspected with the researcher the consistent representation of the KMEs' elements using the aKMEOnt.

Table 6.8: Comparing KMEs Elements of the Financing Case Study with their Semantic Representation in the aKMEOnt

aKMEOnt elements	KMEs of Financing case study	aKMEOnt using Financing (Protégé ontology editor)	Remarks
Tools (integrative)	6 tools were identified as integrative by the *Financing* case study	6 input instances of class 'Tool' were created and classified as integrative using data-type property and asserted to belong to the information technology KME	Consistent representation of tools in terms of number and semantics through the tool data-type property 'IsIntegrativeTechnolog'

Business Behaviour	14 business behaviour elements (7 business functions, 7 services) were identified by the *Financing* case study	14 input instances of class 'Business Behaviour' were created and classified into functions and services using 'hasType' property and asserted as belonging to the organisational structure KME	Consistent representation of business behaviour in terms of number and semantics
Positions	24 positions of the *Financing* case study were identified	24 input instances of the class 'Position' were created and asserted to belong to the organisational structure KME	Consistent representation of positions in terms of number and semantics
Customers (external)	7 customers were identified as external ones and are in relation with the *Financing* case study	7 input instances of the class 'Customer' were created and asserted to belong to the knowledge context KME	Consistent representation of customers in terms of number and semantics through the customer data-type property 'IsExternal Customer'
Restrictions (external)	12 restrictions were identified as external ones and are related to the *Financing* case study	12 input instances of class 'Restriction' were created and asserted to belong to the knowledge context KME	Consistent representation of restrictions in terms of number and semantics through the restriction data-type property 'IsExternal Restriction'
(E-Documents) (type: contracts)	4 documents were found to be contracts in the documents that were accessed in the *Financing* case study	4 input instances of class 'E-document' were created and asserted to belong to the business repository KME	Consistent representation of restrictions in terms of number and semantics through the restriction data-type property 'hasType'
Problem (type: external)	3 problems were mentioned as a solved problem related to culture values	3 instances of class 'Problem' were created and asserted to belong to the culture KME	Consistent representation of restrictions in terms of number and semantics through the restriction data-type property 'IsAdapted Problem'

The verification of the aKMEOnt using the *Financing* case study has shown the following findings that have been verified by the Financing team:

(1) The KMEs elements have been elicited correctly and the instantiation of the aKMEOnt indicates the same number and semantics of the KMEs elements.

(2) No errors have been detected using the Protégé development editor after conducting consistency checking of the instantiated aKMEOnt using the Financing KMEs (see Figure 6.7). Free errors detection shows that the aKMEOnt demonstration using the Financing KMEs is structurally and logically consistent and considers the constructs of the ontology language and has no contradiction.

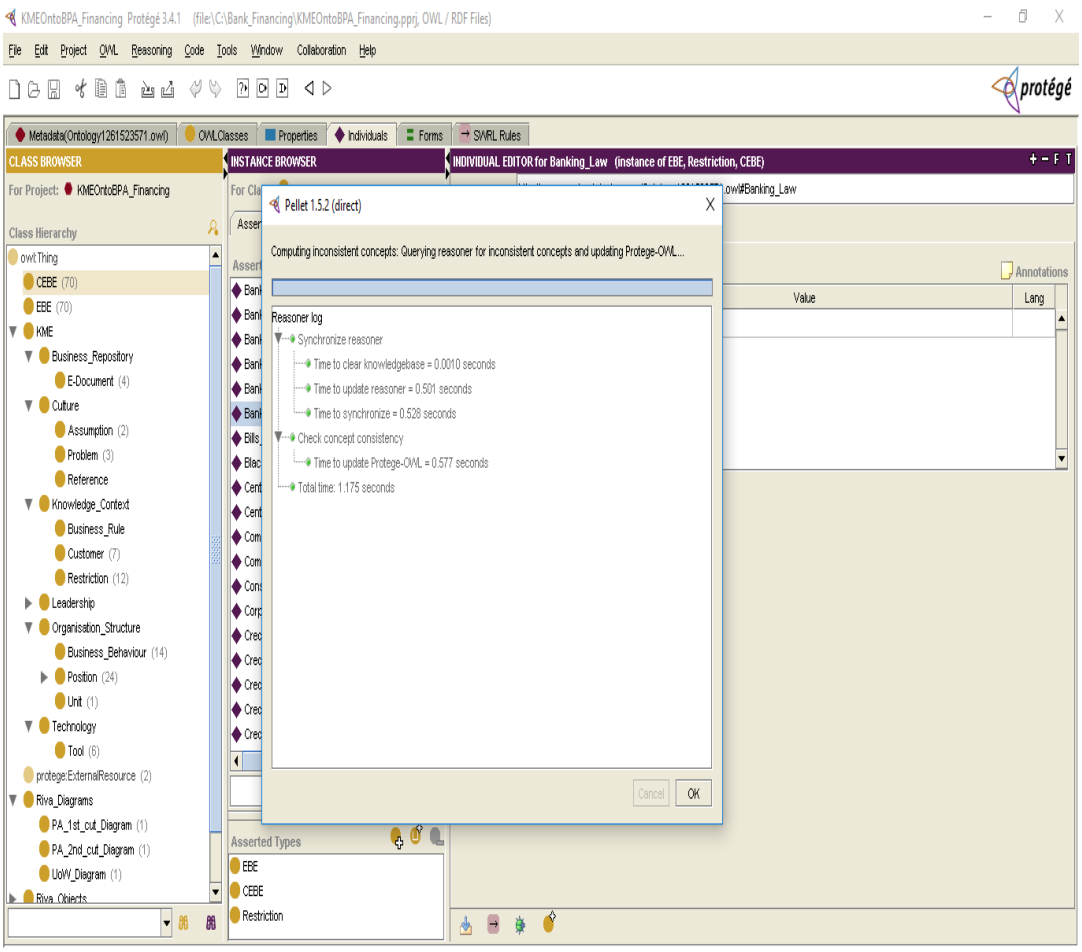


Figure 6.7: Checking Consistency of the aKMEOnt Elements in Financing Case Study using Pellet 1.5.2 Reasoner in Protégé Tool

6.4.2 Validation of the Riva "as-is" BPA

The Riva "as-is" BPA of the *Financing* case study is validated with the Financing team. Informing the validation of the Riva "as-is" BPA requires checking the validity of the Riva BPA elements. The Riva EBEs, UOWs and their 'generate' (g) relationships, in addition to

the CPs, CMPs, 1st cut diagram and applied heuristics to the 2nd cut diagram are the main Riva "as-is" BPA elements that are used to check validity. Table 6.9 shows the BPA elements that have been validated with the support of the Financing team.

Table 6.9: Validated Riva "as-is" BPA Elements of the Financing Case Study

Riva BPA elements	Financing Riva-based BPA	Remarks
EBEs	37 entities were identified as EBEs during a brainstorming meeting with the Financing team	*Are these the right EBEs that characterise the financing business?* ***Yes***
UOWs	17 EBEs were selected and considered as UOWs	*Are these the right UOWs?* ***Yes***
Generate Relationships	22 Generate relationships were identified between UOWs	*Are these the right relationships between UOWs?* ***Yes***
CPs	17 CPs corresponding to UOWs belong to 1st and 2nd cut PA diagrams	*Are these the right CPs that correspond to their UOWs?* ***Yes***
CMPs	17 CMPs corresponding to UOWs belong to the 1st cut and 5 out of 17 belong to the 2nd cut PA diagram	*Are these the right CMPs that correspond to their UOWs?* ***Yes***
Request relationships in the 1st cut diagram	22 request relationships were identified in the 1st cut diagram	*Are these the right identified request relationships?* ***Yes***
Deliver relationships in the 1st cut diagram	22 deliver relationships were identified in the 1st cut diagram	*Are these the right identified deliver relationships?* ***Yes***
Start relationships in the 1st cut diagram	22 start relationships were identified in the 1st cut diagram	*Are these the right identified start relationships?* ***Yes***
Applying heuristics in the 2nd cut diagram	12 CMPs were folded in CPs and 14 delivery chain relationships were short-circuited into 7 delivery relationships resulting in the Riva 2nd cut diagram in Figure 6.3	*Are these the right folded, omitted and short-circuited CMPs in Riva 2nd Cut diagram?* ***Yes***

6.4.3 Validation of the KMEOntoBPA Framework

The KMEOntoBPA framework is validated with the support of the Financing team. Checking the validity of the CEBEs and comparing the Riva "as-is" BPA to the knowledge-based BPA are the main validations that have been applied.

6.4.3.1 Validity of the CEBEs

The validity of the CEBEs was checked with the Financing team according to their characterisation of the Financing business in the bank as well as if there is any missing. Ould's (2005) suggested questions for brainstorming CEBEs are also used as a support for these CEBEs. Table 6.10 shows identified CEBEs and their corresponding questions.

Table 6.10: Validated Financing CEBEs corresponding to Ould's Suggested Questions

Candidate Essential Business Entities (CEBEs)	Riva Ould Suggested Question (Ould,2005)	Validated as EBEs
Consumer & Corporate Financing Requests, Customer Identification and Verification, Trade Finance, Credit Operations, Islamic Investment, Blacklist Management, Credit Executive	What do we make? Or What do we care for?	Validated
Commodity Financing, Described Commodity Financing, Utility Financing, Real Estate Financing, Qard Hassan Financing, Letter of Credit issuance, Bills for Collection	What do we sell or provide? What product lines do we have? What services do we offer? What service lines do we have?	Validated
Core Banking System - iMAL Facility Management, iMal Islamic Invest, iMal Trade Finance, Bank Intranet, Internet Banking / Web Access, Funded Customers System, Customers Special Cases, Customer Relationship Officer, Senior Customer Relationship Officer, Customer Relationship Supervisor, Bank Manager, Credit Manager , Credit Supervisor, Senior Credit Officer, Credit Officer , Credit Review Manager, Credit Review Supervisor, Senior Credit Review Officer, Credit Review officer, Credit Executive Manager, Credit Executive Supervisor, Senior Credit Executive Officer, Credit Executive Officer, Credit Operations Manager, Credit Operations Supervisor, Senior Credit Operations Officer, Credit Operations Officer, Trade Finance Manager, LC Supervisor , Senior LC Officer, LC Officer	What sort of things do we deal with day in and day out?	Validated
Ijarah Contract, Istisna Contract, Ju'alah Contract, Murabaha Contract, Commodity Delivery. Further answers are also included in previous questions.	Are there things that our customers have, or want, or do, that might be EBEs for us?	Validated
Jordan Central Bank Instructions, Central bank Law,Trade Law, Investment Promotion Law, Law Regulating the Exchange, Public Debt Law, Banking Law, Sharia Restrictions, Bank Policy ,Income Tax Act, Leasing Act, Electronic Transactions Act	What things can we simply not get away from?	Validated
Bank Customer, Corporate, Local Bank, Foreign Bank, Central Bank, Retail, SMEs	Who are our external customers?	Validated

6.4.3.2 Comparing the Knowledge-based BPA to the Riva "as-is" BPA

The Riva "as-is" BPA of the bank's *Financing* case study is used as a benchmark to inspect the knowledge-based BPA approach. Same quantitative and qualitative criteria that were used to compare between both BPAs in previous DSRM iterations, are used in this iteration. The quality of the elements of the knowledge-based BPA regarding their importance, defects, comprehensiveness and their reflection of real Financing business is also discussed in this section. Table 6.11 compares the two BPAs utilising the bank *Financing* case study. The number of both BPAs elements including (EBEs, UOWs, CPs, CMPs) were derived from the Riva "as-is" BPA (review Section 6.3.1) and the knowledge-based BPA (review Section 6.3.2). The Financing team reviewed and agreed on the results that were found after this comparison.

Table 6.11: Comparing the Knowledge-based BPA with the Riva as-is BPA using the Financing Case Study

Criteria	Riva "as-is" BPA	Knowledge-based BPA	Remarks
No. of EBEs	37	70	EBEs number of knowledge-based BPA exceeds the Riva" as-is" BPA
No. of UOWs	17	20	Missing UOWs in the Riva "as-is" BPA are mainly in business functions
No. of CPs in the Riva 2nd cut PA diagram	17	20	The missing UOWs reflect the number of corresponding CPs in the Riva process architecture
No. of 2nd cut folded CMPs	12	12	Same number of folded CMPs in both approaches
Is traceability of the sources of the BPA elements supported?	No	Yes	Semantic Riva "as-is" BPA tracks BPA elements but not the original source of each element
Identification (Is it a knowledge-based BPA?)	Brainstorming (not knowledge-based)	Financing KMEs or resources (knowledge-based)	The approach to identifying the CEBEs/EBEs
Support of Robustness and learning capability criteria	No	Yes	Responding to business changes and learning from the environment

Different numbers of EBEs in previous iterations including this one is clear in both BPA approaches. The approach of brainstorming CEBEs with Ould suggested questions in order to derive CEBEs in the *Financing* case study was non-systematic. It also required restricted time meeting with domain experts. Therefore, the brainstormed CEBEs which are used to extract EBEs are limited. They are also not supported with documents and based on individuals' memories. One the other hand, the elicitation of CEBEs in the knowledge-based BPA approach was simple, flexible, structured and formal with regard using the Financing related documents. Therefore, the EBEs are higher in the knowledge-based BPA and provide a thorough representation of the *Financing* case study. In addition, they extend to cover new area in the Financing business such as the problems in relation to the Financing in the bank such as commodity delivery.

The knowledge-based BPA has also extra UOWs and CPs compared to the Riva "as-is" BPA. These additional UOWs and CPs represent essential processes that their absence leads to misunderstanding in the workflow of the Financing business in the bank. The new UOWs of the knowledge-based BPA include *Consumer & Corporate Financing Requests, Islamic Investment, Trade Finance and Commodity Delivery*. These UOWs reflect more reality to the business and workflow of the *Financing* case study.

Common BPA elements which include EBEs, UOWs, CPs, and CMPs in both approaches are mainly different in their naming. The knowledge-based BPA elements have the right naming since they were elicited from standard documents. Using ontologies has played a role in highlighting and sharing the right names and make them considerable in communication to the Financing team.

The traceability feature in the KMEOntoBPA has added a significant value in understanding the Financing processes. It also clarified how different Financing elements are created and how to access and track these elements. Figure 6.8 shows the distribution of the EBEs according to the KMEs of the *Financing* case study. The organisational structure KME has the highest number of EBEs with around 54%. The knowledge context KME has the second highest number of EBEs with around 27%.

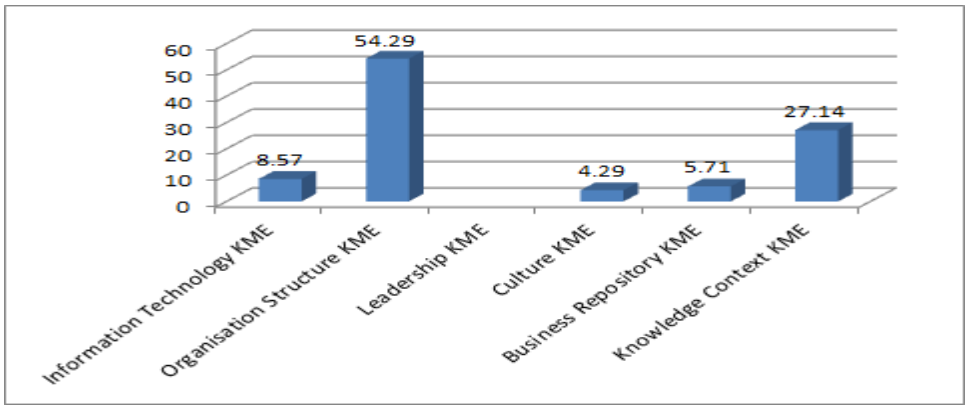


Figure 6.8: Distribution of EBEs Percentages according to the KMEs of Financing Case Study

Although the knowledge context KME has the second highest number of EBEs, one UOW is identified by this KME. Furthermore, four UOWs are identified by the business repository KME and one by the culture KME. These numbers show that the business repository KME has more impact on the BPA development and its UOWs, CPs and CMPs elements in the *Financing* case study. Figure 6.9 shows the distribution of the UOWs and other corresponding CPs and CMPs in the *Financing* case study. Consequently, it can be concluded that the organisational structure KME is the most critical KME in the BPA development of the *Financing* case study followed by the business repository KME.

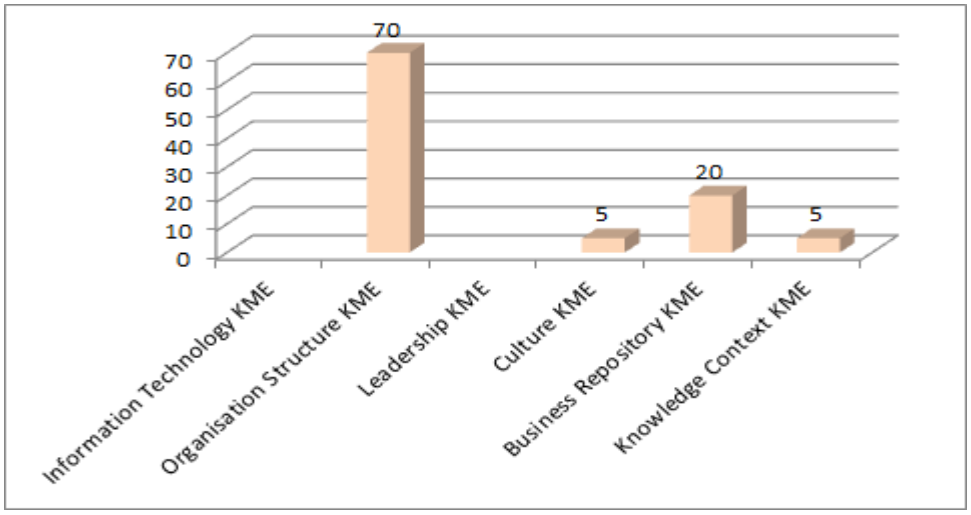


Figure 6.9: Distribution of UOWs, corresponding CPs and CMPs percentages according to the KMEs of the Financing Case Study

The KMEs using the semantic approach has shown a significant role in achieving robustness and learning capability for the BPA of the *Financing* case study. These criteria were asserted with the Financing team for the following:

(1) The knowledge-based BPA is flexible and shows the potential to adapt changes and different resources in the Financing business.

(2) The knowledge-based BPA has the ability to learn new resources from the Financing business in the bank and develop accordingly.

These criteria as it was mentioned in previous iterations lead to the accomplishment of an evolutionary dimension to the BPA (Prat et al., 2014), in addition to dynamism and competitiveness.

In conclusion, the knowledge-based BPA is important with regard to reflecting the real business of Financing in the bank. It has also provided more representative BPA elements in relation to the *Financing* case study and compared to the Riva "as-is" BPA.

6.4.4 A Dynamic and Competitive BPA

The validation of the KMEOntoBPA is followed by the evaluation of the effectiveness of the KMEOntoBPA framework in developing a dynamic BPA with a competitive advantage. This evaluation is conducted in relation to the *Financing* case study. As in the second iteration, inspecting the CEBEs/EBEs automation and potential of agile generation of the elements of the knowledge-based BPA, in addition to performing a mixed method approach evaluation, are the main evaluation in this section.

6.4.4.1 Automation and BPA Agility

Automation and agility of BPA is mainly related to identifying the EBEs through the ontology-based KMEs. These EBEs are explored or discovered by the aKMEOnt component of the KMEOntoBPA. Accordingly, the srBPA ontology component is instantiated and a knowledge-based BPA is generated. Algorithms, their corresponding SWRL rules and the Protégé editor tool are used to provide the identification and agile generation of the EBEs and their corresponding elements, i.e., the UOWs, CPs and CMPs.

By instantiating the KMEOntoBPA ontologies using the knowledge resources of the *Financing* case study, the CEBEs/EBEs can be discovered on a regular basis through the Protégé ontology editor. The KMEOntoBPA ontologies provide a real-time detection of the BPA elements of the *Financing* case study. They also support constructing and re-configuring the BPA elements with the business analysts' intervention in addition to tracking the source of these elements.

6.4.4.2 The KMEOntoBPA: Advantages and Supporting Sources of Sustainable Competitive Advantage

The mixed methods approach is used to assess the advantages and the sustainable competitive advantage (SCA) of using the KMEOntoBPA in the *Financing* case study.

Seventeen questionnaires were hand-delivered to the senior staff and managers who were involved with Financing transactions. Questionnaires were followed up by two interviews with the credit and trade finance managers. Same interview questions are used in the *Deposits* and *Financing* case studies in order to enrich and support the findings of the questionnaires (see interview responses Appendix D). Each interview question was labelled as in the *Deposits* case study in order to facilitate referencing and highlight related answers within the questionnaires' results discussion. The questionnaire reliability was tested using Cronbach's alpha test and was found to be within an excellent range (0.957) (see Appendix E).

The normality of data as in the previous iteration was also tested using the Shapiro-Wilk and histogram technique (see Appendix F). According to the Shapiro-Wilk tests, the significance levels of the independent variable, the KMEOntoBPA advantages, and the dependent variable, KMEOntoBPA impact on the sources of SCA were as follows: (p-values = .275, .004, .090, and .445) > 0.05, which means that the data distribution of the study variables is normal.

The correlation between the independent variable, the KMEOntoBPA advantages, and the dependent variable, the impact of KMEOntoBPA on sources of SCA, is also examined as in the second iteration using scatterplot graph and Pearson's correlation coefficient. Accordingly the simple linear regression analysis can be conducted in order to predict the relationship between KMEOntoBPA advantages and the impact of KMEOntoBPA on sources of the SCA variables.

6.4.4.2.1 Advantages of the KMEOntoBPA

Question one (Q1) of the questionnaire in Appendix B.1 examines twelve possible advantages of using the KMEOntoBPA in the *Financing* case study. The advantages have been analysed using a frequency distribution analysis and descriptive statistics (see Appendix G.2). The key findings are as follows:

I. (Q1.7) Increasing the accuracy of service delivery and improving the financial control (mean = 4.53, significance = 1, rate = high) is the most important advantage that the sample strongly agreed with. Interviews show that KMEOntoBPA 'supports completeness and accuracy' (label 6/ Appendix D.2). It also 'supports quick flow of processes and better service' (label 5/ Appendix D.2).
II. More than 85% of the sample (n=17) expressed their agreement on the following advantages (see Table 6.12). These advantages are achieved by using the following KMEs: (1) information technology which 'identifies existing tools and their related processes which minimises time and facilitates communication and sharing

knowledge';(2) e-documents which 'save time and effort' and support 'problem solving'; knowledge context that 'clarifies procedures and policies' and 'increases employees abilities to handle processes' and 'eases process tracking' ; (3) culture that 'increases quality and facilitates customers services'; (4) organisational structure that 'supports quick flow of processes and better service' and leadership that 'manages processes effectively based on working goals' (label 5/ Appendix D.2). KMEOntoBPA also supports 'adapting dynamic changes' or 'changes to environment' (label 6/ Appendix D.2).

III. No respondent strongly disagreed with any of the advantages of the KMEOntoBPA, and only three respondents expressed their disagreement on three advantages.

Table 6.12: Frequency Distribution Analysis and Descriptive Statistics of the KMEOntoBPA Advantages for the Financing Case Study (with Agreement > 85%)

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
1	Reducing the cost of process and services **(significance = 4, mean = 4.29)**	0 (0.0%)	0 (0.0%)	2 (11.8%)	8 (47.1%)	7 (41.2%)
2	Simplifying work procedures and decreasing bottlenecks in the work system **(significance = 3, mean = 4.29)**	0 (0.0%)	0 (0.0%)	1 (5.9%)	10 (58.5%)	6 (35.3%)
3	Reducing cycle time of processes and services **(significance = 2, mean = 4.29)**	0 (0.0%)	1 (5.9%)	0 (0.0%)	9 (52.9%)	7 (41.2%)
4	Increasing the quality of services **(significance = 6, mean = 4.24)**	0 (0.0%)	0 (0.0%)	1 (5.9%)	11 (64.7%)	5 (29.4%)
5	Automating processes and services **(significance = 7, mean = 4.24)**	0 (0.0%)	0 (0.0%)	2 (11.8%)	9 (52.9%)	6 (35.3%)
7	Increasing the accuracy of services delivery and improving the financial control **(significance = 1, mean = 4.53)**	0 (0.0%)	0 (0.0%)	2 (11.8%)	4 (23.5%)	11 (64.7%)
8	Identifying technology tools in organisation **(significance = 5, mean = 4.24)**	0 (0.0%)	0 (0.0%)	1 (5.9%)	11 (64.7%)	5 (29.4%)
10	Developing workers' skills and knowledge **(significance = 8, mean = 4.12)**	0 (0.0%)	0 (0.0%)	2 (11.8%)	11 (64.7%)	4 (23.5%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree						

6.4.4.2.2 KMEOntoBPA Support to Sources of Sustainable Competitive Advantage

In this section the impact of the KMEOntoBPA on the sources of the SCA is measured using FDA and descriptive statistics (see Appendix H). Questions two (Q2), three (Q3) and four (Q4) of the questionnaire in Appendix B.1 examine this impact using 17 paragraphs. These paragraphs represent three main sources of SCA which are: technical capabilities (6 statements), core competences (5 statements) and social capital (6 statements). The key findings are the following:

1) **Technical Capabilities**:

- (Q2.1) 'Knowledge building and unifying of information resources' is the most significant impact of the KMEOntoBPA on technical capabilities (mean = 4.29, significance = 1, rate = high).
- More than 80% of the sample (n= 17) has strongly agreed or agreed on two statements regarding KMEOntoBPA support for technical capabilities (see Table 6.13).
- No disagreement is recorded on any of the statements that represent the impact of KMEOntoBPA on technical capabilities.

Table 6.13: Frequency Distribution Analysis and Descriptive Statistics of KMEOntoBPA Impacts on Technical Capabilities for the Financing Case Study (with Agreement > 80%)

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
1	There is knowledge building and the unifying of information resources **(significance = 1, mean = 4.29)**	0 (0.0%)	0 (0.0%)	1 (5.9%)	10 (58.8%)	6 (35.3%)
2	Tracking and maintenance of the processes and services are regular **(significance = 5, mean = 4.12)**	0 (0.0%)	0 (0.0%)	3 (17.6%)	9 (52.9%)	5 (29.4%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree						

2) **Core Competences**

- (Q3.5) The ability of the bank to cope with changeable business environment is the most significant impact of KMEOntoBPA on core competences (mean = 4.18, significance = 1, rate = high).
- More than 80% of the sample (n=17) has strongly agreed or agreed on three statements regarding KMEOntoBPA support for core competences (see Table 6.14).

Table 6.14: Frequency Distribution Analysis and Descriptive Statistics of KMEOntoBPA Impacts on Core Competences for the Financing Case Study (with Agreement > 80%)

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
2	There is an improvement of 'value-added' in the services and processes **(significance = 4, mean = 4.06)**	0 (0.0%)	1 (5.9%)	2 (11.8%)	9 (52.9%)	5 (29.4%)
4	Services and processes are provided competently **(significance = 2, mean = 4.18)**	0 (0.0%)	1 (5.9%)	1 (5.9%)	9 (52.9%)	6 (35.3%)
5	The bank is able to cope with a changeable business environment **(significance = 1, mean = 4.18)**	0 (0.0%)	1 (5.9%)	2 (11.8%)	7 (41.2%)	7 (41.2%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree						

- No strong disagreement was recorded on any of the statements that reflect the impact of KMEOntoBPA on core competences.

3) **Social Capital**

- (Q4.4) The exchange of knowledge across the bank is the most significant impact of KMEOntoBPA on social capital (mean = 4.41, significance = 1, rate = high).
- More than 85% of the sample (n=17) has strongly agreed or agreed on two statements regarding KMEOntoBPA support to social capital (see Table 6.15).
- More than 70% of the sample (n= 17) has agreed on all the statements regarding KMEOntoBPA support for social capital.
- No strong disagreement was recorded on any of the impacts of KMEOntoBPA on social capital.

Table 6.15: Frequency Distribution Analysis and Descriptive Statistics of KMEOntoBPA Impacts on Social Capital for the Financing Case Study (with Agreement > 85%)

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
4	Knowledge is exchanged across the bank **(significance = 1, mean = 4.41)**	0 (0.0%)	0 (0.0%)	0 (0.0%)	10 (58.8%)	7 (41.2%)
6	The bank is able to access complementary sources of expertise **(significance = 2, mean = 4.29)**	0 (0.0%)	0 (0.0%)	2 (11.8%)	8 (47.1%)	7 (42.2%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree						

According to previous findings, ‘knowledge building and unifying of information resources’, ‘the ability of the bank to cope with changeable business environment’ and ‘exchange of knowledge across the bank’ reflect sequentially the most significant implications of KMEOntoBPA on technical capabilities, core competences, and social capital. These are the sources of sustainable competitive advantage in the *Financing* case study of the bank. These results are in line with the interviewees responses that ensured that KMEOntoBPA supports ‘building knowledge’ and ‘achieving collaboration and exchanging knowledge across the bank’. Moreover, it ‘helps adapting changes to the environment’ (see label 6/ endixAppD.2).

6.4.4.2.3 Correlation between Advantages and the Impact on Sources of Sustainable Competitive Advantage

The correlation between the independent variable, the KMEOntoBPA advantages, and the dependent variable, the impact of KMEOntoBPA on sources of SCA, is examined using a scatterplot graph and Pearson’s correlation coefficient. The scatterplot graph indicates a relationship between KMEOntoBPA advantages and the KMEOntoBPA impact on the SCA variables (see Figure 6.10).

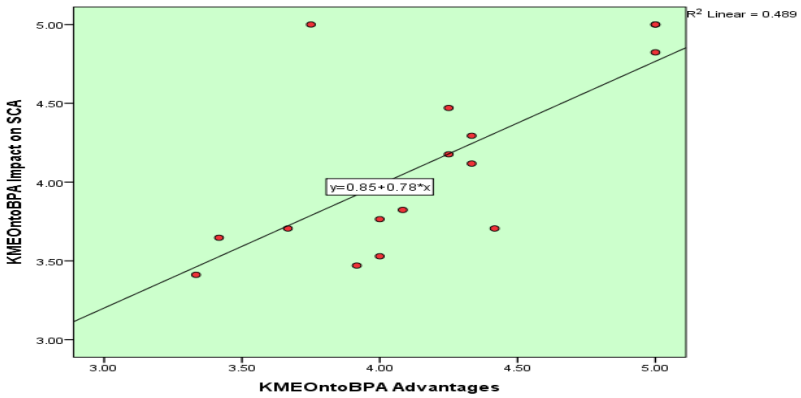


Figure 6.10: The Scatterplot Graph for Correlation Analysis

Pearson’s correlation p-values (.002) in Table 6.16 shows a significant positive relationship between KMEOntoBPA advantages and the impact of KMEOntoBPA on the sources of the SCA ($r = .002$, where $p < .005$). Consequently, the SLRA (or simple linear regression analysis) can be conducted.

The SLRA is performed in order to predict the relationship between KMEOntoBPA advantages and the impact of KMEOntoBPA on sources of the SCA variables. The level of significance/p-value (α) is set at 0.05. Thus, if p is ‘high’ ($p > 0.05$) then there is no evidence to reject the null hypothesis which is the non-significant positive effect between the independent and dependent variables. On the other hand, if p is ‘low’ ($p < 0.05$) then

rejecting the non-significant positive effect between the independent and dependent variables should be considered.

Table 6.16: Pearson's Correlations of the Financing Case Study

		KMEOntoBPA Advantages	KMEOntoBPA Impact on SCA
KMEOntoBPA Advantages	Pearson Correlation	1	.699**
	Sig. (2-tailed)		.002
	N	17	17
KMEOntoBPA Impact on SCA	Pearson Correlation	.699**	1
	Sig. (2-tailed)	.002	
	N	17	17
**. Correlation is significant at the 0.01 level (2-tailed).			

An analysis of variance shows that the positive effect of the KMEOntoBPA advantages on the impact of KMEOntoBPA on sources of the SCA is significant, ($F(1, 15) = 14.370$, $p = .002 < \alpha$) with an R square of .489 (see Appendix I).

6.5 Feedback on the DSRM Third Iteration and Concluding DSRM Iterations

The feedback of this iteration ensures the previous findings of the second iteration. The KMEOntoBPA design appeared to be correct, complete and valid after its demonstration and evaluation using the *Financing* case study and compared to the Riva "as-is" BPA. The elements of the knowledge-based BPA including CEBEs, EBEs, UOWs, CPs and CMPs are representative and reflect the real business of Financing in the bank. They are also represented with a formal naming according to the Financing-related documents in the bank. The organisational structure KME was asserted to have the highest contribution in generating CEBEs, EBEs and UOWs in all of the DSRM iterations. Furthermore, the KMEOntoBPA has shown its robustness and learning capabilities through its abilities to learn and adapt the potential knowledge resources in the environment of the *Financing* case study and evolve the knowledge-based BPA accordingly.

After the verification and validation of the KMEOntoBPA, the evaluation was carried out to assess the effectiveness of the KMEOntoBPA in developing a dynamic and agile BPA with a sustainable competitive advantage. The evaluation shows that the knowledge-based BPA in the *Financing* case study is dynamic and agile since it automates the generation of the CEBEs then the EBEs and adapts new knowledge resources in the Financing business. In addition, it supports the re-configuration of BPA elements by providing up-to-date naming or

removal of business entities such as *Utility Financing or Real State Financing* which can be introduced after SWRL rules execution with different names (For example: *Service Financing* instead of *Utility Financing*) or omitted at all from the KMEOntoBPA. The KMEOntoBPA also has the ability to achieve several advantages such as increasing the accuracy of service delivery, improving the financial control and reducing the cycle time of processes and services. Most of the KMEOntoBPA advantages were agreed with more than 85% of the sample. Moreover, the KMEOntoBPA has shown several impacts on the sources of the sustainable competitive advantage. No disagreement was recorded regarding the impacts of the KMEOntoBPA on technical capabilities and no strong disagreement was recorded in relation to the impacts of the KMEOntoBPA on core competences and social capital.

In this iteration, the correlation between the independent variable, the KMEOntoBPA advantages, and the dependent variable, the impact of KMEOntoBPA on sources of SCA has reported a significant positive relationship between both variable. Accordingly, the simple linear regression analysis was conducted and the analysis showed that the positive effect of the KMEOntoBPA advantages on the impact of KMEOntoBPA on sources of the SCA is significant.

Based on the previous feedback of the third iteration, a summary of this feedback is as follows (see Table 6.17):

Table 6.17: Summary of the Feedback of the DSRM Third Iteration using the Financing Case Study

No.	Outcomes
1	The knowledge-based BPA elements are correct, valid and the BPA is representative and reflects the real business environment of the Financing case study
2	The KMEOntoBPA has the ability to adapt the potential changes in knowledge resources of the Financing case study which adds robustness and learning capabilities to its developed knowledge-based BPA
3	The KMEOntoBPA automates the generation of CEBEs/EBEs. It is also dynamic and agile regarding the generation and re-configuration of different BPA elements
4	The KMEOntoBPA has several advantages and support sources of SCA including technical capabilities, core competences and social capital
5	There is a positive relationship detected between the KMEOntoBPA advantages and the KMEOntoBPA impact on the sources of SCA
6	The KMEOntBPA framework has ensured the evaluation of the second iteration using the Financing case study and achieved the objective of developing an effective BPA

In conclusion, the KMEOntoBPA framework has been developed using the iterations of the DSRM. These iterations have simplified and supported an understanding of the KMEOntoBPA development. They have also provided an incremental development and inspection of the KMEOntoBPA by using different banking case studies, which represent the core functionalities of the bank and complete its overall BPA. The first iteration has revealed significant defects in the KMEOntoBPA design regarding the missing services, which results in a framework that is still not complete or validated. These defects were addressed in the second iteration and the design of the KMEOntoBPA framework appeared to be complete and validated. The KMEOntoBPA framework has also been evaluated to assess its effectiveness and the objective of effectiveness is achieved using the second iteration. However, the KMEOntoBPA framework with new modifications needs to be evaluated using a different case study with another iteration in order to be inspected and ensure its achievement of its objectives. Thus, a final or a third iteration has concluded the DSRM iterations and informed the objective achievement of the KMEOntoBPA framework in developing an effective BPA. By meeting this objective, the third iteration of the DSRM could finalise the iterations of this research.

After finalising the iterations of the DSRM using the core banking case studies, a summary of CEBE numbers that have been translated into BPA elements pre and post using KMEs, is presented in Table 6.18.

Table 6.18: A Summary of the CEBE Numbers translated into Riva BPA Elements Pre and Post using KMEs in all DSRM Iterations

DSRM Iterations	Pre-KMEs/Riva "as-is" BPA		Post KMEs	
	EBEs	UOWs (Processes)	EBEs	UOWs (Processes)
First Iteration	36	17	45	9
Second Iteration	48	25	66	29
Third Iteration	37	17	70	20

The results in Table 6.18 show a variance of CEBEs that have been translated into the main elements of the Riva BPA before and after using KMEs. The first iteration using the *Treasury* case study shows that CEBEs that are classified as Treasury processes (UOWs) are fewer after using KMEs. Nevertheless, the EBEs are still higher and these EBEs and UOWs are considered more formal and thus it is possible use them as information entities for the bank *Treasury* case study. Conversely, the second and third iterations using the *Deposits* and

Financing case studies respectively, show that CEBEs after using KMEs are more representative for extracting a higher number of processes (UOWs). In addition, they have higher number of CEBEs that are classified as EBEs; they are also more formal and able to be used as information entities in the bank *Deposits* and *Financing* case studies.

6.6 Chapter Summary

This chapter is a final iteration of the DSRM, which addresses research question RQ4. This iteration was conducted to inspect and evaluate the KMEOntoBPA framework using different functionalities in another banking case study. The demonstration and evaluation phases of the DSRM were applied to the KMEOntoBPA using the *Financing* case study. The demonstration included a development of the Riva "as-is" BPA in addition to instantiation of the KMEOntoBPA ontologies using the KMEs input resources of the *Financing* case study. Different evaluation types were conducted after the demonstration phase. These evaluation types imply verification, validation, dynamism and support to the sustainable competitive advantage. The feedback of the evaluation shows that the KMEOntoBPA develops a correct, valid and representative knowledge-based BPA using the *Financing* case study and compared it to the Riva "as-is" BPA. The KMEOntoBPA also shows that the knowledge-based BPA is dynamic and agile in the generation of CEBEs, EBEs and their corresponding BPA elements. Furthermore, it has robustness and learning capabilities which are addressed through adapting the potential new knowledge resources and changes to Financing business. Moreover, the KMEOntoBPA has the ability to achieve several advantages and supports the sources of SCA which include technical capabilities, core competences and social capital. Finally, this chapter meets the objective of developing an effective BPA using the KMEOntoBPA and concludes DSRM iterations.

Chapter 7
Research Conclusion and Future Work

This research has investigated the possibility of developing a Riva-based BPA using KMEs, where both the BPA and KMEs are semantically represented using ontologies. Specifically, it is a knowledge-based approach that attempts to facilitate and automate the generation of the CEBEs in order to produce a dynamic BPA with a competitive advantage. The DSRM process model was applied to incrementally build, demonstrate and evaluate the research solution, namely, the KMEOntoBPA framework (review Figure 3.4 Chapter 3). The KMEOntoBPA identifies the knowledge resources or capabilities of the organisation using the abstract KMEs' ontology, the aKMEOnt, and employ them to extract the CEBEs according to the Riva BPA method. These knowledge-based CEBEs have been used to develop and generate a dynamic and competitive knowledge-based BPA. Thus, the use of semantic KMEs results in developing an effective BPA. In the next section, a fulfilment of the research questions and hypothesis is presented followed by bridging the research gap analysis. Thereafter, research main findings and contributions are discussed, and finally the research is concluded with research boundaries and limitations in addition to future work directions, respectively.

7.1 Fulfilment of the Research Questions and Research Hypothesis

In this section, the main outcomes of this research are summarised. These outcomes are used to answer the research questions and inform the research hypothesis. A bottom-up approach using the research primary concerns in addition to the research outcomes of the research chapters describe how the research hypothesis will be confirmed or unconfirmed (see Figure 7.1).

According to Figure 7.1, the first two research questions (RQ1 and RQ2) have been answered in Chapter 2. The first research question (RQ1: *What existing knowledge management enablers are appropriate to drive the process of BPA development?*) involves investigating the knowledge infrastructural capabilities (or KMEs) that are significant in implementing knowledge management and facilitating the sharing of knowledge resources in an organisation. Sections 2.3.2 and 2.4 are the main outcomes of Chapter 2 that answer the first research question (RQ1). Section 2.3.2 introduces knowledge as a critical strategic

resource and emphasises that the knowledge resource should be generated, captured and utilised by means of KMEs. Section 2.4 presents the KMEs that were found appropriate to drive the process of BPA development. These KMEs are *information technology, leadership, culture, organisational structure, business repository and knowledge context*.

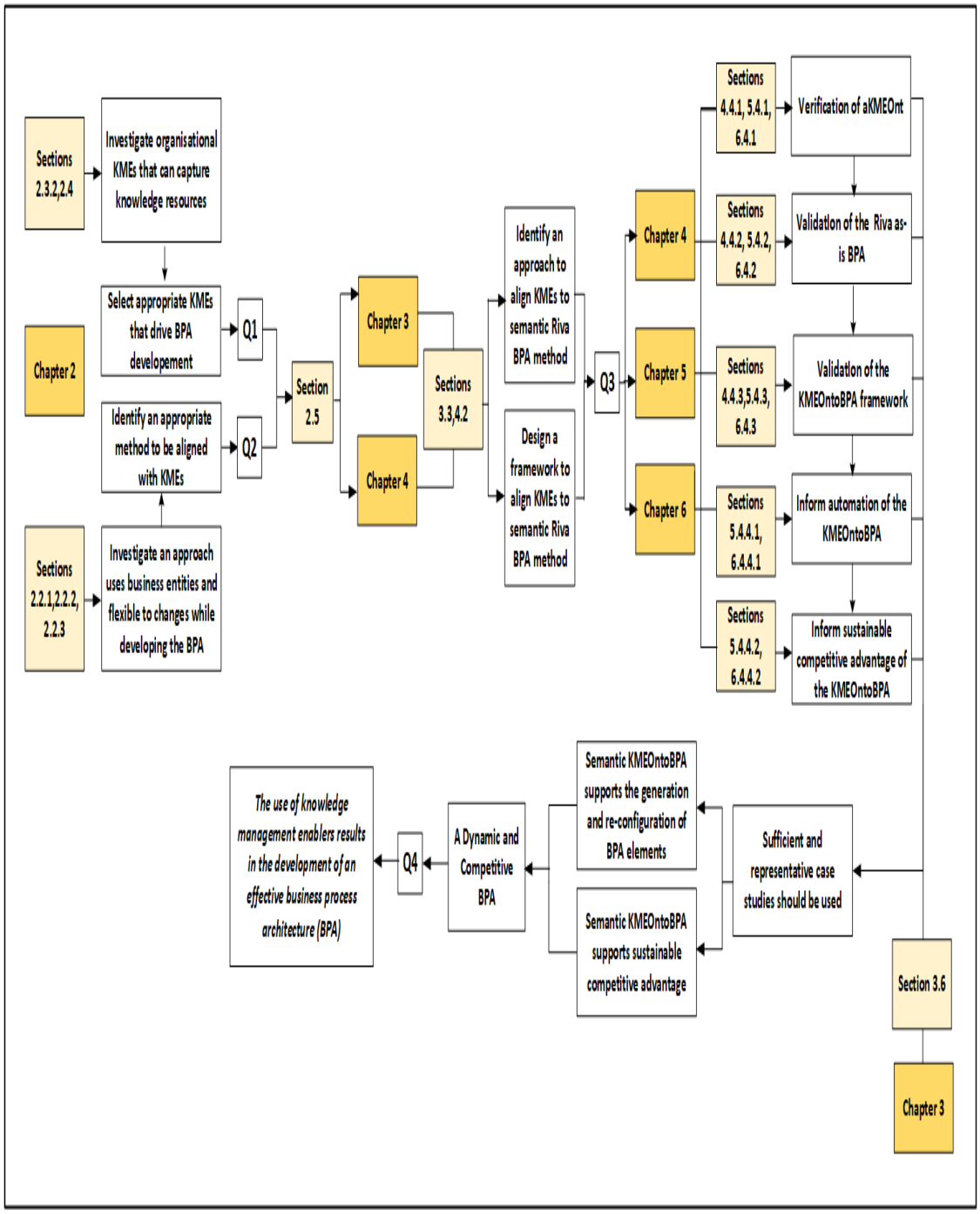


Figure 7.1: The Bottom-Up Answering of the Research Hypothesis

The second research question (RQ2: *What BPA method is appropriate to investigate the role of knowledge management enablers in driving the development of process architectures?*) is related to inspecting an appropriate BPA method. An appropriate BPA method in this research should be flexible in adopting knowledge resources in order to develop its elements.

Section 2.2.1 provides a brief review of BPA modelling approaches and leads the research coupled with the research gap analysis in Section 2.5 to identify the object-based BPA modelling, specifically the Riva method. *The Riva method is an appropriate approach since it can embrace and utilise knowledge resources as business entities in order to generate its elements*. However, the Riva method alone is still static and lacks tracking and adopting recent or changeable knowledge resources in order to be dynamic and generate or re-configure its elements regularly. Automated and flexible emerging features are required to meet these shortages. Therefore, Section 2.2.3 completes the answer to the second research question (RQ2) by presenting ontologies and the semantic Riva BPA, the *srBPA ontology*. The srBPA ontology provides the automation and flexibility features that are needed to align the Riva BPA method with the KMEs and achieve a dynamic BPA. The gap analysis in Section 2.5 guides the research towards addressing its third question (RQ3). The gap analysis is summarised by the following: (1) BPA modelling approaches are not dynamic and not flexible enough to adopt changes and be competitive; (2) knowledge management which supports competitive advantage through acquiring and evolving knowledge in dynamic settings is not utilised in BPA modelling approaches and is only directed towards business process management; (3) KMEs which are recommended in KM implementation in order to improve dynamic capabilities are not formally utilised to drive the development of business processes; and finally (4) the Riva BPA method requires an independent method that generates dynamic CEBEs in order to be an effective BPA.

The third research question (RQ3: *How can knowledge management enablers be used to drive the development of BPA?*) is concerned with investigating an approach to aligning the KMEs with the semantic Riva BPA. Answering this question has been accomplished in this research through the development of a process enacted by the KMEOntoBPA which is presented in Section 3.3 and 4.2. The process starts by utilising the KMEs in a particular domain of expertise such as the bank case studies in this research. Accordingly, the CEBEs of the KMEs are identified. These CEBEs are the key entities in the Riva BPA method, which the srBPA ontology leads through the development of semantic enriched BPA for a particular domain of interest. Utilisation of KMEs includes the steps of KMEs and CEBEs instantiation. These steps are followed by the srBPA instantiation which is summarised by the steps of instantiating EBEs, UOWs, generate relations, CPs, CMPs, request relations, start relations, and deliver relations, respectively.

The new proposed solution, the KMEOntoBPA framework, requires an evaluation of its effectiveness in order to answer the fourth research question (RQ4: *To what extent can knowledge management enablers drive the development of an effective BPA?*). The effectiveness has been determined by the achievement of a dynamic BPA with a sustainable

competitive advantage. The competitive advantage should be sustainable in order to ensure that the new BPA approach is strategic and adds a sustained superior performance over competitors on long term (Nyaga and Whipple, 2011). The CSPs could support the sustainability feature if it is well-developed in Riva method. However, the new semantic KMEs with knowledge resources that support dynamism in the overall BPA can be sufficient to address dynamic environment, provide a strategic resource-based vision and achieve sustainability .The assessment of these objectives is not applicable without the verification and validation of the KMEOntoBPA using sufficient and representative case studies. The representative and sufficient cases studies, which were introduced in Section 3.6, can support an incremental, complete development and evaluation of the KMEOntoBPA and its developed knowledge-based BPA. The KMEOntoBPA is verified through the new aKMEOnt component using the case studies of the DSRM iterations in Sections 4.4.1, 5.4.1 and 6.4.1. The elements of the KMEs of each case study were correctly captured and the instantiation of the aKMEOnt showed the same number and semantics of the KMEs elements without reporting errors while checking consistency using the Protégé Tool.

The validation test is accomplished by checking the CEBEs and comparing the knowledge-based BPA with the validated Riva "as-is" BPA along with the support of domain experts in each case study. The Riva "as-is" BPA is validated in Sections 4.4.2, 5.4.2 and 6.4.2 for each case study. The domain experts of each case study have validated the elements of the Riva "as-is" BPA including EBEs, UOWs, CPs and CMPs and their corresponding relationships. Checking CEBEs and comparing the knowledge-based BPA with the Riva "as-is" BPA for each case study is explained in Sections 4.4.3, 5.4.3, and 6.4.3. The validation of the first iteration in Section 4.4.3 showed shortcomings in the CEBEs, specifically the services CEBEs, which reflected the other BPA elements and caused defects in the knowledge-based BPA regarding a reflection on the real workflow of business and the abilities to adopt changes. Thus, the knowledge-based BPA was still not complete and modifications were implemented on the KMEOntoBPA framework design in the second iteration. On the other hand, the validation of the second iteration in Section 5.4.3 showed that the CEBEs are representative and their derived knowledge-based BPA is complete and reflects the real workflow of business with abilities to adopt changes and learn new knowledge resources. According to this validation the objective of a dynamic and competitive BPA is evaluated in Sections 5.4.4.1 and 5.4.4.2. The knowledge-based BPA in these sections showed potential abilities to adopt new knowledge resources and generate new CEBEs. This is, in addition to a re-configuration of BPA elements, which results in the knowledge-based BPA being dynamic and agile. Furthermore, the findings of the questionnaires supported by an interview showed that the knowledge-based BPA has several advantages and supports sources of SCA

including technical capabilities, core competences and social capital. These results in the second iteration needed to be inspected and emphasised with another iteration and evaluation using a different case study in Sections 6.4.3, 6.4.4.1 and 6.4.4.2. The validation of the knowledge-based BPA in Section 6.4.3 ensured the same results of validation in Section 5.4.3 and accordingly the knowledge-based BPA was evaluated regarding dynamism and support to sources of SCA in Sections 6.4.4.1 and 6.4.4.2. This evaluation showed that the knowledge-based BPA after the modifications to the KMEOntoBPA framework design in the second iteration can still be dynamic and agile using a different case study; and several advantages were recorded in addition to its support for sources of SCA.

In conclusion, the collective findings in answering the above research question, lead to a conjecture that using KMEs to drive the development of object-based BPAs (such as Riva) results in an effective business process architecture where dynamism and sustainable competitive advantage are attained. However, these conclusions suggest the potential generalisation of findings using further larger scale case studies in different domains such as healthcare and manufacturing.

7.2 Bridging the Research Gap Analysis

In this research, bridging the gap analysis has been addressed through the following: (1) *applying the appropriate knowledge infrastructural capabilities or KMEs*; (2) *finding an appropriate business process architecture*; and (3) *using the semantic ontologies*.

Using the selected KMEs in this research (leadership, information technology, organisational structure, culture, business repository and knowledge context) has supported the dynamic capabilities of the BPA. Each KME in relation with other KMEs had a role in dynamic generation, re-configuration and tracking different knowledge resources which exist in each case study. In addition, some of these knowledge resources involve crucial processes that reflect the real business in each iteration and develops its BPA. They also accept the changes in the business environment and accordingly provide dynamic elements to the BPA, which implies Riva CEBEs, EBEs, UOWs and their corresponding elements. Thus, the KMEs have achieved a dynamic feature and facilitated the implementation of knowledge management.

Finding an appropriate BPA in order to utilise KMEs and their dynamism is related to embracing different knowledge resources as business objects. Riva is an object-based BPA method that has shown its ability to employ different knowledge resources as business entities. These business entities have been considered as CEBEs which can be filtered into Riva BPA elements in order to develop a BPA that can accept new knowledge resources from different KMEs. Subsequently, the Riva method has demonstrated through its

application to representative and sufficient banking case studies that an object-based BPA approach can adopt knowledge management through its enablers and develop its process architecture.

Using semantic ontologies is related to the dynamism of a BPA and its linkage with different KMEs. The KMEOntoBPA has automated the generation and re-configuration of EBEs in the different bank case studies. It has also shown the Riva BPA's flexibility to adopt and track new knowledge resources as CEBEs/EBEs and develop the bank case studies UOW diagrams, 1st and 2nd cut process architectures. Hence, a dynamic BPA method in addition to an "EBE-independent method for classifying businesses objectively and accurately" (Beeson, Green and Kamm, 2013, p.56), is achieved and supported by using semantic ontologies.

Finally, the main elements that bridge the gaps in this research which include KMEs, the Riva BPA method and semantic ontologies have constructed the research framework, i.e., the KMEOntoBPA. The KMEOntoBPA has introduced a dynamic BPA which has resulted in a BPA that supports sources of sustainable competitive advantage using the bank *Deposits* and *Financing* cases studies.

7.3 Research Main Findings

The research main findings are summarised as follows:

(1) Information technology, leadership, culture, organisational structure, business repository and knowledge context are appropriate KMEs that can be used to generate representative CEBEs. However, the contribution of each of these KMEs in generating EBEs, UOWs and their corresponding BPA elements differs in the number and the importance of these elements since a KME can generate only EBEs while another can derive EBEs that are classified as UOWs. In addition, the organisational structure KME has the highest contribution with regard to generating different BPA elements, which is reasonable since the semantic representation of this KME has significant concepts that characterise the core business of the bank such as positions, and business behaviours like services and functions.

(2) There is a variance of CEBEs pre and post using KMEs. The number of CEBEs translated into processes using the *Treasury* case study is less than the pre-KMEs (the Riva "as-is" BPA) ones. However, the CEBEs post-KMEs are dynamic, more formal and can be used as information entities. On the other hand, the number of CEBEs translated into processes in the *Deposits* and *Financing* case studies is more than the pre-KMEs (the

Riva "as-is" BPA) ones. They are also dynamic, more formal and representative compared to the pre-KMEs ones.

(3) The Riva BPA method is an appropriate object-based BPA method that can embrace different knowledge resources in order to translate them into business objects that are considered as CEBEs.

(4) Using semantic ontologies is an appropriate approach to support a dynamic BPA. Semantic ontologies can align between disciplines such as the KM and the BPA as demonstrated in the banking case studies. They can also support an agile generation and re-configuration of BPA elements with robustness and learning capabilities, which are achieved through adapting the potential new knowledge resources which represent changes to the business environment. Furthermore, they resolve problems of semantic heterogeneity such as different terms that define a *Bank Customer*, which include *Corporate, Local Bank, Foreign Bank, Central Bank, Retail and SMEs*.

(5) Aligning KMEs with a Riva BPA using a semantic driven approach generates a knowledge-based BPA that has shown several possible advantages such as: (i) increasing the accuracy of service delivery and improving the financial control (with mean scores of 4.56 in *Deposits* and 4.53 in *Financing* case studies); and (ii) reducing the cycle time of processes and services (with mean scores of 4.56 in *Deposits* and 4.29 in *Financing* case studies). It also supports the sources of sustainable competitive advantage as no disagreements were recorded in the *Deposits* case study regarding the impacts of KMEOntoBPA on technical capabilities, core competences and social capital. No disagreements were also recorded regarding the impacts of the KMEOntoBPA on technical capabilities in the *Financing* case study, and no strong disagreement in relation to the impacts of the KMEOntoBPA on core competences and social capital. In addition, more than 80% of the sample in the *Financing* case study strongly agreed or agreed on three statements regarding the KMEOntoBPA support to core competences, while more than 70% agreed on all the statements regarding KMEOntoBPA support to social capital.

(6) The implementation of KMEs using semantic ontologies provides a concrete application to KM and highlights the flow of knowledge in the bank in relation to its business processes. This implementation supports the bank in planning their resources and developing a strategy based on a knowledge-based view.

(7) The DSRM appeared to be an appropriate methodology in relation to investigating the role of KMEs in driving the development and demonstration of the KMEOntoBPA framework using the banking case studies.

7.4 Research Contributions

The main contributions of this research can be summarised by the following:

- **The KMEOntoBPA Framework**

The KMEOntoBPA framework is the main research artefact. The KMEOntoBPA stems initially from the RBV (or resource-based view) of organisations, which emphasises the value of organisation resources in sustaining a competitive advantage. It also stimulates the consideration of KM enabling factors during knowledge management implementation. The KMEOntoBPA adopts the RBV and its KMEs consideration and develops a semantic-based framework in order to achieve a dynamic and competitive BPA. This knowledge-based BPA automates the generation of BPA and supports the dynamic re-configuration and traceability of its elements and their original sources. The KMEOntoBPA framework has also revealed different advantages using the Deposits and Financing case studies such as increasing the accuracy of the service delivery, simplifying work procedures and decreasing bottlenecks in the work system. In addition to these advantages, the KMEOntoBPA has shown its support for sources of sustainable competitive advantage. This framework can be further enriched to include domain specific the KMEs meta-model. Two sub-contributions arises from the KMEOntoBPA:

a. The Abstract Knowledge Management Enablers Ontology (aKMEOnt)

The aKMEOnt is one of the main artefacts in the KMEOntoBPA framework and it is a significant outcome of this research. The aKMEOnt is an abstract ontology of the KMEs domain that has been constructed using the ontology method introduced by Noy and McGuinness (2001). Information technology, leadership, culture, organisational structure, knowledge context and business repository are the utilised KMEs in the aKMEOnt. The aKMEOnt enables a formal shared understanding of the KMEs domain which can be presentable and usable in the knowledge management area. It simplifies the application of KM in organisations and supports controlling its different processes. It also provides an abstract view of the KMEs domain for decision makers and facilitates the description of the flow of knowledge in organisations. Furthermore, it contributes towards automating the alignment between KM, business processes and computer-based systems. The aKMEOnt has a significant role in building a knowledge-based BPA throughout the semantic process of identifying the CEBEs for the Riva BPA method.

b. KMEs-driven Riva BPA method

As a product of this research, the object-based Riva method has been extended to include KMEs in driving the BPA development, but it still maintain the original Riva method rigour

in checking on the conformance of CEBEs identification leading into the EBEs, UOWs, 1st and 2nd cut process architectures steps.

- **A Banking Riva-based BPA**

A Riva-based BPA for the banking business, specifically Islamic banking, has been introduced in this research as a prototype that has been validated by a banking institution. This BPA contributes to the banking financial domain. It facilitates an understanding of the banking business and the general differences between Islamic and non-Islamic banking. Moreover, it supports the development of its model of processes and generates a solution to adopting KM in that domain. However, it certainly needs wider evaluation by several banking institutions before it can be classified as a reference BPA model for banking.

7.5 Research Boundaries and Limitations

This research focuses mainly on the proposition that semantic KMEs can be a driver for the development of an effective BPA that is based on an object-based method and, in particular, the Riva method (Ould, 2005). Therefore, this research is limited to the KMEs' area and does not extend to other areas in the same discipline such as KM methods or processes. The selected KMEs within this research have been identified based on their significance to KM implementation (Theriou, Maditinos and Theriou, 2011).

With regard to the section related to the Riva method, the research implementation for the BPA elements in the 1st and 2nd cut PA diagrams is limited to the CMPs and CPs. The case strategy processes are eliminated since "the CSP concept is not developed as the CP and CMP concepts" in the Riva method (Beeson, Green and Kamm, 2013, p.40) and heuristics regarding the CSPs are not highlighted in the Riva method (Ould, 2005). Moreover, the research is mainly interested in the agile and sustainable competitive advantage implications of using the KMEs in the overall BPA development. The development of the CSPs is not the specific interest of this research and they have not been developed in the ontology Riva method.

This research is also limited to the BPA development of the core functionalities of the selected bank, which include the case studies of *Treasury, Deposits* and *Financing*. Each case study is restricted to a specific part of the bank. The *Treasury* and *Financing* case studies are related to the bank headquarters while the *Deposits* case study is related to a bank branch. Expanding the scope of the research to cover all business functions of the bank in order to evaluate the research framework (review Figure 3.4 Chapter 3), i.e., the KMEOntoBPA, requires further complex arrangements to conduct workshops and training regarding the Riva method and the KMEOntoBPA framework. It also involves the

attendance of extra domain experts and senior employees who work in relation to these core functionalities. Such aspects are challenging and are beyond the bank's abilities within the limited time of this research and are not considered as impacting on the research conclusions.

Finally, other limitations are related to the instances or the input knowledge resources that instantiate the overall concepts of the KMEOntoBPA framework. The bank requested the concealment or omission of any knowledge resources that are not related to the derivation of the CEBEs and hence to ensure they are confidential unless they are necessary or obligatory in the KMEOntoBPA instantiation.

7.6 Future Work Directions

- **Using aKMEOnt with Different Business Process Modelling Approaches**

This research used the aKMOnt to drive the development of an object-based BPA method. For future work, it is recommended that aKMEOnt is applied in order to lead the development of different business process modelling approaches such as the role-based, function-based and goal-based ones.

- **Deriving EIA and SOA from the aKMEOnt**

In previous research, the srBPA was used to derive the Enterprise Information Architecture (EIA) (Ahmad, 2014) and Service Oriented Architecture (SOA) (Yousef, 2010). Using the aKMEOnt in order to derive these architectures can be aimed at providing a dynamic EIA and SOA with a competitive advantage. Thus, the aKMEOnt will be able to bridge the gap between the KM domain on the one hand and the SOA and EIA domains on the other hand.

- **Enhancing the KMEOntoBPA Framework with Different Business Domains**

The KMEOntoBPA currently applies six main KMEs. These KMEs can be enhanced or more efficiently utilised with other case studies in different business domains. Other business domains can reveal whether each KME in a BPA development can significantly be different in its overall effectiveness. It also states whether the aKMEOnt can be generalised to further business domains.

- **Using aKMEOnt in the Reverse Engineering of Business Processes**

The dynamic state of the aKMEOnt and the inference reasoning among its elements can play an important role in the reverse engineering of business process models. The aKMEOnt can detect missing elements or problems that the business processes must handle or repair, in addition to managing business changes in the organisation.

- **Developing of Processes Meta-Models using the KMEOntoBPA Framework**

Processes meta-models are to be developed to inform the operationalisation of the KMEOntoBPA framework in terms of its dynamism and sustainable competitive advantage. In this regard, processes meta-models for CPs, CMPs, and CSPs can be developed to inform effectiveness not only from a BPA perspective, but also from a workflow-based point of view (i.e. at the level of business process models), and therefore, full traceability from KMEs through BPA to workflow models can be achieved to inform conformance to dynamism and the attainment of a sustainable competitive advantage in a workflow managed context.

7.7 Conclusion Remarks

The development of Riva BPA method using KMEs can produce a dynamic BPA with a competitive advantage if semantic ontologies are grounding this alignment. The semantic KMEs present dynamic and up-to-date knowledge resources that are filtered to CEBEs then to EBEs which constitute the main building block of the Riva method. This new approach of generating BPA elements adds a new value to the Riva-based BPA regarding dynamism and competitive advantage. It also employs the knowledge management, specifically the KMEs, in addressing dynamic business challenges through the development of an effective BPA as well as resolving the static disadvantage in current BPA modelling approaches. In addition, it directs the research towards an important area such as process architectures and suggests different future work which facilitates the integration between business and information systems domains.

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Appendix A
The srBPA Main Elements

A.1 srBPA Main Concepts and Attributes

The srBPA presents semantically the main elements of the Riva method which include EBE, UOW, CP and CMP and their corresponding relationships. An overview of these elements is shown in Table A.1. Main classes and attributes are described to understand key concepts and the relations between them.

Table A.1: srBPA Main Concepts and Attributes (Yousef and Odeh, 2014)

Concept	Description	Attributes
EBE	The Essential Business Entities of an enterprise.	1) isConsideredUOW: Boolean.
UOW_Diagram	The units of work diagram according to the Riva method.	1) hasUOW of type UOW, and 2) hasOutsideWorld of type Outside_world.
PA_1st_Cut_Diagram	The 1st cut process architecture diagram according to the Riva method.	1) hasCP of type CP, 2) hasCMP of type CMP, and 3) hasOutsideWorld of type Outside_world.
PA_2nd_Cut_Diagram	The 2nd cut process architecture diagram according to the Riva method.	1) hasCP of type CP, 2) hasCMP of type CMP, and 3) hasOutsideWorld of type Outside_world.
UOW	The units of work in the UOW diagram, according to the Riva method.	1) belongsToUOWDiagram of type UOW_Diagram, 2) hasCorrespondingCP of type CP, and 3) hasGenerateRelation of type Generate.
CP	The case processes in the 1st cut and 2nd cut PA diagrams, according to the Riva method.	1) belongsTo1stCutDiagram of type PA_1st_Diagram, 2) belongsTo2ndCutDiagram of type PA_2nd_Diagram, 3) hasCorrespondingUOW of type UOW, 4) hasRequestRelation of type Rrequest, 5) hasDeliverRelation of type Deliver, 6) hasStartRelation of type Start.
CMP	The case management process in the 1st cut and 2nd cut PA diagrams, according to the Riva method.	1) belongsTo1stCutDiagram of type PA_1st_Diagram, 2) belongsTo2ndCutDiagram of type PA_2nd_Diagram, 3) hasManagingCP of type CP, 4) hasStartRelation of type Start, and 5) isActive of type Boolean.
Outside_World	The outside world in the UOW, 1st cut and 2nd cut PA diagrams, according to the Riva	1) hasOutsideWorld _Relation of type Outside_relation, 2) belongsToUOWDiagram of type

	method.	UOW_Diagram, 3)belongsTo1stCutDiagram of type PA_1st_Diagram, and 4) belongsTo2ndCutDiagram of type A_2nd_Diagram.
Generate	The generate relationship in the UOW diagram between UOW class members.	1) hasUOWSource of type UOW, 2) hasUOWDestinaiton of type UOW, and 3) belongsToUOWDiagram of type UOW_Diagram.
Request	The relationship in the PA diagram between members of the CP and the CMP classes.	1) hasCPSource of type CP, 2) hasCPDestination of type CP, 3) hasCMPDestinaiton of type CMP, 4) isActive of type Boolean, 5) belongsToPA1Diagram of type PA_1st_cut_diagram, and 6) belongsToPA2Diagram of type PA_2nd_cut_diagram.
Deliver	The deliver relationship in the PA diagrams between the CP class members.	1) hasCPSource of type CP, 2) hasCPDestinaiton of type CP, 3) isActive of type Boolean, 4) belongsToPA1Diagram of type PA_1st_cut_diagram, and 5) belongsToPA2Diagram of type PA_2nd_cut_diagram.
Start	The start relationship in the PA diagrams between members of the CP and the CMP classes.	1) hasCMPSource of type CMP, 2) hasCPSource of type CP, 3) hasCPDestinaiton of type CP, 4) isActive of type Boolean, 5) belongsToPA1Diagram of type PA_1st_cut_diagram, and 6) belongsToPA2Diagram of type PA_2nd_cut_diagram.
Outside_relation	The relation from the outside world to a member of the UOW, CP or CMP classes.	1) hasOutsideWorldSource of type outside_world, 2) hasUOWDestination of type UOW, 3) hasCPDestination of type CP, 4) hasCMPDestination of type CMP, 5) isActive of type Boolean, 6) belongsToPA1Diagram of type PA_1st_cut_diagram, 7) belongsToPA2Diagram of type PA_2nd_cut_diagram, and 8) belongsToUOWDiagram of type UOW_Diagram.

The EBE class defines the essential business entities of the a case study. EBE has a boolean property isConsideredUOW which is set true for the all EBE instances that are considered as UOWs.

Generating Riva process architecture (PA) requires defining three classes to represent three diagrams: the UOW diagram, the 1st cut diagram and the 2nd diagram. The members of the defined classes UOW, CP and CMP which set up these diagrams are related to each other through the object properties: hasUOW, hasCP, hasCMP and hasOutside_World.

The UOW class creates the instances of the units of work that constitute the UOW diagram. UOWs are the members of EBEs that are considered as UOWs and its isConsideredUOW property is set true.

The case process (CP) and case management process (CMP) classes generate the 1st and 2nd cut diagrams. A set of object properties defines the diagram type to which each of the defined classes belongs to. The other object properties are used to reinforce the Riva rules. For example hasCorresponding CP and hasManagingCP are used to ensure that every UOW corresponds to a CP and every CMP has a CP corresponds to it, respectively.

Finally, the last four classes (generate, request, start, deliver) are used to present the relationships in the Riva diagrams. Generate class implies a UOW generates another. Request class indicates that a CP is calling a CMP. Start class connects a CMP to its corresponding CP and deliver class links CP to a CP or CMP to a CP.

A.2 srBPA Riva Steps and SWRL Rules

Semantic Web Rule Language (SWRL) presents the Riva rules that govern the relationship between Riva concepts and translate into proper diagrams. Table A.2 summarises these rules.

Table A.2: SWRL Rules used in srBPA and their Explanations (Yousef and Odeh, 2014)

SWRL Rule	Description
Rule_UOW_Instances: EBE(?x) ^ isConsideredUOW(?x, true) →UOW(?x)	Units of work are the essential business entities as can be decided to be considered UOW.
Rule_hasCorrespondingElement: hasCorrespondingCP(?x,?y) → hasCorrespondingUOW(?y,?x)	This rule emphasizes that only elements corresponding to each other, do so in both directions. So, if a UOW corresponds to a CP, then this CP also corresponds to that UOW.
Rule_hasGenerateRelation.: UOW (?u) ^ hasGenerateRelation (?u, ?g) →Generate(?g) ^ hasUOWSource (?g, ?u)	All relations between UOWs are Generate relation. i.e. each UOW generates (or calls for or demands or activates or requires) another UOW. Although the concepts generate, calls for,demands, … each may include different functionalities or meanings but they can be treated the same in Riva. So

	we use the name Generate to refer to all these concepts and to mean in general that it will cause the generation of another UOW.
Rule_1st_cut_translated_relations: UOW(?a) ^ UOW(?b) ^ Generate(?g) ^ hasUOWSource(?g,?a) ^ hasUOWDestination(?g, ?b) ^ hasCorrespondingCP(?a, ?acp) ^ hasCorrespondingCP(?b, ?bcp) ^ CP(?acp) ^ CP(?bacp) ^ hasManagingCP(?bcmp,?bcp) ^ CMP(?bcmp) ^ hasRequestRelation(?acp, ?r) ^ hasStartRelation(?bcmp, ?s) ^ hasDeliverRelation(?bcp, ?d) ^ PA_1st_cut_Diagram(?d1) → Deliver(?d) ^ hasCPSource(?d, ?bcp) ^ hasCPDestination(?d, ?acp) ^ Request(?r) ^ hasCPSource(?r, ?acp) ^ hasCMPDestination(?r, ?bcmp) ^ Start(?s) ^ hasCMPSource(?s, ?bcmp) ^ hasCPDestination(?s, ?bcp) ^ belongsTo1stCutDiagram(?acp,?d1) ^ belongsTo1stCutDiagram(?bcp,?d1) ^ belongsTo1stCutDiagram(?bcmp,?d1)	This long, yet simple, rule directly translates step 5 in the Riva method, where it states that the three relations in the 1st cut diagram,“Deliver”, “Request” and “Start” along with their proper sources and destinations are there because of a relation “Generate” between two UOWs. The sources and destinations of these two UOWs correspond to the CPs and CMPs in the 1st cut diagram.
Rule_inactive_CMP_relevant_Relations: CMP(?bcmp) ^ isActive(?bcmp, False) ^ hasStartRelation(?bcmp, start) ^hasRequestRelation(?acp, ?request)^ hasCMPSource(?request, ?bcmp) → Request(?request) ^ isActive(?request, False) ^ Start(?start) ^ isActive(?start, False)	This rule ensures that when we apply the heuristics to delete a CMP from the 2nd cut PA diagram, all relations related to it are deleted recursively.

Appendix B

Design of English and Arabic Version of the Research Questionnaire and Interview

B.1 English and Arabic Version of Research Questionnaire

Faculty of Environment and Technology
SERG Group

Dear All,

This questionnaire is part of a PhD study about **Investigating the Role of Knowledge Management in Driving the Development of an Effective Business Process Architecture: The Case of Banking in Jordan.** This questionnaire consists of two sections:

The **first section** investigates the advantages of using the application of the KMEOntoBPA in the development of a business process architecture (BPA) in the bank Deposits/ Financing case study.

The **second section** investigates the extent to which the KMEOntoBPA application supports the underlying sources of the sustainable competitive advantage of the bank Deposits/Financing case study via **Technical Capabilities, Core Competences** and **Social Capital.**

We would be very appreciative if you spent 15 minutes to complete the attached questionnaire and return it to the researcher. In addition, we can assure you that all information provided will be treated confidentially and used for research purposes only.

Thank you for your participation in this study. Please don't hesitate to contact us if you have any questions regarding this survey or the study.

Yours faithfully,

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Section One – Development of the BPA using the KMEOntoBPA:

This section presents the advantages of using the application of the KMEOntoBPA in the development of a BPA in the bank Deposits/ Financing case study.

Q1. To what extent do you agree that the application of KMEOntoBPA can yield the following advantages in the Financing/Deposits case study? Please put [x] in the appropriate box **[1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree]**

No.	Paragraph	1	2	3	4	5
1	Reducing the cost of process and services					
2	Simplifying work procedures and decreasing bottlenecks in the work system					
3	Reducing cycle time of processes and services					
4	Increasing the quality of services					
5	Automating processes and services					
6	Improving streamlining amongst services and processes					
7	Increasing the accuracy of services' delivery and improving the financial control					
8	Identifying technology tools in an organisation					
9	Making fast and rational decisions					
10	Developing workers' skills and knowledge					
11	Improving the coordination and information sharing amongst all levels and departments throughout the organisational structure of the bank					
12	Improving balance amongst responsibilities and authorities					

Section Two: Underlying sources of Sustainable Competitive Advantage

This section consists of three questions which aim to investigate to what extent the application of the KMEOntoBPA supports the underlying sources of the sustainable competitive advantage of the bank Deposits/Financing case study.

.**Q2.** To what extent do you agree or disagree with the following statements regarding KMEOntoBPA support and its relationship to **Technical Capabilities** of the bank Financing/Deposits case study, please put [x] in the appropriate place **[1= strongly disagree, 2 = disagree, 3 = neutral , 4 = agree , 5 = strongly agree]**

No.	Paragraph	1	2	3	4	5
1	There is knowledge building and the unifying of information resources					
2	Tracking and maintenance of the processes and services are regular					
3	Computerised systems in documentation and databases are used					
4	There is a standardisation and simplification of the processes and procedures via technical systems					
5	There is coordination amongst departments and branches					
6	(Internal) customer feedback is integrated in the design of procedures and processes					

Q3. To what extent do you agree or disagree with the following statements regarding the KMEOntoBPA support and its relationship to **Core Competencies** of the bank Financing/Deposits case study. Please put [x] in the appropriate place **[1= strongly disagree, 2 = disagree, 3 = neutral , 4 = agree , 5 = strongly agree]**

No.	Paragraph	1	2	3	4	5
1	New knowledge and experiences are provided					
2	There is an improvement of 'value-added' in the services and processes					
3	They provide protection and build on the current competitive position					
4	Services and processes are provided competently					
5	The bank is able to cope with a changeable business environment					

Q4. To what extent do you agree or disagree with the following statements regarding the KMEOntoBPA support and its relationship to **Social Capital** of the bank Financing/Deposits case study, please put [x] in the appropriate place **[1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree]**

No.	Paragraph	1	2	3	4	5
1	The communication system in problem solving is effective					
2	Relationships with the customers are positive					
3	There is cooperation amongst employees					
4	Knowledge is exchanged across the bank					
5	There is consistency in the organisational structure					
6	The bank is able to access complementary sources of expertise					

Many Thanks

جامعة غرب انجلترا
كلية البيئة والتكنولوجيا
فريق سيرج للبحوث العلمية

السادة البنك العربي الإسلامي الدولي ،

تحية طيبة وبعد ،

هذه الاستبانة هي جزء من متطلبات الحصول على درجة الدكتوراة بعنوان **استكشاف دور إدارة المعرفة في قيادة تطوير كفاءة هيكل عمليات الأعمال**. تتكون الاستبانة من أربعة قسمان هما كالآتي :

القسم الأول / وخاص بالتحقق من منافع استخدام KMEOntoBPA في تطوير هيكل عمليات الأعمال لحالة دراسة الودائع/التمويلات في البنك.

القسم الثاني / وهو خاص بالتحقق من مدى دعم KMEOntoBPA لعناصر الميزة التنافسية المستدامة لحالة دراسة الودائع/التمويلات البنكية من خلال القدرات التقنية والكفاءات الجوهرية ومن ثم شبكة العلاقات الاجتماعية.

يرجى التكرم بمنح ما لا يزيد عن 15 دقيقة للإجابة على فقرات الاستبانة ومن ثم تسليمها للباحث. ونؤكد حفاظنا على سرية المعلومات المقدمة والمستخدمة لغايات البحث العلمي فقط ، شاكرين لكم المشاركة ومرحبين بأي استفسارات تخص هذه الاستبانة أو موضوع البحث.

مع فائق الشكر والتقدير

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القسم الأول –منافع استخدام KMEOntoBPA في تطوير هيكل عمليات الأعمال

يتضمن هذا القسم تقديم صورة واضحة حول منافع استخدام KMEOntoBPA في تطوير هيكل عمليات الأعمال لحالة دراسة الودائع/التمويلات البنكية.

1. إلى أي مدى توافق أو لا توافق على أن تطوير هيكل عمليات الأعمال في البنك باستخدام KMEOntoBPA سيضيف المنافع التالية. يرجى وضع إشارة [x] في المربع المناسب **[1 = لا أوافق بشدة ، 2 = لا أوافق ، 3 = محايد ، 4 = أوافق ، 5 = أوافق بشدة].**

الرقم	الفقرة	1	2	3	4	5
1	تقليل كلفة العمليات والخدمات					
2	تبسيط الإجراءات وتقليل الاختناقات في نظام العمل					
3	تقليل الوقت اللازم لإنجاز العمليات والخدمات					
4	تحسين جودة الخدمات					
5	أتمتة العمليات والخدمات					
6	تحسين تناسق العمليات والخدمات					
7	تحسين دقة الخدمات والرقابة المالية					
8	تحديد التقنيات / التكنولوجيا المستخدمة					
9	اتخاذ القرارت العاجلة والراشدة					
10	تطوير معرفة ومهارات العاملين					
11	زيادة التنسيق وتبادل المعلومات بين مستويات وأقسام البنك المختلفة					
12	تحسين التوازن بين المسؤوليات والسلطات					

القسم الثاني – المصادر الأساسية للميزة التنافسية المستدامة:

يتضمن هذا القسم ثلاثة أسئلة تهدف إلى استكشاف مدى دعم KMEOntoBPA للمصادر الأساسية للميزة التنافسية المستدامة لحالة دراسة الودائع/التمويلات البنكية.

2. إلى أي مدى توافق أو لا توافق على الفقرات التالية والمتعلقة بدعم KMEOntoBPA للقدرات التقنية لحالة دراسة الودائع/التمويلات البنكية. يرجى وضع إشارة [x] في المربع المناسب **[1 = لا أوافق بشدة ، 2 = لا أوافق ، 3 = محايد ، 4 = أوافق ، 5 = أوافق بشدة].**

الرقم	الفقرة	1	2	3	4	5
1	بناء المعرفة وتوحيد مصادر المعلومات					
2	متابعة دورية وصيانة للعمليات والخدمات					
3	استخدام الأنظمة المحوسبة في التويثق وإيجاد قواعد المعلومات					
4	تبسيط الإجراءات والعمليات بالاعتماد على الأنظمة التقنية					
5	التنسيق بين الأقسام والفروع					
6	دمج التغذية الراجعة من الزبون الداخلي في تصميم الإجراءات والعمليات					

3. إلى أي مدى توافق أو لا توافق على الفقرات التالية والمتعلقة بدعم KMEOntoBPA للكفاءات الجوهرية لحالة دراسة الودائع/التمويلات البنكية. يرجى وضع إشارة [x] في المربع المناسب **[1 = لا أوافق بشدة ، 2 = لا أوافق ، 3 = محايد ، 4 = أوافق ، 5 = أوافق بشدة].**

الرقم	الفقرة	1	2	3	4	5
1	تقديم معرفة وخبرات جديدة					
2	تحسين للقيمة المضافة للعمليات والخدمات					
3	حماية للمركز التنافسي والبناء عليه					
4	تقديم الخدمات والعمليات بشكل مؤهل وكفؤ					
5	قدرة البنك على التكيف مع بيئة الأعمال المتغيرة					

4. إلى أي مدى توافق أو لا توافق على الفقرات التالية والمتعلقة بدعم KMEOntoBPA لرأس المال الاجتماعي لحالة دراسة الودائع/التمويلات البنكية. يرجى وضع إشارة [x] في المربع المناسب **[1 = لا أوافق بشدة ، 2 = لا أوافق ، 3 = محايد ، 4 = أوافق ، 5 = أوافق بشدة].**

الرقم	الفقرة	1	2	3	4	5
1	كفاءة نظام الاتصالات في حل المشكلات					
2	تعزيز العلاقات الطيبة مع العملاء					
3	التعاون بين الموظفين					
4	تبادل المعرفة في البنك					
5	التناسق في الهيكل التنظيمي					
6	قدرة البنك على الوصول إلى مصادر الخبرة اللازمة للتطوير					

انتهى مع جزيل الشكر والاحترام

B.2 English and Arabic Version of Research Interview

- **English Version of Research Interview**

1. What are the main driving factors in the development of an effective business process architecture in the bank? **[value = high, moderate , low , none]**

- Dynamic business environments such as new financial products, new banking services **(high, moderate, low, none)**.
- Changing the organisation environment such as knowledge building, exploitation of resources and competences and improvement of organisational learning **(high, moderate, low, none)**.
- New technologies such as the development of customer relationship management systems (CRM) and e-banking **(high, moderate, low, none)**.
- Changing customer needs **(high, moderate, low, none)**.
- Competition - new competitors and new markets **(high, moderate, low, none)**.
- Others: please state.

2. What are the existing problems or defects of business processes in the bank Deposits/Financing and how you solve these problems?
3. What are the suggested processes that need to be developed in the bank?

- Financing related processes (For Financing case study interview) :
- Deposits related processes (For Deposits case study interview):
- Others:

4. Do the current business processes solve the newly revealed problems?

- Financing related processes **(most of the time, some of the time, seldom, never)**
- Deposits related processes **(most of the time, some of the time, seldom, never)**

5. What are the main expected benefits of using semantic knowledge management enablers in the development of the bank Deposits/Financing BPA?

- Technology:
- Culture:
- Organisational Structure:
- Leadership:
- Business Repository :
- Knowledge Context:

6. Do you think that the KMEOntoBPA application supports the bank Deposits/Financing with regard to the following:

i. Accuracy and completeness in achieving the department goals:

ii. Traceability and tracking changes in processes:

iii. Adaptability to dynamic environment changes:

iv. Competitive advantage regarding :

a. Technical capabilities such as knowledge building, coordination among departments and branches and regular tracking and maintenance

b. Core competences such as providing new knowledge and experience

c. Social capital such as cooperation among employees and exchange knowledge across the bank

Arabic Version of Research Interview

1) ما هي أهم العوامل الدافعة لتطوير كفاءة عمليات الأعمال داخل البنك ؟ [القيمة = مرتفع ، متوسط ، منخفض]
   - ديناميكية بيئة العمل مثل المنتجات المالية ، الخدمات البنكية الجديدة (مرتفع ، متوسط ، منخفض).
   - بيئة البنك المتغيرة مثل البناء المعرفي ، استغلال الموارد والكفاءات وتطوير التعليم المنظمي (مرتفع ، متوسط ، منخفض).
   - التكنولوجيا الحديثة مثل تطوير أنظمة إدارة علاقات العملاء (CRM) وال e-banking (مرتفع ، متوسط ، منخفض).
   - حاجات الزبائن المتغيرة (مرتفع ، متوسط ، منخفض).
   - التنافسية ، وجود منافسين جدد وأسواق جديدة (مرتفع ، متوسط ، منخفض).
   - عوامل أخرى:
2) ما هي أهم المشاكل أو العيوب التي تواجه عمليات الأعمال في الودائع/ التمويلات البنكية وكيف يتم معالجتها ؟
3) ما هي العمليات المقترحة التي تحتاج إلى تطوير في البنك؟
   - فيما يتعلق بعمليات التمويلات
   - فيما يتعلق بعمليات الودائع
   - عمليات أخرى
4) هل عمليات الأعمال الحالية تعالج ما يظهر من مشاكل المستجدة؟
   - العمليات المتعلقة بالتمويلات (في غالب الأوقات ، في بعض الأحيان ، نادرا ، لا تعالج نهائيا).
   - العمليات المتعلقة بالودائع (في غالب الأوقات ، في بعض الأحيان ، نادرا ، لا تعالج نهائيا).
5) ما هي أهم المنافع المحتملة من استخدام دلالات ممكنات إدارة المعرفة في تطوير هيكل عمليات أعمال الودائعظ التمويلات البنكية؟
   - تكنولوجيا المعلومات :
   - الثقافة:
   - الهيكل التنظيمي:
   - القيادة:
   - مستودع الأعمال (الوثائق الالكترونية):
   - سياق المعرفة:
6) هل تعتقد أن تطبيق KMEOntoBPA يدعم الودائع/التمويلات البنكية فيما يتعلق بالآتي؟
   - الاكتمال والدقة لتحقيق أهداف القسم
   - تتبع التغييرات على العمليات
   - التكيف تبعا للتغييرات البيئية المحيطة
   - الميزة التنافسية فيما يتعلق ب:
     1. القدرات التقنية مثل بناء المعرفة والتنسيق بين الأقسام والفروع والتتبع المنتظم والصيانة الدورية.
     2. الكفاءات الجوهرية مثل تزويد معرفة وخبرات جديدة
     3. رأس المال الاجتماعي مثل التعاون بين الموظفين وتبادل المعرفة والخبرات عبر أقسام البنك
   - تطوير عوامل أخرى

Appendix C

CEBEs of Riva “as-is” BPA

C.1 CEBEs of Riva "as-is" BPA of Treasury Case Study

CEBEs were tested using Riva filters in order to extract EBEs. Filters include testing each CEBE by placing the word 'a' or 'the' in front of each and bracketing entities that are simply roles and not part of the essence of business. Each CEBE in Table C.1 is inspected by attempting to place 'the' or 'a' such as 'the' Asset and Liability Management or 'the' Bank Policy and all CEBEs passed this filter test. CEBEs which are simply roles and not part of the essence of business are written in blue colour and considered as non-EBEs (see Table C.1). Same filters are also used to extract EBEs in Deposits and Financing case studies.

Table C.1: CEBEs of Riva "as-is" BPA of the Treasury Case Study

No.	**Riva Ould Suggested Question (Ould,2005)**	**Treasury Candidate Essential Business Entities (CEBEs)**
Q1	What do we make? Or What do we care for?	Asset and Liability Management, Cash Analysis, Cash and Liquidity Management, Balance Sheet Risks Control, Treasury Operations Executive
Q2	What do we sell or provide?	Currency, Sukuk
Q3	What product lines do we have?	Capital Market Trading, Sukuk Purchase Order, Money Market Trading, Short-Term Sukuk Purchase Order, Forex Trading, Currency Purchase /Sell Order, Letter of Credit, Bills for Collection, Managing Accounts with the Correspondent Banks, Money Transfer, Monitoring the Centres of Foreign Currencies
Q4	What services do we offer?	
Q5	What service lines do we have?	
Q6	What things can we simply not get away from?	Central Bank Regulations, Bank Policy, Sharia Restrictions
Q7	Who are our external customers?	Bank Customer, Central Bank, Retail, SMEs, Corporate, Local Bank, Foreign Bank
Q8	Who are our internal customers?	Financial Control Department, Financing Department, Deposits Department, Bank Board, Central Operations Department **(Riva Filter: These are simply roles and not of the essence of the business. Therefore, they are not considered EBEs)**
Q9	Are there things that our customers have, or want, or do, that might be EBEs for us?	Answers are included in questions 3, 4 and 5.
Q10	What things do we think differentiate our organisation from others in the same business?	Nothing specific compared to other Islamic banks.
Q11	What sort of things do we deal with day in, day out?	Core Banking System, SWIFT, Thomson Reuters, Treasury Manager, Capital Market Trader, Forex Trader , Money Market Trader and also answers in questions 1, 3, 4 and 5

Q12	What events in the ‘outside world’, the world outside our organisation, do we need to respond to?	Central Bank Regulatory Requirements
Q13	What entities are listed in our corporate data model?	Not possible to infer feedback about
Q14	What things do our information systems keep information on?	Not possible to infer feedback about

C.2 CEBEs of Riva "as-is" BPA of Deposits Case Study

Table C.2: CEBEs of Riva "as-is" BPA of the Deposits Case Study

No.	Riva Ould Suggested Question (Ould,2005)	Deposits Candidate Essential Business Entities (CEBEs)
Q1	What do we make? Or What do we care for?	Deposit Services Request, Cash and Teller Services Request, Customer Information File-CIF, Accounts Executive, Customer Verification, Deposits, Account, Blacklisted People
Q2	What do we sell or provide?	Deposits, Cash, Cheque, Currency
Q3	What product lines do we have?	Bank Statement, Bills Payment, Cash Deposit, Cash Withdrawal, Cheque Book Ordering, Cheque Cashing, Cheque Clearing, Cheque Deposit, Currency Exchange, Current Account, E-Card, Fixed Account, Joint Account, Money Transfer, Safe Box Deposit, Salary Transfer, Saving Account
Q4	What services do we offer?	
Q5	What service lines do we have?	
Q6	What things can we simply not get away from?	Central Bank Regulations, Bank Policy, Sharia Restrictions
Q7	Who are our external customers?	Bank Customer, Central Bank, Retail, SMEs, Corporate, Local Bank, Foreign Bank
Q8	Who are our internal customers?	Financial Control Department, Financing Department, Treasury Department, Bank Board, Central Operations Department **(Riva Filter: These are simply roles and not of the essence of the business. Therefore, they are not considered EBEs)**
Q9	Are there things that our customers have, or want, or do, that might be EBEs for us?	Answers are included in questions 3, 4 and 5
Q10	What things do we think differentiate our organisation from others in the same business?	Nothing specific compared to other Islamic banks.
Q11	What sort of things do we deal with day in, day out?	Banking System, Automated Teller Machine – ATM, Account Form, Safe Box Form, Bank Branch,Teller, Bank Manager, Customer Relationship Officer, Internet Banking and also answers in questions 1, 3, 4 and 5.
Q12	What events in the 'outside world', the world outside our organisation, do we need to respond to?	Central Bank Regulatory Requirements
Q13	What entities are listed in our corporate data model?	Not possible to infer feedback about
Q14	What things do our information systems keep information on?	Not possible to infer feedback about

C.3 CEBEs of Riva "as-is" BPA of Financing Case Study

Table C.3: CEBEs of Riva "as-is" BPA of the Financing Case Study

No.	Riva Ould Suggested Question (Ould,2005)	Financing Candidate Essential Business Entities (CEBEs)
Q1	What do we make? Or What do we care for?	Financing Request, Credit Approval, Customer Verification, Black Listed People
Q2	What do we sell or provide?	Financing Service
Q3	What product lines do we have?	Commodity Financing, Described Commodity Financing, Financing Executive, Bills for Collection, Utility Financing, Qard Hassan Financing, Real Estate Financing
Q4	What services do we offer?	
Q5	What service lines do we have?	
Q6	What things can we simply not get away from?	Central Bank Regulations, Bank Policy, Sharia Restrictions
Q7	Who are our external customers?	Bank Customer, Central Bank, Retail, SMEs, Corporate, Local Bank, Foreign Bank
Q8	Who are our internal customers?	Financial Control Department, Treasury Department, Deposits Department, Bank Board, Central Operations Department, Risk Department **(Riva Filter: These are simply roles and not of the essence of the business. Therefore, they are not considered EBEs)**
Q9	Are there things that our customers have, or want, or do, that might be EBEs for us?	Answers are included in questions 3, 4 and 5. Customers may want (Invoice)
Q10	What things do we think differentiate our organisation from others in the same business?	Financing Services Diversification
Q11	What sort of things do we deal with day in, day out?	Financing Report, Bank Manager, Financing Supervisor, Banking System, Bank Branch, Ijarah_Contract, Internet Banking, Istisna Contract, Ju'alah Contract, Letter of Credit, Financing Manager, Murabaha Contract, Customer Relationship Officer and also answers in questions 1, 3, 4 and 5.
Q12	What events in the 'outside world', the world outside our organisation, do we need to respond to?	Central Bank Regulatory Requirements,
Q13	What entities are listed in our corporate data model?	Not possible to infer feedback about
Q14	What things do our information systems keep information on?	Not possible to infer feedback about

Appendix D

Interview Responses of the Bank Deposits and Financing Case Studies

D.1 Interview Responses – Deposits Case Study

One structured interview was conducted with the bank branch manager. Each question of the interview is followed by its answer as the following:

1. What are the main driving factors in the development of an effective business process architecture in the bank? **[value = high, moderate , low , none] (Label 1: Main driving factors of BPA development)**

Bank branch manager answer:

- Dynamic business environments such as new financial products, new banking services **(high, moderate, low, none)**.
- Changing the organisation environment such as knowledge building, exploitation of resources and competences and improvement of organisational learning **(high, moderate, low, none)**.
- New technologies such as the development of customer relationship management systems (CRM) and e-banking **(high, moderate, low, none)**.
- Changing customer needs **(high, moderate, low, none)**.
- Competition - new competitors and new markets **(high, moderate, low, none)**.

2. What are the existing problems or defects of business processes in the bank Deposits and how you solve these problems? **(Label 2: Business processes problems and solutions)**

Bank branch manager answer:

Compatibility between IT systems and processes, communication and demonstration of business processes, and tracking changes on business processes are the main problems. The difficulties in the demonstration of business processes are related to unclear authorities. As for tracking changes, every day there a new thing appears, so we have to make a balance with the new external knowledge. These problems are solved by training, placing clear policies and procedures, and using information technology.

3. What are the suggested processes that need to be developed in the bank Deposits? **(Label 3: Suggested processes for development)**

Bank branch manager answer:

All processes in the deposits are in continuous development. There are improvements on all the processes. We keep tracking problems in any process in order to solve and update.

4. Do the current business processes solve the newly revealed problems? **(Label 4: Current processes response to new problems)**

Bank branch manager answer:

Deposits related processes **(most of the time, some of the time, seldom, never).**

5. What are the main expected benefits of using semantic knowledge management enablers in the development of the bank Deposits BPA? **(Label 5: Benefits of using semantic KMEs in the development of BPA)**

Bank branch manager answer:

A knowledge-based BPA that is developed based on semantic KMEs such as (1) Organisational structure, can inform individuals' duties and develop processes to reach goals. It also clarifies chain of commands with organisation and understand the hierarchy and roles which provides clarity, non-random and quick decision making; (2) Culture, can solve problems, increase productivity and save time by the principle of collaboration; (3) Leadership, supports understanding and quick achievement of the processes; (4) Business repository, can be a reference to quick decision making and processes accomplishment, reduces cost and communication, and facilitates quick processes achievement ; (5) Knowledge context, organises and gives flexibility to processes, reduces risks and costs on processes, achieves customers goal and the required quality, and support quick decision making; and (6) Information technology, supports identifying the tools that are used to accomplish these processes and develop the performance of the organisation and employees.

6. Do you think that the KMEOntoBPA application supports the bank Deposits with regard to the following: **(Label 6: Addressing goals, traceability , adaptability and sources of competitive advantage)**

i. Accuracy and completeness in achieving the department goals:

Bank branch manager answer:

Yes, it can support accuracy and completeness in achieving goals.

ii. Traceability and tracking changes in processes:

Bank branch manager answer:

Yes I agree that KMEOntoBPA can track changes and add traceability feature to the bank processes

iii. Adaptability to dynamic environment changes:

Bank branch manager answer:

Yes KMEOntoBPA helps adapting dynamic changes to environment.

iv. Competitive advantage regarding:

a. Technical capabilities such as knowledge building, coordination among departments and branches and regular tracking and maintenance

Bank branch manager answer:

Yes it is effective in building knowledge and integrating between departments and processes maintenance.

b. Core competences such as providing new knowledge and experience

Bank branch manager answer:

Yes it supports competences and provides fresh knowledge. New knowledge and experience would be supported by using KMEs

c. Social capital such as cooperation among employees and exchange knowledge across the bank

Bank branch manager answer:

Yes it supports collaboration and exchanging knowledge between departments.

D.2 Interview Responses –Financing Case Study

Two structured interviews were conducted with the credit and trade finance managers. Each question of the interview is followed by its answer as the following:

1. What are the main driving factors in the development of an effective business process architecture in the bank? **[value = high, moderate , low , none]. (Label 1: Main driving factors of BPA development)**

Trade finance manager answer:

- Dynamic business environments such as new financial products, new banking services **(high, moderate, low, none)**.
- Changing the organisation environment such as knowledge building, exploitation of resources and competences and improvement of organisational learning **(high, moderate, low, none)**.
- New technologies such as the development of customer relationship management systems (CRM) and e-banking **(high, moderate, low, none)**.
- Changing customer needs **(high, moderate, low, none)**.
- Competition - new competitors and new markets **(high, moderate, low, none)**.

Credit manager answer:

- Dynamic business environments such as new financial products, new banking services **(high, moderate, low, none)**.
- Changing the organisation environment such as knowledge building, exploitation of resources and competences and improvement of organisational learning **(high, moderate, low, none)**.
- New technologies such as the development of customer relationship management systems (CRM) and e-banking **(high, moderate, low, none)**.
- Changing customer needs **(high, moderate, low, none)**.
- Competition - new competitors and new markets **(high, moderate, low, none)**.

2. What are the existing problems or defects of business processes in the bank Financing and how you solve these problems? **(Label 2: Business processes problems and solutions)**

Trade finance manager answer:

Compatibility between IT systems and processes, employee familiarity with business, processes communication and demonstration of business processes, accessing the right resources, finding quick and right solutions for problems and tracking changes on business processes are all existing problems in the Bank Financing department, in addition to the

weak knowledge in banking business which is not well-supported by universities. These problems are solved by training in two sides. The first side is the knowledge side which provides employees with knowledge about their roles and duties. The other side is the practical one which facilitates communication and support employees with skills that are necessary to run future business.

Credit manager answer:

Employee familiarity with business processes, not adhering to regulations, risk reputations, and credit operations risk are the main problems. All these problems are treated by training courses and communicating experienced and fresh employees.

3. What are the suggested processes that need to be developed in the bank Financing? **(Label 3: Suggested processes for development)**

Trade finance manager answer:

All trade finance processes need to be developed continuously.

Credit manager answer:

Mainly tracking customers, marketing financing services and dealing with people financing request are the main suggested processes.

4. Do the current business processes solve the newly revealed problems? **(Label 4: Current processes response to new problems)**

Trade finance manager answer:

Financing related processes **(most of the time, some of the time, seldom, never).**

Credit manager answer:

Financing related processes **(most of the time, some of the time, seldom, never).**

5. What are the main expected benefits of using semantic knowledge management enablers in the development of the bank Financing BPA? **(Label 5: Benefits of using semantic KMEs in the development of BPA)**

Trade finance manager answer:

A BPA that is developed based on semantic KMEs has many benefits for example: Information technology identifies existing tools and their related processes which minimises time and facilitates communication and sharing knowledge; Culture supports saving time and informing urgent cases; Organisational structure contributes in determining roles and responsibilities with flexibility in changing from time to another according to new business requirements; Leadership manages processes effectively based on working goals; E-documents support quick access and achievement of processes. They also save time and effort in taking decisions on top and on managerial level; Knowledge context clarifies

procedures and policies, and supports adhering to regulations that are place by the bank. They also increase employee abilities to handle processes.

Credit manager answer:

A BPA that is developed based on the semantic KMEs has several advantages: Information technology provides information about tools and their users which supports work achievement; Organisational structure supports quick flow of processes and better service; Business repository supports quick information access decision making, and problem solving; Knowledge context reduces operations risks and eases process tracking; Culture helps in problem solving , increases quality and facilitates customers services.

6. Do you think that the KMEOntoBPA application supports the bank Financing with regard to the following: **(Label 6: Addressing goals, traceability , adaptability and sources of competitive advantage)**

i. Accuracy and completeness in achieving the department goals:

Trade finance manager answer:

Yes, it achieves completeness and accuracy.

Credit manager answer:

Yes they support accuracy and completeness.

ii. Traceability and tracking changes in processes:

Trade finance manager answer:

Yes they support tracking changes

Credit manager answer:

Yes I agree that they support tracking changes and traceability.

iii. Adaptability to dynamic environment changes:

Trade finance manager answer:

Yes they support adapting dynamic changes.

Credit manager answer:

Yes I agree they can help adapting changes to environment.

iv. Competitive advantage regarding:

a. Technical capabilities such as knowledge building, coordination among departments and branches and regular tracking and maintenance

Trade finance manager answer:

Building knowledge, coordination and tracking processes all these issues can be achieved by using KMEs in developing BPA.

Credit manager answer:

I think using KMEs would greatly affect integration between processes and support regular tracking.

b. Core competences such as providing new knowledge and experience

Trade finance manager answer:

Using KMEs would achieve knowledge sharing and variety of experience.

Credit manager answer:

Yes, using KMEs would provide new knowledge and various experiences.

c. Social capital such as cooperation among employees and exchange knowledge across the bank

Trade finance manager answer:

Yes the use of KMEs would achieve collaboration and exchanging knowledge between the employees of the bank.

Credit manager answer:

Definitely collaboration and participation would increase by using KMEs.

Appendix E
Research Instrument Reliability

E.1 Questionnaire Reliability – Deposits Case Study

The number of items in the questionnaire is 29 and the number of valid cases (respondents) in Deposits case study is 9. The value calculated of Cronbach's Alpha coefficient using 29 items is 0.914, which is very high. The lower limit for Cronbach's Alpha is 0.70. Reliability can be categorised into four levels according to Cronbach's Alpha: low (≤ 0.50), moderate (0.50-0.70), high (0.70-0.90), and excellent (≥ 0.90). Thus, the research instrument has excellent reliability according to the value of Cronbach's Alpha in Table E.1.

Table 7.1: Reliability Analysis of the Deposits Case Study - Case Processing Summary

		N	%
Cases	Valid	9	100.0
	Excluded[a]	0	.0
	Total	9	100.0

Cronbach's Alpha	N of Items
.914	29

E.2 Questionnaire Reliability – Financing Case Study

The number of items in the questionnaire is 29 and the number of valid cases (respondents) in the Financing case study is 17. The value calculated of Cronbach's Alpha coefficient using 29 items is 0.957, which is very high. The lower limit for Cronbach's Alpha is 0.70. Reliability can be categorised into four levels according to Cronbach's Alpha: low (≤ 0.50), moderate (0.50-0.70), high (0.70-0.90), and excellent (≥ 0.90). Thus, the research instrument has excellent reliability according to the value of Cronbach's Alpha in Table E.2.

Table E.2: Reliability Analysis of the Financing Case Study - Case Processing Summary

		N	%
Cases	Valid	17	100.0
	Excluded[a]	0	.0
	Total	17	100.0

Cronbach's Alpha	N of Items
.957	29

Appendix F
Normality Tests

F.1 Normality Tests - Deposits Case Study

The data distribution of study variables is normal if the significance levels of the variables (p-values) using Shapiro-Wilk test are more than 0.05. Otherwise, the data significantly deviate from normal distribution. The null hypothesis or (H_0) here is that there is no difference between the dependent and independent variables, and the normal distribution. The level of significance (p) for all variables (.405, .809, .772 and .314) is more than 0.05. These values are derived using Shapiro-Wilk normality test which is conducted using the descriptive statistics in IBM SPSS tool for statistical analysis (see Table F.1). Thus, (H_0) should be accepted and the alternative hypothesis (H_1) should be rejected. Furthermore, the independent and dependent variables have the shape of a normal distribution (see Figure F.1)

Table F.1: Shapiro-Wilk Normality Tests - Deposits Case Study

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
KMEOntoBPA Advantages	.221	9	.200*	.922	9	.405
KMEOntoBPA Impact on Technical Capabilities	.175	9	.200*	.961	9	.809
KMEOntoBPA Impact on Core Competences	.137	9	.200*	.953	9	.722
KMEOntoBPA Impact on Social Capital	.241	9	.141	.910	9	.314

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

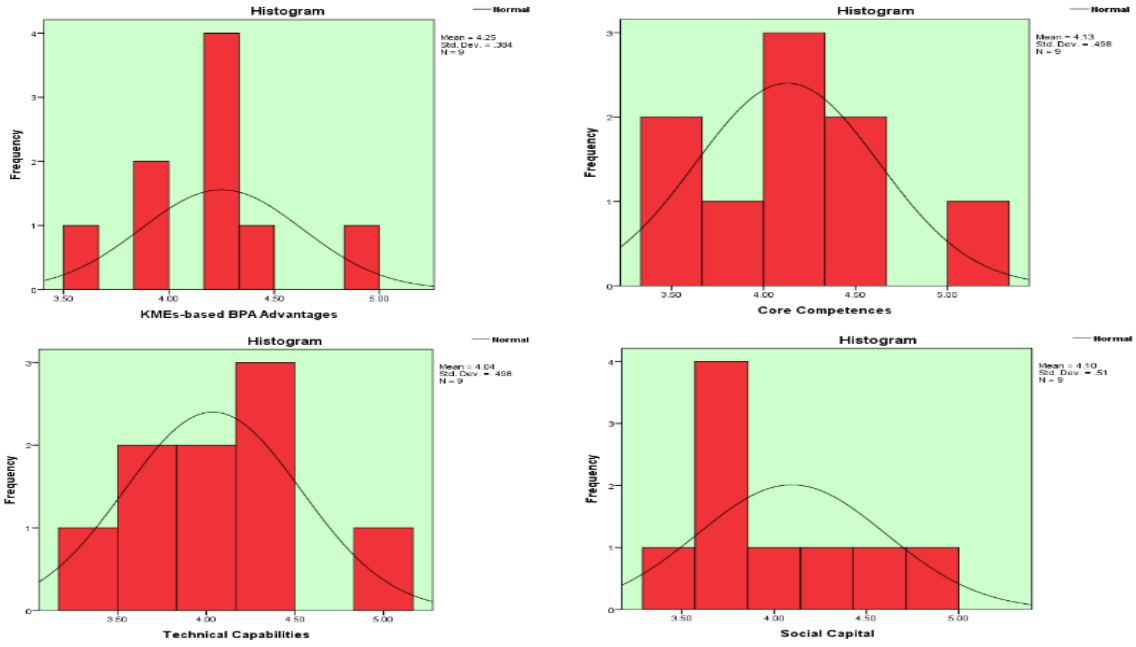

Figure F.1: Testing the Normality of Independent and Dependent Variables using Histogram Technique - Deposits Case Study

F.2 Normality Tests - Financing Case Study

The data distribution of study variables is normal if the significance levels of the variables (p-values) using Shapiro-Wilk test are more than 0.05. Otherwise, the data significantly deviate from normal distribution. The null hypothesis or (H_0) here is that there is no difference between the dependent and independent variables, and the normal distribution. The level of significance (p) for all variables (.275, .004, .090, and .445) is more than 0.05. These values are derived using Shapiro-Wilk normality test which is conducted using the descriptive statistics in IBM SPSS tool for statistical analysis (see Table F.2). Thus, (H_0) should be accepted and the alternative hypothesis (H_1) should be rejected. Furthermore, the independent and dependent variables have the shape of a normal distribution (see Figure F.2)

Table F.2: Shapiro-Wilk Normality Tests - Financing Case Study

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
KMEOntoBPA Advantages	.135	17	.200*	.936	17	.275
KMEOntoBPA Impact on Technical Capabilities	.288	17	.001	.822	17	.004
KMEOntoBPA Impact on Core Competences	.130	17	.200*	.907	17	.090
KMEOntoBPA Impact on Social Capital	.120	17	.200*	.949	17	.445

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

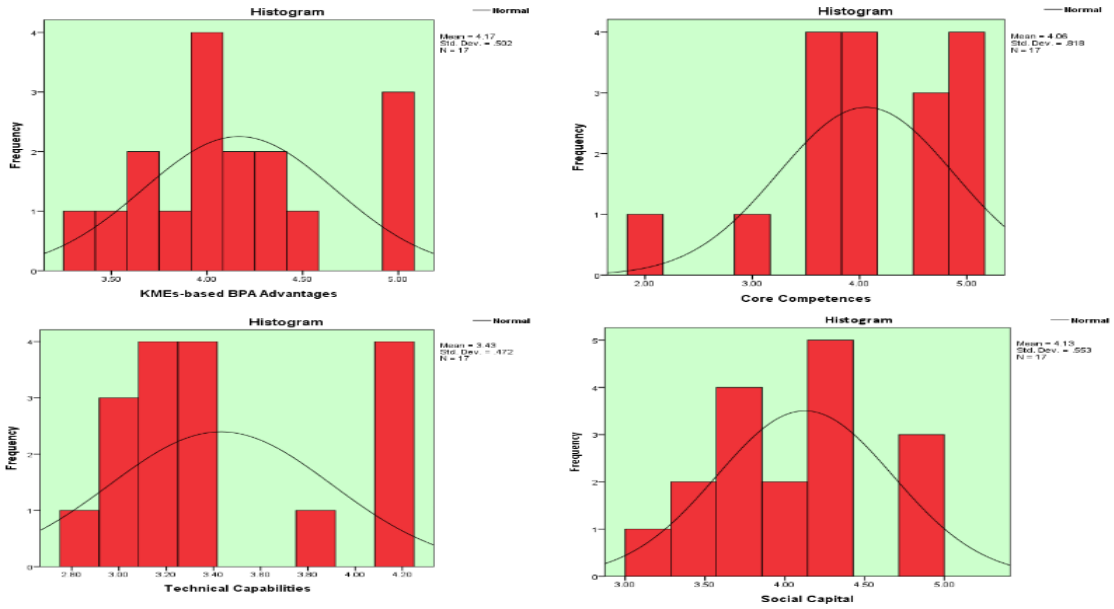

Figure F.2: Testing the Normality of Independent and Dependent Variables using Histogram Technique - Financing Case Study

Appendix G

Frequency Distribution Analysis and Descriptive Statistics of the KMEOntoBPA Advantages

G.1 Frequency Distribution Analysis and Descriptive Statistics of KMEOntoBPA Advantages – Deposits Case Study

Table G.1.1: FDA of the KMEOntoBPA Advantages - Deposits Case Study

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
1	Reducing the cost of processes and services	0 (0.0%)	1 (11.1%)	0 (0.0%)	4 (44.4%)	4 (44.4%)
2	Simplifying work procedures and decreasing bottlenecks in the work system	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (55.6%)	4 (44.4%)
3	Reducing cycle time of processes and services	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (44.4%)	5 (55.6%)
4	Increasing the quality of services	0 (0.0%)	0 (0.0%)	1 (11.1%)	4 (44.4%)	4 (44.4%)
5	Automating processes and services	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (55.6%)	4 (44.4%)
6	Improving streamlining amongst services and processes	0 (0.0%)	0 (0.0%)	1 (11.1%)	5 (55.6%)	3 (33.3%)
7	Increasing the accuracy of service delivery and improving the financial	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (44.4%)	5 (55.6%)
8	Identifying technology tools in organisation	0 (0.0%)	0 (0.0%)	1 (11.1%)	5 (55.6%)	3 (33.3%)
9	Making fast and rational decisions	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (66.7%)	3 (33.3%)
10	Developing workers' skills and knowledge	0 (0.0%)	0 (0.0%)	1 (11.1%)	5 (55.6%)	3 (33.3%)
11	Improving the coordination and information sharing amongst all levels and departments throughout the organizational structure of the bank	0 (0.0%)	0 (0.0%)	4 (44.4%)	3 (33.3%)	2 (22.2%)
12	Improving balance amongst responsibilities and authorities	0 (0.0%)	1 (11.1%)	2 (22.2%)	5 (55.6%)	1 (11.1%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.						

Table G.1.2: Descriptive Statistics of the KMEOntoBPA Advantages - Deposits Case Study

Questions	N	Minimum	Maximum	Mean	Std. Deviation	Sig.
Q1.Advg.7	9	4	5	4.56	.527	1
Q1.Advg.3	9	4	5	4.56	.527	2
Q1.Advg.2	9	4	5	4.44	.527	3
Q1.Advg.5	9	4	5	4.44	.527	4
Q1.Advg.9	9	4	5	4.33	.500	5
Q1.Advg.4	9	3	5	4.33	.707	6
Q1.Advg.10	9	3	5	4.22	.667	7
Q1.Advg.8	9	3	5	4.22	.667	8
Q1.Advg.6	9	3	5	4.22	.667	9
Q1.Advg.1	9	2	5	4.22	.972	10
Q1.Advg.11	9	3	5	3.78	.833	11
Q1.Advg.12	9	2	5	3.67	.866	12
Valid N (listwise)	9					

G.2 Frequency Distribution Analysis and Descriptive Statistics of KMEOntoBPA Advantages – Financing Case Study

Table G.2.1: FDA of the KMEOntoBPA Advantages - Financing Case Study

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
1	Reducing the cost of process and services	0 (0.0%)	0 (0.0%)	2 (11.8%)	8 (47.1%)	7 (41.2%)
2	Simplifying work procedures and decreasing bottlenecks in the work	0 (0.0%)	0 (0.0%)	1 (5.9%)	10 (58.5%)	6 (35.3%)
3	Reducing cycle time of processes and services	0 (0.0%)	1 (5.9%)	0 (0.0%)	9 (52.9%)	7 (41.2%)
4	Increasing the quality of services	0 (0.0%)	0 (0.0%)	1 (5.9%)	11 (64.7%)	5 (29.4%)
5	Automating processes and services	0 (0.0%)	0 (0.0%)	2 (11.8%)	9 (52.9%)	6 (35.3%)
6	Improving streamlining amongst services and processes	0 (0.0%)	0 (0.0%)	4 (23.5%)	8 (47.1%)	5 (29.4%)
7	Increasing the accuracy of services delivery and improving the financial control	0 (0.0%)	0 (0.0%)	2 (11.8%)	4 (23.5%)	11 (64.7%)
8	Identifying technology tools in organisation	0 (0.0%)	0 (0.0%)	1 (5.9%)	11 (64.7%)	5 (29.4%)
9	Making fast and rational decisions	0 (0.0%)	1 (5.9%)	2 (11.8%)	10 (58.5%)	4 (23.5%)
10	Developing workers' skills and knowledge	0 (0.0%)	0 (0.0%)	2 (11.8%)	11 (64.7%)	4 (23.5%)
11	Improving the coordination and information sharing amongst all levels and departments throughout the organisational structure of the bank	0 (0.0%)	0 (0.0%)	4 (23.5%)	9 (52.9%)	4 (23.5%)
12	Improving balance amongst responsibilities and authorities	0 (0.0%)	1 (5.9%)	6 (35.3%)	7 (41.2%)	3 (17.6%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.						

Table G.2.2: Descriptive Statistics of the KMEOntoBPA Advantages - Financing Case Study

Questions	N	Minimum	Maximum	Mean	Std. Deviation	Sig.
Q1.7	17	3	5	4.53	.717	1
Q1.3	17	2	5	4.29	.772	2
Q1.2	17	3	5	4.29	.588	3
Q1.1	17	3	5	4.29	.686	4
Q1.8	17	3	5	4.24	.562	5
Q1.4	17	3	5	4.24	.562	6
Q1.5	17	3	5	4.24	.664	7
Q1.10	17	3	5	4.12	.600	8
Q1.6	17	3	5	4.06	.748	9
Q1.11	17	3	5	4.00	.707	10
Q1.9	17	2	5	4.00	.791	11
Q1.12	17	2	5	3.71	.849	12
Valid N (listwise)	17					

Appendix H

Frequency Distribution Analysis and Descriptive Statistics of KMEOntoBPA Impact on Sources of Sustainable Competitive Advantage (SCA)

H.1 FDA and Descriptive Statistics of KMEOntoBPA Impact on Sources of SCA – Deposits Case Study

H.1.1 Technical Capabilities

Table H.1.1.1: FDA of KMEOntoBPA Impacts on Technical Capabilities - Deposits Case Study

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
1	There is knowledge building and the unifying of information resources	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (66.7%)	3 (33.3%)
2	Tracking and maintenance of the processes and services are regular	0 (0.0%)	0 (0.0%)	1 (11.1%)	7 (77.8%)	1 (11.1%)
3	Computerised systems in documentation and databases are used	0 (0.0%)	0 (0.0%)	4 (44.4%)	3 (33.3%)	2 (22.2%)
4	There is a standardisation and simplification of the processes and procedures via technical systems	0 (0.0%)	0 (0.0%)	3 (33.3%)	4 (44.4%)	2 (22.2%)
5	There is coordination amongst departments and branches	0 (0.0%)	0 (0.0%)	2 (22.2%)	4 (44.4%)	3 (33.3%)
6	(Internal) customer feedback is integrated in the design of procedures and processes	0 (0.0%)	0 (0.0%)	2 (22.2%)	4 (44.4%)	3 (33.3%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.						

Table H.1.1.2: Descriptive Statistics of KMEOntoBPA Impacts on Technical Capabilities - Deposits Case Study

Question No.	N	Minimum	Maximum	Mean	Std. Deviation	Significance
Q2.1	9	4	5	4.33	.500	1
Q2.6	9	3	5	4.11	.782	2
Q2.5	9	3	5	4.11	.782	3
Q2.2	9	3	5	4.00	.500	4
Q2.4	9	3	5	3.89	.782	5
Q2.3	9	3	5	3.78	.833	6
Valid N (listwise)	9					

H.1.2 Core Competences

Table H.1.2.1: FDA of KMEOntoBPA Impacts on Core Competences - Deposits Case Study

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
1	New knowledge and experiences are provided	0 (0.0%)	0 (0.0%)	1 (11.1%)	6 (66,7%)	2 (22.2%)
2	There is an improvement of 'value-added' in the services and processes	0 (0.0%)	0 (0.0%)	1 (11.1%)	6 (66.7%)	2 (22.2%)
3	They provide protection and build on the current competitive position	0 (0.0%)	0 (0.0%)	2 (22.2%)	5 (55.6%)	2 (22.2%)
4	Services and processes are provided competently	0 (0.0%)	0 (0.0%)	1 (11.1%)	5 (55.6%)	3 (33.3%)
5	The bank is able to cope with a changeable business environment	0 (0.0%)	0 (0.0%)	2 (22.2%)	2 (22.2%)	5 (55.6%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.						

Table H.1.2.2: Descriptive Statistics of KMEOntoBPA Impacts on Core Competences - Deposits Case Study

Question No.	N	Minimum	Maximum	Mean	Std. Deviation	Significance
Q3.5	9	3	5	4.33	.866	1
Q3.4	9	3	5	4.22	.667	2
Q3.2	9	3	5	4.11	.601	3
Q3.1	9	3	5	4.11	.601	4
Q3.3	9	3	5	4.00	.707	5
Valid N (listwise)	9					

H.1.3 Social Capital

Table H.1.3.1: FDA of KMEOntoBPA Impacts on Social Capital - Deposits Case Study

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
1	The communication system in problem solving is effective	0 (0.0%)	0 (0.0%)	2 (22.2%)	5 (55.6%)	2 (22.2%)
2	Relationships with the customers are positive	0 (0.0%)	0 (0.0%)	1 (11.1%)	6 (66.7%)	2 (22.2%)
3	There is cooperation amongst employees	0 (0.0%)	0 (0.0%)	2 (22.2%	5 (55.6%)	2 (22.2%)
4	Knowledge is exchanged across the bank	0 (0.0%)	0 (0.0%)	0 (0.0%)	7 (77.8%)	2 (22.2%)
5	There is consistency in the organisational structure	0 (0.0%)	0 (0.0%)	1 (11.1%)	6 (66.7%)	2 (22.2
6	The bank is able to access complementary sources of expertise	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (66.7%)	3 (33.3%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.						

Table H.1.3.2: Descriptive Statistics of KMEOntoBPA Impacts on Social Capital - Deposits Case Study

Question No.	N	Minimum	Maximum	Mean	Std. Deviation	Significance
Q4.6	9	4	5	4.33	.500	1
Q4.4	9	4	5	4.22	.441	2
Q4.5	9	3	5	4.11	.601	3
Q4.2	9	3	5	4.11	.601	4
Q4.3	9	3	5	4.00	.707	5
Q4.1	9	3	5	4.00	.707	6
Valid N (listwise)	9					

H.2 FDA and Descriptive Statistics of KMEOntoBPA Impact on Sources of SCA – Financing Case Study

H.2.1 Technical Capabilities

Table H.2.1.1: FDA of KMEOntoBPA Impacts on Technical Capabilities - Financing Case Study

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
1	There is knowledge building and the unifying of information resources	0 (0.0%)	0 (0.0%)	1 (5.9%)	10 (58.8%)	6 (35.3%)
2	Tracking and maintenance of the processes and services are regular	0 (0.0%)	0 (0.0%)	3 (17.6%)	9 (52.9%)	5 (29.4%)
3	Computerised systems in documentation and databases are used	0 (0.0%)	0 (0.0%)	4 (23.5%)	7 (41.2%)	6 (35.3%)
4	There is a standardisation and simplification of the processes and procedures via technical systems	0 (0.0%)	0 (0.0%)	4 (23.5%)	7 (41.2%)	6 (35.3%)
5	There is coordination amongst departments and branches	0 (0.0%)	0 (0.0%)	4 (23.5%)	7 (41.2%)	6 (35.3%)
6	(Internal) customer feedback is integrated in the design of procedures and processes	0 (0.0%)	0 (0.0%)	5 (29.4%)	8 (47.1%)	4 (23.5%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.						

Table H.2.1.2: Descriptive Statistics of KMEOntoBPA Impacts on Technical Capabilities - Financing Case Study

Question No.	N	Minimum	Maximum	Mean	Std. Deviation	Significance
Q2.1	17	3	5	4.29	.588	1
Q2.3	17	3	5	4.12	.781	2
Q2.5	17	3	5	4.12	.781	3
Q2.4	17	3	5	4.12	.781	4
Q2.2	17	3	5	4.12	.697	5
Q2.6	17	3	5	3.94	.748	6
Valid N (listwise)	17					

H.2.2 Core Competences

Table H.2.2.1: FDA of KMEOntoBPA Impacts on Core Competences - Financing Case Study

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
1	New knowledge and experiences are provided	0 (0.0%)	2 (11.8%)	3 (17.6%)	7 (41.2%)	5 (29.4%)
2	There is an improvement of 'value-added' in the services and processes	0 (0.0%)	1 (5.9%)	2 (11.8%)	9 (52.9%)	5 (29.4%)
3	They provide protection and build on the current competitive position	0 (0.0%)	1 (5.9%)	4 (23.5%)	5 (29.4%)	7 (41.2%)
4	Services and processes are provided competently	0 (0.0%)	1 (5.9%)	1 (5.9%)	9 (52.9%)	6 (35.3%)
5	The bank is able to cope with a changeable business environment	0 (0.0%)	1 (5.9%)	2 (11.8%)	7 (41.2%)	7 (41.2%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.						

Table H.2.2.2: Descriptive Statistics of KMEOntoBPA Impacts on Core Competences - Financing Case Study

Question No.	N	Minimum	Maximum	Mean	Std. Deviation	Significance
Q3.5	17	2	5	4.18	.883	1
Q3.4	17	2	5	4.18	.809	2
Q3.3	17	2	5	4.06	.966	3
Q3.2	17	2	5	4.06	.827	4
Q3.1	17	2	5	3.88	.993	5
Valid N (listwise)	17					

H.2.3 Social Capital

Table H.2.3.1: FDA of KMEOntoBPA Impacts on Social Capital - Financing Case Study

No.	Item	Frequency (Valid Percentage)				
		1	**2**	**3**	**4**	**5**
1	The communication system in problem solving is effective	0 (0.0%)	1 (5.9%)	2 (11.8%)	9 (52.9%)	5 (29.4%)
2	Relationships with the customers are positive	0 (0.0%)	0 (0.0%)	3 (17.6%)	11 (64.7%)	3 (17.6%)
3	There is cooperation amongst employees	0 (0.0%)	0 (0.0%)	3 (17.6%	10 (58.8%)	4 (23.5%)
4	Knowledge is exchanged across the bank	0 (0.0%)	0 (0.0%)	0 (0.0%)	10 (58.8%)	7 (41.2%)
5	There is consistency in the organisational structure	0 (0.0%)	1 (5.9%)	2 (11.8%)	9 (52.9%)	5 (29.4 %)
6	The bank is able to access complementary sources of expertise	0 (0.0%)	0 (0.0%)	2 (11.8%)	8 (47.1%)	7 (42.2%)
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.						

Table H.2.3.2: Descriptive Statistics of KMEOntoBPA Impacts on Social Capital - Financing Case Study

Question No.	N	Minimum	Maximum	Mean	Std. Deviation	Significance
Q4.4	17	4	5	4.41	.507	1
Q4.6	17	3	5	4.29	.686	2
Q4.5	17	2	5	4.06	.827	3
Q4.3	17	3	5	4.06	.659	4
Q4.1	17	2	5	4.06	.827	5
Q4.2	17	3	5	4.00	.612	6
Valid N (listwise)	17					

Appendix I

Simple Linear Regression Analysis

I.1 Simple linear Regression Analysis - Financing Case Study

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	KMEOntoBPA Advantages[b]	.	Enter
a. Dependent Variable: KMEOntoBPA Impact on Sources of SCA			
b. All requested variables entered.			

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.699[a]	.489	.455	. 41431
a. Predictors: (Constant), KMEOntoBPA Advantages				
b. Dependent Variable: KMEOntoBPA Impact on Sources of SCA				

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.467	1	2.467	14.370	.002[b]
	Residual	2.575	15	.172		
	Total	5.041	16			
a. Dependent Variable: KMEOntoBPA Impact on Sources of SCA						
b. Predictors: (Constant), KMEOntoBPA Advantages						

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	**(Constant)**	.854	.866		.986	.340	-.992	2.699
	KMEOntoBPA Advantages	.783	.206	.699	3.791	.002	.343	1.223
a. Dependent Variable: KMEs-based BPA Impact on Sources of SCA								

Appendix J
Research Publications

- Sabri, M., Odeh, M. (2019) The impact of knowledge management on the development of innovative business process architecture modelling: The case of banking in Jordan. *International Journal of Technology Management and Sustainable Development* [Accepted].
- Sabri, M., Odeh, M. and Saad, M. (2019) Deriving object-based business process architecture using knowledge management enablers. *International Arab Journal of Information Technology*, Special Issue [Accepted].
- Sabri, M., Odeh, M. and Saad, M. (2019) Incremental development of business process architecture using the design science research methodology. *The 18th European Conference on Research Methodology for Business and Management Studies (ECRM19*). South Africa, 20-21 June [Accepted].
- Sabri, M., Odeh, M. and Saad, M. (2018) Linking knowledge management enablers to business process architecture: A semantic-driven approach. In: *The 19th International Arab Conference on Information Technology (ACIT)*. Beirut, 28-30 November 2018.
- Sabri, M., Odeh, M. and Saad, M. (2017) A semantic representation of the knowledge management enablers domain: The aKMEOnt ontology. *Proceedings of the 18th European Conference on Knowledge Management ECKM*. Spain, 7-8 September, pp. 1196-1204.