A CASE STUDY ON INTER-ORGANISATIONAL TECHNOLOGY TRANSFER IN THE DEFENCE INDUSTRY

by

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Abstract

As part of the offsets, the defence industrial partnerships typically involve technology transfer (TT) between a local recipient and a foreign supplier. This acquisition of technology does not however automatically lead to increased capabilities, often resulting the governments and the local recipients left unhappy with the level of received TT and the demonstrated technological and process capabilities.

The purpose of this study is (i) to establish a systematically constructed defence offset TT process description, and (ii) to identify the critical success factors enabling an efficient technology transfer project with a knowledge absorption and organisational learning ability that results in a long term sustainable competitive advantage for the local recipient, (iii) to investigate how the interaction of these success factors change the behaviour of a TT system, and (iv) how alternative industrial participation policies would result in a better performance.

The study is an exploratory sequential multi method study conducted in three phases. In Phase 1 a systematic literature review is conducted and as a result a conceptual theoretical framework is constructed based on the key concepts regard the factors enabling a successful TT and their relations emerging from the literature. In Phase 2, a level 2 SCOR model is constructed and the technology transfer success factors are identified by applying a novel integrated case study and Straussian grounded theory approach under the interpretative assumptions and purposive sampling in a global defence industry organisation. As a result, the theoretical position of local recipient's management, financial planning, supply chain management, and local production planning were advanced as the main factors that the local recipient organisation can best influence to enhance the project's efficiency and success. In Phase 3, a system dynamics TT model was constructed to test and compare the interaction of the critical success factors and how they change the behaviour of the TT system through different hypotheses. The combined findings of the system dynamics modelling and the process analysis in study's Phase 1 and Phase 2 respectively suggest changes to a typical industrial participation management policy in terms of the local recipient selection, TT process management and control, and the management of the local supplier network. As a result, the defence industry organisations and economies involved in the defence contracting can better plan and manage their related industrial participation TT activities.

To date, the body of technology transfer research has focused on the factors influencing the technology absorption and the identification of meta mechanisms between the supplier and recipient organisations in a context of a multinational corporation and as an intra-firm activity, providing little insight to the actual practical operational level technology transfer process. This study seeks to fill this gap by advancing a more profound understanding of the process activities and the main factors through which the local recipient organisation can best influence the project's success and manage the inter-organisational technology transfer operations more effectively in a highly technologically complex operational environment. Furthermore, this study demonstrates the application of a novel methodology of integrated case study and Straussian grounded theory approach, as well as the application of qualitative system dynamics modelling approach. The theoretical contribution of this study is in the perspective of the receiver of a TT and the prerequisites on both country, management and operational levels in order to achieve a sustainable TT.

This is a single case study, only reflecting the supplier view. Future research could explore the other dimensions of the process to confirm the identified factors playing a role over time, expanding the approach from conceptual to empirical domain.

Keywords

Constructive realism, pragmatic, mixed methods, multi method, explorative sequential, case study, Straussian grounded theory, defence, supply chain, strategic alliances, technology transfer, offset, inter-organisational, knowledge acquisition, SCOR, system dynamics, systematic literature review

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1. INTRODUCTION AND BACKGROUND

The following section present the introduction and background for this mixed methods research focusing on establishing the inter-organisational technology transfer (TT) success factors in the defence industry. Extract of this Chapter 1 was published in the Journal of Global Operations and Strategic Sourcing, Bezuidenhout, S. and Bean, W.L. (2021), "A case study on inter-organisational technology transfer in the defence industry", Journal of Global Operations and Strategic Sourcing, Vol. ahead of print, https://doi.org/10.1108/JGOSS-10-2020-0058.

1.1. Defence Industry Technology Transfer

Global military spending was estimated at $1.8 trillion in 2018, where most countries include offset requirements in their defence contracts (Tian et al. 2019). As one of these governmental instruments, the defence industry technology transfer (TT) occupy a particular but significant niche of technological capability acquisition through the supply chain. The purpose of the TT in the defence offset context is two-fold: (i) to enable the receiving country industry to independently produce and maintain the product under the armaments contract in a warfare situation (i.e. strategic role), and (ii) to compensate and justify the high cost related to the armaments procurement by transferring part of the related work for the receiving country industry (i.e. political role). Technology is also a critical input requirement for economic development where the acquisition of capabilities may lead to increased productivity, innovation and a broader economic development (Bengtsson and Dabhilkar 2009, Lyles and Salk, 2007, Batchelor and Dunne 2000, Kumar et al. 1999, Cohen and Levinthal 1990, Contractor and Sagafi-Nejad 1981).

As a part of the offset, the foreign defence suppliers are typically required to manufacture all or part of their contract products locally in the purchasing country. Thus offset agreements develop industrial relationships through production and knowledge transfer from the foreign supplier to their local partners. The major defence suppliers often have distinctive capabilities to manage their inter-organisational TT, and these capabilities are recognised as strategic and as a corporate competitive advantage.

According to Batchelor and Dunne (2000) the defence industry partnership between the foreign supplier and the local partner is typically a non-equity partnership. The foreign supplier is a globally operating defence industry organisation with high capabilities in their specific product portfolio. In contrast, the local partner may represent a wide variety of different types and sizes of companies (e.g. defence and non-defence industry related, small to large). Furthermore, partnerships in their traditional sense are considered to be formed between companies with complementing portfolios. Still, defence industrial partnerships may also be formed between fierce competitors in certain markets with similar products and offerings and yet sharing their core technologies and knowledge in other markets (Batchelor and Dunne 2000).

Typically the local recipients don’t have extensive prior experience on the TT. Consequently, they don't have existing effective routines to manage all the aspects of the process. Also, to date, there are no systematically constructed best practices or process guidelines available despite the significant role and economic weight of the technology acquisition. Instead, the body of research has focused on the factors influencing the technology absorption (Malm et al. 2015, Knudsen et al. 2013, Simonin 1999, Grant and Gregory 1997, Szulanski 1996, Zander and Kogut 1995, Cohen and Levingthal 1990) and on the identification of meta mechanisms between the supplier and recipient organisations (Capasso et al. 2005, Stock and Tatikonda 2000, Albino et al. 1999, Lyles and Salk 2007, Lasserre 1982), providing very little insight into the actual operational transfer process between the supplier and the receiver.

This study seeks to fill this gap (i) by advancing the understanding by first establishing a systematically constructed level 2 Supply Chain Operations Reference (SCOR) model map and (ii) by identifying the defence offset TT process pain points and critical success factors. Furthermore, (iii) a system dynamics model is designed to investigate how these identified factors are linked, how they produce the behaviour of the entire TT system and lastly, (iv) how alternative defence industrial participation policies could produce more efficient and effective results.

A novel integrated case study and Straussian grounded theory approach under the interpretative assumptions and purposive sampling in a global defence industry organisation is applied for this study (Palinkas et al. 2015, Thai et al. 2012, Halaweh et al. 2008). Case studies are typical for defence studies with high access restrictions, but grounded theory applications aren't previously applied to investigate the TT process performance factors specifically.

1.2. Research Problem

Currently there are no existing effective routines to manage the defence TT operations or understanding of the critical key success factors. The acquisition of a technology does not however automatically lead to increased capabilities but this organisational learning process needs to be effectively managed (Reddy and Zhao 1990).

According to the previous studies, to effectively manage TT and both individual and organisational learning, a view of the process and related sequences of activities is needed (Cusumano and Elenkov 1993). There is, however, a limited research coverage explicitly focusing on the aspects of the international inter-organisational TT process, mainly on the meta-level processes involved (Fredriksson 2018, Mam et al. 2015, Knudsen and Madsen 2013, Mariotti 2012, Ivarsson and Alvstam 2005, Albino et al. 1999, Szulanski 1996, Wei 1995, Mansfield 1975) and the conditions stimulating and facilitating learning during the transfer process (Easterby-Smith et al. 2008, Inkpen 1998, Szulanski 1996, Zander and Kogut 1995, Mansfield 1975).

Of these, Szulanski (1996) provides a best practice perspective, the most comprehensive TT process description that is based on four stages, namely the initiation (including all the events leading to the decision to transfer), the implementation (where the relationship between the parties is established, and the resources and practices are being transferred), the ramp-up (where the recipient begins to apply and use the transferred knowledge) and finally the integration (when recipient's practices stabilise and become institutionalised). Similarly, three meta-level steps have been identified to be involved in a defence offset specific environment, including the initial assessment, industrialisation focusing on the capability gaps, and ramp-up (Fredriksson et al. 2018, Malm et al. 2015).

These both outline the main operational level, but this study argues it does not build further understanding across the different operational areas nor provide a basis for detailed process documentation and enable systematical and standardised management. The primary value in Szulanski's study relies upon further identifying factors causing internal stickiness, i.e. the sources of difficulty in transferring knowledge, such as the low recipient absorptive capacity, the causal ambiguity, and the arduous relationship between the parties (Szulanski 1996). The results further indicate that organisations' difficulties in transferring technology might have less to do with motivational factors and more on that organisations don't know how to (Williams 2007, Szulanski and Jensen 2006, Szulanski 1996). Thus, the organisations must better understand the transfer process and develop mechanisms to foster inter-organisational learning. Only an adequately detailed process model can provide a baseline for projection, reviews, streamlining and overall efficient management of the process and, as a result, bring the best results (Cusumano and Elenkov 1993, Reddy and Zhao 1990). Based on the literature examination, we can find that this question has not been adequately addressed in previous scientific studies.

To date, the body of TT research has focused on the factors influencing the technology absorption and the identification of meta mechanisms between the supplier and recipient organisations in a context of a multinational corporation and as an intra-firm activity, providing little insight to the actual practical operational level TT process (d'Agostino et al. 2019, Lorell et al. 2002, Batchelor and Dunne 2000, Davidson and McFetridge 1985, Mansfield and Romeo 1980, Contractor and Sagafi-Nejad 1981, Mansfield 1975). This study argues that this perspective needs to be also extended to include systematically developed and communicated operational practices (the processes and management of operational activities). Hence this case study builds towards that theoretical context that is now lacking, and advances a more profound understanding of the process activities and the main factors through which the local recipient organisation can best influence the project's success and manage the inter-organisational TT operations more effectively in a highly technologically complex operational environment.

The aim and objective of this study is to establish a systematically constructed defence offset TT process description and identify the process pain points and critical success factors and to investigate the behaviour of these factors.

1.2.1. Research Questions

Considering the problem, the central research question is:

How can the TT process effectively managed and implemented in an offset context?

To investigate the problem and to answer to the central research question, further secondary sub questions must be addressed:

(i) What is the TT process in the defence offset context,
(ii) What are the critical factors that enable a successful TT project with the knowledge absorption and organisational learning ability,
(iii) How does the interaction of the critical TT success factors change the behaviour of the TT system, and
(iv) How do alternative industrial participation policies result in better performance?

The objective of this research is to advance the better understanding of operational level defence TT process and its critical success factors, to investigate how these identified factors are linked and how they produce the behaviour of the entire TT system, and how alternative defence industrial participation policies could produce more efficient and effective results.

1.2.2. Research Contribution

This research makes a significant contribution to the existing body of knowledge because it will potentially provide relevant output(s) that may allow to identify, expand and critique the existing body of knowledge and as a result, enable the further development of the process operations and the governmental policies related to the defence offset TT. Hence, this research potentially improves the overall efficiency of the TT operations and the local TT receiver to attain more sustainable competitive advantage over the long term. In addition, this research will extend the methodological body of knowledge by applying novel approaches, namely the integrated case study and Straussian grounded theory, as well as the qualitative-quantitative system dynamics approach.

2. RESEARCH DESIGN AND METHODOLOGY

2.1. Research Philosophy

In this thesis, it is not intended to discuss the fundamentals and origin of the research philosophy in more detail but simply to address some of the main aspects for the audience to better understand the overall approach and the ontological and epistemological assumptions guiding the research. O'Gorman and MacIntosh (2015) states that in order to comprehensively establish the research design the researcher must specify *the ontology* i.e. the nature of reality, *the epistemology* i.e. the relationship between the researcher and the reality and how the valid knowledge is obtained, *the methodology* i.e. the approach to conduct a research, *the data gathering techniques* and *the data analysis techniques* as illustrated in Figure 2.1. Further, the researcher must systematically demonstrate throughout the research process how the chosen ontology guided the data collection and analysis as well as contributed the findings (O'Gorman & MacIntosh 2015). As discussed by Rubin and Rubin (2012), all these choices form the basic assumptions for the research; what is considered to be important, what can be known, and what kind of tools and standards are appropriate for the approach. As a whole, the assumptions form the *research philosophy* (Rubin & Rubin 2012).

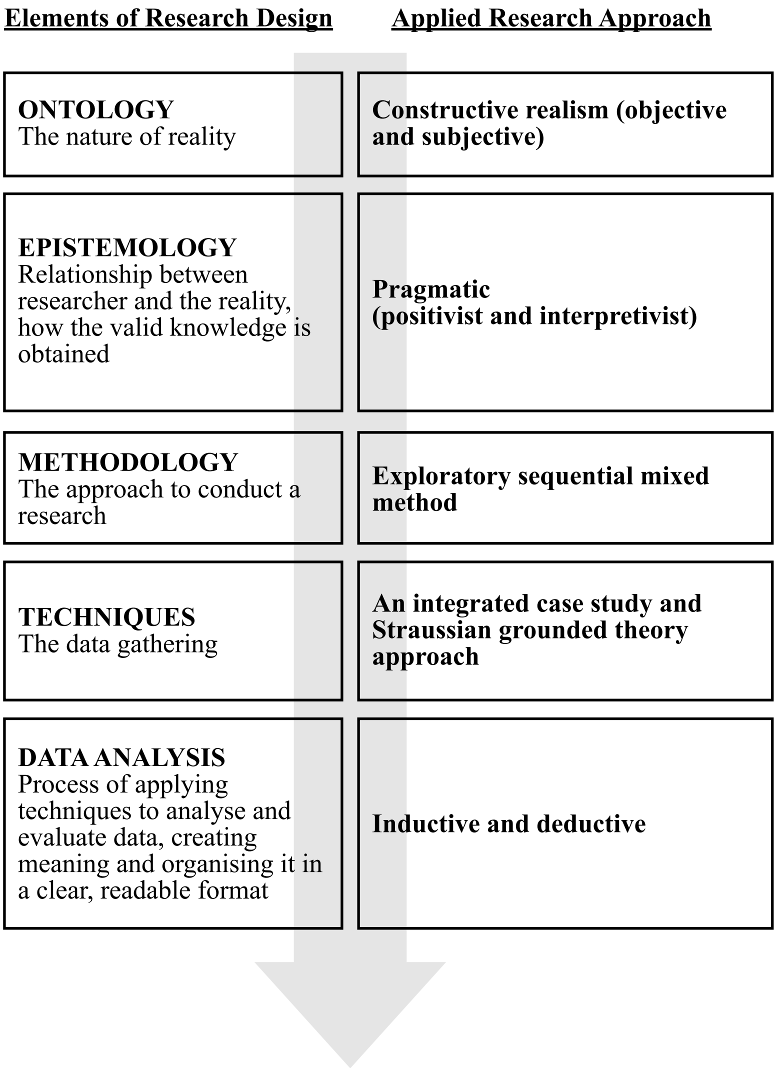

Figure 2.1 Research Design (illustration created based on the text of O'Gorman & MacIntosh 2015).

Typically industrial engineer studies ignore the the overall philosophical discussion, or similarly to the philosophy of technology, the discussion of philosophical aspects is mainly restricted to the impact of engineering to the society rather than to the engineering research itself (Franssen, Lokhorst & van de Poel, 2013). However, it can be said to be relevant to establish a clear ontology and epistemology for a research in order to further align the overall research perspective and to create clear understanding how the knowledge is developed and what knowledge fundamentally can be considered to be 'true' as well as establishing the other practical considerations and assumptions regards the research. Reflecting this, the literature concerning the philosophy of engineering is in general scarce, and the few existing references mainly implicates the strong foothold of purist positivist science approach almost to the point of isolation. As Rubin and Rubin (2012) suggest, many positivist researchers may look down anything not involving a precise measurement or mathematical approach and simply rejecting the qualitative approach as 'non scientific' (Rubin & Rubin 2012) of which could lead to constraining the academic curiosity and creativity when building new knowledge (Feilzer 2010).

O'Gorman and MacIntosh (2015) describe ontology as the nature of reality, a system of belief that reflects an interpretation of an individual about what constitutes a fact or in other words what can be qualified as a 'true knowledge', and associated with a question whether the research perspective is *objective* or *subjective*. Objective perspective is based on quantifiable and measurable realist approach where facts are independent of the human mind i.e. objective, when subjective perspective is open to interpretation and the reality is therefore subjective. It is also important to recognise that these perspectives are not exclusive but research can be positioned between these two as well (O'Gorman & MacIntosh 2015).

This research reflects both of these aspects, objective and subjective view, in its philosophical positioning ranging from deductive scientific view and pure quantitative aspects to the inductive reasoning and qualitative view. Furthermore, this research adopts a constructive realism perspective incorporating parallel the objective and subjective realities to the research phenomenon, aspiring to *understand* the research phenomena as well as to find workable *solutions* for the actors in the field. Cupchik (2001) defined that in constructivism alone the meaning is generated subjectively by individuals based on their experiences and assumptions of the reality. In positivism on the other hand the reality is objective to the research phenomenon regardless of the subjective beliefs and perspectives. Constructive realism aspires to accommodate both of these approaches and emphasises the fact that phenomena should be understood as processes and not simply quantitative nor qualitative accounts subject to bias when constructing data on their own, hence advocating more deeper dialogue between constructivism and positivism (Cupchik 2001).

This research stems from industrial engineering with technology management focus, trying to explain how the defence TT process are constructed and more so providing meaningful contribution how these complex adaptive systems should be best managed. As stated by Franssen, Lokhorst and van de Poel (2013), the engineering design must always involve the considerations of practical rationality where the balance between the beliefs and set objectives is sought. These objectives are set based on their value to a decision maker and the choice of action is based on the value maximisation respective to the situation and aspiration to seek practical applications for ideas thus the approach is an outcome based (Franssen, Lokhorst & van de Poel, 2013). Hence this research's objective according to the principles of constructivism is to create knowledge that guides practice, where researcher operates as an actor rather than just a reactor and processor of information, studying issues of interest and value (Mir & Watson 2000). Consequently it can be argued, that in a complex and constantly changing environment, such as defence industry and its offset related TT, the constructivist methodologies work well at the level of focused and applicable assumptions (Mir & Watson 2000, Blumer 1969). The industrial engineering research emphasis must be in the practical approach incorporating more of the industry specialists insight in order to achieve the increased level of performance. Businesses and managers within the industries are in constant need of useful tools and sensible information to better operate in the increasingly complex environment.

In summary, to develop working systems an engineer needs to utilise not only the traditional objective mathematical and technical engineering skills, but also to understand managerial and process approaches that reflect the subjective experiences and knowledge thus creating knowledge through interpretation (Dias de Figueiredo 2008, Institute of Industrial and Systems Engineering 2018, cited by Billing et al. 2001). This research aspires to create knowledge holistically that first and foremost guides practise and therefore the traditional barriers needs to be removed and constructive approach must be incorporated with the positivist view in order to provide the adequate perspective and depth to the study. As a result, the research ideally contributes through systematic research approach to the knowledge community.

2.2. Research Design

The overall objective of this research is firstly to better understand the context of phenomena and the relations within, and secondly to enable better management of the process by seeking possible practicable solutions for the local actors operating in the environment. Hence, this research adopts *a pragmatic viewpoint* arguing that there cannot be a single reality but a holistic approach is needed where the interpretivist human science is integrated to the positivism of natural science, as concluded by Feilzer (2010). Either the observable research phenomena and/or the subjective meanings can provide acceptable knowledge. In other words, pragmatism rejects the distinction between positivism and interpretivism i.e. the typical division between natural sciences and social sciences, and combines them both. The researcher can be open to any method that best addresses the research problem. As this research by its nature is multifaceted, it adopts a pragmatic pluralist strategy described by Watson (1997). This is seen appropriate when the researcher does not want to produce a single comprehensive theoretical perspective but rather to establish a particular grounds related to specific objectives. Furthermore, pragmatic pluralism involves utilising elements of theories and methods from various disciplines in creating added value to a wider research audience, consistently conceptualising and to building theory for the academic purposes as well as to create deeper understanding and guide the professional practitioners (Watson 1997).

2.3. Methodology

The research philosophy provides the grounds for the methodological strategies that can be used to discover the aspired knowledge through a research. This research involves collecting and integrating both qualitative and quantitative forms of data in order to provide more holistic view and deeper understanding of a research problem than either of the different approaches could do alone (Creswell & Plano Clark 2011). This kind of *mixed methods* research approach is typical to pragmatism that emphasises using all approaches possible to best understand the research problem (Creswell & Creswell 2018, Creswell & Plano Clark 2011, Johnson et al. 2007, Biesta 2010). As discussed earlier, the quantitative research generally dominates the engineering and the technology management research fields, but the use of mixed methods research approach is growing interest especially due to its more holistic approach and the ability to add value to complex phenomenas where the human aspects in the operations are important (Cameron and Molina-Azorin 2011, Cameron et al. 2015, Creswell & Creswell 2018). Further, in their study on mixed methods Johnson et al. (2007) identified several other reasons for utilising multiple method research such as triangulation, access to richer data and expansion of data, elaboration of the results, and discovery of possible contradictions (Johnson et al. 2007).

This research follows exploratory sequential approach which starts with the exploratory phase, and is followed by the confirmatory phase, and at the end is concluded by a meta inference (Cameron 2015, Biesta 2010). In other words, in this strategy the findings from the initial exploratory phases are used to build a model that can be tested and analysed quantitatively in the confirmatory phase hence the qualitative findings are informing the design of the quantitative phase of the research (Creswell and Creswell 2018). The overall approach is illustrated in Figure 2.2 and further described by using Morse's notation system in Figure 2.3.

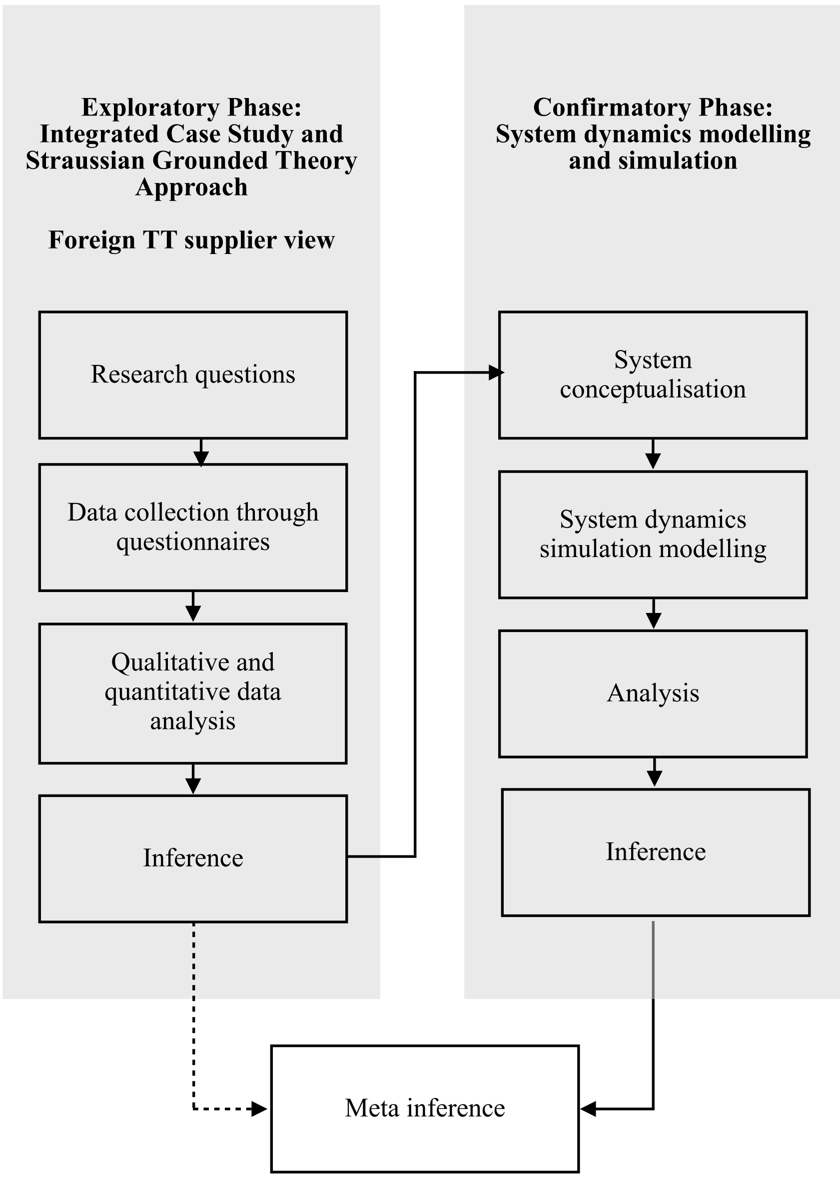

Figure 2.2 Exploratory sequential approach diagram (illustration created based on the presentation of Cameron 2015).

[QUAL + quan] → [qual + QUAN] = Meta inference

Figure 2.3 Exploratory sequential approach rubric (rubric created based on Morse 1991, cited in Creswell & Plano Clark 2011).

In this approach the data collected from the exploratory phase forms a basis for more generalised theory and ideas and thus *inductive reasoning* is used to answer the research questions (Hollard et al. 1986, Crewswell & Plano Clark 2011). A further *deductive reasoning* is used in the confirmatory phase when experimenting the predictions developed based on the exploratory phase (Creswell & Creswell 2018). Overall the process of analysing the system is *reductive*, seeing to reduce the complexity of the phenomena (Chalmers & Jackson 2001).

The data analysis incorporates both qualitative and quantitative elements in order to provide a more deeper analysis and understanding of the study phenomena. In the exploratory phase the qualitative data analysis explores the opinions and experiences of the expert participants, and the quantitative data analysis includes the preparation of descriptive statistics after which a theory is established through generalisation and inductive reasoning. In the confirmatory phase a qualitative data is converted into quantitative form and deductively analysed through system dynamics simulation modelling in order to reach a confirmatory conclusion. After the overall data analysis is finalised, a meta inference is completed in order to synthesise the results.

In all, the exploratory research methodology is based on an integration of a case study and Straussian grounded theory method under interpretative assumptions and applying a purposive sampling approach (Creswell & Creswell 2018, Palinkas et al. 2015, Thai et al. 2012, Walker & Myrick 2006, Halaweh et al. 2008, Corbin & Strauss 1990). The following confirmatory research methodology is based on systems dynamics analysis, modelling and simulation with a purposive sampling approach (Sterman 2000, Wolstenholme 1990, Roberts et al. 1983, Richardson and Pugh 1981, Forrester and Senge 1980, Randers 1980). The overall research approach is illustrated in Figure 2.4. As the research is based on small sample size, the approach involves multiple phases and multiple angles in order to increase the confidentiality via triangulation.

Triangulation Study Approach

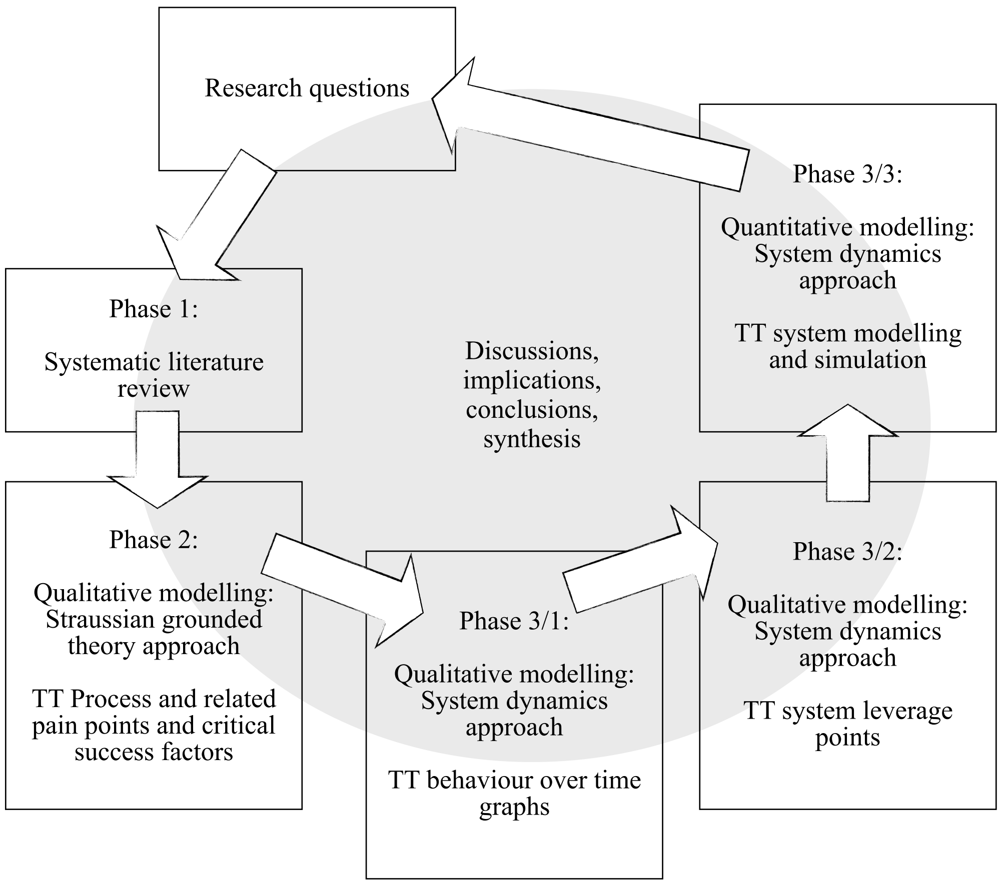

Figure 2.4 The multi-phased and multi-angled research mixed methods approach.

2.4. Case Study Approach

This is a case study based empirical investigation of a contemporary TT phenomena within its real life context, where the boundaries between the TT phenomena and the context are not fully evident (Yin 2014). This case study is a non-experimental research where in-depth descriptions are gathered relative to a specific individual, project, program or environment for the purpose of learning more about poorly understood defence industry TT (Creswell and Creswell 2018, Yin 2014, Leedy & Ormrod 2015). In other words, a case study approach allows the in-depth investigation of the TT phenomenon and the collection of a rich description (Yin 2014, Halaweh et al. 2008).

This study is based on a single case study framework as the study nature is more unique and revelatory and not focused on testing a well formulated theory, (Creswell and Creswell 2018, Yin 2014, Halaweh et al. 2008). A mixed methods case study design is applied where both qualitative and quantitative types of data are collected concurrently and the results are merged together to analyse the case (Creswell and Creswell 2018). The descriptive phenomenological information acquired through a case study are expected to reveal elements that are most relevant to the defence TT in an offset context, and these elements can then be further integrated with other knowledge gathered in order to be used in an exploratory study (Page and Mayer 2005). As Page and Mayer (2005) state, every phenomenon is unique of which contributes to a better understanding of the whole (Page and Mayer 2005). Due to the nature of the approach, the research hypotheses are not formulated at the beginning but as the key issues emerge during the investigation (Page and Mayer 2005).

The TT case study provides more deeper and detailed answers to ‘how’ and ‘why’ research questions, and as a result is well suited to the preliminary early stages of research in this defence industrial participation area where the theory still seems to be inadequate, supporting the incremental theory building (Rowley 2002, McCutcheon and Meredith 1993). It could be argued that a case study approach might be the only possibility of investigating defence industry TT in an offset context where there are very few examples to study, the phenomena is unfamiliar and it is not clear what conditions carry relevance or importance (McCutcheon and Meredith 1993). The case study approach is central to the scientific development by providing supplement to the other methods but due to the small sample size it does not yet provide basis for generalisation (Flyvbjerg 2006). Although this TT case study approach might be viewed lacking rigour and objectivity when compared to other approaches, it can be considered as a useful tool for the exploratory stage of a research project (Rowey 2002). Furthermore, the case study approach suit for contemporary event such as defence industry TT where the investigation is taking place in a real context without investigators control or manipulation, providing valuable information about the phenomena and an insight to the real conditions of operations and as resulting in workable answers for professionals (Rowey 2002, McCutcheon and Meredith 1993). In the core of this TT case study is the professional knowledge and expertise of a defence industry supplier that has experience of numerous international TT projects (Flyvbjerg 2006). Under these circumstances this case study's strength lies in its focus on actual conditions and ability to examine unfamiliar situations (McCutcheon and Meredith 1993). This proximity to reality and the learning process it generates, as research is simply just a form of learning, constitutes a prerequisite for advanced understanding (Flyvbjerg 2006). Examples of related high technology case study research in the TT context are presented in Table 2.1 to provide illustrations of the possible range of theory building from case studies (Eisenhardt 1989).

Table 2.1: Examples of related high technology case study research in TT context.

Study	Description of cases	Research problem	Output
Fredriksson et al. (2018)	Defence industry: SAAB offset cases of inter-organisational transfer of capability	Identification of strategies to increase inter-organisational transfer capability	To reach the performance goals of the TT there needs to be a balance between supplier's disseminative capability and receiver's absorptive capability
Malm et al. (2015)	Aircraft industry: Lessons learned from 3 offset case studies of TT from SAAB to South Africa, Czech and India	The exploration of how capability gaps can be identified and dealt with	The capability gap between the supplier and the recipient has to be dealt with both on an individual and organisational level
Knudsen & Madsen (2013)	Danish global industrial product manufacturing companies: 3 empirical cases of manufacturing facility relocation	The exploration of specific practices of management to identify the mechanisms for supporting the transfer of knowledge	Identification of time and space gaps and establishing better management practices to facilitate the process
Ivarsson & Alvstam (2005)	Automobile industry: 4 cases of TT to local suppliers at Volvo Truck and Bus plants in Brazil, China, India and Mexico	What extent are local suppliers able to win contracts with foreign global companies, what extent and in which ways technological assistance is provided, and how does it contribute to improve the production quality?	The long term relationships are important in interfirm learning but short term relationships an also generate benefits for local suppliers

2.5. Straussian Grounded Theory Approach

Grounded theory approach is a type of qualitative research aimed at inductively deriving theory through a systematic application of methods about defence industry TT in an offset context (Leedy and Ormrod 2015, Evans et al. 2013, Walker and Myrick 2006). Grounded theory is a design approach where the researcher derives a general, abstract theory of a TT process, its activities and interactions grounded in the views of TT experts (Creswell and Creswell 2018). The research process involves using multiple stages of data collection, refinement and defining the interrelationship of categories of information where the direct contact with the reality permits the development of a testable, relevant and valid theory through a methodological, rigorous and structured analysis (Creswell and Creswell 2018, Charmaz 2006, Glaser and Strauss 1967). The general objective of grounded theory is to generate theories derived from qualitative data in order to understand the social context and using a systematic set of procedures to develop an inductively derived theory or a model about a phenomenon (Halaweh et al. 2008). Mintzberg (1979) emphasised the importance of getting into the real organisations as is the case in this study in order to measure real organisations (Minzberg 1979).

Grounded theory was developed by Glaser and Strauss in the early 1960's, and their combined work can be considered as the first version of this theory. The later divergence between the two original authors led to what is commonly termed the Glaserian and the Straussian variations to the grounded theory (Evans and Moores 2013, Halaweh et al. 2008). Opposite to the Glaserian abstract logic, a Straussian approach starts with a general idea of the research topic under investigation after which the theory is forced with structured questions, and conceptual description, to explain the phenomena and interpreted by an observers through inductive-deductive method where specific examples lead to generalisation (Halaweh et al. 2008). As emphasised by Corbin and Strauss (1990) a survey of the TT literature is conducted before the fieldwork commences hence the researcher enters the research area with some knowledge of the phenomenon being studied. It can be argued that the researcher in any case cannot be an impartial observer as the researcher inevitably has an interpretive influence over the analysis thus the researcher actively constructs rather than neutrally discover in the grounded theory approach (Charmaz 2006, Bryant 2003). The literature is used to derive questions that the researcher desires to use in the field work and the literature also directs the theoretical sampling i.e.

sampling needed to create theory, and is helpful for theoretical sensitivity. Furthermore, it can be used to provide a supplementary validation (Halaweh et al. 2008, Corbin and Strauss 1990). Unlike in the Straussian approach where a theory is forced out from the data into a predetermined paradigm model relationships the Glaserian approach allows the theory emerge naturally (Halaweh et al. 2008). The main characteristics of the Glaserian and Straussian approaches are compared in the Table 2.2. For this study the Straussian grounded theory is considered to be more appropriate.

Table 2.2: The main characteristics of the Glaserian and Straussian approaches compared (Howard-Payne 2016, van Niekerk and Roode 2009, Halaweh et al. 2008, Heath and Cowley 2004).

	Glaserian approach	**Straussian approach**
Purpose	To generate concepts and relationships that explain, account for and interpret the variation in behaviour in an area of study	To describe the full range of behaviour occurring in the area
Ontological and epistemological position	Critical realism *"Findings are deemed to be revealed from within the data"*	Pragmatic relativism *"Contextualism where the findings are constructed by inter-subjective understandings of the phenomenon"*
Role of the researcher	Detached observer	Inter-subjective relationship where the researcher is personally engaged to better describe and understand the environment as the participants perceive it to be
Role of literature	Review of literature is only conducted after the emergent theory is adequately developed to allow the literature to be used as additional data	Literature review is conducted prior the research and together with researcher's past experiences influences the study by simulating theoretical sensitivity and generating hypotheses
Formulating research questions	No predetermined questions	Starts with the determined research question, partially based on the existing literature
Data coding and analysis process	Inductive approach where the theory emerges from the data 1st phase: substantive coding 2nd phase: theoretical coding	Inductive-deductive approach where the theory emerges from the data and is then verified in the data 1st phase: open coding 2nd phase: axial coding 3rd phase: selective coding
Theoretical sensitivity	Based on researchers ability to generate concepts and their properties form the data	Emphasis on researcher's insight and ability to give meaning to the data, capacity to separate the pertinent from non-pertinent

Theory	Generates abstract theory	Creates explanatory theory that closely approximated the reality it represents
Theory verification	In principle the theory is too fluid and changeable in time to consider reproducibility but can be modified if needed	Three levels of criteria to judge the emerged theory (1: validity, reliability, credibility of the data, 2: adequacy of the research process, and 3: the empirical grounding to the research findings)

2.6. Rationale for the Approach

In essence there is great similarities as well as some differences between the case study and the Straussian grounded theory methods as illustrated in Table 2.3.

Table 2.3 Similarities and differences between the case study and Straussian grounded theory methods (Halaweh 2012, Rowey 2002).

	Case Study Method	**Straussian Grounded Theory Method**
Similarities:		
Suitability	Well suited for unfamiliar contemporary research areas or preliminary stages of research in the real conditions and context without researcher's control or manipulation	Well suited for research areas where the direct contact with the reality is not possible
Ontological and epistemological position	*Interpretive* where it is believed that the individual shapes the society and the use of qualitative humanistic methods are used, or *positivist* where it is believed that the society shapes the individual and scientific quantitative methods are used	*Interpretive* where it is believed that the individual shapes the society and the use of qualitative humanistic methods are used, or *positivist* where it is believed that the society shapes the individual and scientific quantitative methods are used
Role of literature	Literature review as a starting point in developing the case study protocol including setting the research objectives and questions	Literature review is conducted prior the research and together with researcher's past experiences influences the study by simulating theoretical sensitivity and generating hypotheses
Data collection	Multiple sources acceptable	Multiple sources acceptable
Theory	Generalisation in interpretive case study research involves developing theories and concepts and drawing out specific implications	Generalisation is achieved through the higher abstraction of concepts
Formulating research questions	Clear statement of the research problem and questions before entering the study	Starts with the determined research question, partially based on the existing literature, research problem and questions are continuously developed throughout the process
Differences:		
Study boundaries and specifications	Phenomenon is a specific, bounded system	No specific boundary, data collected from any context according to the emergent issues
Research outcome	The outcome is a detailed description of the case and the units of analysis	The outcome is conceptual categories and theories
Procedures and techniques	Less rigorous procedures and techniques for analysis data	Systematic data analysis procedures and techniques

Multiple authors state that case study and grounded theory approaches can be used in combination however most of these do not provide specific answers as why they can be integrated or why they are consistent with each others (Halaweh 2012, Fernández 2005, Hughes and Jones 2003, Fernández et al. 2002, Pandit 1996, Eishenhardt 1989). The grounded theory and case study researches are both typically associated with integrative paradigms suitable for this study (Halaweh et al. 2008). Hence understanding the defence industry TT in an offset context as it is from subjective experiences of individual experts in the field, using meaning oriented methodologies (versus measurement), such as surveys and interviews, as well as relying on a subjective relationship between the researcher and subjects. Interpretive research further aims to understand the TT phenomenon within its natural setting and utilising the available human insight (Halaweh et al. 2008). In the first phase, the case study strategy starts with establishing the problem statement and research questions, directing the researcher to focus on the collection of relevant information from the TT study point of view. The literature review on the other hand forms a basis for the study propositions (Yin 1994). In general, it is argued that it is impossible to start the research without pre-determining some of the variables under study when the relationships between the variables should only be discovered and established based on the further study analysis (Halaweh 2012). All this follows the Straussian approach where the researcher cannot start without a literature review on the TT phenomenon but is not limited by the literature having flexibility to incorporating emerging ideas to the study (Halaweh 2012). In the case of TT research the integration of case study to the grounded theory method is justified by the highly standardised Straussian analysis approach that adds rigour to the otherwise weaker qualitative single case analysis through its systematic procedures (Halawah 2012). Also, the TT case study is by its nature bounded to a specific scope of the research case where the Straussian approach is not bind with a set boundary but rather can move outside the set focus area if needed as the issues emerge (Halawah 2012). Hence the two approaches compliment each other and add the rigour to the study. Furthermore, the Straussian constant comparative analysis continues to apply data irrespective of the fact that the data has been gathered from a single case thus removing the discussion of the case saturation point (Halaweh 2012). To conclude, in order to study the unique and not well known phenomenon of defence offset related TT both case study and the Straussian grounded theory approaches are well suited, providing access to a study area with high entry boundaries, the different methods complimenting each other and strengthening the rigour of the overall investigation and theory building.

2.7. Data Inquiry and Analysis Approach

Although some slight variations do exist, a certain framework applies to all case studies (Eisenhardt 1989). The Straussian grounded theory method follows a systematic and in detail defined procedure and the overall processes of building theory by integrating a case study and a Straussian grounded theory approach applied in this study is illustrated in Table 2.4 (Strauss and Corbin 1994, Corbin and Strauss 1990).

Table 2.4 The processes of building theory from the case studies and the Straussian grounded theory approach in this TT case study context (Aldiabat and Le Navenec 2018, Halaweh 2012, Halaweh 2008, Walker 2006, Eisenhardt 1989, Strauss and Corbin 1994, Corbin and Strauss 1990).

Straussian Grounded Theory Method	**Case Study Method**	**Integrated Case Study and Straussian Grounded Theory Approach Applicable to This Study**
	Process Steps:	
Initiation Establishing the research topic	**Initiation** Establishing the research topic	**Initiation** Establishing the research topic
Literature review Establishing the research questions and the proposed initial model conceptual analysis	**Literature review** Literature review as a starting point in developing the case study protocol including setting the research objectives and questions	**Literature review** Establishing the research questions and the proposed initial model conceptual analysis
Sampling Theoretical sample selection	**Case selection** Theoretical sample selection	**Case selection** Theoretical sample selection
Determining instruments and protocols Data collection methods, qualitative and quantitative	**Determining instruments and protocols** Data collection methods, qualitative and quantitative, data analysis methods	**Determining instruments and protocols** Data collection methods, qualitative and quantitative
Data collection and interrelated constant comparisons and analysis 1st Open coding (codes ja concepts) 2nd Axial coding (categories) 3rd Selective coding (central categories, properties) The development of a reflective matrix (contextualised model)	**Data collection and initial overlapping analysis**	**Data collection and interrelated constant comparisons and analysis** 1st Open coding 2nd Axial coding 3rd Selective coding The development of a conditional matrix
	Data analysis	
Developing theory/model and evaluation of research quality Developing hypotheses about relationships among categories and verified, broader structural conditions analysed, focusing on 'how' the model works and 'why' certain activities take place	**Developing hypotheses** Iteration, searching evidence for 'why' behind the relationships	**Developing theory/model and evaluation of research quality** Developing hypotheses about relationships among categories and verified, broader structural conditions analysed, focusing on 'how' the model works and 'why' certain activities take place
Literature review Contrasting findings against the literature	**Literature review** Contrasting findings against the literature	**Literature review** Contrasting findings against the literature
Closure Theoretical saturation	**Closure** Theoretical saturation when possible	**Closure** Theoretical saturation when possible

Due to the nature of the integrated case study and Straussian grounded theory approach the overall process of data collection, and the data analysis, as well as the study outcomes to some extent, are somewhat integrated to each other. Therefore the general procedure, including the data collection and analysis, will be discussed here together for each research phase.

Initiation

The researcher's previous experience, understanding and interest in defence industrial participation and offset together with the access to the defence industry companies initiates and further conceptualises this study.

Literature review

This research applies a methodological systematic literature review approach as described by Flink (2005) in order to establish the theoretical framework for the study. The systematic literature review is used to identify the relevant concepts and theories, integrate what research has been done so far, as a basis in forming questions for the further field study as well as to direct the theoretical sampling and later a background where to compare the findings (Creswell and Creswell 2018, Halaweh et al. 2008, Thai et al. 2012).

As a mixed methods approach, the narrative methodology literature review related to the execution of each sequential phase is presented together with the phase in question consistent with the method used (Creswell and Creswell 2018). The use of literature in this study not only frames, guides and directs this study but also establishes a basis for forming questions and comparing and contrasting findings (Creswell and Creswell 2018, Leedy and Ormrod 2015, Thai et al. 2012, Halaweh et al. 2008).

Case selection

The context of the defence offset related TT is complex and multi-faceted. The phenomena is constructed by variety of social and organisational aspects representing different countries and cultures and integrating global organisational actors, operations and processes as described in Figure 2.5. Firstly, the case selection is restricted by the reach and access to the relevant defence organisations thus reducing the number of cases that could be feasibly considered for selection. Out of this narrowed pool of cases and in an effort to account the dynamics of TT the sample is purposively finalised to reflect the theoretical concerns and to consider adequate variation across the different organisations, processes and operations. The foreign supplier view is selected for this study due to the access and in order to have a niche approach to the entire defence offset TT ecosystem and the related TT learning activities that compliments the typical macro view of the domestic recipient government or organisation. This study argues that a global defence supplier with extensive TT experience with numerous projects and operating with multiple recipients has valuable insight and relative objectivity to assess and analyse such factors and identify general operational steps in a TT project. As a result, the defence industry organisations and economies involved in defence contracting can better plan and manage their related industrial participation TT activities. The research is further conducted in a South African industrial participation context. When the number of cases selected is small a purposive modes of sampling is more viable rather than a random sampling (Seawright and Gerring 2008). The more detailed case selection methodology and the purposeful sampling is discussed together with each sequential phases.

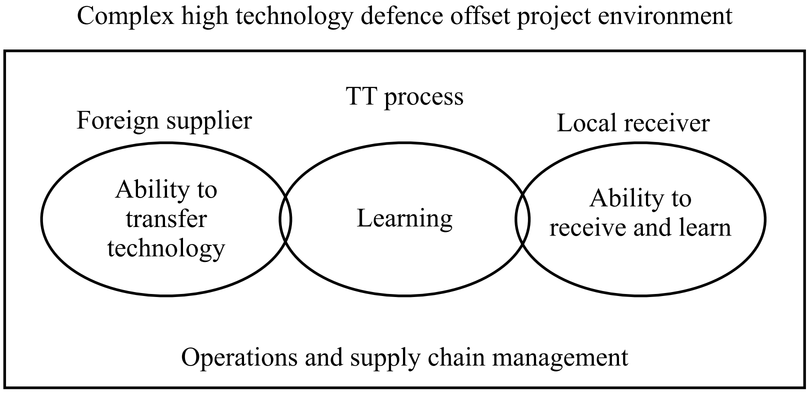

Figure 2.5: The approach for the context-sensitive case selection following the framework of Poulis et al. (2013).

This study is based on *primary data* collected from the industry experts by using *survey questionnaires* and *interviews*. This approach enables to collect and analyse a data that is specific to the purpose of the research problem. The grounded theory research typically involves a recommended sample of 20-30 and a case study a sample of 3-10

(Creswell and Creswell 2018). Due to the sensitive nature of defence industry and the high access restrictions to any information within such organisations a purposeful sampling approach was applied in order to (i) learn in-depth form the specific environment of interest, (ii) efficiently use all the available sources of information due to limited access, and (iii) choose a specific focus group of people who represent the widest experience and highest knowledge on the research area and that can answer the research question (Tie et al. 2019, Leedy and Ormrod 2015, Palinkas et al. 2015). Three types of experts are required; *stakeholders* who are directly affected, *experts* who has relevant experience, and *facilitators* who have the ability to clarify, synthesise, or provide alternative views of the reality (Scheele 1975). Thus, every TT specialist involved in the TT operations (sample size = 8) are engaged in the research to achieve appropriate saturation within the case organisation. Furthermore, the eight representatives all have 15-20 years of individual experience of multiple international inter-organisational TT projects and a comprehensive, in-depth understanding of the process, its requirements and possible issues negatively affecting the TT. They also represent all organisation levels, from the operational activities to the mid-management up to the executive level. As a result, using a purposive sample increases the consistency and homogeneity, narrows down the variation, and focuses on similarities, assists in describing, illustrating and generalising what is typical in the inter-organisational TT process from the supplier point of view (Palinkas et al. 2015). Strauss and Corbin (1998) emphasise that grounded theory research is about discovering information rather than testing it. Hence, the sample size does not need to follow statistical sampling principles but theoretical sampling (Strauss and Corbin 1998). After all, the overall purpose of this study is to provide output for an initial theoretical conceptualisation that should be expanded through further cases studies.

Determining instruments and protocols

A cross-sectional data generation and collection is conducted through a semi-structured questionnaire with both structured and open ended questions that are sent to the supplier focus group in 2019, providing a rich and deep insight into the complex phenomena under investigation as well as anonymity (Cresswell and Creswell 2018, Leedy and Ormrod 2015, Tai et al. 2012). The chosen data collection method is selected in order

(i) to provide the informants enough time to fully consider their perception and articulation, (ii) to provide the informants the freedom to choose the best time in their busy schedules to answer to the questionnaire, and (iii) to provide the informants possibility to review and decline any answer due to potential security and/or confidentiality issues. Personal interviews would be difficult to implement due to schedule conflicts and the possible researcher's present bias regards the responses (Creswell and Creswell 2018). The global COVID-19 pandemic and resulting travel and contact restrictions also create an obstacle for conducting personal interviews.

Data collection and interrelated constant comparisons and analysis

The data analysis incorporates both qualitative and quantitative elements in order to provide a more deeper analysis and understanding of the case. The different components are in constant interaction and their outcomes are integrated throughout the study. The qualitative analysis is a constant comparative process based on Straussian approach on applying the open, axial and selective coding methods (Tie et al. 2019, Thai et al. 2012, Halaweh et al. 2008, Walker 206, Corbin and Strauss 1990). Codes are further developed into categories lastly forming a synthesis through an iterative process involving inductive conceptualisation (Tie et al. 2019, Halaweh et al. 2008, Walker 2006, Corbin and Strauss 1990). The quantitative data analysis includes the preparation of descriptive statistics. After the overall data analysis is finalised, a meta inference is completed in order to synthesise the results.

Developing theory/model and evaluation of research quality

The gathered data is coded according to Straussian approach in three cycles. The first cycle coding involves breaking down the data and looking for similarities and differences and thus forming initial tentative and provisional codes and concepts (Saldaña 2016, Corbin and Strauss 1990). Furthermore, the properties and dimensions of code categories are searched by developing relationships among them (Saldaña 2016, Walker and Myrick 2006). A special emphasis is placed on searching and identifying of processes, actions that have causes and consequences (Saldaña 2016). The second cycle axial coding approach studies the relationships of categories and their subcategories and how they were relating to each others, focusing on the conditions or situations in which the phenomena occurs, the actions or interactions of the people in response to what is happening in the situations and the consequences or results of the action taken or inaction (Saldaña 2016, Halaweh et al. 2008, Walker and Myrick 2006, Corbin and Strauss 1990). The third and last selective coding cycle involves selecting a central category representing the main theme of the study and reflecting how the other categories related to this central category as well as to each others in order to form an integrated and refined model (Saldaña 2016, Hallaweh et al. 2008, Walker and Myrick 2006). In summary, the Straussian grounded theory coding process arrives to the research model from data as described in Figure 2.6:

Codes → Concepts → Categories → Model

Figure 2.6: The Straussian grounded theory coding sequence (Halaweh et al. 2008).

A number of validity strategies are implemented in order to ensure the qualitative validity, reliability and the interpretative rigour of this study.

Closure

Following the Straussian grounded theory approach the saturation determines the closure of the research. Saturation is an essential methodological principle of qualitative research that in broad terms is used as a criterion for discontinuing further data collection and analysis when further new information, thus new theoretical categories, is not been generated (Saundes et al. 2018). It has its origins in the grounded theory and saturation is seen as a form of qualitative rigour guarantee (Saunders et al. 2018, Glaser and Strauss 1967). Furthermore, it is related to the notion of a theoretical sampling guided by the emerging theory and combining the sampling, data collection and analysis rather than treating them separately as in linear process (Saunders et al. 2018). The saturation is reached when the properties of theoretical categories are adequately developed indicating that the analysis is at a more advanced stage and at a higher level of theoretical generality, when the dimensions and gaps between each category of the emerged theory have been developed in detail (Saunders et al. 2018).

2.8. System Dynamics Approach

Due to the limited access to available data this study uses system dynamics modelling approach to gain more understanding on the complex defence offset TT system and employing the mixed use of Straussian grounded theory and system dynamics modelling in a secondary analysis of qualitative data (Akcam et al. 2019, Suliza et al. 2014). The purpose is to further explore on how the implementation of the ideal operating model and the position of local recipient's management, financial planning, supply chain management and the local production planning as the main factors that the local recipient organisation affect the efficiency and successfulness of the project. The systems dynamics approach is applied in order to test the behaviour of a TT model (Luna-Reyes & Andersen 2003). The system dynamics implement qualitative and quantitative approaches to build a model where the qualitative data assists in gaining more understanding on how the dynamics interaction occurs in the system while the quantitative data is utilised to develop feedback models (Luna-Reyes & Andersen. 2003). The ability of a system dynamics approach is to enable deeper understanding of the relevant factors that are present in the system, to identify the structure of the system and to analyse the effects of different type of interactions within the set system (Luna-Reyes & Andersen. 2003). Overall, the systems dynamics approach is an iterative process that starts with the initial problem articulation and the boundary selection, following by the development of the dynamic hypothesis and the formulation of the actual model, the testing of the model through a study of interactions, and finally to conclude the outcome and findings through a policy formulation and evaluation (Serman 2000).

The data is based on the Phase 2 survey outputs and further individual unstructured discussions with the focus group participants conducted in 2020. The interview discussions extend the initial answers to the open ended questions addressed in 2019, and involve unstructured interviews intending to elicit more specific views and opinions of the participants and provided a more in-depth examination of the initial survey data (Creswell & Creswell 2018).

2.9. Validity and Reliability

In order a study to be informative, it should be both valid and reliable. However, at the same time it must be acknowledged, that it is impossible to eliminate all threats to research reliability and validity but the emphasis should be in minimising the impact of the possible threats (Hammersley 2010, Marais 2012). In qualitative research the validity does not carry the same connotations as in the quantitative research (Creswell & Creswell 2018). This study is based on the qualitative findings hence the validity refers to the accuracy of the findings (Creswell & Creswell 2018). The qualitative reliability indicates that the approach is consistent across different studies (Gibbs 2007).

A multiple validity strategies are used of which the most important is *triangulation*. Different data sources and analysis approaches are used to build a coherent justification for the identified themes and concepts (Creswell & Creswell 2018). Hence, the mixed methods approach can be said to increase the overall validity of this study. Furthermore, the study informants, although from a one organisation, represent broad spectrum and multiple operational and managerial levels and hence provide different perspectives to the study. A one single organisation as a study focus carries relevance as it possesses specialised information on the study focus area that is otherwise difficult to access to. Hence it is a sufficient contribution to knowledge through learning in depth and in detail narrative analysis from a specific organisation with an extensive knowledge base. In all, the research is focusing on a new phenomena that is suitable for a qualitative research design. One organisation and a sample of 8 is adequate for a qualitative study that does not otherwise form a meaningful statistical quantitative analysis basis as such.

Informants are participating throughout the research process to the *checking* and final confirmation of the research findings and hence determining the accuracy of the research output. This process involves also conducting follow up discussions and interviews and providing the informants an opportunity to comment the findings.

The researcher *reflexivity* is shaped by her long background in the defence industry offsets. This also provides more *in-depth understanding* of the defence industry TT ecosystems that lends increased credibility to the analysis and the research findings can be stated to be more accurate and valid as a result.

The completed TT system model validation approach combines two complimentary elements, namely *testing the structure* and *the behaviour* (Forrester and Sage 1980, Barlas 1996, Sterman 2000) of which is discussed in more detail in the relevant sub-section.

This study applies novel *research methodologies* but the selection is based on taking into account of the characteristics of the study and following the logic and procedures effectively utilised in previous similar studies (Leedy & Ormrod 2015). The discussion on related studies is presented with each subsection.

In terms of the reliability, the procedures covering the systematic literature review, the integrated case study and Straussian grounded theory approach as well as the system dynamics modelling are documented in their respective subsections in great detail in order to enable the *replication of procedures* (Creswell & Creswell 2018, Yin 2009).

To conclude, it can be stated this study represents reasonably valid and reliable measures of the characteristics and phenomena under investigation, obtaining informative and useful data for addressing and solving the set research problem (Leedy & Ormrod 2015).

2.10. Generalisability

The term generalisation is used limitedly in this study as the intent of this research is to provide a *conceptual TT domain representation* and not to present a comprehensive answer to all the multifaceted complex TT challenges. Therefore, it could be sated that this study focuses on *particularity* rather than generalisability of which should be a focus of a good case study based qualitative research (Creswell & Creswell 2018). The results of this study may however further be generalised to a broader theory once additional cases and findings under this study focus area are studied (Creswell & Creswell 2018). This study procedures and the development of research outputs are well documented hence the replication of the findings is possible in a new case setting.

2.11. Limitations

Every study has certain weaknesses or limitations that might affect its results and conclusions (Leedy & Ormrod 2015):

The research sample size is small, and only consists of representatives of a one foreign TT supplier organisation. The sample size does not include the local TT recipient view. Despite the limitations, a global defence supplier with extensive TT experience with numerous projects and operating with multiple recipients has valuable insight and relative objectivity to assess and analyse such factors and identify general operational steps in any global defence TT project.

This study is based on a conceptual TT domain representation, representing abstract ideas and explaining the TT phenomena under the study. The overall output, the theory presented, may be wrong until it is proven and tested in an observable domain of the defence TT ecosystem in an empirical study. It could however be argued that the study informants through their experience in the field hold significant empirical knowledge that is reflected in this research. Both of the approaches have their uses and the modern good quality scientific research is typically based on a combination of both conceptual and empirical approaches.

For this case study, there are no directly available quantitative data for the simulation purposes. There also are no literature sources on how to quantitatively describe the key variables related to the established TT model. Traditionally system dynamics approach depends upon quantitative data to generate feedback models as a mathematical representation of problems and policy alternatives (Akcam et al. 2019, Luna-Reyes et al. 2003, Forrester 1994). This study is based on qualitative data that resides in a mental database. There are no formalised guidelines how to incorporate this qualitative information to the modelling process (Akcam et al. 2019, Turner et al. 2013, Ackman et al. 2011, Luna-Reyes et al. 2003, Forrester 1994). The uncertainty associated with the quantification of qualitative variables may cause the simulation results to be misleading or very fragile in some cases (Coyle 2000, Wolstenholme 1990). A heuristic framework with low empirical content has however a useful role in providing a flexible idea about the problem and can be used to explore the empirical TT phenomena through the system dynamics analysis (Akcam et al. 2011, Kelle 1997). The use of more falsifiable concepts that have a higher empirical content may have a risk of forcing data into preconceived ideas (Akcam et al. 2011). This qualitative element is essential providing an dimension enriching and advancing the knowledge on the TT phenomena.

The researcher reflexivity is shaped by her long background in the defence industry offsets. At the same time when this provides more in-depth understanding of the defence industry TT ecosystems and providing increased credibility to the analysis, it also can be causing reinforcement of existing personal pre-assumptions and hence negatively affect the research outputs through bias.

To reduce the above risks and to increase the validity of the findings the research process the research process from the data acquisition and analysis to the conceptual theory formation is transparent and systematic. As this study has a strong pragmatic foundation, it is also important to note that the validity must be judged by the receiving end, the professionals, as well. Hence the study incorporates a strong reflection element to encorporate this approach.

3. PHASE 1 - THE SYSTEMATIC LITERATURE REVIEW

The global defence industry supply chains are complex networks operating in a demanding high technology environment and often driven by offset compensation requirements. As a part of the offset, the foreign defence suppliers are typically required to manufacture all or part of their contract products locally in the purchasing country. Thus, offset agreements develop industrial relationships through production and knowledge transfer from foreign suppliers to local partners. The major defence suppliers often have distinctive capabilities to manage these inter-organisational TTs, and these capabilities are recognised as a strategic and corporate competitive advantage. The primary purpose of this review is to examine the knowledge acquisition in a defence offset context and ascertain the critical factors enabling a successful TT based on evidence of successful management of a TT process.

The defence industry partnership between the foreign supplier and the local partner is typically a non-equity partnership. The foreign supplier is a globally operating defence industry organisation with high capabilities in its specific product portfolio. In contrast, the local partner may represent various types and sizes of companies (e.g., defence and non-defence industry related, small to large size). Furthermore, partnerships in their traditional sense are considered to be formed between companies with complementing portfolios. Still, defence industrial partnerships may also be formed between fierce competitors in certain markets with similar products and offerings and yet share their core technologies and knowledge in other markets.

3.1. Literature Research Strategy

This study applies the methodological systematic literature review approach described by Flink (2005) to provide the most comprehensive summary of relevant literature regarding the research problem. First, the overall process is anchored to the formulated research objectives and questions to identify what is needed to know exactly and precisely. Secondly, the research strategy is established based on the research objectives and questions. This involves the identification of search terms, the most relevant and credible sources of information, and establishing the practice and quality screens for the information obtained, i.e. the reasons including and excluding of information from the review. Lastly, the synthesis of results discusses the quality of the information reviewed and provides analysis and interpretation of the current knowledge, explaining and concluding the findings and limitations (Flink 2005). A clearly defined framework reduces the risk of bias and increases transparency; hence it forms a basis for good quality literature review. The applied systematic literature review framework is illustrated in Figure 3.1.

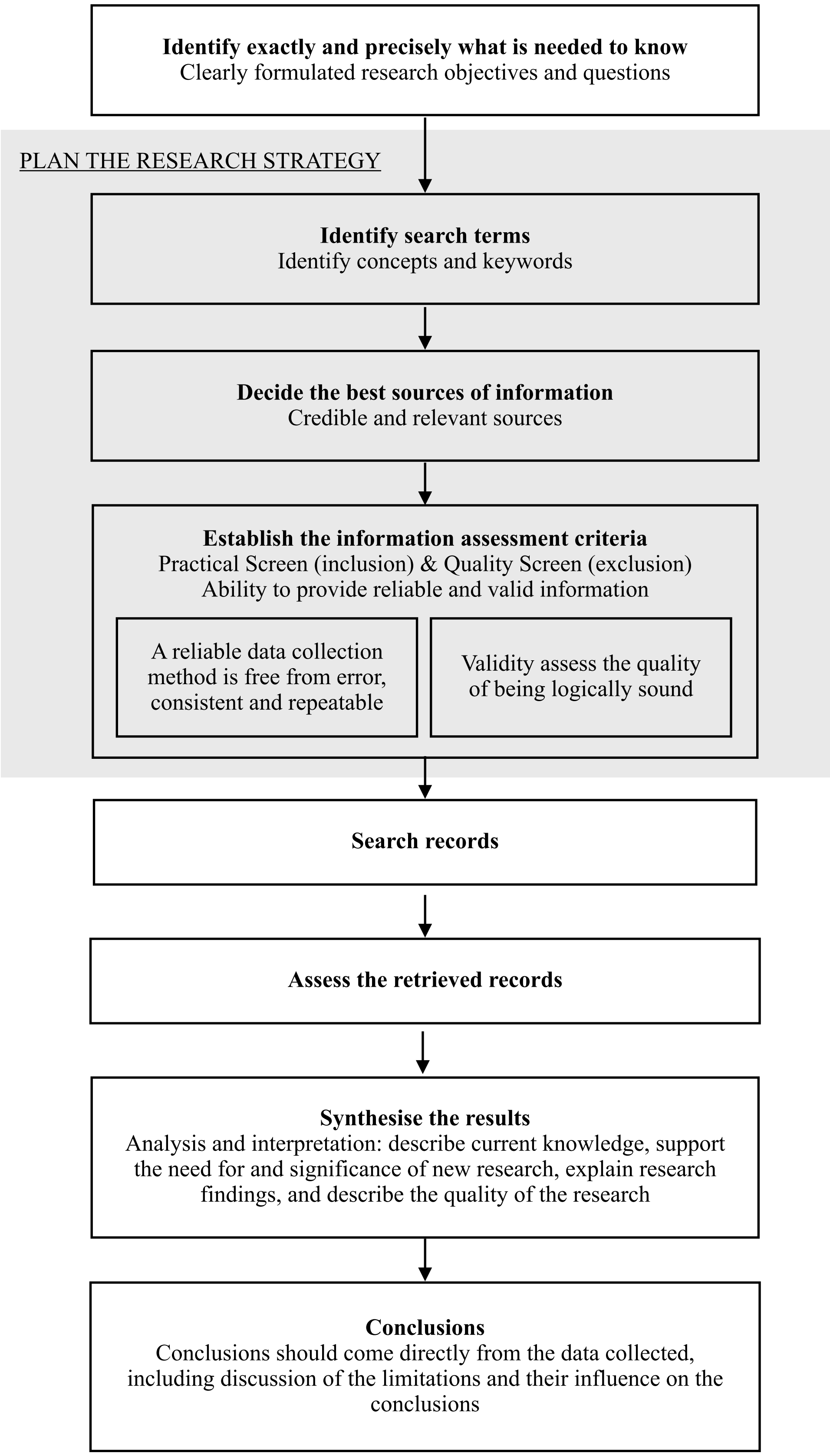

Figure 3.1 Systematic literature review framework

(illustration created based on Fink 2005).

Identification of the search terms

The research title, objective and questions are used as an anchoring point in identifying search concepts and keywords. Following Feak and Swales (2009), the main study heading together with the research questions and respective sub-questions are used as a starting point and broken down to a table of search terms with related research concepts, their possible synonyms, broader and narrower view terms, related terms that might be linked to the search terms by their subject matter, alternative spelling options, and lastly, possible different parts of speech (Feak & Swales 2009). The list of search terms is presented in Table 3.1. In order to focus the search, words defence, offset, countertrade and supply chain are used as key database search terms, whereas the other words had more of an assisting role and were expected to be linked to the key terms.

Table 3.1 The completed table of search terms (table created based on Feak and Swales 2009).

Strategic defence industry supply chain alliances in the offset context and their impact on supplier development in South Africa					
Concepts	**Defence industry**	**Strategic supply chain alliances**	**Offset**	**Supplier development**	**South Africa**
Synonyms	Arms industry	Strategic supply chain partnership(s)	Countertrade	Enterprise development	Republic of South Africa
	Arms trade	Critical partnership(s)	Counter trade		RSA
		Key partnership(s)	Counter-trade		SA
			Defence offset		
Broader terms	Defence	Supply chain management	Industrial partici-pation (IP)	Sustainability	Southern Africa
		Value system(s)	Defence trade	Supplier network	Africa
			Defence industry strategy	Capability / capabilities	
				Competiti-veness	
				Business development	
				Knowledge sharing	
Narrower terms	Land systems	Industrial partnership(s)	TT	Local manufacturing	

Strategic defence industry supply chain alliances in the offset context and their impact on supplier development in South Africa					
Concepts	**Defence industry**	**Strategic supply chain alliances**	**Offset**	**Supplier development**	**South Africa**
	Aerospace	Supplier(s)	Defence industrial participation (DIP)	Local supplier(s)	
	Maritime		Directorate army acquisition		
Related terms	Warfare industry		Defence industry strategy	Supplier capability / capabilities	SANDF[1]
	Defence companies		International trade	Impact	ARMSCOR[2]
	Defence forces		Compensation trade	Performance measurement	The DTI[3]
	Military		Barter	Supplier management	SADI[5]
			Counter purchase	Supplier program(s)	
			Government trade	Supplier relationship management	
			GOCA[6]		
Alter-native spelling	Defense		Offsets		South African
Parts of speech	Defence industries				South Africa's
	Defence industry's				
	Defence industrial				

[1] South African National Defence Force (SANDF)

[2] Armaments Corporation of South Africa (ARMSCOR)

[3] The Department of Trade and Industry (The DTI)

[4] South Africa's Defence and Aerospace Industry's Association (AMD)

[5] South African Defence Industry (SADI)

[6] Global Offset and Countertrade Association (GOCA)

Identification of the information sources

The search concepts and terms form a basis for further identifying information sources, namely *database and non-database resources*. This study focuses on databases relevant to the study area, covering multi-disciplinary databases and specific subject databases such as defence/military, economics, and African studies. The non-database resources focus on grey literature such as government, organisation, industry and commercial material published for non-academic purposes, including reports, thesis, conference proceedings, etc. The overall objective of the source selection is to ensure adequate coverage of the search to find all the relevant literature regarding the study. The twenty (20) databases considered and the eleven (11) databases used for this systematic literature review are presented in Table 3.2.

Table 3.2 The databases considered and selected for the systematic literature review.

Database Provider *Online address*	**Focus Description**	**Selected**
AJOL African Journals Online *www.ajol.info*	Multidisciplinary, scholarly journals published in Africa, peer reviewed literature	Screened, no relevant results found
BASE Bielefeld University *www.base-search.net*	Multidisciplinary large scale data engine providing documents of academic quality and relevance from more than 6,000 sources and including deep web searches ignored by more commercial search engines	Yes
EconBiz German National Library of Economics *www.econbiz.de*	Peer reviewed both non-commercially and commercially focused literature in business studies and economics from German, Europe and world.	Yes
Google Scholar Google *scholar.google.co.za*	Commercial large scale multidisciplinary search engine for scholarly literature from academic sources, including both peer reviewed and grey literature	Yes
Hathi Trust Digital Library University consortium *catalog.hathitrust.org*	Large scale digital content repository of over 60 research libraries in USA, Canada and Europe	Yes
Jane's Defence Weekly Jane's Defence Weekly magazine *www.janes.com*	A weekly magazine reporting on military and corporate affairs in the defence sector	No, requires subscription to access. Could be interesting.
JSTOR Journal Storage *www.jstor.org*	Multidisciplinary large scale digital library focusing on more than 2,000 academic journals	Yes

Database Provider *Online address*	**Focus Description**	**Selected**
Mendeley Mendeley *www.mendeley.com*	Multidisciplinary crowdsourced database	No, not adequate coverage, overlapping with other databases.
Microsoft Academic Microsoft *academic.microsoft.com*	Commercial multidisciplinary scientific research and conference papers	No, no adequate wide coverage.
NBER National Bureau of Economic Research *nber.org*	Economic research papers	No, system is very slow and does not function very well.
OAIster OCLC *oaister.worldcat.org*	A multidisciplinary cataloging system representing millions of records from different open access digital resources	Yes
OpenSIGLE Institut de l'information scientifique et technique *www.opengrey.eu*	European grey literature index	Yes
Paperity Paperity *paperity.org*	Multidisciplinary large scale open access scholarly journals and papers	Yes
Questia Questia *www.questia.com*	Historical multidisciplinary online research library including newspapers, books and magazines	No, requires subscription to access. Could be interesting.
RePEc Volunteer collaboration *repec.org*	Research papers in economics	No, already includes to Google Scholar
ScienceDirect Elsevier *www.sciencedirect.com*	Subscription based access to large scale database of scientific and medical research	Yes
Science.gov science.gov alliance including 18 scientific and technical organisation in US *www.science.gov*	Multidisciplinary government information and science results	Yes
Scopus Elsevier *www.scopus.com*	World's largest multidisciplinary abstract and citation database of peer reviewed research literature	No, already included to University of Pretoria and Google Scholar databases
University of Pretoria Library University of Pretoria *library.up.ac.za*	Multidisciplinary large scale open and subscription based access to scholarly journals, books and papers	Yes
WorldWideScience Multilateral alliance of member countries *www.worldwidescience.org*	Multidisciplinary global science database hosted by governmental organisations	No, requires access. Could be interesting.

Establishing the information assessment criteria

As a part of the systematic literature review framework, the inclusion and exclusion criteria must be established. Inclusion criteria determine the factor(s) that make literature eligible to be included in the review, and exclusion criteria, on the other hand, determine the factor(s) that make literature ineligible to be included in the review (Feak and Swales 2009). The inclusion and exclusion criteria applied during this study's literature screening process are described in Table 3.3 below.

Table 3.3 The inclusion and exclusion criteria applied during the literature screening process.

	Inclusion Criteria (Practical Screen)	**Exclusion Criteria** (Quality Screen)
Language	English	Non English
Publication time	Published in 1994 or later, reflecting the current environment (after the end of Apartheid in South Africa)	Published pre 1994
Geographical coverage	Studies in any geographical location	
Study field	Countertrade related, public procurement with compensation requirement	
Type of countertrade	Direct industrial participation with local production requirement	
Industry focus	Defence and aerospace related	Non defence or aerospace related
Operational focus	Studies seeking to understand the supply chain formation, management and/or relationships	
Macro / micro view	Micro view; studies seeking to understand companies experiences and requirements from the participant point of view	Macro view with a policy approach studies focusing only in the impact of countertrade to the society as a whole

The set criteria are aimed to weigh more on the practical screen and subject matter rather than the research design aspects, thus allowing greater flexibility and a broader horizon when identifying relevant records. The overall focus of the systematic literature review is to find all the publicly available peer-reviewed and grey literature sources of any possible micro view data, i.e. the records reflecting experiences and requirements from the suppliers' point of view.

Search and assessment of records

The database searches were conducted using the keywords and assisting terms together with the Boolean logic, Truncation and Wildcards techniques, and limiting the search to only English language records. The following search terms were applied to all selected databases:

- "offset*" OR "countertrade" OR "counter trade" OR "counter-trade"
- "defen?e" AND "offset" OR "countertrade"
- "counter trade" OR "counter-trade"
- "defen?e offset"
- "directorate army acquisition"
- "defen?e industry"
- "defen?e companies"
- "industrial participation"
- "industrial participation" AND "IP"
- "industrial participation" AND "defen?e"
- "industrial participation" AND "ARMSCOR"
- "industrial participation" AND "South Africa" OR "RSA"
- "local manufacturing" OR "local production"
- "supplier development"
- "supplier development" AND "offset"
- "supplier development" AND "local manufacturing"
- "TT" AND "defen?e"
- "TT" AND "local production" OR "local manufacturing"
- "strategic supply chain" AND "defen?e"
- "supply chain" AND "defen?e"
- "supply chain" AND "offset"
- "defen?e industry" AND "value system"

As a result, 249 relevant records were identified from the selected 11 databases and 21 records from other sources. After the removal of duplicates, the total search output was 262 records.

The search was followed by a screening phase where the records were partially screened to assess their suitability for the research. The screening covered the title, abstract, keywords and the table of contents of the records. The screening was conducted against the inclusion and exclusion criteria, explicitly excluding all the records published pre 1994 and only including records from the defence and aerospace industries and the records related to the supply chain management. As an outcome of this screening, a total of 112 records were accepted.

In the third phase, the eligibility of the complete text records was assessed against the inclusion and exclusion criteria, emphasising the micro view (the records reflecting experiences and requirements from the suppliers' point of view) and the defence offset environment approach. As a result, further 24 records were rejected, and 88 were accepted for the final literature synthesis.

The overall search process followed the PRISMA approach, discussed by Liberati et al. (2009) and Moher et al. (2009), illustrated in Figure 3.2 below.

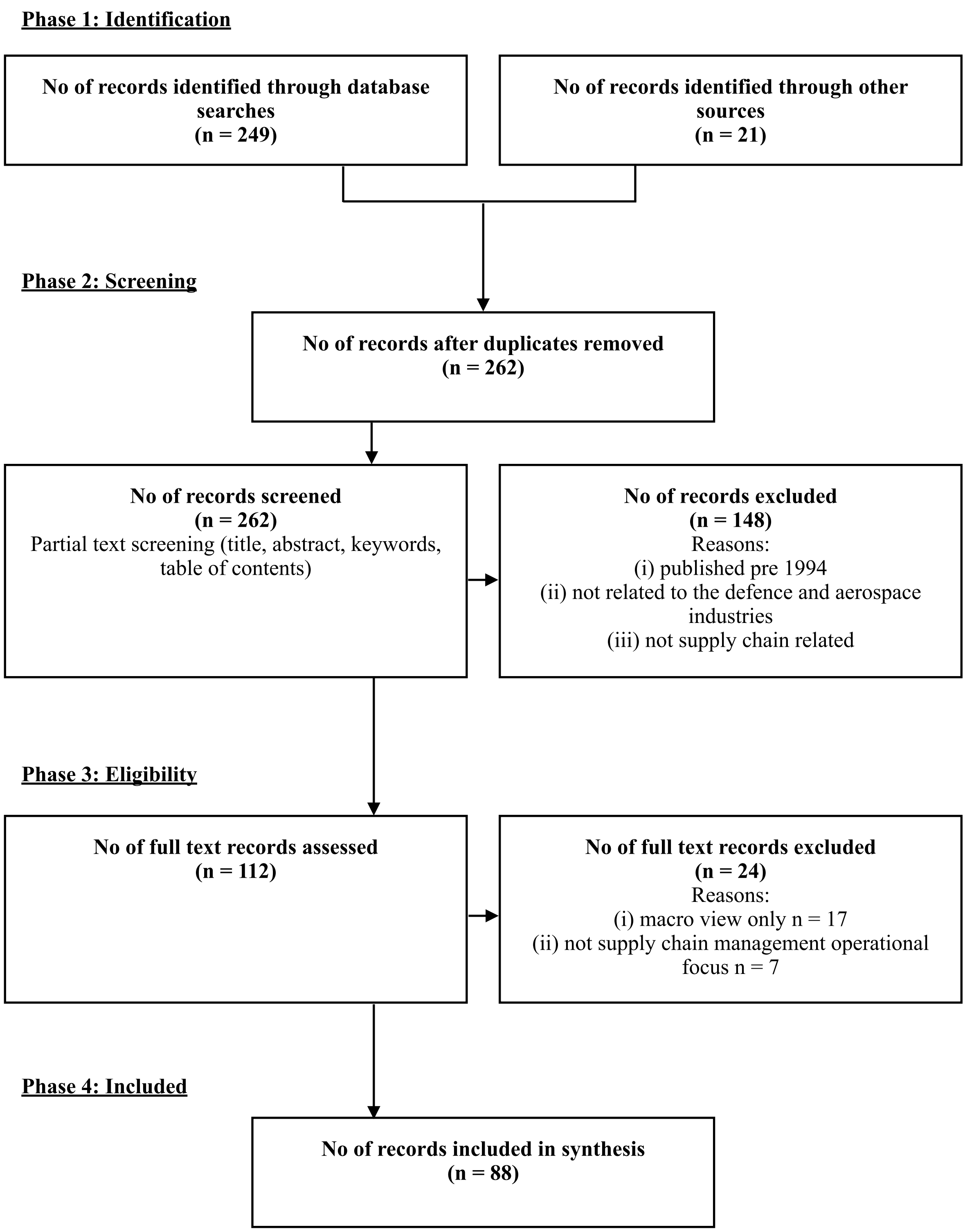

Figure 3.2 PRISMA flow diagram (illustration created based on Liberati et al 2009, and Moher et al 2009).

In the following, the synthesis and conclusion of the literature review are presented in subsequent sections, divided into relevant themes and topics under the broad umbrella of defence offset TT.

3.2. Purpose and Structure of the Literature Review

The purpose of this literature review is threefold. Firstly, to provide context and background to the global defence industry ecosystem and the operational environment through a descriptive literature discussion from both the economy and industry perspectives and how they link. Secondly, to present a more profound synthesis on the existing defence industry TT literature more specifically. Lastly and most importantly, to develop a theoretical framework for this study through a critical discussion on the key concepts and their relations emerging from the TT literature. The overall literature review approach is illustrated in Figure 3.3.

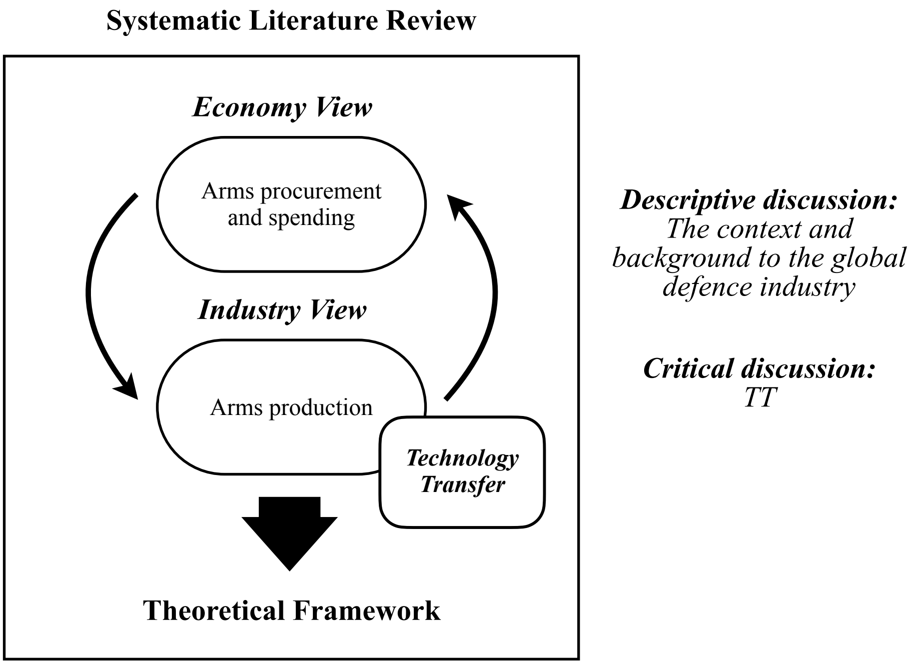

Figure 3.3 The overall literature review approach.

3.3. Economy View

As a result of the systematic literature review, the TT related literature can be divided into sources with a broader economic or industrial perspective. This section discusses the findings related to the sources that can be allocated under the economy view umbrella.

3.3.1. The Arms Procurement and Spending

Arms production is a general term for the production of military goods and services. As such, not a defined industrial sector but cutting across multiple manufacturing industry sectors such as motor vehicles, aircraft, spacecraft, transport equipment, chemicals and weapons and ammunition (Sköns and Dunne 2008). Arms production's unique characteristics, such as the scale, scope, and timeframe of a typical defence programme, distinguish it from civilian production and challenge typical management thinking (Howard et al. 2018, Sköns and Dunne 2008). Due to its nature, arms production comes with a high degree of state control and regulation where the government is typically also the sole purchaser of the products resulting in a monopsonistic market environment where a single buyer substantially controls the market offered by many potential sellers (Sköns and Dunne 2008, Wilding 2006).

The widely documented decline in military spending and arms production following the Cold War ended overnight after the terrorist attacks on New York and Washington on 11 September 2001, resulting in massive military operations in Afghanistan and Iraq. The ripple effects reviving the defence industry globally (Maye 2017, Kiss 2014, Sköns and Dunne 2008, Cullen and Hickman 2001, Pages 1995). Concurrently it changed the type of equipment and systems required as the future war scenario shifted away from the traditional large-scale war to respond to more diverse and unpredictable threats (Sköns and Dunne 2008, Gates 2004). By 2011 the industry once more faced a downturn after the withdrawal of forces from Iraq, only yet again to peak up in 2016 due to the rise of the Islamic State (Wang et al. 2018, Maye 2017). In 2015 the United States comprised 36% of the total global annual spending of 1.65 trillion US dollars. China followed with 143 billion US dollars, and the Gulf region ranks third with 80 billion US dollars (Mayne 2017, Willen et al. 2013).

The defence expenditure represents an average of 2% of gross domestic product, forming technical, military, political and financial ties between the nations and the international military establishments (Kiss 2014, Stuys 2004). In making national arms procurement decisions, the security and political concerns come before the economic logic (Gholz et al. 2018, Maye 2017, Jackson 2004). Also, the nature of the competition and bidding of contracts is quite different from that in the commercial sector, emphasising socio-political and technical criteria (Graham et al. 2001). Defence purchases are infrequent, and the contract spans typically over 20-30 years (Cullen and Hickman 2001). Governments want to secure their interdependence and that the national economy continues to benefit from the defence technology development (Antill et al. 2001, Hayward 2001). At the same time, the governments do recognise that in order for the national defence industry to have a sustainable future, its business needs to have a global scale of operation and have good sources of competitive advantage through the global knowledge networks (Antill et al. 2001). The locally-based arms production is the most expensive option, in some cases even uneconomical for smaller countries. The technology is often not readily available in the local industrial base (Bachelor and Dunne 2000). Hence, importing arms may be the only option that often comes with a premium attached to delivery obligations set to the foreign suppliers in the form of offsets, resulting in a higher purchase price (Bachelor and Dunne 2000). The purpose of offset is to relocate economic activity to the purchasing nation and thus compensate for the high investment associated with the arms purchases (Kirchwehm 2014). Offset is one of the most complicated forms of business to governments (B2G) and business to business (B2B) involving various stakeholders where each of them are pursuing their interests in a complex high technology environment (Kirchwehm 2014). Even with perfectly designed arms programmes, governments would face the constant increase in costs in pursuing the best technology, which raises the question of supporting the domestic industry should be the deciding factor (Antill and Ito 2012). To add, the monopolistic state-owned defence enterprises often come with bloated resources and excess productive capacity, the overall industry typically struggling to keep pace with state-of-the-art production practices (Bitzinger 2011). Most of the national defence industries are heavily platform-centric and 'metal bashers', primarily just duplicating military systems that have been in production for 20 years or more as opposed to innovators (Bitzinger 2011). The heavy emphasis on self-reliance results in resources wasted on replicating the development and manufacture of systems already widely available on the global arms market (Bitzinger 2011).

A future defence supplier is increasingly judged on their performance and ability to develop more open and trust-based relationships with the other members of a global supply chain (Howard et al. 2016, Graham and Hardaker 1998). The suppliers participating in defence contracts are required to have strong programme management and systems integration skills, a critical financial mass and the intellectual skills to be able to deliver a required high complex technology solution and related integrated logistical services through the different phases of the life cycle, the organisational skills to manage the supply network consisting of companies that often compete with each other in other programmes (Gates 2004). This increasing diversity has given rise to the adoption of joint venture and alliance structures to bring together all the required knowledge and skills set (Gates 2004, Graham et al. 2001).

3.3.2. Strategies

To adjust to the increasing global level competition and the simultaneously diminishing overall markets, the contractors typically have pursued different kinds of strategies such as downsizing, concentration and diversification, or a mix of these approaches (Hall et al. 2007, Dunne and Haines 2006, Botha 2003, Dunne and Lamb 2003, Pages 1995). Most of the prime contractors have significantly reduced their workforce base (Pages 1995). Since 1993 the US-based defence giants, such as General Dynamics and McDonnell Douglas, have each laid off more than 15,000 employees and sold off divisions and thus shrinking by 20-60% (Pages 1995). Similarly, the prime contractors have increasingly reduced their supplier base to be more competitive, relying on strategies involving closer cooperation and technology-sharing with a smaller number of high-quality subcontractors (Hayward 2005, Pages 1995). All this has caused a ripple effect down in the supply chain where the trend for the subcontractors is to either consolidate or exit (Kiss 2014, Pages 1995). These small and medium-size sub-suppliers had to specialise and develop their excellence with complementary competencies or face disappear (Struys 2004). In addition, the majority of the successful suppliers have chosen to refocus on commercial markets and thus reduce their dependency on arms sales (Sköns and Dunne 2008, Andersson and Lillecreuz 2001, Pages 1995). Only certain products typically related to weapon systems can genuinely be considered defence unique, and the commercial, technological innovations have rapidly begun to surpass the defence advances hence turning the table from the military R&D spin-off benefits for the civilian economy to the civilian market advances instead of providing benefits for the national defence (Pages 1995). The overall defence technological base is divided between the fast-moving technologies (such as electronics) and the slow-moving mature technologies (such as aircraft engines, artillery and ammunition), where the fast movers are purchased according to commercial practices. In contrast, government purchases will dominate the slow-moving fields (Pages 1995). As the electronic battlefield becomes more and more real, innovation in the fast-moving sectors becomes increasingly essential to military success. These subcomponents may eventually comprise the most critical defence industrial sectors as increasingly smart components are placed on older platforms (Pages 1995). The future of defence operators located in small economies lies in becoming a niche producer where the essential strategy would be producing advanced defence material and focusing on the high technology industry and permanent innovation (Pedone 2017, Balakrishnan 2008, Hall et al. 2007, Dunne and Haines 2006, Hayward 2005, Batchelor and Dunne 2000). Adopting an agile strategy is recommended in supply chains where the underlying products are characterised by high customisation levels, low quantities distribution, long replenishment lead times, and unpredictable demand (Essig et al. 2010).

Some of the large prime level suppliers, such as Lockheed Martin, the former European Aeronautic Defense and Space Company (EADS) now rebranded as Airbus Group, and Matra Bae Dynamics Aerospatiale (MBDA), chose to further strengthen their position on the arms market by concentrating and specialising exclusively on the defence industry and purchasing further defence business and thus created world's largest defence contractors in the process (Maye 2017, Sköns and Dunne 2008, Pages 1995). The global market comprises a critical component of the concentration strategy, making these giants increasingly aggressive exporters (Lorell et al. 2002, Pages 1995). The increasing aspiration supports this to international cooperation with ally nations. The focus is shifting to technological cooperation and component sharing instead of co-production or co-development of new systems (Pages 1995). Today's arms manufacturing is strongly characterised by industrial linkages, international subcontracting, joint ventures, cross-border mergers and acquisitions instead of single country patterns (Kiss 2014, Pages 1995). It could be argued that to some extent, much of the defence industry outside the United

States must embrace globalisation in order to create economies of scale and to survive (Maye 2017, Bitzinger 2011). In all, the modern defence industry operates as part of a network of excellence, relying on flexible production systems and dual technologies to cater for a wide range of demands in a diverse range of markets (Hall et al. 2007). Both industrial participation as a form of offsets and the role of the state are also significant factors affecting the strategy formation in the defence acquisition ecosystem.

3.3.2.1. Conversion and Diversification

Although the prime contractors as system integrators are highly defence specialised, many industry experts believe defence conversion is an effective mean for the lower tier suppliers to meet new economic challenges, especially when the civil versus military identity is slowly becoming more and more difficult to distinguish and that governments are increasingly encouraging more commercial firms to sell directly to the military (Gholz et al. 2018, Kiss 2014, Pages 1995). Increased commercialisation and commercial-military systems integration of the defence industry is unlikely over the short term. In contrast, the shift from defence to commercial markets through two-tiered industry is more likely successful, especially where there are synergies between the military and civil technologies (Gholz et al. 2018, Sköns and Dunne 2008, Pages 1995). Typically smaller firms appear to be much more interested and successful in diversification than their larger primer contractor counterparts (Pages 1995). The companies that diversified into civil production developed new commercial activities through organic growth or acquiring existing businesses (Sköns and Dunne 2008). According to the Stockholm International Peace Research Institute (SIPRI) (referenced by Sköns and Dunne 2008), 75% of those companies that survived the industry declined after the end of the Cold War, have diversified their production (Sköns and Dunne 2008). A study on three UK prime contractors discovered only one-third of their suppliers to be more than 25% defence dependent (Dowdall 2004). An actual conversion to dual-use technologies (i.e. to products and technologies that have both civil and military purposes) or civil production, a strong commitment by management together with a network of relations due to the offset policies has proven to be critical to a successful diversification (Balakrishnan 2008, Sköns and Dunne 2008, Botha 2003, Pages 1995).

Gholz et al. (2018) findings suggest that the ministry of defence or the public state-owned defence enterprises do not necessarily need to fully convert and learn to be more commercial in their contracting practices or try to create contact between the government and the commercial suppliers but rather to encourage and ensure that the first-tier suppliers are willing and able to engage with the commercial sector for the best efficiency and results (Gholz et al. 2018). Furthermore, the fact that subcontractors are contrary linked to the prime contractor rather than the Ministry of Defence could be thought to encourage the commercial sector and the smaller companies to participate in defence projects since these business-to-business (B2B) contracting arrangements are less administratively complex than business-to-governments (B2G) (Matthews and Parker 1999).

3.3.2.2. Alliances

Globalisation has proceeded rapidly and, in most cases, taken the form of strategic alliances that are argued to provide greater strategic flexibility than acquiring equity (Waissi et al. 2013, Sanderson 2009, Lorell et al. 2002, Pages 1995, Frear and Metcalf 1995). The increased political pressure to cut defence budgets and the drive of technology towards more complex and expensive systems have challenged the ability of national economies to support significant players (Sanderson 2009). Companies use international collaboration, joint ventures and strategic alliances to achieve benefits of size without losing independence and to gain market access (Lorell et al. 2002, Pages 1995). The restructuring of the global defence industry has made competition harder and, as a response by major manufacturers, produced more mergers, acquisitions and strategic alliances. (Sanderson 2009, Graham et al. 2001) Although globalisation is viewed as an imperative, most defence executives are still searching for the most effective way to overcome the constraints and enter new markets. Most of these executives perceive their current global capabilities as weak relative to their primary competitors (Lorell et al. 2002). Only those with a clear picture seek strategic alliances (Lorell et al. 2002). The TT agreements are an essential mechanism for establishing partnerships, and offset programs can play a vital part in accelerating this development (Pedone 2017, Kirchwehm 2014).

International collaboration has become a routine feature of much defence development and procurement. Governments compensate domestic firms for buying overseas by guaranteeing a certain amount of work to firms in the domestic economy. (Graham and Hardaker 1998) Finding a mutually beneficial alliance partner is a critical success factor for various companies (Wang et al. 2018). However, this is typically not any objective in an offset environment. The participation with a work share of local industries was made a precondition for Turkey's participation in the Joint Strike Fighter project (Güvenç and Yank 2012). With the finalisation of the arms package number of European defence companies made investments in local defence companies, particularly in aerospace and IT companies (Sköns and Dunne 2008). At the same time in South Africa, the arms deal has sparked a growing number of joint ventures between European and South African defence companies, involving licensing and co-production transactions with TTs and possibilities to become part of global supply chains (Pedone 2017, Kirchwehm 2014, Batchelor and Dunne 2000). These competition based defence policy initiated collaboration structures create further backward linkages in the supply chain when the local prime contractors subcontract some of the work, often not defence-specific, to other smaller civil companies, creating clusters of industries in the same industrial area. Still, they do not preclude long-term relationships (Balakrishnan 2008, Hall et al. 2007). Without a more profound, inter-organisational alliance approach, the goals will remain conflicting and thus diluting the attainable benefits and improved performance (Wilding 2006). This kind of deeper integration would require a change away from the adversarial attitude of conflict to mutual support and cooperation where the customer and supplier commit to continuous improvement and shared benefits by exchanging information openly and resolving problems by working together (Wilding 2006).

The strategic collaboration through offsets and industrial cooperation aims to gain increased access to all levels of foreign technology, including source codes, hardware integration, equipment, software and other systems, together with training and learning processes for local engineers, artisans other professionals (Pedone 2017). Successful offset programs do have in common that they effectively address three issues: (i) ensure that the TT allows the receiver to not only assimilate but also to commercialise the technology by generating enablers, a pool of talents through the co-production or licensing, (ii) encourage the win-win in joint venture dynamics, focusing on developing long term capabilities, and (iii) relieving the operational readiness by assuring the relevant OEM expertise is present in the recipient country, mandate joint venture of an OEM with trusted national champions with a track record of delivering (Kirchwehm 2014, Willem et al. 2013). Capabilities obtained through TT have later provided local strategic partners and recipients opportunities to become a third-tier subsystem equipment supplier within the OEM's global supply chain (Balakrishnan 2008).

Partnering is argued to be an iterative and evolutionary learning process in which people interact in uncertain ways with other contextual elements such as power, culture, structure, financial resources and technology and needs to be led by a skilled, flexible and well-resourced buyer (Sanderson 2009). It is argued that public sector buyers will often find themselves at a skill and resource disadvantage, subsequently resulting in an unbalanced relationship (Sanderson 2009). Talented suppliers manifest a strong vertical relationship with their customers, reflecting the use of formal long-term collaborative agreements between customer and supplier and involving the extensive sharing of information and the development of open-book policies (Smith and Tranfield 2005). In all the primes are encouraged to make themselves more of a partner than just a contributor, working up and down in the supply chain (Smith and Tranfield 2005).

3.3.2.3. The Role of the State

Despite the increasing privatisation, the state's role remains essential, but the relationship between states and the domestic arms producers has become less exclusive (Howard et al. 2016, Kiss 2014, Hayward 2001). The new structure of the arms sector, in theory, means that companies have considerably more freedom in the way they execute an order. At the same time, the military decision-makers are not limited to the product range of their countries key companies (Kiss 2014). Hence national governments depend less on their country's arms industry bases to arm their forces than they once did (Kiss 2014, Balakrishnan 2008).

Hall et al. (2007) state that the defence capabilities should not be retained in public ownership as designated sole sources, but the privatisation process should be fully completed. As a result, the defence deals would be awarded based on open international competition, where the local suppliers would be left to find areas where they have competitive advantages. The problem with this ideal approach is certain defence-specific capabilities that cannot be sustained under free-market competition (Hall et al. 2007). Balakrishnan (2008), however, found that the governments are increasingly allowing the international suppliers and local companies to collaborate independently on projects. By contrast, local industries demand stronger government participation in offsets project determination and monitoring as it is often irregular and mostly reactive and non-proactive. The government role is arguably to smooth the process of local companies acquiring technology from overseas suppliers through industrial collaboration (Balakrishnan 2008).

3.3.2.4. Offset

Buying the latest military equipment from the world's leading producers is a costly undertaking that can burden the Department of Defence and the entire state budget for decades. In order to compensate for this, purchasers can negotiate offsets (Kiss 2014, Bachelor and Dunne 2000). In 1999 the South African cabinet approved an R30 billion arms acquisition programme (Dunne and Haines 2006). The government decided to procure from foreign suppliers based on the view that maintaining a general capability in military production locally was not feasible (Dunne and Haines 2006). To justify this decision and win public support for the acquisition, the South African government emphasised the positive effects of industrial participation on the economy and maintaining the local defence industry (Kirchwehm 2014, Dunne and Haines 2006, Dunne and Lamb 2003). The South African defence industrial policy aimed to retain and create jobs, improve skills, allow maintaining a sustainable local defence industrial capacity and indigenous manufacturing capabilities with strategic logistic support, to promote value-added arms exports and to promote TT and joint ventures (Kirchweh 2014, Kiss 2014, Balakrishnan 2007, Dunne and Lamb 2003). The defence industrial participation policy has seen local companies benefiting from foreign suppliers buying subsystems, and components from the domestic defence industry, either under license or in collaboration with the foreign suppliers (Dunne and Haines 2006, Dunne and Lamb 2003). The objective has been to provide orders to local companies and opportunities to develop niches in the international market through links with foreign companies (Dunne and Lamb 2003). A South African state-owned aerospace and military technology conglomerate Denel and certain private companies have been involved in international defence industry supply chain networks as a result of defence industrial participation projects but have not seen much in terms of absorption and creation of technologies through TT (Balakrishnan 2008, Dunne and Haines 2006).

Over 130 countries have some form of offset policy. As officially referred to in South Africa, offset or industrial participation became mandatory for all government purchases in September 1996 (Bachelor and Dunne 2000). Offsets gradually became an increasingly important factor in selecting potential foreign suppliers, and it is unlikely that offsets will disappear in the foreseeable future (Kiss 2014, Bachelor and Dunne 2000). The offset programmes offered were typically given more weight than the quality, price or other parameters of competing products, having a 20-30% overall impact on decision making (Kiss 2014). Within the scope of offset, the role of TT and innovation have been more and more emphasised since the beginning of the 2000s (Kiss 2014). Offset performance is not easy to evaluate. Years later, it may be not easy to trace what has happened and evaluate the results, particularly the less direct benefits and results that seem mixed (Kiss 2014, Willen et al. 2013, Güvenç and Yanik 2012 Dunne and Haines 2006). The impact of offsets is often found to be especially problematic in terms of job creation, the strengthening of backward and forward supply chain linkages, and technology enhancement (Dunne and Haines 2006). Dunne and Haines (2006) highlight that the local defence companies expected to benefit from offset programmes often produce technologically sophisticated goods but are typically deeply conservative in outlook and used to dependence on safe government orders. This does not make them suitable catalysts in the development of intellectual capital through learning. What is required is a 'high degree of local technological absorptive capacity to be achieved through a state-sponsored 'civil-military, Science and Technology strategy'. (Dunne and Haines 2006)

The lack of a standardised approach in dealing with prime suppliers offset programmes has resulted in primes having too much latitude in deciding how and when to discharge their obligations and too often chose to do so in ways that produced questionable and behind schedule benefits upon the national economy (Hall et al. 2007). Kirchwehm (2014) further states that most of these system integrators also pass these obligations into the lower stages of their supply chain. As a result, the lower-tier companies are increasingly coming into contact with the offset. Only having minimal experience or knowledge on the topic or how to offset activities could affect their business in the future. Noticeable is that this lack of knowledge is related to the companies of the selling side and companies in the participating industry that should benefit from the requested offsets.

Furthermore, as companies keep a narrow contract manufacturing view of their operations, they miss the opportunity to expand the benefits beyond the original offset programme (Kirchwehm 2014). (Kirchwehm 2014). To support this, Balakrishnan (2008) argues that TT and adaptation by itself will not be sufficient if the local companies cannot sustain their businesses or are unable to utilise the skills acquired outside the contract context. What is required is that offsets projects are well-planned and not once-off contract activities (Balakrishnan 2008).

3.3.3. South Africa

As discussed by Botha (2003), Dunne and Lamb (2003) and Bachelor and Dunne (2000) in South Africa, the arms industry proliferated in the years 1961 to 1989 as South Africa adopted an aggressive foreign policy and became involved in the regional conflicts. An independent arms industry development was led by the arms procurement agency of the South African Department of Defence, the Armaments Corporation of South Africa (Armscor), as substituting goods could not be imported due to the international sanctions by the United States against South Africa. By the end of the 1980s, South Africa had a substantial defence industry and became self-sufficient in arms production. The industry employed more than 8% of the total employed in the country's manufacturing sector and had a supplier network of almost 3,000 local companies. By the 1990s, the procurement expenditure declined by 60% due to the collapse of apartheid and the subsequent defence budget cuts. Consequently, the industry tried to compensate for the South African Defence Force demand decline by branching out to the civilian markets by adopting a diversification strategy. In 1992, a new government-owned corporation, Denel, was established, where all Armscor's manufacturing activities were transferred. In contrast, Armscor's functions were restricted to procurement, support and control only. Its role is to manage the acquisition processes for the Department of Defence from the technical, legal and financial perspectives. In addition to this, Armscor facilitates the participation of the local industry in the international defence market and co-manages the industrial participation (offset) programmes with the Department of Trade and Industry (DTI) to leverage the economic and industrial benefits through government procurement. Denel is expected to operate on a commercial profit-oriented basis rather than purely national defence strategy motivations. The sanctions were lifted in 1994, resulting in the South African companies competing in the international market. The defence industry was seen as a strategic and economic asset that had to be retained and developed to earn foreign exchange and develop a high technology manufacturing capacity and skills that could be migrated back to the rest of the industry. Exports that have been growing steadily since 1994 and were seen to assist the local companies to reach internationally competitive standards, to achieve efficient economies of scale and to generate monies for research and development, especially as the Department of Defence does not have the resources to sustain the technological development on its own. Traditionally there has been relatively low vertical integration in the local manufacturing supply chain network. Internationally, partnerships are utilised, often in joint ventures involving equity participation on both macro and maso levels. Further strategic alliances were facilitated through industrial participation. The interaction and benefits gained from these industrial participation-based alliances have, however, been more mixed and problematic where the expectations often did not materialise in terms of long term job creation, the strengthening of backward and forward linkages and technology enhancement (Botha 2003, Dunne and Lamb 2003, Bachelor and Dunne 2000).

3.3.4. Economic Impact of Arms Production

A major channel by which military spending is hypothesised to impact the economy positively is through technological innovation from the military sector to the civil one as a technological spin-off. It has been argued that the complex technology related to military production stimulates the overall industrial base. However, others suggest the linkages to the civil economy in such economies are small. According to Sköns and Dunne (2008), the arms industry accounts for only 1% or less of the gross domestic product and employment in the global perspective. On the contrary, more recent rapid development in commercial technologies, especially in electronics, has led to spin-in, with civil technologies increasingly used in arms production (Sköns and Dunne 2008). Sköns and Dunne (2008) argue that there is no objective evidence that military spending plays any significant role in economic development (Sköns and Dunne 2008). Opposite to this, Matthews and Parker (1999) state that it is incontestable that the defence sector plays a pivotal role in generating economic activity (Matthews and Parker 1999). Sköns and Dunne (2008) assess more of the current market situation from the European perspective.

In contrast, Matthews and Parker (1999) assess from the United States point of view where the defence industry can perhaps be stated to be the only one with significant volumes and capabilities due to the market size. Since arms production requires significant investments, has long technology maturation cycles, and has limited linkages within the economy, questions can be raised about its potential to contribute to long-term growth (Kiss 2014). In purely economic terms, arms production can mostly be inefficient and highly expensive, with only a limited export potential (Bathcelor and Dunne 2000). In Australia, there is some evidence of genuine long term gain where the Australian engineers and other specialists employed locally in foreign-owned subsidiaries have benefited from training at the central facilities of the parent company (Hall et al. 2007). The simultaneous increase of technological complexity and the decrease of order volumes will inevitably result in economically inefficient excess capacity if the function of the local defence industry is mainly focused on preserving jobs (Jackson 2004). This imbalance of capacity can, however, be resolved by finding export markets (Jackson 2004).

In 2011 Turkey's work-share of the Joint Strike Fighter program was found unsatisfactory by Turkish procurement officials (Güvenç and Yanik 2012). According to Kirchwehm (2014), a way to avoid this would be to align the conflicting stakeholder interests at the beginning of the programme with the right incentives involving the original equipment manufacturers (OEMs), local partners, and offsets government agencies to better collaborate in creating sustainable economic-development and commercial value beyond the contract context. This can only be achieved through a gradual process (Kirchwehm 2014). Gholz et al. (2018), on the other hand, highlights the importance the commercial-military integration through the supply chain, linking the defence production to the broader economy (Gholz et al. 2018). There is real economic value only when the skills acquired through military-oriented production are transferable to the commercial sector (Kirchwehm 2014). In all, governments and specialist defence companies alike face the need to find ways to better adjust to a broader global stream of innovation that will probably fundamentally change the way they do business as a whole (Hayward 2001).

Like in many offset projects before, in the case of Malaysia, the offset has provided mixed results, as described by Balakrishnan (2008). The success has been focused on technology capability building, and human skills development limited to the contract context and military-civil diversification. The successful diversification through offsets was based on several factors:

- Malaysia has a strong civil-based industry, especially in electronics and aerospace, supported by the civil-defence-based business structure of the local defence companies.
- OEMs were more receptive to transferring non-defence technologies and collaborating on civil projects due to the above characteristics.
- Offsets have successfully enhanced and strengthened existing strong backward linkages within the civil sectors, mainly in electronics and aerospace. Local companies find it easier to source from companies with generic expertise.

However, Offsets have failed to create marketing opportunities for Malaysian defence companies because the government and local companies lack a structured marketing strategy to develop and promote products internationally. Similarly, minimal defence exports have been generated through offsets activities. The general nature of Malaysian offsets projects is primarily focused on training and promoting civil work for both indigenisation and export. There are no policy intentions to promote joint or licensed defence production. For example, the offsets have successfully improved worker skills in quality and process control requirements, enabling the civil industry better to meet the international level competitiveness (Balakrishnan 2008). Opposite to Malaysia, the South African offsets in the civil sector have not been as successful (Botha 2003, Dunne and Lamb 2003, Bachelor and Dunne 2000). Perhaps it would be beneficial to adjust the overall governmental offset approach to best fit the industrial landscape in order to maximise the economic benefit instead of having a fixed ‘one fits all approach or artificially trying to revive, subsidise or ‘resuscitate’ a non-viable and often too expensive national defence industrial base.

3.4. Industry View

This section discusses the systematic literature review findings related to the sources identified as having a broader industry view.

3.4.1. Arms Production

There is no generally agreed definition of arms production, and the efforts to develop definitions that encompass all facets of this field have proved problematic. In a general sense, arms production can be defined as the production of military goods and services. Military goods are usually defined to include weapon systems and all other products that have been developed and produced specifically for military use (Kiss 2014, Sköns and Dunne 2008, Dunne and Haines 2006). One important difficulty in defining arms production is to decide whether the production of subsystems, components, and parts should be included or if the term arms production is limited to only the production of final weapon systems. An arms-producing company can also be defined in different ways. It can present a company engaged in arms production, regardless of the proportion of military sales in the total sales. However, few companies produce exclusively for the military market when most companies have a mixed military and civil production. However, most of them have divisions that are specialised in military production.

Most commonly, the term arms industry refers only to the arms-producing activities of companies (Kiss 2014, Sköns and Dunne 2008, Dunne and Haines 2006). Similarly, the term arms industry is sometimes used to refer to the sum of arms-producing companies, while at other times, it refers only to the arms-producing parts of these companies. These variations can be significant since arms production can take up only a tiny part of a company's total sales and employment.

According to Kiss (2014) and Sköns and Dunne (2008), the capacity to develop and produce effective weapon systems is highly concentrated in a few countries where the United States by far is the biggest arms-producing country accounting for roughly half of the total global arms production. The United States Department of Defense arms procurement and R&D increased from 90 billion USD in 1995 to 148 billion USD in 2006. Simultaneously, the United States arms exports have increased by over 3 billion USD between 1995 and 2004. Thus, the United States arms production value has likely increased at least 150 billion USD in 2005. While several countries also have small-scale manufacturing capability for small arms and light weapons, few have a significant defence industrial base. So most depend on imports for their acquisition of arms, at least for major weapon systems. None of them has increased their arms production on the same scale as the United States (Kiss 2014, Sköns and Dunne 2008).

According to Hayward (2001), North American and West European companies are the dominant forces in the world defence business. An analysis of the national distribution of the top 100 shows just how concentrated the world defence industry is, with Japan as the leading non-Western defence industrial nation. In terms of published revenue (which will understate the significance of the Russian and Chinese industries due to laking publicly available data), Japan has the largest defence-industrial sector outside Europe and the US, followed by Israel, India and Taiwan. Several Latin American countries and South Africa also have significant defence industrial assets. Motives for developing indigenous defence-industrial complexes have ranged from security autarky to stimulating economic development. As a minimum, states have sought to offset the cost of defence equipment procurement with some degree of domestic production. In some cases, states have deliberately targeted the defence sector as a source of technological innovation, often with mixed results and usually at a much greater cost than commercial-off-the-shelf purchases (Hayward 2001).

Throughout modern history, the nations have been independently responsible for their arms production by controlling or ultimately owning their defence companies (Maye 2017). Nevertheless, globalisation is accelerating the emergence of transnational defence markets and corporate structures, amplified by the international supply chains, foreign investment in national-defence companies and the fact that defence industries were falling behind the commercial sector in terms of technological innovation and manufacturing efficiency (James and Hall 2008, Hayward 2001). According to Hayward (2001), by the beginning of the 21st century, the world industry was consolidated into four major defence prime contractors and a group of leading semi-primes and specialist high-level subsystem suppliers, namely BAE Systems, Lockheed Martin, Boeing, Raytheon, General Dynamics, EADS, Northrop Grumman and GE-Honey. The formation of EADS and BAE Systems in Europe created two transnational defence primes that only BAE Systems can claim to be a global mega prime. The US primes size is staggering, but they only have very few overseas assets, networks of collaborative activity. However, globalisation is much more significant below the prime level surface. Further down the supply chain, the need to insert leading-edge commercial technology into defence systems have stimulated the internationalisation process together with interest in capturing the potential cost and time savings of commercial-off-the-shelf (COTS) components. (Hayward 2001).

As illustrated in Figure 3.4, James and Hall (2008) discuss how France, the USA, and the UK are major defence exporting countries. All insist on maintaining a domestic defence industrial base, which accounts for most national defence needs. This could suggest that if a country wishes to have a sustainable national defence industry, this industry must have access to commercially viable export markets or enjoy government subsidies to maintain the operations of both. For the make-or-buy approach, the critical considerations will be horizontal and vertical integration implications and their implications to the domestic defence industry's economic, contractual and organisational arrangements and its operating size and corporate governance (James and Hall 2008).

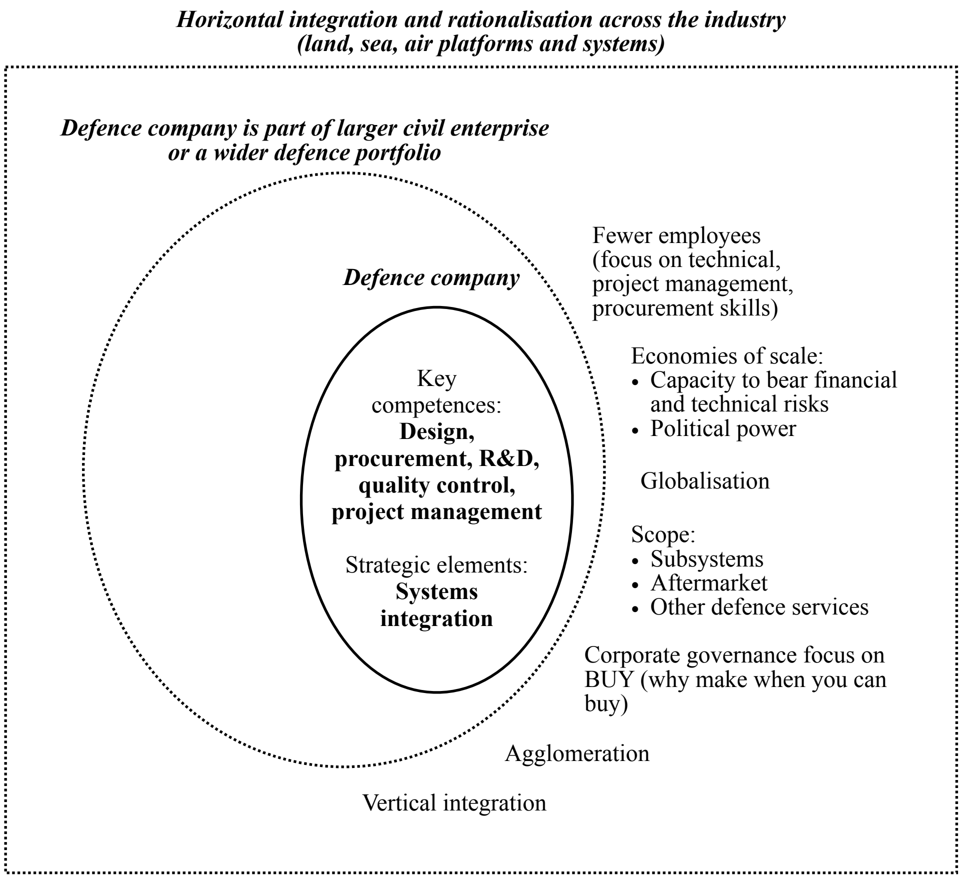

Figure 3.4: 21st century defence company (illustration created based on the texts of James and Hall 2008, Hayward 2001, Andersson and Lilliecreuz 2000).

According to James and Hall (2008), Hayward (2001), Andersson and Lilliecreuz (2000), the defence 21st-century defence company has considerably fewer people employed as the global outsourcing of components, parts and subassemblies become a norm. The essential in-house functions will be design, procurement, R&D, quality control, project management and systems integration when up to 50% of the other production activities will potentially be outsourced. The defence company structure is hollow, with only the core competencies (e.g. design, procurement, R&D, quality control, project management) and the strategic elements (e.g. systems integration) remaining. It typically is a small part of a much larger civil industry enterprise or a broader defence portfolio. The economies of scale, scope and agglomeration will be realised through rationalisation across the wider defence industry.

Regarding those employees who remain, there will be technical staff engaged in design and R&D, but greater importance will be placed on procurement and project management. Corporate governance reflects the focus on critical competencies and strategic elements, emphasising 'buy' rather than 'make'. There will also be fewer defence firms due to the horizontal integration. The resulting increase in company scale is imperative in building resistance to financial and technical risks. It also provides greater political power for managing customer relationships and influencing the procurement process. As over 70% of the value of a complex weapon system is derived from subsystems, a defence company seeks to integrate vertically to develop more subsystems. Defence companies have equally recognised the value of the aftermarket, upgrades and technology insertion over the lifetime of a weapon platform or defence system. There are also other defence service opportunities in training, simulation and logistics management that, as a result, will take the defence company ever closer to the battlefield itself. The globalisation of the industry will further force the defence companies to operate internationally to stay competitive (James and Hall 2008, Hayward 2001, Andersson and Lilliecreuz 2000).

Sköns and Dunne (2008) further characterise the defence industry that usually operates in a monopsonistic market where the national government is the single customer and regulates exports. Similarly, the defence companies are mostly national monopolies. This results in a natural triad structure with close relations between the defence contractors, the procurement executive, who is typically a government agent, and the military. There are also elaborate rules and regulations on contracts to assure public accountability. These characteristics create a market that favours companies specialising in defence work as they know their way around the red tape and have contacts within the military and the procurement executives. They focus on becoming experts at getting money out of the government rather than being successful in commercial markets. As a result of the structure of the market, there are barriers to both entry and exit, meaning that not only it is difficult to enter into the defence sector to produce weapon systems or upgrade from subcontractor status, but also that it is difficult for the defence companies themselves to leave the industry. Furthermore, the government, as a major stakeholder, a defence company is under pressure to support government goals, such as the maintenance of employment, rather than the profit as in a purely commercial business environment. This situation causes conflicts when the defence companies are, however, required to operate in an increasingly competitive global market where downsizing and capacity adjustments together with constant improvement of productivity and business practices are a commercial necessity (Sköns and Dunne 2008, Kopac 2006)

The defence supply companies have been broadly categorised into new and old technology suppliers by Downdall (2004). The new technology refers to the introduction and employment of advanced technologies, even from other industry sectors. These category suppliers operate globally, supplying most of the industry primes while remaining small in facilities and employment. They also typically exhibit strong growth potential. On the contrary, the old technology suppliers are the more traditional suppliers whose outputs are based on drawings and sometimes even equipment supplied by the customer. The technology itself is matured and carries low risk and greater operator familiarity but offers low potential for exports or further commercial exploitation. Typically the old technology supply companies and their management prefer a risk-averse approach, being satisfied with the existing status quo and reluctant to build new competencies, lacking true entrepreneurial vision. While many of these companies have acquired ISO qualifications, few have fully embraced modern technologies, best practices, and other advanced business management approaches. These companies also have deficiencies in using information technology, seeking cost savings via civil and dual-use applications or through their supplier network collaboration. The new technology suppliers employ more modern and flexible manufacturing technologies than the old technology suppliers. More and more, there is an end customer pressure to move away from companies just selling assets, old technologies to being asked to ensure the asset are available and running at a high level, with a responsibility to provide proper training, maintenance and other services. In other words, these suppliers are expected to take responsibility for the role of the Department of Defence itself (Zuckerman 2007, Smith and Tranfield 2005, Downdall 2004).

3.4.2. Defence Industry Structure and Supply Chain

The complex systems are typically presented in terms of a hierarchy, the literature emphasising the development of a tiered structure of supply chains (Gholz et al. 2018, Smith and Tranfield, 2005, Pages 1995). In the interests of efficient project management, the Ministry of Defence traditionally places large defence contracts in the hands of a single prime contractor where the responsibility for design and supply chain management rests on the industry, the end customer purchasing all its needs as systems (Gates 2004). The prime supplier must be able to integrate the whole system to understand that it fits the overall national defence scheme, i.e. system of systems (Gates 2004). In the future, this may grow even with the requirements to understand and manage the interface to broader global meta systems to ensure network-enabled capability (Gates 2004). This prime contractor as the system integrator is located at the top of the supply chain pyramid and is responsible for the project management, final assembly and systems integration (Matthews and Parker 1999, Page 1995). Prime level's strategic objective is to withdraw from the traditional manufacturing and focus on the higher value-added design, development and integration (Matthews and Parker 1999). The global industry rationalisation has created the first tier of fewer, larger, and more skilled suppliers that delegate responsibility for managing lower-tier suppliers and subcontractors to the first-tier suppliers (Gholz et al. 2018). The prime contractors and the first tier suppliers have strong and deep relationships characterised by high levels of technological interdependency (Gholz et al. 2018). System integrators typically are interested in fostering specialisation among their strategic suppliers and ensuring that suppliers' technology and business practices are aligned to the integrator's specific requirements (Gholz et al. 2018).

Within this hierarchy, not all components and their suppliers are equally significant, regardless of their location in the supply chain (Gholz et al. 2018). Some lower-tier suppliers may be technologically important, such as suppliers of microprocessors or advanced materials, and some may even integrate complex subsystems, combining sophisticated components from different industrial sectors (Gholz et al. 2018). Nevertheless, the literature generally implies that the most technologically sophisticated and important suppliers are found at the first tier (Gholz et al. 2018, Koblen and Niznikova 2013, Smith and Tranfield 2005). There are, however, implications that the lower tier suppliers also provide complex integrations of subsystems. This could imply that the systemic complexity grows in the pyramid when going up rather than the level and sophistication of the technology. According to the study of Gholz et al. (2018), the horizontal specialisation differs with distance from the prime contractor, and there is also an important borderline between the first and the second tier. Nearly half of the suppliers located in the first-tier are firmly defence oriented when most of the suppliers on lower tiers are commercially oriented (Gholz et al. 2018). Gholz et al. (2018) argue that this demonstrates the importance of the supply chain as a source of commercial-military integration, linking defence production to the broader economy (Gholz et al. 2018). Hence the supply chain provides a mechanism for the systems integrators to obtain horizontal technology spill-overs from the commercial sector. The first-tier suppliers intermediary these defence specialised systems integrators and the commercial sector suppliers located in the lower tiers (Gholz et al. 2018). Roughly half of the defence contract value remains with the prime contractor; the rest are passed to lower levels (Page 1995). Systems integrators derive the benefits of specialisation primarily from their first-tier suppliers and general-purpose technologies from the lower tier suppliers (Gholz et al. 2018).

Driven by the supplier's outstanding performance or the offset obligations set by the end customer, the globally operating prime contractors integrate national suppliers into their supply chains, usually at a lower level (Kiss 2014). Only a handful of these companies have achieved a higher position in the hierarchy as preferred long-term partners. Many of these become isolated from their national context and are taken over by a foreign enterprise over time (Kiss 2014). For example, there has been a growing number of joint ventures over the past 15 years between European and South African defence firms due to the South African arms deal package. These joint ventures involve learning opportunities through the TTs and, to some extent, have allowed South African defence firms to become part of these European companies' global supply chains (Dunne and Lamb 2003). Hence this selective integration has contributed to the domestic defence base (Kiss 2014). By some estimates, systems integrators contract out 60–70% of work on their suppliers (Gholz et al. 2018). According to Downfall (2004), in 1993, just 6 out of over 200 first-tier suppliers consisted 60% of the total prime contractor purchases in the Warrior Armoured Fighting Vehicle programme in the United States, and the Piranha APC programme 2 out of 200 first-tier suppliers consisted 60% of the total purchases. The first tier used 18 suppliers each, and the second tier used 7 suppliers each (Dowdall 2004).

Similarly, according to Waissi et al. (2013) study on the Arizona aerospace and defence supplier network, an average small and medium-size first-tier component supplier has at least 50 suppliers.

Each of which 5 to 9 is considered as key suppliers (Waissi et al. 2013). As a result, of offset majority of the arms contract may be supplied from local sources. However, this typically involves many international companies acting through their subsidiaries established in the country of question (Pedone 2017). According to Kiss (2014), the subcontractors are diverse and range significantly from employing a handful of people to employing thousands. They can be exclusively defence-oriented or entirely civil, or a combination. They can also be available as part of high-tech producers or integrators for other subcontractors. Some are state-owned, some private. Suppliers in lower tiers tend to be smaller than the prime contractors. However, they are often more advanced technologically in their product and service portfolio area and more agile and efficient. Cutting-edge technologies, innovations, new products and methods are typically developed at these lower levels of the supplier chain (Kiss 2014, James and Hall 2008).

The relationship between the buyer-supplier can be described as a triadic arrangement formed by the government agency, prime contractor and the suppliers where the members of the triad can take different roles over time or change entirely at the different phases of the defence contract fulfilment period (Howard et al. 2016). Furthermore, the relationships within the global supply structure and the competing supply chains in a broader context are generally obscure. Before any major defence contract is awarded, the different bidders, i.e. the prime contractors, build parallel supplier chains that often employ the same subcontractors who also benefit from their primes' competition until the delivery contract is signed (Kiss 2014, Oyetola et al. 2014). The primes and their first-tier subcontractors share most of the arms contract when the minor defence related subcontracts are allocated to the smaller lower tier companies (Kiss 2014). To add to this, a single company may be a tier-one supplier to one company and a tier two supplier to another company. The position could also change from one project to another (Antill et al. 2001). In this complex subcontractor cobweb, it has become increasingly difficult to define the national identity of many companies since the production premises, markets, and ownership are not necessarily at the exact geographical location. The development of new products typically involves input from subcontractors around the globe (Kiss 2014). The large systems integrators typically dominate the relationship with the end customer, the Ministry of

Defence, and close relationships with the direct first-tier suppliers. However, they are typically not involved in managing the lower tiers of the supply chain (Gholz et al. 2018). Throughout the defence supply chain, the different parties are mainly influenced by their immediate customer rather than the distant or even unknown prime system integrator or Ministry of Defence that the downstream are not even in direct contact with (Gholz et al. 2018). Furthermore, the lower tiers do not necessarily know that their product or a subassembly is part of a complex defence system (Gholz et al. 2018). The overall defence industry tier structure is illustrated in Figure 3.5.

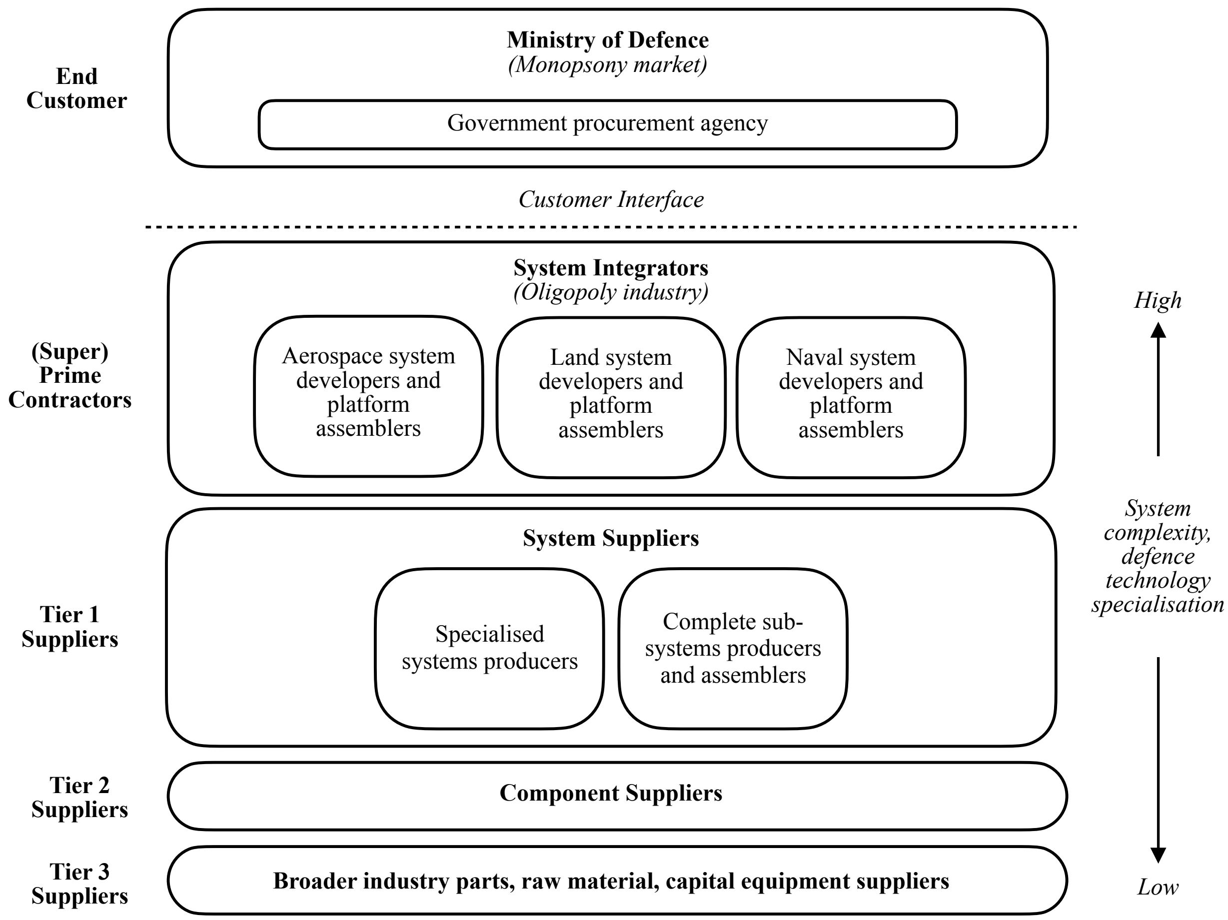

Figure 3.5: The defence industry tier structure (illustration created based on the texts of Gholz et al. 2018, Koblen and Niznikova 2013, Smith and Tranfield 2005, Dowdall 2004, Jackson 2004, Matthews and Parker 1999, Pages 1995).

Despite this fact, the companies within the supply chain are highly interdependent due to the global competition that makes collaboration a commercial imperative (Green et al. 2005). The need for collaborative working is linked to the sector's overall existence where the different actors on different levels are locked into each others success in a very competitive market (Zukerman 2007, Green et al. 2005). The highly technologically based companies in general typically have more closer, collaborative relationships with their customers. (Graham and Hardaker 1998). According to Koblen and Niznikova (2013), the defence supply chain has the following key challenges in its supply chain management for the middle term future:

(i) An increasing level of integration in strategic alliances aligned with technological development and industrial ramp-up is at the core of collaboration required to move from ad hoc solutions to anticipation and better-managed interfaces between parties.

(ii) Significantly increasing supply chain complexity and the difficulty of balancing cost targets, offset requirements, quality standards, currency volatility and operational efficiency.

(iii) Sub tiers as a growing source of innovation and R&D partners.

(iv) Supplier selection and capability assessment as incorporating with the small and medium-sized enterprises who frequently offer the innovation but may lack the stability to commit to long term arrangements is difficult.

(v) Development of supplier capabilities, improving processes and the detection of supplier weaknesses.

(vi) Rigid supply chain coordination and standardisation.

(vii) The overall performance and efficiency of the supply chain (Koblen and Niznikova 2013, Gates 2004).

In addition, it is imperative to facilitate communication, coordination, and execution across the supply chain and mutual collaboration (Searcy et al. 2004). However, partners are still taking a short term view and thus unable to utilise all the benefits attainable from their co-operative supply chain relationships (Wilding 2006). The competition will increasingly be between the supply chains and supply networks rather than between competing companies as in the traditional sense. The shift to strategic supplier alliances involves much tighter cooperation between the companies (Beelaerts et al. 2012).

In all, the defence supply chain structure is dynamic. The complexity and technological sophistication constantly grow at the lower level tiers where the commercially based innovation is increasingly acting as a basis for the defence products, hence turning the innovation pyramid upside down. TT based strategic alliances also cannot be identified as a typical supply chain relationship. The better utilisation of TT is forcing the receiving companies and governmental policies and management of defence programmes to create or further develop supply chain strategies and deeper partnership relationships.

3.4.3. Sustainability and Supplier Development

Generally, sustainability varies in its meaning, and it is usually viewed from social, economic and environmental perspectives (Oyetola et al. 2014). In this study, sustainability refers to organisations economic capability to be financially viable and successfully remain in business in the long term. According to Gates (2004), there is likely to be demand for a company that specialises in delivering defence capability through long term relationships, with specialist knowledge of its various national customers and a willingness to work openly and closely with them. Furthermore, a sustainable defence supplier company has the agility to integrate diverse technologies into a system and deliver both hardware and service (Gates 2004). Talented suppliers are more likely to adapt over time and be active in innovating both product and process innovations (Smith and Tranfield 2005). They also are actively focusing on enhancing their innovation capabilities through alliances and acquisitions (Wang et al. 2018). So it could be concluded that a company that actively pursues cooperation and seeks to operate collaboratively, regionally and internationally, will be at the forefront of long-term innovation and ultimately the company survival.

Supplier development is a relatively new, mainly a private-sector concept, covering any effort of an organisation to increase its supplier's performance or capabilities (Winner 2012). This philosophy is based on the idea that a more robust, more capable supplier has a positive impact on the competitiveness and costs of an organisation (Winner 2012). The defence industry supply chain management typically does not involve any supplier development elements in their processes because effective supplier development programmes cannot exist in the government ecosystem for the appearance of unfairness towards other competing suppliers (Winner 2012). The focus is on the acquisition and the supplier selection process to provide the best value through supplier competition and lower the overall costs related to the contract (Winner 2012). However, a robust supplier development programme would assist in reducing costs related to government contract administration and operational inefficiencies (Winner 2012). After the government contract award, the three aspects monitored throughout the execution of the arms programme are cost, quality and delivery (Winner 2012). Unlike the private sector, the government is solely focused on monitoring that the set contractual quality requirements are met and lacks any involvement in assisting the supplier in fixing any possible quality issues (Winner 2012). It could be argued that the supplier development should form part of the government defence contracting and offset programmes, providing possibilities to achieve more long term commercial benefits. Current fixed-price contracts would need to change to include cost reductions and performance improvement goals over the contract's life (Winner 2012).

3.4.4. The Acquisition of Technological Capability in the Offset Context

Competencies, as industrial development and innovation capability, for example, are anchored in the technologies an organisation possesses. These technologies can systematically be built and acquired to improve an organisation's economic performance and enable technological upgrading and competitiveness. However, it is essential to note that technology acquisition does not automatically lead to increased capabilities (Reddy and Zhao 1990).

The TT of knowledge in international defence industry supply chains is established based on the offset requirements between two organisations; the foreign supplier and the local partner. TT is seen as imperative to support and secure the self-reliance in defence technology in a wartime situation, leverage the local defence industry capabilities, and support the local defence industry economically. To fulfil these objectives, learning through TT must be successful. These alliances based on offset requirements are typically one-way learning environments where the local partner is the only receiver. Unlike the typical definition for an alliance (Choo and Bontis 2002), they are also involuntary arrangements. The alliance is only taking place due to the objective of winning the supply contract under local manufacturing requirements.

Ivarsson and Alvstam (2005) discuss the importance of inter-organisational linkages between vertically related companies due to the natural need for continuous coordination of activities and thus the exchange of information. It could be argued that these linkages are especially crucial in a defence industry environment where the domestic market alone rarely can provide effective means for the local companies to reach an adequate level of competence and operational excellence. Thus to support the local capabilities, the foreign defence industry suppliers are required to commit to the local production and, further, to provide the selected local partner(s) with extensive technological assistance (Ivarsson and Alvstam 2005). On the other hand, the recipient of this kind of assistance cannot be just a passive receiver but is also required to allocate substantial resources to secure the absorption and adaptation of technological knowledge and capabilities (Reddy and Zhao 1990).

In general, the objective of the acquisition is to gain possession of relevant technology in the form of firm-specific information regards the production process and product design. Hence the technology can be defined as an intangible, tacit, often uncodified knowledge about a specific application accumulated in a firm over time (Zhao and Reisman 1992). The leading management theorists, such as Porter (1985), consider this technology a firm-specific valuable strategic asset that can, as a competitive advantage, even alter the structure of an entire industry (Porter 1985). Zander and Kogut (1995) similarly argue that the innovation capabilities rest on their ability to replicate the production and sales capability of a new product or a service. However, replication alone cannot form a sustainable basis for the long term development of competitive advantage and innovation capabilities. Still, it can build the necessary technological capability of the recipient. (Zander and Kogut 1995).

Reddy and Zhao (1990), in their literature review on international TT, identified several typologies of technological capabilities such as operational, duplicative and innovative capabilities (Westpahl, Kim and Dahlman 1985 as cited by Reddy and Zhao 1990). Again, companies do not acquire skills to imitate and replicate but to increase their capabilities, competitive advantage, and innovativeness. This acquired ability to create better value is at the core of offset. Capasso et al. (2005) discussed that in their aspiration of value creation, the organisations enter a strategic network to pursue valuable information exchange. Thus organisational networks allow companies to access critical resources from their environment. Unlike in firms' systems, the focus of strategic networks is on the company opposite to the network level. One of the primary motivations for forming strategic alliances is learning and integrating knowledge into an organisation (Capasso et al. 2005). In the defence offset context, the objective is learning by gaining access to competencies and existing business. Alliances are an alternative to the acquisition, often involving acquiring unrelated assets (Capasso et al. 2005).

3.4.5. Technology Transfer

Economists initially introduced the concept of TT, and the first empirical studies regarding the cross-border TT in multinational corporations were presented by Baranson (1970) and Davies (1977). They took the initial steps to develop a deeper understanding of the international inter-organisational TT phenomena by focusing on the primary cost analysis and the factors affecting the transfer between organisations. As a whole, the initial TT study audience was mostly economic policymakers and often derived from the technology development of the recipient organisation located in a developing country (Contractor and Safati-Nejad 1981, Davies 1977, Teece 1977, Mansfield 1975, Baranson 1970). Lasserre (1982), as one of the first, narrowed the study lens by comprehensively studying and analysing the training as the primary key success factor. In 1990 Galbraith introduced the concept of flexible and transportable manufacturing through the floating factories, which was further deepened by Zander and Kogut (1995) with the discussion of modularity of organisational capabilities. By the change of the decade, the attention still very much remained on the factors affecting the TT, namely the factors affecting the absorptive capability of the recipient (Szulanski 1996), the learning capability in alliance (Capasso et al. 2005), and the factors enabling the organisational learning and innovation through the TT (Ivarsson and Alvstam 2005). In all, the research has been very much economist driven, focusing on the broader aspects of the impact of the TT to the receiving country and the related governmental policies to foster such transfer (d'Agostino et al. 2019, Lorell et al. 2002, Batchelor and Dunne 2000, Davidson and McFetridge 1985, Mansfield and Romeo 1980, Contractor and Sagafi-Nejad 1981, Mansfield 1975). Currently, only very few studies involve a more pragmatic, process analysis perspective suggesting how the local suppliers could improve their operations and, as a result, better compete within the international market (Fredriksson et al. 2018, Ivarsson and Alvstam 2005, Zander and Kogut 1995). Reflecting this, Ivarsson and Alvstam (2005) emphasise that a high level of local sourcing does not automatically result in technological learning. However, a more strategic role and a long term relationship with the supplier seems to be a critical determinate. Even in simple assembly operations, a successful TT does generate linkages throughout the local supply network, resulting in broader technological upgrading (Ivarsson and Alvstam 2005).

Offsets often result in the governments and the local recipients being left unhappy with the level of received TT and the demonstrated technological and process capabilities as the TT output in general (Kiss 2014). However, in these cases, the barriers typically originated at the recipient end, such as the availability of suitable local partners and the limited capability of adopting and implementing new technology (Kiss 2014). Kiss (2014) argues that transferring technology to the state-owned defence industry is the most challenging part of the offset, not least because of the often high technology gap between the foreign supplier and the local recipient (Kiss 2014). The local defence companies often produce technologically sophisticated goods. However, at the same time, they are deeply conservative in their attitudes as their whole existence is based on solid reliance on safe government orders and support (Dunne and Haines 2006).

To effectively manage TT and individual and organisational learning, a view of the process and related sequences of activities is needed (Cusumano and Elenkov 1993). There is, however, a limited research coverage explicitly focusing on the aspects of the international inter-organisational TT process, mainly on the meta-level processes involved (Fredriksson 2018, Mam et al. 2015, Knudsen and Madsen 2013, Mariotti 2012, Balakrishnan 2008, Ivarsson and Alvstam 2005, Albino et al. 1999, Szulanski 1996, Wei 1995, Mansfield 1975) and the conditions stimulating and facilitating the learning during the transfer process (Easterby-Smith et al. 2008, Inkpen 1998, Szulanski 1996, Zander and Kogut 1995, Mansfield 1975). Of these, Szulanski (1996) provides a best practice perspective, the most comprehensive TT process description that is based on four stages, namely the initiation (including all the events leading to the decision to transfer), the implementation (where the relationship between the parties is established, and the resources and practices are being transferred), the ramp-up (where the recipient begins to apply and use the transferred knowledge) and finally the integration (when recipient's practices stabilise and become institutionalised). Similarly, three meta-level steps have been identified to be involved in a defence offset specific environment, including the initial assessment, the industrialisation focusing on the capability gaps, and the ramp-up (Fredriksson et al. 2018, Malm et al. 2015). These both outline the main operational level 1, but we argue it does not build further understanding across the different operational areas nor provide a basis for detailed process documentation and thus enable systematical and standardised management. The primary value in Szulanski's study relies upon further identification of factors causing internal stickiness, i.e. the sources of difficulty in transferring knowledge, such as the low recipient absorptive capacity, the causal ambiguity, and the arduous relationship between the parties (Szulanski 1996). The results further indicate that organisations' difficulties in transferring technology might have less to do with motivational factors, and organisations will learn. However, somewhat more on that organisations do not know how to (Szulanski 1996). Thus, the organisations must better understand the transfer process and develop mechanisms to foster inter-organisational learning. Only an adequately detailed process model can provide a baseline for projection, reviews, streamlining and overall efficient management of the process and, as a result, bring the best results. However, based on the literature examination, we can find that this question has not been adequately addressed in previous scientific studies.

According to Balakrishnan (2008), technological learning is often a tacit, complex, costly and time-consuming process with an uncertain outcome. It hence cannot be expected to occur automatically, but it requires significant resources and commitment from the participating firms (Balakrishnan 2008). The technological capability can be divided into four levels: (i) operational skills involving the basic manufacturing and supporting operations, (ii) duplicative skills to expand the existing capacity, and the ability to acquire and integrate foreign technologies, (iii) complex engineering skills together with an ability to adapt and improve the acquired technologies, and lastly, (iv) innovation skills to generate new technologies (Balakrishnan 2008). Hence, the creation of enablers allowing the assimilation and, more importantly, the commercialisation of the acquired technology should be considered an essential aspect and outcome of a TT project (Willen et al. 2013). These enablers are more anchored to the human 'software' capital, i.e. the know-how dimension in terms of design and creation of engineering solutions and production engineering skills, rather than the traditional technological 'hardware' (Pedone 2017). The broader TT could be divided into two sub-approaches based on the overall objective: the transfer of capability to assimilate the production under the defence contract or the transfer of broader capabilities related to production and innovation. It should be discussed should the TT, instead of focusing on the assimilation of traditional product and technological capabilities, instead focus on design and engineering capabilities and business practices that would enable more sustainable future success.

The driver for the TT is the potential positive impact on the recipient, which can be challenging to measure but typically is related to increased productivity and new products (Ivarsson and Alvstam 2005). In the long term, the recipient's ability to build competitive advantage through the practical application of the knowledge received from the core of the competitive strategy and economic growth when over 50% of economic growth is based on some technological change (Capasso et al. 2005, Szulanski 1996, Zhao and Reisman 1992, Reddy and Zhao 1990, Conractor and Sagafi-Nejad 1981, Teece 1977). In all, the TT and adaptation will not be sufficient if the industries cannot sustain their businesses or cannot utilise the skills acquired for further development. What is required is that offsets projects are well-planned and not 'one-off' activities and that they can secure work from the foreign vendors' value chains through buy-backs, joint ventures and coproduction. (Balakrishnan 2008). In all, the growth is a function of the technology, the dependence it creates, the terms of acquisition and the TT process where the retentive capacity of the recipient determines the success of the transfer (Capasso et al. 2005). Hence how well the recipient has absorbed and integrated the transferred technology as a part of their operations and the absorbed new capability cannot be identified from the old skills.

To conclude, the current literature offers a relatively narrow economist driven meta-level perspective to the inter-organisational TT where the TT mechanism is seen as dependent on the relationship between the supplier and the recipient as well as the absorptive capability of the recipient and presented in a context of a multinational corporation and as an intra-firm activity. This study argues that this perspective needs to be extended to include systematically developed and communicated operational practices (the processes and management of operational activities). The literature provides little evidence on operational level research despite the identified gap in recipients' capabilities to comprehend and execute a TT project in a complex operational environment such as in the defence industry. This study would further provide a feasible operational theoretical context that is now lacking.

Several factors are affecting the success of TT:

(i) *Product and production techniques* (i.e. the context of TT) affects the feasibility of the transfer. The novelty, complexity and tacitness are the main sub-dimensions influencing the TT process and statistically significant factors (Easterby-Smith et al. 2008, Stock and Tatikonda 2000, Davison and McFetridge 1985). Also, the broader access the recipient has to the capabilities (such as designing, testing, manufacturing, etc.), the more successful the transfer (Zander and Kogut 1995).

(ii) *Type of transfer* where evidence suggests that a codified knowledge such as documents, reports and specifications, for example, is a much less effective way of transferring technology than a person-based training and assistance. TT involves learning which can be improved by using appropriate training methods and a comprehensive approach (Lyles and Salk 2007, Lasserre 1982, Mansfield 1975). Teece (1981) further argues that the transfer of knowledge may be impossible without a team of people to cover an entire process (Teece 1981).

(iii) *Type of knowledge*. Lyles and Salk (2007) suggest that tacit managerial knowledge acquisition has a more significant positive impact on performance than technical knowledge acquisition (Lyles and Salk 2007). This suggests that the focus should be more on managerial knowledge combined with technical knowledge to enhance the recipient's innovation capabilities.

(iv) *Codification* is where the accumulated experience, both on the individual and organisational level, facilitates and drives the ability to transfer tacit capabilities into a comprehensive code (Malm et al. 2015, Zander and Kogut 1995). Codification can also be seen as the ability to read and understand, based on the recipient knowledge and existing level of capabilities, combined with previous experiences.

(v) *Relationship between the organisations through inter-organisational dynamics and interaction.* The more of a technological gap between the supplying and receiving organisation, the more established and long-term the relationship must be. The TT must broadly cover different operational activities (Ivarsson and Alvstam 2005, Contractor and Sagafi-Nejad 1981). Contractor and Sagafi-Nejad (1981) further hypothesise that the value of the TT correlates with the type of alliance, increasing from a short term contract to the full-blown equity affiliation (Contractor and Sagafi-Nejad 1981). In the defence offset, on the other hand, the relationship between the donor and the recipient organisations is typically established at a faster speed. Szulanski (1996), in his study on the internal transfer of best practices, research highlights that instead of allocating resources on improving the organisational learning capabilities, it would be more beneficial to establish and maintain closer relationships between the organisational units and to communicate practices in order to improve the transfer systematically. Furthermore, the success of the transfer of tacit knowledge depends on the communication, coordination, coordination and overall intimacy of the relationship between the donor and the recipient (Stock and Tatikonda 2000, Szulanski 1996). The contextual differences such as different leadership approaches, levels of authority, different languages, and confusion regarding the definitions are best developed through social activities between the two organisations to improve personal relationships (Malm et al. 2015, Easterby-Smith et al. 2008). Lyles and Salk (2007) results indicate that shared management joint ventures perform the best. When the domestic partner has the dominant equity position, the knowledge transfer typically lacks performance (Lyles and Salk 2007). On the other hand, managing cultural differences and conflicts may be more challenging in shared management joint ventures, creating the need for more discussion and negotiation on decisions (Lyles and Salk 2007).

(vi) *Recipient capabilities*. According to Teece (1977) recipient's technical and managerial competence, especially managers broad experience in the technology and industry to be transferred, will determine the ease of the absorption. The well established and experienced organisations with the industry knowledge are more likely to be able to better and more quickly understand and apply the codified knowledge in their production (Teece 1977). This, together with the recipient's in-house R&D capability to solve unexpected ad-hoc problems and any possible prior TT experience, has a significant role in enabling a successful transfer (Galbraith 1990, Teece 1977, Zander and Kogut 1995, Davidson and McFetridge 1985). In general, the accumulated experience of the recipient with the technology is considered critical and determines the overall learning capability and the ability to understand new technologies (Zander and Kogut 1995). Reflecting this, the TT is often promoted as a driver for industrial development from developed to developing countries but deemed unsuccessful due to the recipient's inability to understand and apply the technology (Zander and Kogut 1995). Organisation's ability to recognise, assimilate and apply new external information in a commercial context is critical, especially to its innovative capabilities and is more likely to be developed and maintained when the knowledge to be transferred is closely related to the organisation's current knowledge base (Kumar et al. 1999, Cohen and Levinthal 1990). It is also essential to recognise that organisation's absorptive capacity is not an automatic byproduct of knowledge transfer. However, if an organisation wishes to acquire and apply unrelated knowledge, a dedicated effort and deliberate strategy ad management attention are required to create adequate absorptive capacity (Cusumano and Elenkov 1994, Cohen and Levinthal 1990). Lyles and Salk (2007) research results are consistent with that of Cohen and Levinthal (1990), suggesting that a significant indicator of knowledge acquisition performance is related to the capacity to learn (Lyles and Salk 2007). Grant and Gregory (1997) review addressed the appropriateness and robustness factors of the host labour, organisational capabilities, and infrastructure. Here the productivity, education and language homogeneity, labour turnover, organisational, technical capabilities and familiarity with manufacturing methods, support capabilities, among others, were the most relevant review addressed the appropriateness and robustness factors of which the supplier quality, cost, delivery, flexibility, service and proximity of local or international supplies are relevant (Grant and Gregory 1997).

(vii) *Supplier capabilities*. Similarly to the recipient, also supplier's previous experiences with the TT increase the probability of success as well as supplier's willingness to be involved and to provide support has an impact on the outcome (Easterby-Smith et al. 2008, Lyles and Salk 2007, Grant and Gregory 1997, Davidson and McFetridge 1985). Malm et al. (2015) argues that the disseminative capacity (identification of the capability gap and appropriate response to bridge it, appropriate documentation, organisation, training) of the supplier is the most significant success factor (Malm et al. 2015).

(viii) *Receiving country factors*. The level of receiving country infrastructure and general development, as well as the geographical distance between the recipient and the donor, cultural and attitudinal differences, work practices, approach to the problem solving and quality perception, language differences, units, standards, and other differences, have all an impact (Kumar et al. 1999, Grant and Gregory 1997, Branson 1977, Teece 1977). Also, the prior existence of a subsidiary or a local business entity in the host country (Davison and McFetridge 1985).

The most important origins of stickiness, i.e. the difficulties and significant barriers related to the TT, can be concluded to be (i) lacking absorptive capacity of the recipient, (ii) causal ambiguity, and (iii) the problematic relationship between the donor and the recipient contrary to the prior studies suggesting that the influencing factors are related to the characteristics of the knowledge transferred, to the donor (motivation and reliability factors) and the recipient (motivation, absorptive and retentive capacity), and of the overall TT context, i.e. the situation the transfer takes place (Szulanski 1996). Already the initial TT studies identified donors' willingness and ability to transfer the capabilities and the absorptive capability of the recipient as the main factors of successful technology transplants (Baranson 1970). Teece (1977) especially emphasised the donor's experience and accumulation of skills to facilitate the TT process (Teece 1977).

To conclude, the global market for high-high-technology industries is increasingly more dynamic. Companies decentralise their operations, downsize their fixed assets and introduce "floating factories" that can be adjusted and relocated as a flexible strategic response to the evolving competitive landscape. Correspondingly, this has increased the formation of strategic alliances and partnerships and the use of TTs to attain strategic flexibility (Galbraith 1990). These core manufacturing transfers through modular core technologies or technological bundles, each representing a transferrable operation or a process that a product or its sub-components are based upon, from one organisation to another, can be used to stimulate innovation at the recipient environment or to enable the recipient to enter and compete in an international market (Galbraith 1990). From an evolutionary perspective, the focus is on identifying, adapting and operating imported technologies (Invarsson and Alvstam 2005). This type of cross-border knowledge transfer enables the recipient possibly to grow their overall output and employment, distribute the skills and know-how, broaden the geographical coverage, or be promoted to become a global supplier (Invarsson and Alvstam 2005). All cross-border transfers are formed between two organisational units. Especially in the external transfers can be considered a 'learning race' where the benefits of learning do not typically accumulate equally to both parties. However, the other organisation will exploit the gained knowledge more (Choo and Bontis 2002). The main difference between outsourcing and offset is to be anchored to the purpose of the activity. In offset, the case is to enhance the long-term economic development in the host country (Fredriksson et al. 2018). The efforts and investments made in developing in-house manufacturing capabilities have a far more critical impact on operating performance and innovating capabilities than partial outsourcing. Hence, outsourcing to complement the overall strategy will elevate and further develop internal manufacturing capacity and capability (Bengtsson and Dabhilkar 2009).

3.5. The Conceptual Theoretical Framework

The Straussian grounded theory approach is an inductive methodology in nature, where the objective is to let the data lead the construction of theory and form the basis for the theory discovery in the context the phenomena under study occurs, rather than the research process be led and to some extend be restricted by an existing theoretical framework (Donald 2014). Hence, this study is based on Straussian grounded theory methodology that could have been approached without a theoretical framework. However, a sound theoretical literature base and further theoretical framework assist in developing the initial focus group questionnaires and the final reflection of data gathered and conclusions made. The theoretical framework, in this case, has been used for explanatory purposes as the conceptual basis for understanding and connecting the researcher to the existing knowledge. While every attempt was made to ensure the 'purity of the findings and the alignment with a traditional Straussian grounded theory approach, it is argued that the findings and the investigation would not be as rich and informative in the absence of a theoretical framework (Donald 2014).

This section presents the conceptual, theoretical framework, the reflection perspective for this study, based on the relevant key concepts regarding the factors enabling a successful TT and their relations emerging from the literature. The conceptual, theoretical framework introduces and describes the existing TT key concepts and explains why the research problem under this study exists and how it is grounded to the already established ideas. Furthermore, it guides the research by determining the possible aspects of measure and the statistical relationships to look for and providing a basis for interpreting and understanding the relevance of the findings.

This study framework is built on several concepts and not a single theory due to the lack of robust critical literature linked to the phenomena under study. The defence industry-related TT literature does not provide a single well-developed theory. However, it is instead fragmented into the isolated case based concepts under the two macro viewpoints presented, the economy and industry views. As illustrated in Figure 3.6, the framework incorporates the key concepts from three main perspectives identified to provide a complete theoretical foundation. Firstly, the accumulation of technological capability and the collaboration dynamics of the supplier and local recipient are the main focus of the existing literature through the concepts established by Kiss (2014), Vats et al. (2013) and

Lorell et al. (2002). Secondly, the study is anchored to the South African defence industry ecosystem, specifically through the findings of Dunne and Haines (2006) investigation. Thirdly, Searchy et al. (2004) methodological tool provide a perspective on inter-organisational coordination development. To summarise, the framework incorporates the perspectives of the TT and the defence industry transformation success factors in the South African context and the inter-organisational coordination development. This anchors the framework to the research objective to better understand the TT critical success factors and how they are linked and produce the behaviour of the entire TT system.

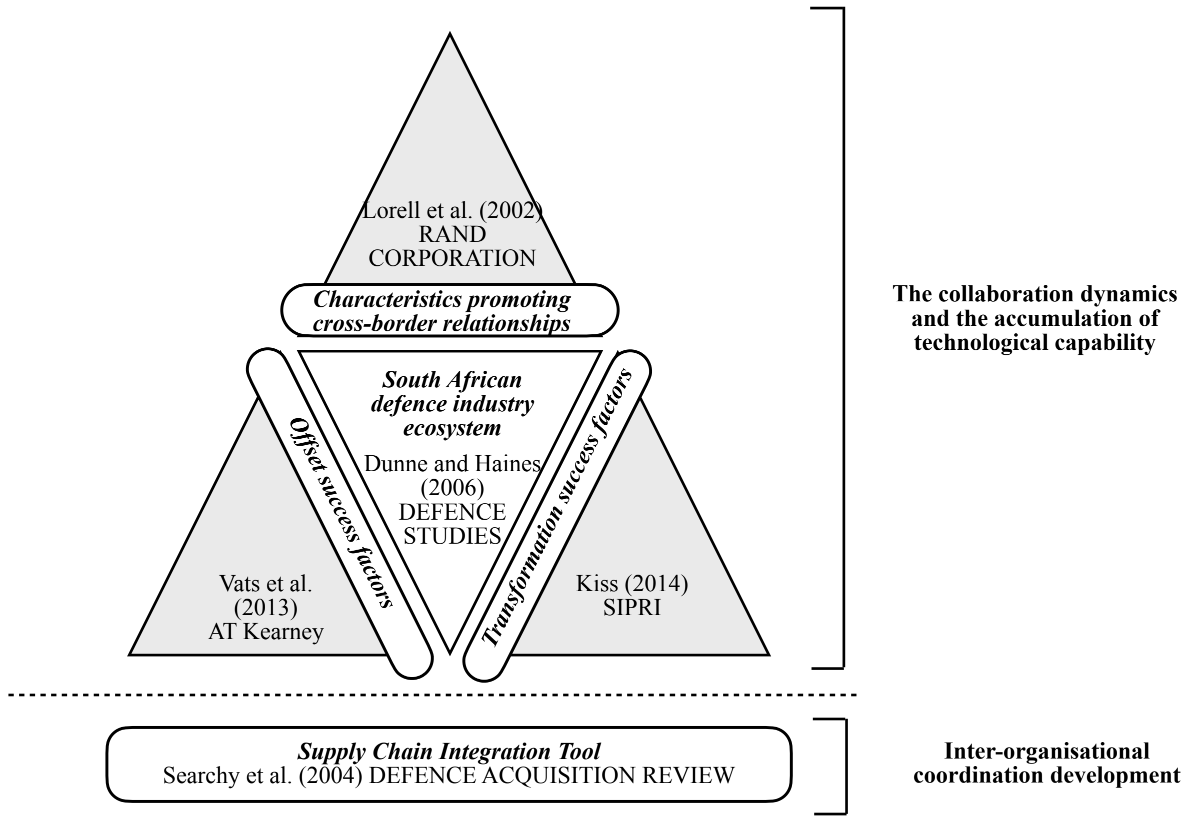

Figure 3.6: The theoretical framework.

The collaboration dynamics and the accumulation of technological capability can be analysed from the incorporated perspectives of characteristics promoting the cross border relationships (Lorell et al. 2002), the offset success factors (Vats et al. 2013) and the transformation success factors (Kiss 2014). These three perspectives cover the whole process of a domestic defence company developing into international cooperation and partnerships, being able to actively and efficiently receive knowledge, capabilities and other benefits through an offset programme, and lastly transforming into a commercially successful corporation and away from being just a fully government subsidised nationalised asset. Lastly, these three perspectives are also reflected against the context and lessons learned from the South African defence industry transformation (Dunne and Haines 2006).

The study of highly authoritative defence industry specialised RAND Corporation (Lorell et al. 2002) on the new cross-border business relationships identified that the types of programmes showing the most promise for promoting potential military-political and economic benefits have some or all the following characteristics:

(i) Voluntarily structured by participating companies rather than governments based on the best business practices.

(ii) Structured to satisfy the existing arms exports and technology security.

(iii) Focusing more on promoting existing products or modifications thereof or on specific market sectors.

(iv) Focus on subsystems, munitions or discrete components or areas rather than on large, complex programmes for the development of entire weapon system platforms.

(v) Designed to gain and expand active reciprocal market access through new programmes.

(vi) Motivated to add to the company's product portfolio a highly competitive product in a market sector dominated by another company. Thus promoting greater competition.

(vii) This is characterised by a mutual perception of balanced and complementary bilateral market access opportunities and TT (Lorell et al. 2002).

Vats et al. (2013), in their white paper, argues that the defence industry can create value to the economy through offset programmes by highlighting the TT, the win-win dynamics in joint ventures and relieving operational readiness as the main success factors as follows:

- By engaging in the TT, the value created through the offset programme goes beyond just basic contracting. Imperative from the TT value creation point of view are the joint research and development activities, the talent pool generation, and the possibility to assimilate and further commercialise the technology through the established international industry partners.

- In order to encourage the win-win dynamics, the ownership structure must create a stimulus for the venture to expand beyond the single contract scope and further down to the value chain, innovate, and develop and manage long term capabilities rather than just focusing on short term dividends. Also, robust financial programme support from the government is a necessity.
- The foreign offset partner must be a true partner of the national armed forces and understand the specific capability requirements and the long term planning in order to be able to deliver actual operational readiness (Vats et al. 2013).

Vats et al. (2013) suggest that the local offset recipient companies tend to maintain a narrow contract manufacturing view and limit themselves to attain the potential additional value beyond the initial offset transaction. To avoid this, the conflicting stakeholder interests between the foreign supplier, the local recipient and the local supply chain network, and the governmental agencies and the armed forces should be realigned towards a consolidated defence sector delivering extended economic, commercial and defence capabilities (Vats et al. 2013). Some would question if these commercial, political, economic and national security-based interests can truly ever be optimally orchestrated and hence the dynamics profoundly changed, even when evolutionary step-by-step executed over a long time. However, vats et al. (2013) argues that offset programmes can play a vital role in accelerating this evolution towards a more consolidated sector with high-value creation and export leadership where the most important is to secure the broader commercialisation of the TT (Vats et al. 2013).

Kiss (2014) identifies the critical defence industry transformation success indicators. In general, the adjustment to the changing political and economic environment in domestic and international contexts results from state intervention, offset deal with a foreign supplier, restructuring, learning process, full order books, financial stability, easy access to credit, and stable external links. The most successful organisations are characterised by the following three indispensable factors: (1) state backing and state orders even on a small scale, (2) in-depth restructuring, and (3) international links. The various forms and scale of state backing are typically sufficient to guarantee survival, but the defence companies stagnated if they failed to revamp radically. However, the company level restructuring is not proven to be sufficient alone, but only the restructuring combined with stable international linkages would lead to sustainable long term success. The state orders are essential for the domestic defence industry to gain initial access to the foreign markets. The international links took various forms such as export deals, long term cooperation projects, access to resources, offset agreements and joint research and development projects (Kiss 2014).

According to Kiss (2014), the further less crucial but significant factors enabling the defence industry transformation are the overall development of the economic environment and the internal cohesion of the arms industry in general. The internal cohesion included efficient communication and division of labour, pooling of resources, defence-related research and development and strong linkages with the armed forces. Kiss (2014) also emphasises that while marketing and language skills can be acquired relatively quickly, success is based on the attitudes at both the shop floor and management levels. In addition to this, one of the most critical long term success indicators is the organisation's ability to identify new market niches or credit lines. This ability is based on accumulated knowledge and experience, the appreciation of human resources, the ability to excel in teamwork, the encouragement of creativity and innovation, the modern management culture and overall work ethic. To conclude, the most successful companies can synthesise their heritage and new trends (Kiss 2014).

Kiss (2014), in her extensive comparative study covering six (6) East-Central European countries and their defence industrial base transformation after the Cold War and economic and social change, also analysed and categorised the defence companies based on their performance and transformation capabilities as illustrated in Figure 3.7.

Outstanding Companies	Standard Companies	Struggling Companies
A small group of outstanding companies providing high tech products for the Ministry of Defence, usually having international production and trade circuits. Most tend to be privately owned (but could be public too). Small employers, small portion of output and exports.	Standard average companies providing employment and manufactures bulk of military related products. Slow and arduous restructuring process, significantly reducing scope of their activities and the output volume, revamping profile and introducing measures to improve efficient and profitability.	Struggling companies, important in terms of employment and output volume. Often a principal employer in the area, close links to the political elite.
Baseline characters prior the successful transformation: • Good performance • Access to capital • Access to markets • Not dependent on local political elite • Did not suffer from unfavourable geographical location • Government policy had limited impact on the company but state agencies sought cooperation with them and included their products in the development and export proposals	**Baseline characters prior the successful transformation:** • Formerly state owned, now run by entrepreneurs or pervious management • Bulk output, traditional, middle range weapons sold to their national armed forces or to emerging market in developing countries • Occasional excellent items • Vulnerable to external factors • Financially unstable	**Baseline characters prior an unsuccessful transformation:** • Difficulties to adjust to the constantly changing conditions of the market • Financially balanced at the edge of bankruptcy • Usually survived by occasional or regular lifesaving assistance from the state, which they received even when privately owned.

Key Factors Predicting Company Transformation Success
- Emphasis on preserving and developing the human capital
- Continuous investments in research and development even during the periods of financial hardship
- Actively seeking to join the international production and trade circuits from an early stage of the organisational development

Figure 3.7: The categorisation of defence companies based on their performance and transformation capabilities (illustration created based on the text of Kiss 2014).

Dunne and Haines (2006) have analysed the South African defence industry environment and how this ecosystem has transformed in the early 21st century. This process is illustrated in Figure 3.8. The South African defence industry has gone through considerable restructuring in response to external and internal changes. The reduction in government demand led to downsizing, increased industry concentration and a push for exports. The scale of economic costs and the political pressure made the maintenance of the national industrial base impossible. There were attempts to privatise the state-owned defence enterprise Denel and a further aspiration to find an international defence operator to take a strategic equity partnership in Denel. However, as the efforts regard the restructuring and rationalisation of Denel became less imperative and taken over by the political motivations, the negotiations for such buy-in and partnership fell through.

Nevertheless, the government's decreasing involvement continued, highlighting the objective of locating the state-owned enterprise Denel and the other parastatals at the centre of a more robust economy and away from relying on secured public contracts. The Strategic Defence Package and its offset components provided a lifeline to the South African defence industry, but the evidence questions its overall value to the broader economy. The larger private defence sector firms, such as Reunert and Grintek, performed well, but then for the state-owned company Denel, the offsets proved to be more problematic and less profitable. Although the general opinion, the larger state-owned defence corporation is more favoured in the South African defence programmes at the expense of the smaller private firms. However, Denel and certain private companies are drawn further into the international defence production supply chains due to industrial participation. However, they have not seen much in terms of TT and the use of indigenous technology. In all, the government’s two-decades-long hands-off policy has led to the significant decline of the defence industry. However, the government is re-evaluating its position due to the current industrial problems and failure to reach a more commercially operating business model (Dunne and Haines 2006).

Figure 3.8 The South African defence industry transformation (illustration created based on the text of Dunne and Haines 2006).

The most significant findings of Dunne and Haines (2006) analysis are:

(i) the complex systems based multi-task defence industrial participation work is complicated for the local suppliers to handle logistically,

(ii) the lack of contract negotiation process transparency has created a politically motivated environment where successful industrial participation planning is almost impossible,

(iii) the poor planning and lower than initially planned production volumes have led to higher costs to the local suppliers,

(iv) the foreign offset obligors prefer to set up a local subsidiary rather than working through an existing local company,

(v) the industrial participation has focused chiefly on not overly high-tech manufacturing operations, and thus it is not genuinely supporting the technological potential of the local suppliers,

(vi) for relatively small economies, such as South Africa, the only possible defence industrial future lies in becoming a niche producer (Dunne and Haines 2006).

According to Dunne and Haines (2006), the domestic defence companies that are expected to benefit from offset related industrial participation activities are often producing technologically sophisticated goods but are profoundly conservative and non-agile in their business management methods as well as used to be dependent on government orders and support (Dunne and Haines 2006). Hence their capabilities and business focus have somewhat evolved towards maximising the money received from the government rather than developing efficient business practices and building a competitive advantage to operate in the international market. As a result, Dunne and Haines (2006) state that this does not make them suitable catalysts in developing intellectual and social capital. What is required is a high degree of local technological absorptive capacity through a state-sponsored civil-military, science and technology strategy (Dunne and Haines 2006).

The collaboration dynamics and the accumulation of technological capability discussion can be further reflected against the perspective of inter-organisational coordination development through a Searchy et al. (2004) supply chain integration tool. Search et al. (2004) introduced a methodology for integrating suppliers and customers to develop inter-organisational coordination with the following four steps:

(1) Companies must make aware of the fundamental dynamics of the supply chain and the problems occurring through value stream simulation.

(2) Alignment of capabilities through establishing an understanding of each supply chain actor individual capabilities and the capability comparison with the partners.

(3) Creation of mutually agreeable action items for improving the supply chain through better communication, coordination and execution.

(4) Assignment of responsibilities and execution of the action items (Searchy at al. 2004).

To conclude, the sustainable TT from the collaboration dynamics and the development of inter-organisational coordination and the accumulation of technological capability point of view can be further explained by using the following factors illustrated in Figure 3.9.

Relationship Characteristics Promoting Benefits (Lorell et al. 2002)

- Voluntary structured by participating companies
- Promoting existing products or modifications thereof
- Focus on subsystems or components rather than complex main level systems
- Cooperation adding a highly competitive product to the product portfolio
- Balanced and complementary bilateral market access opportunities and TT

Offset Success Factors (Vats et al. 2013)

- TT including;
  - joint research and development activities
  - talent pool generation
  - assimilation and commercialisation of the technologies through established international partner
- Win-win dynamics in joint ventures where;
  - ownership structure stimulates the venture to go beyond the single contract scope as well as to expand further down to the value chain
  - innovation, development and management of long term capabilities is a focus
  - there is a strong financial support from the government

Defence Industry Transformation Success Factors (Kiss 2014)

- State backing and state orders
- In-depth restructuring with international linkages
- International links in a form of;
  - export deals
  - long term cooperation projects
  - access to resources
  - offset agreements
  - joint research and development projects
- Ability to synthesise the heritage and new trends, a modern management culture with appreciation of human resources, the ability to excel in teamwork and the encouragement of creativity and innovation
- Emphasis on preserving human capital
- Continuous investments in research and development
- Actively seeking to join international production and trade circuits

South African Defence Ecosystem Transformation (Dunne and Haines 2006)

- Complex multi-task industrial participation work is difficult to handle logistically by the local suppliers
- Lacking contract negotiation transparency has created politically motivated environment where successful industrial participation planning is almost impossible
- Poor planning and lower than initially planned production volumes lead to higher costs to the local suppliers
- The foreign offset obligor prefers to set up a local subsidiary rather than working through an existing local company
- Industrial participation mostly focuses on non high-technology manufacturing operations and thus does not support the local supplier's technological potential
- Small economies defence industrial base should focus on becoming a niche producer

Inter-organisational coordination development (Searchy et al. 2004)

Summary of the Key TT Sustainability Success Factors (Kiss 2014, Vats et al. 2013, Dunne and Haines 2006, Searchy at al. 2004, Lorell et al. 2002)

- Focus on subsystem and components rather than complex main level systems
- Focus on high-technology manufacturing operations that support the existing product portfolio in niche market space
- TT including;
  - joint research and development activities
  - talent pool generation
  - assimilation and commercialisation of the technologies through established international partner
- Comprehensive and detailed industrial participation pre-planning and coordination phase prior start of the industrial participation and TT execution
- Win-win dynamics in joint ventures where;
  - ownership structure stimulates the venture to go beyond the single contract scope as well as to expand further down to the value chain
  - innovation, development and management of long term capabilities is a focus
  - there is a strong financial support from the government
- Ability to synthesise the heritage and new trends, a modern management culture with appreciation of human resources, the ability to excel in teamwork and the encouragement of creativity and innovation

Figure 3.9: The synthesis of the key factors influencing the TT sustainability (illustration created based on the texts of Kiss 2014, Vats et al. 2013, Dunne and Haines 2006, Searchy at al. 2004, Lorell et al. 2002).

This synthesis forms a conceptual, theoretical framework and reflection point for the study. As a result of the synthesis, the key TT sustainability success factors emerge, as illustrated in Figure 3.9. In all, the evolution towards export leadership and a sustainable business model must be systematically managed to capitalise on the benefits of the TT truly. The strategy must reach beyond a single contract scope to build sustainability by engaging parties in mutually beneficial long-term ways and incorporating the whole supply chain network. There must be a bridge to align the national military and civilian ecosystems, appropriate technology acquisition and efficient TT process management system, joint well-targeted research and development activities, development of talent pools, commercialisation focus, commercially sensible technology development, and robust management system and governmental support. Imperative in capturing the value of industrial participation and the TT is integrating the defence offset strategy with the other national economic development strategies and an efficient offset programme management. Ideally, this would lead today's defence industrial participation ventures to become the national industrial champions of tomorrow. This would increase collaboration in building capability and focus on niches in the defence supply chains.

The relationship of these key success factors is further illustrated in Figure 3.10. The local recipient's overall attitude, abilities, and management capabilities form a precondition for the overall project to determine how successful the technology absorption and utilisation can be. The level of preparation and planning, on the other hand, predicts the efficiency of the TT execution. The following execution focus, involvement of the supply chain partners and robust financial support from the government further enable the best value creation and sustainable outputs, such as the ability to commercialise the technology acquired and establish strategic international level partnerships. Hence the local recipient's initial attitude and capabilities, preparation and planning, and the TT execution are variables to the TT outputs.

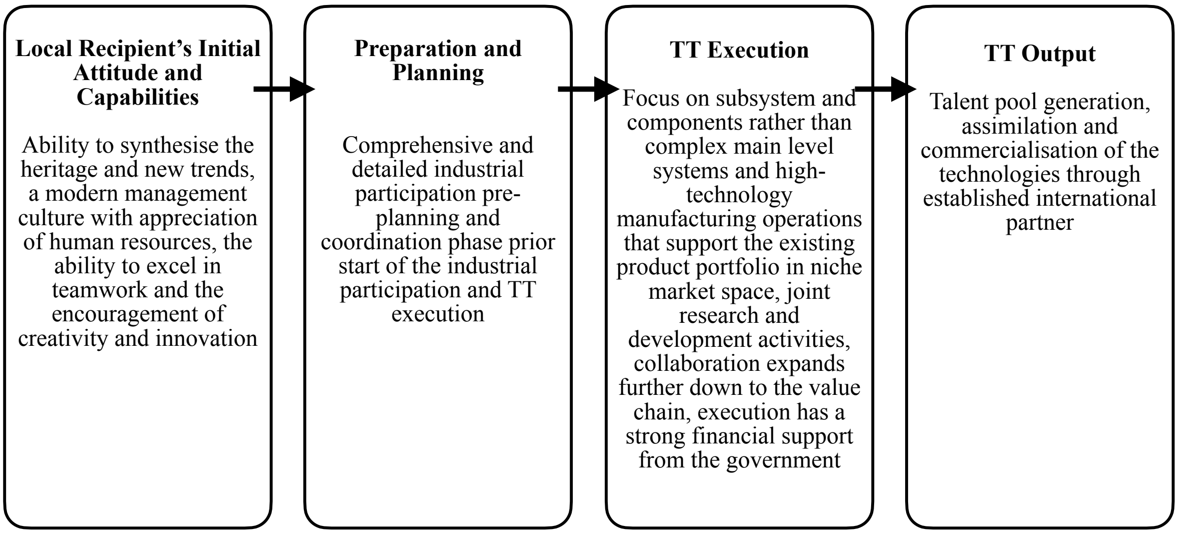

Figure 3.10: The relationship between the key success factors.

The theoretical framework sources have their limitations as well. Although two of the sources are representing globally the most authoritative defence research organisations (Kiss 2014 representing SIPRI and Lorell et al. 2002 representing the US-based RAND organisation), one could, however, question the objectivity of the authors to advise representatives of a global consultancy and analysts company selling defence strategy advisory services (Vats et al. 2013). The defence studies are typically limited in their methodology, either economic literature-based discussions or isolated case studies. However, RAND and SIPRI are exceptions to this offering the most broad-based scientific research in the field. The methodological limitations arise a further question of the validity of the conclusions. While the most informative defence industry literature sources are often grey and limited in their scientific quality and rigour, all information sources are considered necessary since the industry data is not broadly available.

Overall these different theoretical framework concept sources tend to all agree in their conclusions on the fact that the governments should increasingly focus on becoming intelligent customers instead of maintaining costly defence industrial bases and that the national defence organisations should seek to become export leaders in a niche market area and to partner internationally. However, the same sources provide relatively little practical guidance for these companies on how this will be efficiently achieved and managed.

The overall objective of this research is pragmatic, firstly to better understand the context of phenomena and the relations within, and secondly to enable better management of the process by seeking possible, practicable solutions for the local actors operating in the environment. As illustrated in Figure 3.11, the different concepts can also be integrated into the generic business process management (BPM) approach. A combination of methods to collaborate, coordinate and control are used to manage an organisation's business process. Consequently, it can be concluded that these concepts cover the collaboration and coordination aspects, but a few have been investigated from the control point of view. A systematic literature review has shown that no research has been done to clarify the operational level aspects of the international inter-organisational TT process. Additional research on TT needs to be conducted to understand better the operational level management and what factors primarily affect TT sustainability. Hence there is a research gap in studies regards the pragmatic operational process management perspective.

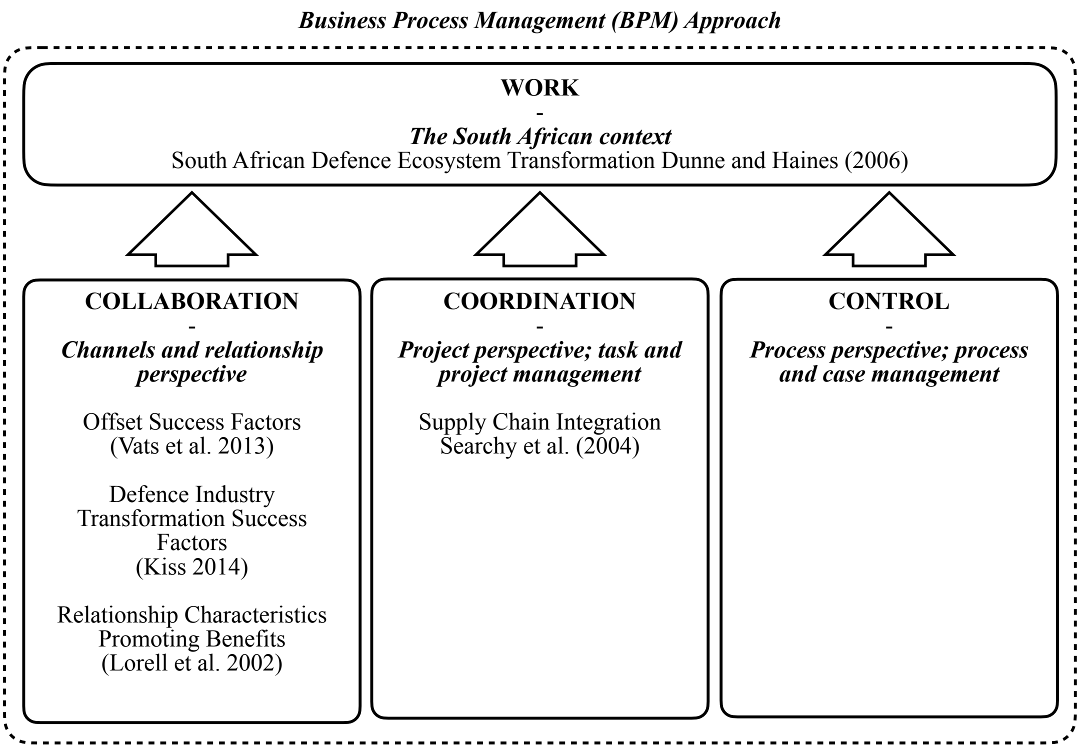

Figure 3.11: TT key concepts integrated into the business process management (BPM) approach.

It is imperative to note that this theoretical framework is not used to limit the scope of the relevant data following the grounded methodology assumptions. However, the framework assists the researcher in providing a reflection point to the data analysis and interpretation and facilitating the more profound understanding of concepts and variables and building new knowledge by validating theoretical assumptions. This study is the first to use this type of theoretical approach. Critics using a more general theoretical approach could argue that using a new conceptual foundation could lack a robust critical literature that would refine and guide the use and even make the base 'atheoretical'. Further, it could be said that the mixing of different concepts could lead to contradictions between the different concepts of the framework. It could, however, be said that a more generic foundation would lack complexity and thus only be able to provide a 'safe' option that does not necessarily engage and articulate profoundly with the phenomena. A more complex and broad conceptual stance allows the researcher to be less theory-driven. There is a possibility to locate the study's outcomes more freely, providing a better baseline for the emergence of new theories. The claim on using a single well established theoretical foundation indicates that only one valid approach is false in its core foundation.

3.5.1. The Integration to the Study

This study will be informed by the conceptual, theoretical framework established on the systematic literature review initiated and guided by the research questions, providing a world view and lens to support the approach and the reflection of study findings (Lysaght 2011). Typically, research follows the typical format of the problem statement, literature review, research design, data analysis, and discussion. The content must be consistent and align with the theoretical framework selected (Grant & Osanloo 2014). In this integrated Straussian grounded and case study approach, the conceptual framework establishes the key factors, constructs and variables as well as presumes relationships between them as well as provides a structure of what has been learned to best explain the phenomena being studied (Grant & Osanloo 2014, Miles & Huberman 1994). Following the Straussian grounded theory approach, the conceptual, theoretical framework presented here, unlike in more traditional studies, does not guide the data collection to prevent any preconception on the findings (Grant & Osanloo 2014). The primary purpose of the framework is to establish a context to the problem and phenomena, scale the problem, identify gaps in the body of knowledge and lastly to provide a reflection point for the study findings after the data analysis where the alignment of findings with existing concepts that can be compared and contrasted in the analysis. (Part 1998). The framework provides a solid basis for understanding and conceptualising the phenomena, allowing the emerging theory to be measured, tested and extended (Grant & Osanloo 2014).

On the other hand, the problem statement defines the root problem and the other variables. It constructs inherent to the problem providing the literature review and the conceptual, theoretical framework a baseline to emerge from (Grant & Osanloo 2014). The purpose and justification of this study are to provide relevant output(s) that may allow to identify, expand and critique the existing body of knowledge and hence, enable the professional and governmental policies related to improving the efficiency of the TT process and delivering more sustainable competitive advantage to the local TT receiver over the long term (Grant & Osanloo 2014).

4. PHASE 2 - THE TECHNOLOGY TRANSFER PROCESS AND THE RELATED PAIN POINTS AND CRITICAL SUCCESS FACTORS

The following section present the Phase 2 study of this mixed methods research focusing on establishing the TT process and the investigation of the process pain points and critical success factors. Extract of this Chapter 4 was published in the Journal of Global Operations and Strategic Sourcing, Bezuidenhout, S. and Bean, W.L. (2021), "A case study on inter-organisational technology transfer in the defence industry", Journal of Global Operations and Strategic Sourcing, Vol. ahead of print, https://doi.org/10.1108/JGOSS-10-2020-0058.

4.1. Methodology

The research phase objective is to analyse the inter-organisational capability transfer process in a defence industry offset environment from a global technology supplier's perspective. As a result, the study aims (i) to develop a SCOR level 2 TT process model in a defence industrial participation context and (ii) identify the related pain points and critical success factors from the supplier's point of view. This research phase is based on a novel integration of a case study and Straussian grounded theory methods under interpretative assumptions with a purposive sampling approach (Palinkas et al. 2015, Thai et al. 2012, Halaweh et al. 2008). A single revelatory case study allows to learn more in-depth from this specific environment of interest (Walsham 1995, Yin 1994), and the constant comparative data analysis through the Straussian approach continue to apply to data irrespective of the case number (Halaweh et al. 2008, Scott 2004, Corbin and Strauss 1990). Case studies are typical in defence studies with high access restrictions, but grounded theory applications aren't previously applied. A specific focus group of eight (8) people representing the most extensive experience of multiple international inter-organisational TT projects and the highest knowledge on the research area with a comprehensive, in-depth understanding of the process, its requirements and possible issues negatively affecting the transfers is selected. Due to the sensitive industry nature, the research is anonymously conducted where any identifying factors related to the organisation or the participants under the study aren't released.

A cross-sectional data generation and collection are conducted through a semi-structured questionnaire (Appendix A) with both structured and open-ended questions that are sent to the focus group in 2019, providing a rich and deep insight into the complex phenomena under investigation as well as anonymity (Creswell and Creswell 2018, Leedy and Ormrod 2015, Thai et al. 2012). The use of literature in this study not only frames, guides and directs this study but also forms a basis for establishing questions and comparing and contrasting findings (Creswell and Creswell 2018, Leedy and Ormrod 2015, Thai et al. 2012, Halaweh et al. 2008). The questionnaire is distributed by email where the questions overlap each other to increase the reliability to achieve adequate saturation without conducting multiple rounds.

The Straussian grounded theory approach is an inductive methodology in nature, where the objective is to let the data lead the construction of theory and form the basis for the theory discovery in the context the phenomena under study occurs, rather than the research process be led and, to some extend, restricted by an existing theoretical framework (Donald 2014). However, the theoretical literature base assists in developing the initial focus group questionnaires and the final reflection of data gathered and conclusions made. Hence the existing theories, in this case, have been used for explanatory purposes as the conceptual basis for understanding and connecting the researcher to the current knowledge.

The data analysis incorporates qualitative and quantitative elements to provide more in-depth analysis and understanding of the case. The different components are in constant interaction, and their outcomes are integrated throughout the study. The qualitative analysis is a continuous comparative process following the Straussian approach on applying the open, axial and selective coding methods (Tie et al. 2019, Thai et al. 2012, Halaweh et al. 2008, Walker and Myrick 2006, Corbin and Strauss 1990). Hence, the qualitative data gathered is coded according to the Straussian approach in three cycles. The first cycle involves breaking down the data and looking for similarities and differences, forming initial tentative and provisional codes and concepts (Saldaña 2016, Corbin and Strauss 1990). Furthermore, the properties and dimensions of code categories are searched by developing relationships among them (Saldaña 2016, Walker and Myrick 2006). A particular emphasis is placed on searching and identifying processes, actions that have causes and consequences (Saldaña 2016). The second cycle axial coding approach studies the relationships of categories and their subcategories and how they are relating to each other, focusing on the conditions or situations in which the phenomena occur, the actions or interactions of the people in response to what is happening in the circumstances and the consequences or results of the action (Saldaña 2016, Halaweh et al. 2008, Walker and Myrick 2006, Corbin and Strauss 1990).

The third and last selective coding cycle involves selecting a central category representing the main theme of the study and reflecting how the other categories relate to this central category as well as to each other to form an integrated and refined model (Tie et al. 2019, Saldaña 2016, Hallaweh et al. 2008, Walker and Myrick 2006, Corbin and Strauss 1990). The quantitative data analysis includes the preparation of descriptive and inferential statistics. After the overall data analysis is finalised, a meta inference is completed to synthesise the results. In summary, the Straussian grounded theory coding process arrives at the research model from data as described in Figure 4.1:

Codes → Concepts → Categories → Model

Figure 4.1: The Straussian grounded theory coding sequence (Halaweh et al. 2008).

4.2. Sampling

Grounded theory research typically involves a recommended sample of 20-30 and a case study a sample of 3-10 (Creswell and Creswell, 2018). Due to the sensitive nature of the defence industry and the high access restrictions to any information within such organisations, a purposeful sampling approach is applied to (i) learn more in-depth from this specific environment of interest, (ii) efficiently use all the available sources of information due to limited access, and (iii) choose a particular focus group of people who represent the most extensive experience and highest knowledge on the research area, and that can answer the research question (Tie et al. 2019, Leedy and Ormrod 2015, Palinkas et al. 2015). Thus, every TT specialist involved in the TT operations (sample size = 8) are engaged in the research to achieve appropriate saturation within the case organisation. Furthermore, the eight representatives all have 15-20 years of individual experience of multiple international inter-organisational TT projects and a comprehensive, in-depth understanding of the process, its requirements and possible issues negatively affecting the

TT. They also represent all organisation levels, from the operational activities to the mid-management up to the executive level as described in the Table 4.1.

Table 4.1: The Respondent Overview

Position Number of People	Role	TT Experience Number of Projects	TT Experience Years
Executive management (1)	Main/Supply contract and TT contract negotiations, TT process sponsor, decision maker	5	15
Project management (2)	Supply contract and TT contract negotiations, contract management, TT process owner, process design and management	4 6	18 20
TT project management (2)	TT design and operations management and training	7 4	16 20
Production management (3)	Operational activities and training	3 4 4	14 17 19

As a result, using a purposive sample increases the consistency and homogeneity, narrows down the variation, and focuses on similarities, assists in describing, illustrating and generalising what is typical in the inter-organisational TT process from the supplier point of view (Palinkas et al. 2015). Strauss and Corbin (1998) emphasise that grounded theory research is about discovering information rather than testing it. Hence, the sample size does not need to follow statistical sampling principles but theoretical sampling (Strauss and Corbin 1998).

4.3. Validity

Several internal and external validity strategies are implemented to ensure the qualitative validity, reliability and interpretative rigour of this study. The study results are treated anonymously to decrease the likelihood of external expectations and opinions affecting the outcome and increase the probability of the actual views being gathered. For triangulation purposes, the literature review is used as a basis for the questionnaire and reflects the results. The data collected from the respondents represent different perspectives through different hierarchies and operations within the organisation. To determine the findings' accuracy, the final report is presented to the respondents to determine whether the respondents feel that the results are accurate as final approval and commenting round for this study.

This research is conducted in a globally operating defence industry organisation with large-scale strategic capabilities in the international TT field. Global defence organisations are diverse in their culture, practices and characteristics, but their knowledge acquisition and TT processes often follow similar operational patterns. This study is restricted to a well representative sample of case respondents with a particular set of characteristics (in-depth knowledge in the TT process and related activities and operations in many TT projects in different countries).

4.4. Results

The inter-organisational TT process from technology supplier's view

To effectively manage their inter-organisational TT process, the case organisation follows a systematic process developed, established and adjusted over the years based on previous experiences and lessons learned. A questionnaire is used to construct and illustrate the process used by the target organisation. The prior information and access to the target organisation process illustration supplemented with the information obtained from the literature review forms a base for the questionnaire. The participants are required to confirm or reject activities taking place during the TT process. Further open-ended questions provide more insight to the process operations. The scope covers both the product-related technology (i.e. proprietary product know-how through product designs and technical specifications) as well as the process related TT (operations associated with the manufacturing of the product). A time horizon of five years represents a conventional contractual TT timespan, bridging from the development to the industrialisation phase.

As a result, the main TT process phases are outlined in Figure 4.2 where the impulse from marketing, in the form of a new potential supply contract, initiates the start of the TT process—followed by the preliminary local participation analysis, the planning, contracting, delivery and implementation and last the closure phases. The main level can further be divided into sales and marketing, and the delivery, which starts only after the confirmation and signing of the supply contract. It is important to note that the process design illustrated here reflects (i) only the supplier view in the international inter-organisational TT process, and (ii) the defence offset context.

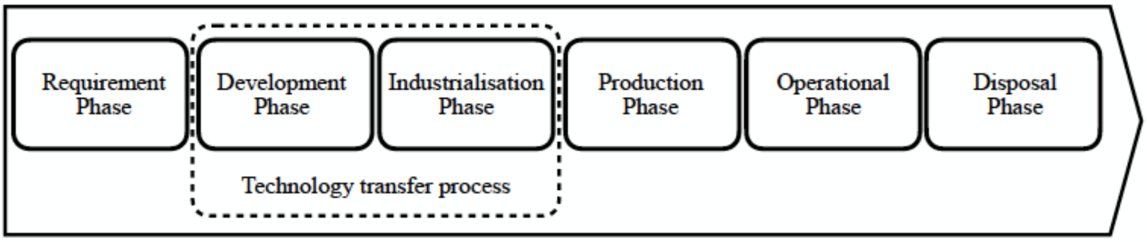

Figure 4.2: The main defence procurement project phases.

The main TT process phases are outlined in Figure 4.3, where the impulse from marketing, in the form of a new potential supply contract, initiates the start of the TT process, followed by the preliminary local participation analysis, the planning, contracting, delivery and implementation and last the closure phases. The main level can further be divided into sales and marketing, and the delivery, which starts only after the confirmation and signing of the supply contract.

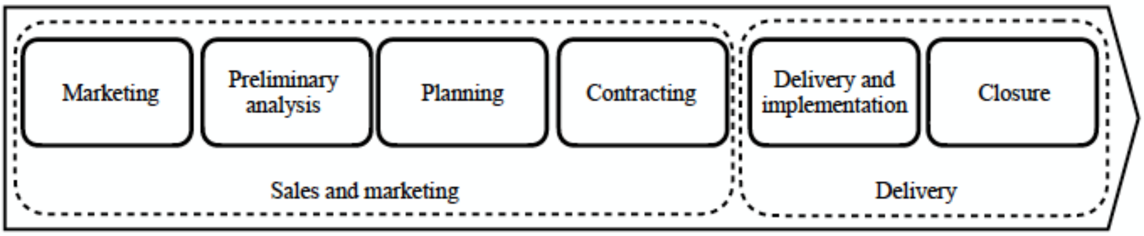

Figure 4.3: The main phases of the TT process in an offset context.

Further exploration of the sub-processes identifies more specific activities and actions involved in the TT. The process is initiated when marketing input is received about an activated marketing project involving a local participation requirement. The TT team receives the local participation requirements, offset legislation and regulations and other possible customer requirements. The local partnering possibilities and the industrial capabilities are analysed to establish what is technologically feasible to produce locally and determine the local production cost level. A preferred local partner is proposed to the executive board for approval. The work distribution and the TT content will be negotiated with the selected local partner.

Further industrial participation survey is used to map the local supply network and its ability to supply products and components in terms of quality, cost and delivery times. Based on the data gathered, a preliminary local participation plan is established, which further forms part of the overall winning concept, i.e. an offer to win the contract. A TT plan specifies how the product and its production technology knowledge is transferred to the local partner, i.e. the local recipient. This will involve a detailed inspection of the local recipient's production and testing facilities and an analysis of their development potential, mapping resources, equipment and technologies, and other local production bases. The overall TT cost and schedule are estimated for the contract offer. The project risks are evaluated in terms of their probability and weight. The nature of the project, the customer requirements and the local partner characteristics are the key factors defining the TT plan. However, a typical TT plan always entails the following essential elements: schedule, the work distribution and the TT content, responsibilities between the parties, resourcing, required training (number of people, training days and the broad overview of the training content), support plan, and need for specialised tools. The TT content in the form of work packages typically includes the design, manufacturing, tooling, quality control and supply chain management elements. This planning phase output is a detailed scope of work in terms of work distribution and content, and schedule. The TT team supports marketing and sales in the main contract and offset agreement negotiations. The objective is that both the local participation contract, the main contract, and the offset agreement are signed parallel. After the contracts have been signed, an internal contract review is organised to establish a standard view regarding the content and the set requirements among the overall project execution team. Similarly, the TT delivery starts with an external contract review involving all the relevant parties and the key personnel from both the supplier and the receiver organisations.

The TT requirements are fulfilled in the delivery and implementation phase, starting after the local participation and offset contract signing, continuing until all the systems have been delivered. It is possibly even longer providing that the relationship between the supplier and local recipient has developed into a genuine business and value creation-based supply chain partnership. In addition to the delivery, the supplier's local participation also supports the local partner in preparing and managing the further life cycle support services. In all, the supplier's local participation support is available throughout all the defence procurement project phases, mainly focusing on the TT but often also including general support for the local partner's project organisation, manufacturing and procurement activities. Depending on the project, the supplier provides support from abroad or relocates personnel to the project country. After receiving the relevant training and support, the local partner's production capabilities are reviewed, and when acceptable performance is demonstrated, the production permit is awarded. The production activities are further regularly monitored, analysed and reported. After stabilised conditions have been achieved, the local production will be offset registered and credited based on the production reports. This may also lead to the identification of additional support needs. After the TT has been completed, the local recipient has reached the required product and process knowledge and the technology to manufacture the contract product independently. A manufacturing readiness review and the local partner will receive a serial production approval once its manufacturing processes and facilities fulfil both the supplier and the contractual requirements. The completion of the TT is also reported and claimed as a defence industrial offset. Any possible corrective actions, approval negotiations or negotiations of possible schedule extension are part of the offset delivery. After the customer approval and the procurement contract finalisation, the supplier completes a comparison between the actual and initially planned outcomes, completes the internal closure activities and conducts the lessons learned for future purposes.

In addition to the open-ended questions answered, the participants were presented with a structured list of technology transfer related problems and requested to select the ones they have encountered in the technology transfer process. The problem list was constructed based on the previous studies and reflected the researcher's knowledge of the environment (Ivarsson and Alvstam 2005, Capasso et al. 2005, Szulanski 1996, Zander and Kogut 1995, Galbraith 1990; Lasserre 1982, Contractor and Safafi-Nejad 1981, Davies 1977, Teece 1977, Mansfield 1975, Baranson 1970). The structured questionnaire demonstrates a relatively small variance between the results of different respondents reflecting the most prominent challenges encountered related to four segments: (i) the knowledge to be transferred (i.e. codifiafibility, complexity, ambiguity and tacitness), (ii) the pre-transfer planning, (iii) the recipient abilities and characteristics, and (iv) the cultural and language differences. Notable is that the segments with the least issues experienced are related to (i) recipient's overall competence and retentive capacity, and (ii) the floor level workers' competence, motivation and ability to communicate. When examining the participant responses as presented in the Table 4.1 the statistical frequency analysis confirms these to be in close proximity to each other, reflecting an overall slight standard deviation ranging from 0.46291 to the individual responses being entirely identical and demonstrating a strong consensus between the respondents. Only the activities related to the local production analysis and reporting, to taking possible corrective actions after the official offset registration, crediting and reporting, and to the comparison of actual and planned in the final reporting phase divided the respondents, the percentage of each response is only 50% out of total responses. According to the respondents, these activities have an essential role in the process. Still, these activities were often not efficiently or entirely executed in the target organisation, which is reflected in the responses.

Table 4.2: The technology transfer process problem frequencies of responses.

Technology Transfer Problems Encountered	**N Valid**	**Per cent of Cases**	**Std Deviation**
Knowledge codiafibility (i.e. the extent the supplier could articulate the knowledge in documents and software such as blueprints, procedural task descriptions, etc.)	8	100%	0.00000
Knowledge complexity (i.e. the technical complexity and technological sophistication of new features and concepts in a technology to be transferred)	8	75%	0.46291
Knowledge ambiguity (i.e. the uncertainty or doubtfulness of the meaning of language, when the language is capable of being understood in more than one way by a user)	8	75%	0.46291
Knowledge tacitness (i.e. the kind of knowledge that is difficult to transfer to another person by means of writing it down or verbalising it)	8	75%	0.46291
Supplier problems to identify local recipient needs	8	75%	0.46291
Inadequate recipient pre-transfer planning	8	100%	0.0000
Inadequate post-transfer control	8	75%	0.46291
Recipient's employee's teachability and absorptive capacity (i.e. the ease at the individual level by which knowledge can be taught to the new workers and the new technological practices can be adapted)	8	50%	0.53452
Availability of qualified technical and managerial personnel with critical skills and know-how	8	50%	0.53452
Recipient lacks retentive capacity (i.e. ability to preserve the routine use of the new technological practices)	8	25%	0.46291
Recipient problems achieving a satisfactory local production performance	8	25%	0.46291

Recipient lacks performance review and evaluation of their operations under the technology transfer	8	50%	0.53452
Recipient's lacking ability to analyse and evaluate their organisational performance	8	75%	0.46291
Recipient's lacking ability to implement improvement suggestions received from the supplier	8	50%	0.53452
Recipient lacks the use of management methods	8	75%	0.46291
The level of the recipient employee's competence	8	25%	0.46291
Recipient's management lacking motivation	8	75%	0.46291
Recipient's floor level workers lacking motivation	8	25%	0.0000
Recipient lacks prior experience and understanding in the contract technology	8	75%	0.46291
Recipient lacks previous experience and understanding of the technology transfer process	8	75%	0.53452
Cultural differences	8	75%	0.46291
Language differences	8	100%	0.46291
Communication issues on management level	8	75%	0.00000
Communication issues on floor level	8	25%	0.46291
The geographical distance between the supplier and the recipient	8	50%	0.53452

A Supply Chain Operations Reference (SCOR) model was further used to illustrate the TT process. The SCOR model is a cross-functional framework that provides a standard terminology to facilitate communication and a tool for the management to design and configure a supply chain to synchronise the alliance dynamics and achieve the desired performance (Delipinar and Kocaoglu 2016, Huan et al. 2004). To be successful in a highly dynamic TT environment, the companies involved cannot operate as individual entities but as network or chain partners.

An industry-standard SCOR process description provides a working platform for an efficient alignment and evaluation of supply chain processes to acquire a more detailed understanding of the process and its possible problems or 'disconnects' as stated in SCOR (APICS 2017, Huan et al. 2004). Furthermore, companies involved in TT activities should integrate their processes and compare them with other companies in the field for benchmarking and evaluation purposes (Delipinar and Kocaoglu 2016). It is important to notice that the SCOR model presents each process element and how they're configured, but it doesn't attempt to describe every process or activity in detail (APICS 2017). The first hierarchy level of the model comprises the five fundamental process types, namely Plan, Source, Make, Deliver, Return and Enable (APICS 2017). As Bolstorff, P. and Rosenbaum (2011) state, the *planning* process aligns resources to meet the expected demand in a long term. The *execution* processes, namely Source, Make, Deliver and Return, involve scheduling, sequencing, transforming and moving products more in a short term. Lastly, the *enable* processes prepare, maintain and manage information or relations between the organisations or business entities upon which *planning* and *execution* rely (Bolstorff, P. and Rosenbaum 2011). By describing the TT process using these standard elements, the model can describe any TT process by using a common set of definitions, regardless of its complexity (APICS 2017). SCOR model presents three process levels, each describing process activities in more detail than the previous one (APICS 2017).

The level 1 TT process illustrated in Figure 4.4 describes the three main independent organisations of foreign TT supplier, local TT recipient and the governmental end customer that is typically represented by the Ministry of Defence (MoD) and/or the Defence Forces the defence offset related TT supply chain. Due to the nature of the supplied product, i.e. the knowledge to be transferred, there are no Source or Return activities involved. The intangible knowledge is already existing in the supplier organisation, and the return once supplied is impossible. In general, the level 1 can describe multiple independent companies as well as interacting business units within the same companies or any other combination of business entities that are involved in performing activities (APICS 2017).

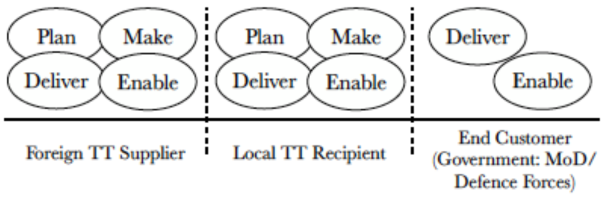

Figure 4.4: The level 1 TT processes.

The level 2 SCOR model further describes how each level 1 category is configured and how the companies involved operate in the supply chain. Table 4.1 is established based on several survey based flowcharts and further discussions with the participants. It lists all possible level 2 configurations for the TT process and their related process identifications based on the SCOR specification. This list was used as a basis to facilitate the further level 2 modelling.

Table 4.3: The level 2 TT process SCOR configurations (APICS 2017).

Level 1 Primary Process	Level 2 Configuration	Process Reference
Plan	Plan Make Plan Deliver	P3 P4
Source	-	-
Make	Engineer-to-Order	M3
Deliver	Deliver Engineer-to-Order Product	D3
Return	-	-
Enable	Manage Supply Chain Performance Manage Supply Chain Human Resources Manage Supply Chain Network Manage Supply Chain Regulatory Compliance Manage Supply Chain Risk Manage Supply Chain Procurement	E2 E4 E7 E8 E9 E10

After the correct configuration is established based on the dialogue with the participants, a thread diagram is constructed depicting the flow of information in terms of the knowledge and technology between the Plan, Make, Deliver and Enable processes and between the different business entities as illustrated in Figure 4.5 (Bolstorff & Rosenbaum 2007). The diagram is also grouping the main process activities under a five project phases. The identified project phases are (1) the Preliminary analysis (colour: blue) , (2) the Planning (colour: teal), (3) the Contracting (colour: yellow), (4) the Delivery and implementation (colour: red), and lastly (5) the Closure (colour: green). Following den Hartog (2011), each business entity (i.e. the TT supplier, local recipient and the end customer) is modelled in a separate flow chart and the process elements are kept in sequence for better clarity. During the modelling it is discovered that some execution and plan processes are supported by enable processes that prepare, maintain and manage information or relations between business entities upon which the planning and execution processes rely. Furthermore, the presence of enable processes is a key in understanding the supply chain performance (den Hartog 2011).

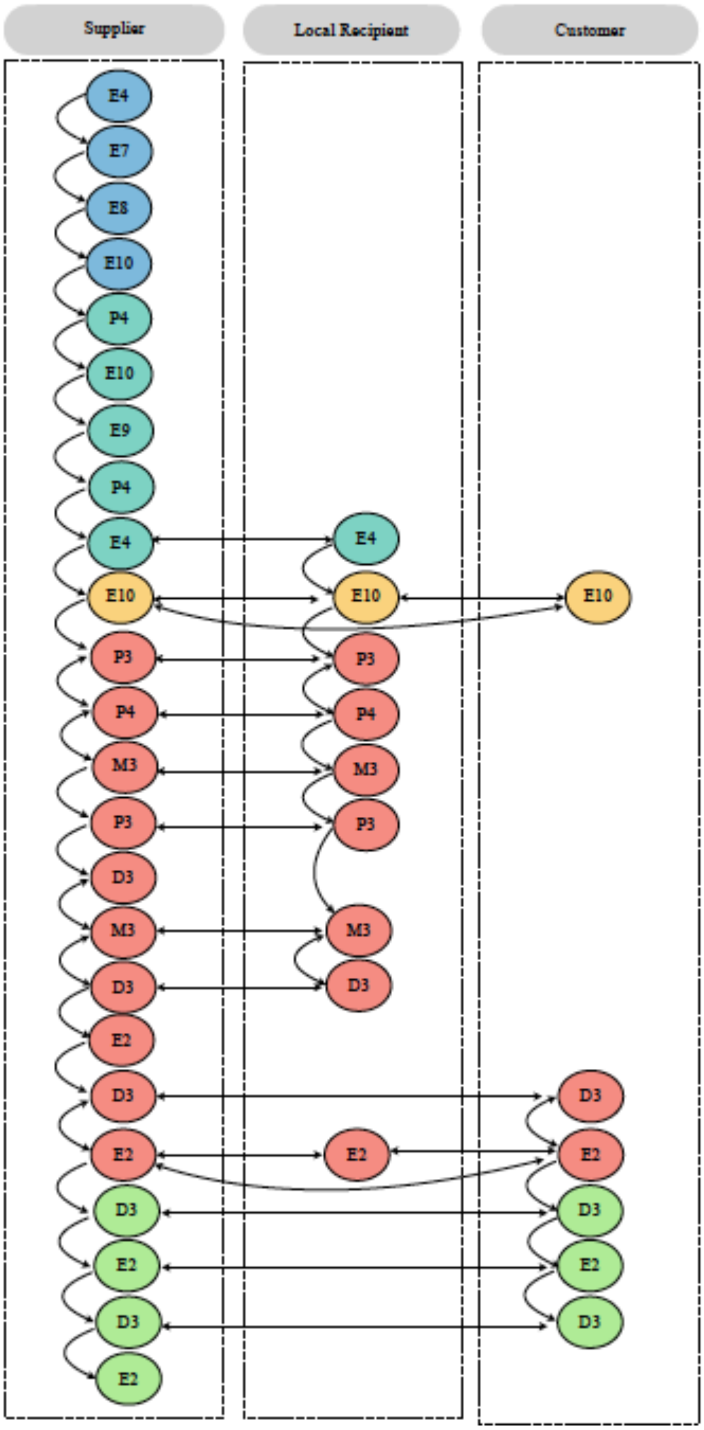

Figure 4.5: The TT process thread diagram (Bolstorff & Rosenbaum 2007).

The level 2 SCOR model illustrated in Table 4.3 further describes how the TT supplier typically performs its operations in the Make and Deliver execution processes. In other words, the level 2 describes for each level 1 category how each of the specific management process is configured (APICS 2017). The execution is supported by the strategic and long term Plan and Enable processes. Although the model defines the main process phases and the general operations and activities taking place during these phases, this study doesn't expand to level 3 that would define each level 2 actual configuration process elements due to the restricted access to more detailed process information. However, level 2 configuration as such is an adequate element of describing a TT supply chain (Bolstorff, P. & Rosenbaum 2011). In general, the configurations of Make and Deliver processes are related whereas the Source processes can be configured differently in terms of how the organisation implement their operations strategy. In this case study context the company is engineering and delivering products and services according to the customer requirements and specifications (M3 engineer-to-order and D3 deliver engineer-to-order product respectively) but due to the nature of the supplied product, i.e. the knowledge to be transferred, there are no Source or Return activities involved.

Table 4.4: The level 2 defence TT process SCOR map.

S = Supplier R = Local Recipient C = Customer	Plan (P)		Make (M)	Deliver (D)	Enable (E)					
TT Process Element	**P3**	**P4**	**M3**	**D3**	**E2**	**E4**	**E7**	**E8**	**E9**	**E10**
The Preliminary analysis										
Establishing organisation and responsibilities						S				
Collection of data							S			
Analysis of local participation rules and regulations								S		
Mapping of potential local partners										S
The Planning										
Cost analysis		S								S
Risk analysis									S	
Establishing the work distribution and the technology transfer content		S				S, R				
The Contracting										
Local participation contracting										S, R
Offset contracting										S, C
Contract review (internal)										S, R
Contract review (external)										S, R, C
The delivery and implementation										
Establishing the organisation and resources	S, R	S, R								
Local partner assessment			S, R							
Finalising the local participation plan	S, R									
Training and support				S						
Local production			S, R	S, R						
Local production analysis and reporting					S					
Local production registering and offset crediting				S, C						
Identification, analysis, planning and implementation of additional local support needs					S, R, C					
The Closure										
Offset registration, crediting and reporting of local production				S, C						
Possible corrective actions					S, C					
Approval negotiations, or negotiations of possible schedule extension				S, C						
Approval				S, C						
Final reporting, comparison of actual and planned					S					
Closure and lessons learned					S					

The SCOR model also provides pre-defined metrics for reliability, responsiveness, agility, costs and assets management that are discussed in relation to the TT process performance assessment. These metrics however cannot be directly incorporated into the TT process so only the general performance metrics are discussed in this research. In the operational level, the customer-focused performance attributes of reliability and responsiveness are prioritised. The reliability addresses the ability to perform tasks as required. It focuses on predicting the outcome of a process, where the responsiveness addresses the speed at which tasks are performed (APICS 2017). The supplier's TT process performance metrics focus on the internal efficiency in terms of achieving the contractual requirements by optimising the use of resources and the effectiveness in terms of how well the required results are achieved. Hence, the Key Performance Indicators (KPIs) focus on productivity, decreasing costs, and increasing profits, directly linked to the supplier's Balanced Scorecard system. There are often also further contractual capacity and quality indicators measuring the amount of acceptable contractual products that the local recipient must be capable of producing after the completion of the TT process. This quality measurement method focuses on the manufacturing output's performance and covers the supply of materials and components. Hence the overall measurement of TT is based on three typical project pillars: cost, quality and time.

The related TT process pain points and critical success factors from the supplier's point of view

After establishing the activities that take place in a TT process, this chapter will outline the main problems arising with executing these activities as in addition to understanding the process, there has to be an understanding of the most significant impact factors. Hence the factors creating barriers or preventing the efficient knowledge exchange between the organisations and on the other hand, what factors amplify the efficiency of the transfer. In terms of the SCOR approach, these factors are points of 'disconnect' in the process that negatively affect the supply chain efficiency and reliability through the generation, misinterpretation, usage or absence of information, plans, schedules, personal capabilities and/or products (APICS 2017).

Following the Straussian procedure, first, the open coding is applied to identify the initial concepts and to categorise the survey data by focusing to the main ideas in sentences and paragraphs, as well as to discover the conceptual properties and dimensions further and thus establish the relationships between the categories (Saldaña 2016, Thai et al. 2012, Halaweh et al. 2008, Walker and Myrick 2006, Corbin and Strauss 1990). A particular emphasis is placed on searching and identifying processes, actions that have causes and consequences (Saldaña 2016). The category names are derived from the words and phrases used by the participants and reflected in the literature. Hence the open coding, also called inductive coding, creates codes based on the qualitative data itself without a preset codebook; all codes arise directly from the participant responses (Saldaña 2016). In this 'microanalysis', the total number of codes generated in the open coding phase is 50 and aren't yet assigned to any category. These codes are listed in Table 4.4 in alphabetical order. The responses were grouped with the same themes under the same code, even when they didn't use the same wording. Due to the manual coding process, the overall objective was to keep the code frames flat and hierarchical, and as a result, the codes to be suitable for a different context and be easier and faster to use and to be more powerful and better organised (Saldaña 2016, Corbin and Strauss 1990).

Table 4.5: The open coding table.

Open Codes				
(1) Ability to implement improvement suggestions	(11) Cultural differences	(21) Material availability	(31) Partnership	(41) Supplier selection
(2) Access control	(12) Development potential	(22) Middle management	(32) Personnel capabilities	(42) Supply chain management and control
(3) Access to information	(13) Equipment	(23) Openness to receive information	(33) Planning	(43) Supply chain network
(4) Appropriate components, parts and services	(14) Facility layout and space	(24) Organisation	(34) Politics	(44) Synchronising
(5) Artesans / blue collar work / floor level work	(15) Financial issues	(25) Organisational ability to adapt to new operation models and methods	(35) Previous TT experiences	(45) Top management
(6) Available time for development	(16) Financial planning	(26) Organisational culture	(36) Procurement	(46) Training
(7) Blurred organisational boarders	(17) Hidden agenda	(27) Organisational maturity	(37) Production	(47) Transparency
(8) Commitment	(18) Hidden corruption	(28) Over confidence	(38) Real time information	(48) Trust
(9) Communication	(19) Inadequate decision making powers	(29) Partner's attitude	(39) Resourcing	(49) Unpaid invoices
(10) Cooperation	(20) Information security	(30) Partner's competence level	(40) Scheduling	(50) Working methods

The theoretical sensitivity is achieved through questioning and systematic comparison to identify possible participant subjectivity and bias as well as possible researcher errors in categorisation, and by using the literature to examine the interpretations related to the environment based on the researchers' experience from the environment, (Walker and Myrick 2006, Strauss and Corbin 1990).

In the second axial coding phase, the fractured data is connected back together by thinking systematically and relating the data to each other (Halaweh et al. 2008, Walker and Myrick 2006). The conditional relationships are analysed by asking questions what, when, where, why, how and with what throughout the process, the result or consequence revealing the pattern behind the concepts and categories (Scott 2004). Furthermore, the axial coding extends the open coding in determining what codes are the dominant and important ones to best represent the phenomena under the study and specifying the contexts, conditions, interactions and consequences of a process (Saldaña 2016). In this phase, the total number of concepts and categories generated is 15. These axial codes are listed in Table 4.5 and also presented in relation to the open codes.

Table 4.6: The axial coding categorisation table.

Axial Codes [Related Open Codes]
Hidden agendas and political motivations hinder the execution of TT [8, 10, 17, 18, 34, 45]
High transparency between the organisations minimise problems and develop trust [1, 2, 3, 7, 9, 10, 20, 25, 26, 29, 47, 48]
Cultural differences are difficult to manage [9, 10, 11, 23, 24, 25, 26, 27, 29, 48]
Top management commitment is critical for the project success [8, 10, 12, 16, 19, 22, 23, 25, 26, 28, 29, 35]
Over optimistic management's expectations regarding the ability to adapt [9, 10, 12, 16, 19, 22, 23, 24, 25, 28, 29, 30, 31, 32, 33, 35]
Adequate financial resources from the start of the project are critical for the TT execution [15, 16, 21, 28, 29, 33]
Typically TT problems are associated with the supplier network not supplying due to unpaid invoices [15, 16, 21, 36, 39]
The available finances determine the learning capability [4, 6, 12, 13, 15, 16, 25, 32, 36, 39, 41, 42, 43, 45, 46, 49]
Issues with the materials procurement cause most of the challenges and delays [15, 16, 21, 33, 36, 41, 42, 43, 45, 49]
Early resourcing and planning of SCM critical [6, 12, 21, 22, 30, 32, 33, 36, 39, 41, 42, 43, 46]
Crating a local supply network requires typically more time than initially anticipated [6, 28, 29, 30, 32, 33, 36, 41, 42]
Local partner typically needs significant assistance in their supplier selection [10, 21, 23, 28, 29, 30, 36, 41, 42, 43, 46]
Local availability of materials often an issue [4, 13, 15, 16, 21, 36, 41, 42, 43]
An overconfidence exists towards the local supplier network capabilities [4, 12, 28, 33, 36, 41, 42, 43, 45]
Initial planning typically would require more time and resources than what is allocated [6, 25, 28, 29, 30, 33, 35, 38, 39, 40, 44, 45, 46]

The third and last selective coding cycle integrates and refines the model created around the primary theme, i.e. central core category (Saldaña 2016, Halaweh et al. 2008, Walker and Myrick 2006, Corbin and Strauss 1990). The emergence of the critical properties and understanding of the consequences indicates the reaching of theoretical saturation (Scott 2004). As a result, a reflective coding matrix is created that further contextualises the primary theme by extending the coding, focusing on the conditions and consequences of the phenomena (Walker and Myrick 2006, Scott 2004). The results are then returned to the individual participants for a review with a possibility to suggest adjustments. A finalised reflective coding matrix is completed after a consensus (defined as > 70% agreement) is achieved, as illustrated in Table 4.6. Hence the reliability in qualitative coding is a representative of collaborative and objective consensus where 70% agreement establishes evidence that the reliability has been achieved (Walker and Myrick 2006, Scott 2004).

Table 4.7: The reflective coding matrix for the main factors of an efficient inter-organisational TT process.

Reflective Coding Matrix				
Core category	The main factors of an efficient inter-organisational TT process at the receiving local partner organisation			
Properties	Management	Controlling	Organising	Planning
Processes	Management	Financial planning and resources	Supply chain management	Local production planning
Dimensions	• Hidden agendas and political motivations hinder the execution of the TT contract. • High transparency between organisations minimise challenges and problems to occur (develop the trust) • Cultural differences are challenging to manage dispute training • Top management willingness and commitment critical for the project success • Senior management is typically least committed of all organisational levels to TT and does not see nor grasp the development potential • The ability to learn depends on the corporate culture and previous experiences in TT • Management is typically over-optimistic in their estimations of how quickly their organisation can adapt to new and how much of the work share they can do in-house • The operational TT team is often equipped with inadequate decision-making power that hinders the operations	• Adequate financial planning from the start crucial for the TT success • Typically TT problems are associated with financial issues (unpaid invoices to the supplier network) • The available finances and resources to implement the development suggestions determine the overall attitude and learning capability at the local receiving organisation	• Issues with the materials procurement cause most of the challenges and delays • Adequate resourcing and planning of procurement and SCM required at an earlier stage (securing material availability, training and support of the supply chain network) • Creating a local supplier network requires resources and time (minimum of two years) • Local partners typically need extensive assistance in supplier selection • Local availability of materials often an issue • Overconfidence regards the local supplier network capabilities to supply new parts and assemblies from the project's very beginning.	• Reserve more time and give more focus on detailed planning at the beginning of the project • Adequate scheduling and resourcing critical, needed resources typically underestimated. • Access to local partner's production information such as operations and scheduling critical (transparency) • Efficient communication difficult especially regards real-time issues and problems experienced, needs high emphasis and detailed planning. • Synchronising the schedules between the supplier and receiver of TT often challenging
Context	Authority over operationalisation and operations development	Facilitator of operations	Sufficient materials and other resources for manufacturing operations	Conditions of the operations; parameters, requirements and interdependencies
Strategies for understanding the consequences	The organisation is open to cooperation, and its goals are aligned to facilitate learning.	Sound financial commitment with understanding that a successful TT requires long term investments and financial resources	Required cooperative supply chain strategies and collaborative product and process planning require time, resources and in-house capabilities building	The TT implementation success rate is directly linked to the quality of the initial planning phase.

The emphasis on model building coding cycles is to explain how the TT works and how it compares to other contexts ("how") and why TT activities take place in certain conditions ("why") (Saldaña 2016). The efficient inter-organisational TT consists of four processes by which the local recipient organisation can best influence the efficiency and success of the project: management, financial resources and planning, supply chain management, and local production planning. These processes are consistently brought up by all the participants. The role of management through the commitment and openness to the inter-organisational learning (75% weight) together with the resources and competence building of supply chain management and the establishment of local supply network (80% weight) are seen as the most crucial, typically creating the highest barriers and obstacles for the TT execution.

From the supplier perspective recipient's top management's openness and commitment to the TT project is considered unquestionably paramount (75% weight). It is, however, highlighted that the motivation to learn and develop operations grew when going down in the organisation. The blue-collar floor workers typically demonstrate the highest interest to learn and adopt knowledge where the management usually are the least committed of all organisational levels, and also often not seemingly understanding or grasping the attainable development potential. Further, the training and support is experienced as the easiest activity to conduct from the supplier point of view, and the overall relationship between the TT team and the recipient floor workers is typically relaxed and uncomplicated. Supplier representatives brought up that hidden agenda, and political motivations of the recipient management often hinder the execution of the TT contract. Also, the recipient management trust and resulting operational transparency between the two organisations are typically difficult to achieve. As a result, the TT team is often equipped with inadequate decision-making powers to execute the local participation plan. Based on the supplier responses, the cultural differences throughout the organisation are difficult to manage despite the extensive training and these factors should be continuously highlighted by the management throughout the process, not just in the beginning. Also, based on supplier experiences the recipient's ability to learn very much depends on the overall organisational culture and previous experiences in TT and similar projects, all factors mostly driven by the management. To assist and advance the TT the recipient management as the highest authority over operationalisation and operations development should be more open to cooperation and the organisational goals should be aligned to facilitate the development through inter-organisational learning.

Typically the TT problems are associated with the financial issues, most commonly to unpaid invoices to the supplier network and thus resulting in production disruptions due to material non-deliveries (58% weight). Adequate and appropriate financial resources allocation and their planning is a fundamental process. Still, as the local partners typically are financially restricted or struggling business entities, the available resources are often in imbalance to the project needs from the start. The available finances and resources to implement the supplier's development suggestions further determine the overall attitude and learning capability at the local receiving organisation. A sound financial commitment with understanding that a successful TT requires long term investments and significant financial resources forms a baseline for the recipient to facilitate the necessary operations.

The supplier representatives agree that the recipient's materials procurement-related issues cause most of the challenges and delays in the TT process (80% weight). Adequate resourcing and planning of the procurement and supply chain management (securing material availability, training and support of the supply chain network) are required at the very beginning of the process. It is estimated that creating a local supplier network requires a minimum of two years to build together with adequate resources as the local recipient typically needs extensive support in supplier selection and the development of supply chain management capabilities. The recipient is generally overconfident at the beginning of the TT process with regards to the local supplier network capabilities to supply new parts and assemblies at the fast schedule. However, based on global project experiences, the local availability of materials is typically an issue in defence industry projects. Sufficient materials and other resources for manufacturing operations require cooperative supply chain strategies and collaborative product and process planning requires time, resources and in-house capabilities building at the recipient organisation.

Through the fourth process, the TT implementation rate is directly linked to the quality of the initial local production planning phase that determines the conditions of the operations; as well as the parameters, requirements and interdependencies. The supplier participants suggested that the local recipient should reserve more time for detailed planning of the project, especially focusing on synchronising scheduling between the supplier and receiver, and securing adequate resourcing for the project (64% weight). Transparency through knowledge sharing is critical as the supplier needs to have access to local partner's production information such as operations and scheduling. This is often experienced as challenging due to trust issues echoing from higher management. Overall, efficient communication from the recipient to the supplier is experienced as difficult; the recipient is usually struggling to communicate problems and challenges in real-time, typically resulting in constant process delays.

In addition to the open-ended questions answered, the participants were presented with a structured list of TT related problems and requested to select the ones they have encountered in the TT process. The problem list was constructed based on the previous studies and reflected the researcher's knowledge of the environment (Ivarsson and Alvstam 2005, Capasso et al. 2005, Szulanski 1996, Zander and Kogut 1995, Galbraith 1990, Lasserre 1982, Contractor and Safafi-Nejad 1981, Davies 1977, Teece 1977, Mansfield 1975, Baranson 1970). The participants also could add problems outside the list. The TT teams are relatively small, and typically, the same people are involved in multiple TT projects from start to finish. Furthermore, the managerial and executive responsibilities are also centred, which decreases the need to conduct extensive studies overarching the entire supplier organisation. Hence with this study sample, it was possible to reach both the operational, managerial and executive-level feedback related to the TT execution and its issues.

The statistical frequency analysis of the structured questionnaire presented in Table 4.7 demonstrates a relatively small variance between the results of different respondents reflecting the most prominent challenges encountered related to four segments: (i) the knowledge to be transferred (i.e. codifiafibility, complexity, ambiguity and tacitness), (ii) the pre-transfer planning, (iii) the recipient abilities and characteristics, and (iv) the cultural and language differences. Notable is that the segments with the least issues experienced are related to (i) recipient's overall competence and retentive capacity, and (ii) the floor level workers' competence, motivation and ability to communicate. The analysis of variance assists in estimating the reliability of the small sample size. It is however important to acknowledge that strictly statistically a low sample size does not necessarily represent the true infinite population variance as more data increases the precise estimates of a group means. Conversely for qualitative studies the objective is not based on the statistical significance but rather data saturation which requires a much smaller purposive sample. The data saturation is achieved when there is enough information to replicate the study when the ability to obtain additional new information has been attained and when further coding is no longer feasible (Fusch and Ness 2015). The Table 4.7 frequencies demonstrate the research has achieved the data saturation.

Table 4.8: The TT process problem frequencies of responses.

TT Problems Encountered	**N Valid**	**Per cent of Cases**	**Std Deviation**
Knowledge codiafibility (i.e. the extent the supplier could articulate the knowledge in documents and software such as blueprints, procedural task descriptions, etc.)	8	100%	0.00000
Knowledge complexity (i.e. the technical complexity and technological sophistication of new features and concepts in a technology to be transferred)	8	75%	0.46291
Knowledge ambiguity (i.e. the uncertainty or doubtfulness of the meaning of language, when the language is capable of being understood in more than one way by a user)	8	75%	0.46291
Knowledge tacitness (i.e. the kind of knowledge that is difficult to transfer to another person by means of writing it down or verbalising it)	8	75%	0.46291
Supplier problems to identify local recipient needs	8	75%	0.46291
Inadequate recipient pre-transfer planning	8	100%	0.0000
Inadequate post-transfer control	8	75%	0.46291
Recipient's employee's teachability and absorptive capacity (i.e. the ease at the individual level by which knowledge can be taught to the new workers and the new technological practices can be adapted)	8	50%	0.53452
Availability of qualified technical and managerial personnel with critical skills and know-how	8	50%	0.53452
Recipient lacks retentive capacity (i.e. ability to preserve the routine use of the new technological practices)	8	25%	0.46291
Recipient problems achieving a satisfactory local production performance	8	25%	0.46291
Recipient lacks performance review and evaluation of their operations under the TT	8	50%	0.53452
Recipient's lacking ability to analyse and evaluate their organisational performance	8	75%	0.46291
Recipient's lacking ability to implement improvement suggestions received from the supplier	8	50%	0.53452
Recipient lacks the use of management methods	8	75%	0.46291
The level of the recipient employee's competence	8	25%	0.46291
Recipient's management lacking motivation	8	75%	0.46291
Recipient's floor level workers lacking motivation	8	25%	0.0000
Recipient lacks prior experience and understanding in the contract technology	8	75%	0.46291

Recipient lacks previous experience and understanding of the TT process	8	75%	0.53452
Cultural differences	8	75%	0.46291
Language differences	8	100%	0.46291
Communication issues on management level	8	75%	0.00000
Communication issues on floor level	8	25%	0.46291
The geographical distance between the supplier and the recipient	8	50%	0.53452

4.5. Discussion

In this study, the focus is on the international externalised TT where the transaction takes place horizontally from a one manufacturing company location to another through formalised relationship, such as a strategic alliance in the form of joint venture, license manufacturing, subcontracting or original equipment manufacturing (Ivarsson and Alvstam 2005, Davison and McFetridge 1985, Mansfield 1975). When the case TT process is compared and reviewed to the process descriptions found in the existing literature, several intersecting points emerge, reflecting similar conditions and environment to this case study. The literature, however, provides a less detailed macro view to the different metal-level aspects of the TT phenomena and its generic concepts (Frederiksson et al. 2018, Malm et al. 2015, Knudsen et al. 2013, Szulanski 1996). It is important to note that the process description is based on experiences and opinions of people that are involved in the TT projects on a day-to-day basis. It is imperative to have a systematic process in place to manage the inter-organisational TT process effectively. This research approach TT from the process modelling point of view, and as a result, presents a more detailed level 2 SCOR TT process description from the selected supplier perspective as illustrated in previous Figures x and x. As the systematically constructed base cases in the defence offset context are rare and typically only outlining the macro-level activity, this research's level 2 SCOR TT process model advances the more profound understanding of the more efficient TT operation management (Fredriksson et al. 2018, Malm et al. 2015, Ivarsson and Alvstam 2005, Simonin 1999, Albino et al. 1998, Szulanski 1996, Wei 1995, Cusumano and Elenkov 1993, Reddy and Zhao 1990, Mansfield and Romeo 1980). The findings suggest that local recipient's management, financial resources and planning, supply chain management and the local production planning are the main factors of an efficient inter-organisational TT process. When looking for patterns, repeated relationships and grouping the data accordingly, the emerging model can be illustrated to represent the theoretical position of inter-organisational TT.

Figure 4.6 illustrates a typical receiving local partner's operating scenario seen from the supplier viewpoint where the TT barriers and obstacles are formed by management that is not fully committed and open to learning, the inadequate financial support and planning, the rushed execution of supply chain management with insufficient resources and capabilities building elements, and finally the inadequate local production planning. These barriers lead to the low performing TT project and unused development potential. The overall focus is on defence product capabilities building, replicating the supplier's processes without more profound learning objectives.

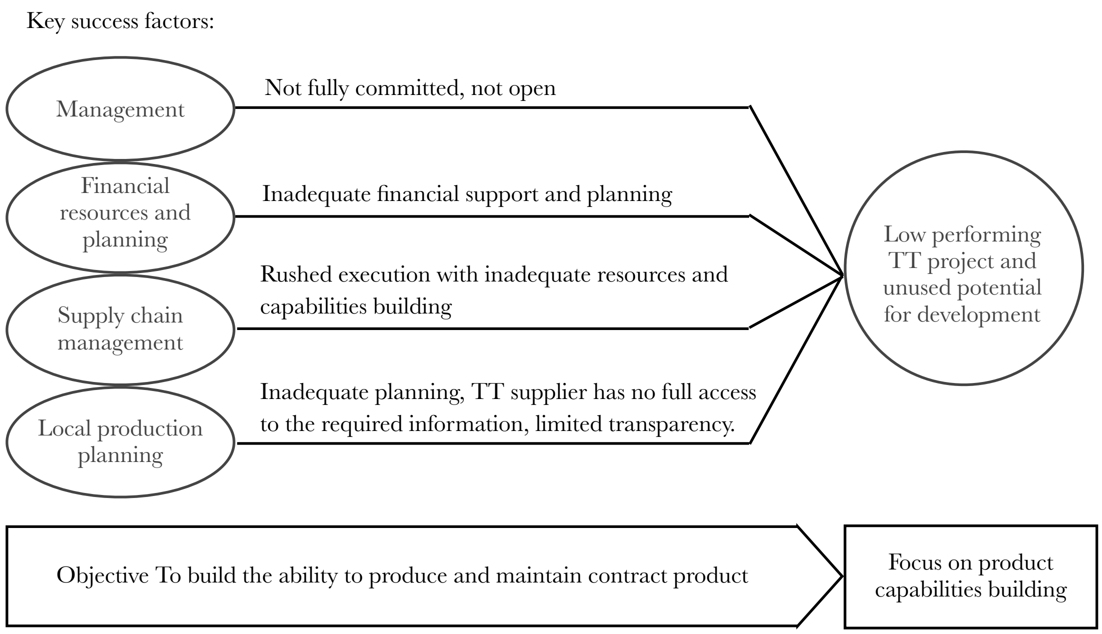

Figure 4.6: Receiving local partner's typical operating scenario.

Figure 4.7, on the other hand, illustrates receiving local partner's ideal operating model, an optimal operating environment. The objective is two dimensional, to build the ability to produce and maintain the contract product and support innovation and organisational learning, developing future capacity and capabilities. This is achieved through management that is open to cooperation and organisational goals to facilitate learning, sound financial commitment and planning throughout the project, adequate time and resources allocated for the in-house supply chain management capabilities development, and lastly, adequate local production planning with transparency between the supplier and recipient organisations. This leads to a successful project with added knowledge absorption and organisational learning capability. These presented models can be reflected the conditions of a successful inter-contextual best practice transfer where well-defined preconditions and planning regarding practices, performances and time, and a strong and stable managerial commitment are the most relevant factors for a successful TT (Capasso et al. 2005). The recipient cannot be passive and expect an automatic increase in the capabilities. Instead, the approach must be more strategic and enable a long term deep relationship with the supplier (Ivarsson and Alvstam 2005, Reddy and Zhao 1990). In all, businesses form inter-organisational alliances to gain access to resources and competencies, to learn (Edmondson and Harvey 2017, Edmondson 2012, Capasso et al. 2005). The core manufacturing and best practice knowledge transfers, replications and relocations through international strategic alliances are critical strategic decisions when organisations seek more flexible manufacturing approaches and growth (Johnson et al. 2017, de Holanda Schmidt Squeff and de Assis 2015, Kiss 2014, Axelson and James 2000).

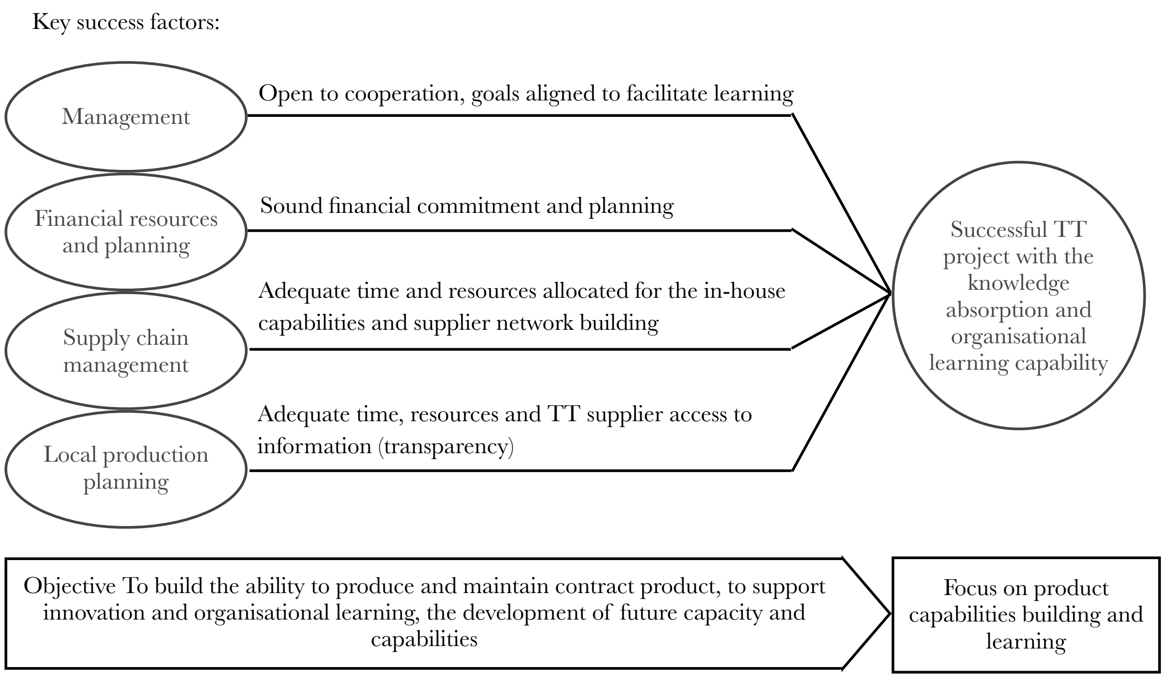

Figure 4.7: Receiving local partner's ideal operating model.

This case study results can be reflected in the literature review where the local recipient's initial attitude and capabilities, preparation and planning, and the TT execution are variables to the TT outputs (Lorell et al. 2002, Vats et al. 2013, Kiss 2014). Hence the results build new knowledge by validating theoretical assumptions. As illustrated in Figure 4.7, the local recipient's overall attitude, abilities, and management capabilities form a precondition for the overall project to determine how successful the technology absorption and utilisation can be. The level of preparation and planning, on the other hand, predicts the efficiency of the TT execution. The following execution focus, involvement of the supply chain partners, and strong financial support from the government further enable the best value creation and sustainable outputs such as commercialising the technology acquired and establishing strategic international level partnerships. Hence the local recipient's initial attitude and capabilities, preparation and planning, and the TT execution are variables to the TT outputs.

Overall the different sources tend to all agree in their conclusions on the fact that the governments should increasingly focus on becoming intelligent customers (Lorell et al. 2002, Vats et al. 2013, Kiss 2014). Simultaneously, these sources provide relatively little practical guidance for these companies on how this will be efficiently achieved and managed. Based on this case study, to truly capitalise on the TT's benefits, the local participation strategy must reach beyond a single contract scope and build sustainability by engaging parties in long-term mutually beneficial ways and incorporating the whole supply chain network.

This study reveals that the management, the financial planning and resources, the supply chain management, and the local production processes were the main factors that the local recipient organisation can best influence the efficiency and successfulness of the project. The role of management through the commitment and openness to the inter-organisational learning as well as the resources and competences building of supply chain management and the establishment of local supply network are being the most crucial processes, typically creating the highest barriers and obstacles for the TT execution.

Recipient's openness and commitment to the TT project is paramount. However, according to the results of this study, the interest to learn and develop in organisations grew down in the organisational levels, the blue-collar floor workers typically demonstrate the highest interest to learn and adopt knowledge where the management usually is the least committed, and also often not seemingly understanding or grasping the attainable development potential. To assist and advance TT the recipient management as the highest authority over operationalisation goals should be aligned to facilitate the development through inter-organisational learning.

Most of the challenges and delays in the TT process are caused by supply chain management. Implementing cooperative supply chain strategies and collaborative product and process planning is paramount and require time, resources and systematic in-house capabilities building at the recipient organisation. It is estimated that creating a local supplier network requires a minimum of two years as the recipient typically needs extensive support in the supplier selection and the development of supply chain management capabilities.

Typically, TT problems are associated with financial issues as the available local recipient resources are often in imbalance to the project needs. Lacking finances results in production disruptions due to material non-deliveries, and determines the recipient's attitude to the development suggestions and the overall learning capability. A sound financial commitment with understanding that a successful TT require long term investments and financial resources forms a baseline for the recipient to facilitate the necessary operations.

It is typical for a defence offset environment that the government requires the foreign supplier to partner with a specific local industry representative. The local organisations often do not have extensive prior experience on TT. As a result, there may not be existing effective routines to manage all the aspects of the process to the extent that the transfer often requires ad hoc solutions. As a result, milestones will be missed, budgetary limits will be exceeded, learning opportunities will not be utilised effectively, and the overall participant expectations will not be met. The TT implementation rate is directly linked to the quality of the initial local production planning phase that determines the conditions of the complex operations. The study suggests that the local recipient should reserve more time for detailed planning of the project, especially focusing on synchronising scheduling between the supplier and receiver, securing adequate resourcing for the project, and providing the supplier with sufficient transparency for the operations data.

In the defence industry ecosystems, governments represent the highest procurement authority, setting the regulations and policies under which the defence contract operate. Governments seek to support the local defence industry and strategies through industrial participation thus an efficient and successful TT from the foreign entity to the local recipient is a high priority to attain benefits in the form of capabilities building and possible future innovations. However, the long term outcomes of the industrial participation activities are generally challenging to monitor, and the transfer process is often also influenced by alternative motivations and underlying politics affecting the inter-organisational cooperation and execution of the TT process. In general, political emphasis is often on the short term benefits of providing work and building capabilities to maintain the contractual product in warfare situations, rather than also trying to grasp the long term benefits in the form of organisational learning and innovations capabilities building. As such, industrial participation comes with a high price tag without real possibilities for significant future returns through the potential industry innovations and evolving.

Governments should engage in activities to enable efficient knowledge absorption and organisational learning. The critical governmental focus should be to ensure that the local recipient has adequate financial status throughout the project as well as to allocate the necessary time for detailed pre-planning between the foreign supplier and the local recipient. The local recipient should build links to both the government authorities to better enforce the understanding of the operational requirements, as well as to the foreign supplier to enable management-led open and cooperative TT environment from the start. The positive effect of a successful TT would not be limited to the local recipient only, but the positive ripple effect may reach several local industry actors through the supply network collaboration.

In terms of performance metrics, standard measurement and assessment should be established to focus on the execution of the critical success factors and the knowledge absorption and organisational learning capability. However, devising such a measurement method within the TT process is not easy as there is no tangible output. How do you assess the quantity and quality of knowledge when the transfer is more qualitative than quantitative exercise? The TT process objective is to establish the related local participation contract that focuses on enabling the local serial production phase rather than the long term potential intangible benefits. Furthermore, the TT process performance measurement cannot be integrated into and managed as a part of the production phase as presented in Figure 2 due to the different aims and nature of these individual phases. Hence, TT and production must have their independent performance measurement approach.

Currently, the TT process is measured only during its execution phase, focusing on its operations and activities. The TT supplier indicators are focused on managing productivity, decreasing costs and increasing the profitability and possible capacity and quality in terms of the acceptable contractual products that the local recipient must be able to produce after the completion of the TT process. A possible measurement for the TT process output's success could involve incorporating the quality and timeline aspects—the quality in terms of the local serial manufacturing output's performance in the production phase. Quality Assurance would be involved from the beginning of the production, assessing the quality of the end product and the supply of materials and components for the production. Secondly, the time in terms of production time and how long it takes to assemble the subsections and the end product. As the technology owner, the TT supplier has an already established baseline that can be used to reflect against what should be achievable in the local serial production phase. If the production takes too much time, it indicates that the local recipient is not as efficient as possible.

4.6. Research and Managerial Implications

A novel integrated case study and Straussian grounded theory approach under the interpretative assumptions and purposive sampling in a global defence industry organisation is applied for this study (Palinkas et al. 2015, Thai et al. 2012, Halaweh et al. 2008). Case studies are typical for defence studies with high access restrictions, but grounded theory applications aren't previously applied in this field.

This research aims to assist the local recipient companies involved in the defence offset TT projects to establish and manage their TT projects more successfully and sustainably. The conceptual framework presented in this paper suggests that TT management is complex and calls for efficient management, especially of the SCOR model 'Plan' process practices and a corporate culture that genuinely facilitates learning. Even though planning activities exist in all companies, they should be considered a strategic tool for its success in the defence TT context. Related to that, a successful knowledge absorption is accomplished by having a management team that is open to cooperation and applying organisational goals that facilitate learning, through having a sound financial commitment and planning throughout the project life cycle, through the allocation of adequate time and resources for the development of the supply chain management, and lastly through thorough local production planning with a commitment to transparency between the supplier and recipient organisations. This receiving local partner's ideal operating model is illustrated in Figure 4.7. The role of the local recipient's management through the commitment and openness to the inter-organisational learning as well as the resources and competence building of supply chain management and the establishment of the local supply network is identified as the most crucial, typically creating the highest barriers and obstacles for the TT execution and thus preventing the knowledge exchange from the supplier perspective.

Furthermore, the TT key success factors' management and the systematic development of the knowledge absorption and organisational learning capability also require the implementation of an efficient performance management system. However, devising a measurement method within the TT is challenging because the output is intangible to a great extent. The SCOR framework could provide a good baseline that can be customised to specific TT needs. In general, the SCOR method should be further investigated if it would be possible to extend it to cover these intangible and qualitative aspects. The SCOR model was initially designed for the manufacturing sector (Delipinar and Kocaoglu 2016), and as Legnani (2011) and Di Martinelly, Riane, and Guinet (2009) point out, the SCOR model sometimes is too general and that certain adaptations that are more targeted to the environment of individual supply chains are necessary. Similarly, the SCOR model best practices database isn't currently reflecting the activities and needs of the defence industry TT and cannot be utilised as such.

The possible broader implications of the present research were that the governments setting the regulations and policies under which the defence contracts operate should engage in activities to enable efficient knowledge absorption and organisational learning and build future innovation capabilities. The key focus should be on ensuring that the local recipient has sufficient financial resources throughout the project and the necessary time for detailed pre-planning.

This study does not answer all the possible questions related to the defence industry TT process, nor does it attempt to. This study extends the few SCOR defence industry applications presented by Bean et al. (2009) and represents activities typical for global defence TT supply chains. While not a comprehensive answer to all the multifaceted challenges, the identified 'Plan' process key success factors provide practical field guidance and direction for future research.

This study had several limitations, which also offer avenues for future research. The data was based on a single case study, only reflecting the supplier view and did not capture the local recipient's views or the broader industrial participation environment. Therefore, future research could explore the other dimensions of the process and analyse them over time as a longitudinal study to better understand the interaction between the supplier and the recipient and other factors playing a role over time. Despite the limitations, this study reported actual experiences from a global TT supplier perspective, giving new insights to limited literature of inter-organisational TT in a complex high technology defence environment.

5. PHASE 3 - THE CONCEPTUALISATION OF TECHNOLOGY TRANSFER SYSTEM

The following section presents the Phase 3 study of this mixed methods research focusing on the TT process modelling through the system dynamics approach.

5.1. System Dynamics Modelling Approach

Due to the limited access to available data, this study uses system dynamics modelling approach to gain more understanding of the complex defence offset TT system and employs the mixed-use of Straussian grounded theory and system dynamics modelling in a secondary analysis of qualitative data (Akcam et al. 2019, Suliza et al. 2014). The purpose is to explore further how the implementation of the ideal operating model and the position of local recipient's management, financial planning, supply chain management and the local production planning as the main factors that the local recipient organisation affect the efficiency and success of the project. Hence, the systems dynamics approach is applied to test a TT model's behaviour (Luna-Reyes & Andersen 2003). Researchers acknowledge the potential of this mixed-method approach, and several successful results have been reported (Axelrod 1976, Black & Carlile 2004, Kapmeier 2006, Kopainsky & Luna-Reyes 2008, Laws & McLeaod 2004, Morrison et al. 2008, Rudolph et al. 2002).

The theory of systems dynamics was first introduced by Professor Jay W. Forrester (1980) from the Massachusetts Institute of Technology in the 1950s. He believed that most organisational problems could be traced back to management and not operations engineering. Furthermore, he proposed that the combined engineering and science approach could assist in identifying and improving these management issues (Forrester 1980). Since the introduction, the founders of the system dynamics field have developed a series of modelling guidelines (Forrester and Senge 1980, Randers 1980, Richardson and Pugh 1981, Roberts et al. 1983, Wolstenholme 1990, Sterman 2000).

The system dynamics implement qualitative and quantitative approaches to build a model where the qualitative data assists in gaining more understanding of how the dynamic interaction occurs in the system. In contrast, quantitative data is utilised to develop feedback models (Luna-Reyes & Andersen. 2003). The model typically consists of three variables: the auxiliary, rate, and stock, and two types of flows, namely the information and material (add reference). In this study, the variables are the output formed based on the Straussian grounded theory qualitative modelling conducted in Phase 2 of this research. These variables and flows form a basis to study the behaviour of a natural system through the interaction that occurs among the variables (Luna-Reyes & Andersen. 2003). A system dynamics approach can enable a deeper understanding of the relevant factors present in the system, identify the system's structure, and analyse the effects of different types of interactions within the set system (Luna-Reyes & Andersen. 2003). Overall, as illustrated in Figure 5.1, the systems dynamics approach is an iterative process that starts with the initial problem articulation and the boundary selection, followed by the development of the dynamic hypothesis and the formulation of the actual model, the testing of the model through a study of interactions, and finally to conclude the outcome and findings through a policy formulation and evaluation (Serman 2000). The data derived from the qualitative approach and the anticipated reactions of the feedback diagram form the basis for the hypothesis generation (Richardson & Pugh 1981). As Luna-Reyes & Andersen (2003) described, the relationships between the different identified variables need to be established to formulate the dynamic simulation model further. To test the model, it is then adjusted and changed to meet set conditions, resulting in changes in the overall system. This also further assists in evaluating and validating if the model reflects the initial problem articulation. Lastly, the findings assist in evaluating the current policies and possibly propose adjustments. System dynamics is an iterative process where the modeller will test a dynamic hypothesis representing a feedback theory or causal structure generating a series of behaviour over time, allowing learning and designing the guidance policies (Luna-Reyes & Andersen 2003).

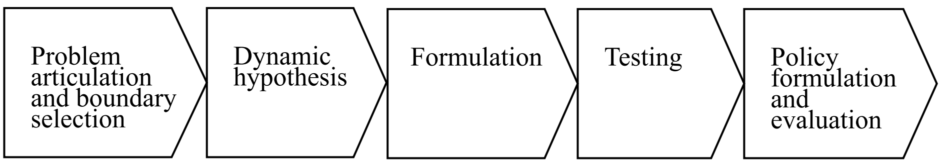

Figure 5.1: The systems dynamics approach process (Serman 2000).

The management of TT, knowledge transfer or any organisational learning is challenging as it typically involves various stakeholders and multiple interactions between them in a complex high technology environment. Hence, applying a system dynamics approach is justified to understand better the challenging ecosystem the knowledge transfer takes place (Rad et al. 2015). However, few studies incorporate the broader spectrum of system dynamics and TT or knowledge transfer and management or organisational learning. In the defence industry scope, there is none (Cosenz and Noto 2016, Cosenz and Noto 2015, Dangelico et al. 2010, Fiala 2005, Hafeez and Abdelmeguid 2003, Lin et al. 2006, Paucar-Caceres and Pagano 2009, Rad et al. 2015, Rodrigues and Martis 2004, Wang 2011, Yim et al. 2004) The studies identified are listed and described in Table 5.1, and can broadly be divided into covering seven research focus areas, namely (F1) the strategic management and system dynamics research (*2 sources*), (F2) management control and strategic learning (*1 source*), (F3) knowledge management and transfer (*5 sources*), (F4) innovation through collaboration and capability to foster knowledge (*2 sources*), and lastly (F5) supply chain performance (*1 source*). Hence, there is a gap where the system dynamics are not discussed in the intra-organisational defence TT. However, the method is considered suitable for the study of a highly complex knowledge transfer environment (Cosenz and Noto 2016, Cosenz and Noto 2015, Dangelico et al. 2010, Fiala 2005, Hafeez and Abdelmeguid 2003, Lin et al. 2006, Paucar-Caceres and Pagano 2009, Rad et al. 2015, Rodrigues and Martis 2004, Wang 2011, Yim et al. 2004).

Table 5.1: Studies related to system dynamics in TT and/or knowledge transfer and/or management, and/or organisational learning.

Literature Source [order of date published]	**Broad Research Focus Area** Research Aim and Relevant Key Findings
Cosenz, F. and Noto, G. (2016) Applying System Dynamics Modelling to Strategic Management: A Literature Review. *Systems Research and Behavioural Science*. Vol. 33, pp. 703-741.	**(F1) Strategic management and system dynamics research** The paper aims to explore and discuss the theoretical and empirical development of system dynamics in the strategic management field through a systematic analysis of the literature in order to highlight the main research themes and developmental patterns of the critical contributions to date, as well as to provide an overview of system dynamics application to strategic management literature for further research to build on. This literature review has evidence that system dynamics must be considered a flexible research methodology that can be soundly integrated with strategic management approaches and frameworks. The majority of the selected studies show that system dynamics has been primarily used as a systemic analysis tool. A systemic analysis is often conducted as a preliminary phase for introducing further research steps, such as simulation, scenario analysis and strategy testing. Simulation is considered the primary tool to discover how complex systems work when real experimentation is too slow, too costly, unethical, or just plain impossible for most social issues we face nowadays. The paper found robust literature about knowledge management. Where system dynamics was used as a tool for decision-makers to explore knowledge transfer and management issues through the adoption of a dynamic perspective of which relevant to this study are Fiala (2005), Hafeez & Abdelmegrid (2003), Paucar-Caceses & Pagano (2009), Yim et al. (2004), Wang (2011).
Cosenz, F. and Noto, L. (2015) Combining system dynamics modelling and management control systems to support strategic learning processes in SMEs: a Dynamic Performance Management approach. *Journal of Management Control*. Vol. 26, pp. 225-248.	**(F2) Management control and strategic learning** Traditional management control systems need to be combined with simulation-based methodologies in order to improve entrepreneurial learning processes and, as a result, to react promptly. The paper aims to show how combining traditional management control mechanisms with system dynamics modelling can effectively result in SMEs' performance measurement and management. The main findings suggest that dynamic performance management may support entrepreneurs in improving the strategic learning processes of SME entrepreneurs by framing the firm's performing system and designing competitive policies aimed to foster the sustainable development of SMEs.

Rad, M. F., Seyedesfahani, M. M. and Jalilvand, M. R. (2015). An effective collaboration model between industry and university based on the theory of self organization. *Journal of Science & Technology Policy Management*. Vol. 6, No. 1, pp. 2-24.	**(F4) Innovation through collaboration and capability to foster knowledge** This study investigates the relationship between university and industry as two significant infrastructures of the national innovation system in all leading scientific and industrial settings. The results show that in the first stage of a relationship, as the type and level of needs and the performance of university and industry are different, human resources cannot improve industrial productivity because of the lack of training necessary for the industry. In the second stage, academic research cannot take an appropriate orientation because of the separation of policies in higher education institutions and industry. Thus, improvement in the industry would be limited to the use of old technologies from foreign partners. As a result of the limitation, the utilisation of universities from industry and their improvement would be restricted. In the third stage, the (self-) organised relationship between industry and university is used effectively to develop an effective collaboration model innovation in each of the two institutions. Thus the research suggests several policies to improve the relationship between industry and university.
Wang, W-T. (2011). System Dynamics Modelling for Examining Knowledge Transfer During Crises. *Systems Research and Behavioral Science*. Vol. 28, pp. 105-127.	**(F3) Knowledge transfer** There have been very few studies engaging in exploring the theme of knowledge transfer in the context of managing organisational crises. Consequently, this study explores this issue concerning a product recall crisis of a motorcycle manufacturer using the method of system dynamics modelling. The research findings illustrate the multiple knowledge transfer mechanisms used and their influence on organisational performance during crises to distribute critical knowledge and facilitate the development of collective understanding within organisations. The research results have enriched the understanding of what knowledge transfer practices are embedded in the organisational processes and how the internal and external environments of the company are thus influenced by the capability to perform effective knowledge transfer practices more comprehensively.
Dangelico, R. M., Garavelli, A. C. and Petruzzelli, A. M. (2010). A system dynamics model to analyse technology districts' evolution in a knowledge-based perspective. *Technovation*. Vol. 30, pp. 142-153.	**(F4) Innovation through collaboration and capability to foster knowledge** The current economic scenario is more and more characterised by knowledge as a critical element to enhance and foster firms and regions innovation and competitiveness, such as in the case of technology districts. They represent typical economic systems constituted by economic actors whose success and survival depend on creating new knowledge and innovation. This paper describes and formalises the complex dynamics generated by knowledge, proximity, and firm agglomeration processes inside a technology district by adopting a system dynamics model. Results show that as cognitive and organisational proximities increase, district actors can fully exploit the benefits of agglomeration in terms of knowledge sharing and creation, favouring the district growth and development.

Paucar-Caceres, A. and Pagano, R. (2009). Systems Thinking and the Use of Systemic Methodologies in Knowledge Management. *Systems Research and Behavioral* Science. Vol. 26, pp. 343-355.	**(F1) Strategic management and system dynamics research** The paper aims to raise knowledge management and systemic practice researchers' awareness of the benefits of further exchange and conversation between these two management fields. Conceptually, systems thinking and knowledge management seems to share similar grounds. At the level of practice, there is also some evidence that established systemic methodologies have been informing knowledge management practice. Results suggest that methods such as systems dynamics, complexity theory, soft systems methodology, viable systems model and critical systems have started to become visible in knowledge management applications.
Lin, C-H., Tung, C-M. and Huang, C-T. (2006). Elucidating the industrial cluster effect from a system dynamics perspective. *Technovation*. Vol. 26, pp. 473-482.	**(F4) Innovation through collaboration and capability to foster knowledge** Focusing on sustaining innovation and strengthening knowledge management may cause the enterprises to maintain a competitive advantage. This study considers four critical interactive dimensions of industrial competitiveness: workforce, technology, money, and market flows. All factors in the cause-and-effect chains influence the industrial cluster effect positively. This study uses a system dynamics perspective to detail the interactive relationships with the four essential loops of industrial competition.
Fiala, P. (2005). Information sharing in supply chains. *Omega*. Vol. 33, pp. 419-423.	**(F5) Supply chain performance** The paper aims to model supply chain dynamics to analyse the supply chain performance in terms of the information flow. The bullwhip effect, describing growing variation upstream in a supply chain, demonstrates that decentralised decision making can lead to poor supply chain performance. The analysis of causes of the bullwhip effect leads to suggestions for reducing the bullwhip effect in supply chains by strategic partnership and more cooperative decision making.
Rodrigues, L. L. R. and Martis, M. S. (2004). System Dynamics of Human Resource and Knowledge Management in Engineering Education. *Journal of Knowledge Management Practice*. October 2004.	**(F3) Knowledge management and transfer** This paper simulates a time-based dynamic model to fill the competence gap of engineering graduates based on the governing system variables. System dynamics is employed to illustrate relations between graduation, recruitment, knowledge transfer, and knowledge loss rates in causal form. Graphs are plotted to estimate the actual competence pool of engineers, competence training completion rate and actual level of competence absorbed under the dynamic conditions of the governing time-based policy parameters. The results reveal that present and future competency gaps can be minimised through time effective competency training programmes.

Yim, N-H., Kim, S-H., Kim, H-W. and Kwahk, K-Y. (2004). Knowledge based decision making on higher level strategic concerns: system dynamics approach. *Expert Systems with Applications*. Vol. 27, pp. 143-158.	**(F3) Knowledge management and transfer** Knowledge management suggests managing and applying knowledge to improve organisational performance by recognising knowledge as a new resource in gaining organisational competitiveness. Applying knowledge to decision making has a significant impact on organisational performance than solely processing transactions for knowledge management. In this research, a method of knowledge-based decision-making using system dynamics, emphasising strategic concerns, is suggested. The proposed method transforms individual mental models into explicit knowledge by translating partial and implicit knowledge into an integrated one. The scenario-based test of the organised knowledge model enables decision-makers to understand the structure of the target problem and identify its fundamental cause, which facilitates effective decision-making. This method facilitates the linkage between knowledge management initiatives and achieving an organisation's strategic goals and objectives.
Hafeez, K. and Abdelmeguid, H. (2003). Dynamics of human resource and knowledge management. *Journal of the Operational Research Society*. Vol. 54, pp. 153-164.	**(F3) Knowledge management and transfer** This paper employs systems dynamics to illustrate the relationship between recruitment, training, skills, and knowledge in a causal loop form. Strategies for human resource management are developed by conducting time-based dynamic analysis. Many companies are in fear of losing critical business knowledge when their employees leave. They have realised that proper management of their skill and competence-base is key to their survival and profitability in the knowledge economy. Therefore, they need to understand the dynamics of their intellectual capital and human resource management policy. The results suggest that the systems dynamics simulations can help estimate training-learning time against the required skill shortages and associated costs and devise efficient human resource management strategies.

5.2. Qualitative Data in System Dynamics Modelling

System dynamics, at its core, is a methodology based on mathematical modelling techniques to explore complex systems and result in a mathematical model quantitatively to describe the structure and behaviour of a complex system (Akcam et al. 2019). Forrester (1975), however, identified qualitative data as the primary source of information in the modelling process, providing richer information that only exists in the knowledge and experience of those active in the working world (Forrester 1975). To compare, a numerical database has the narrowest scope since it is missing structural and policy perspectives completely and is limited in extracting the cause and effect relationships between the variables (Akcam et al. 2019). Qualitative data gathering techniques such as interviews and focus groups incorporated with qualitative data analysis techniques such as the grounded theory methodology have a central role in rigorous system dynamics modelling efforts as described by Luna-Reyes and Andersen (2003). Extracting information from people is not an easy task. However, when successfully done, it provides critical strength to the system dynamics approach through the fundamental and universal structures of real social and physical systems (Forrester 1994).

Halabi et al. (2012) and Myers (1997) highlight that system dynamics modelling, qualitative research, is typically first applied to understand the real-life environment better to extract the causal influences and factor inputs for the model. Hence, a qualitative method is implemented at the early stage in developing a system dynamics model to establish a context for the study and a hypothesis that emerge from a real-world situation (Halabi et al. 2012, Myers 1997). According to the standard system dynamics protocol, the quantitative inputs are derived from balancing the qualitative inputs (Coyle 1998).

5.3. Methodology

The research extends the prior integrated case study and Straussian grounded theory integration presented in Phase 2. Its objective is to further analyse the previously identified TT process pain points and critical success factors through a system dynamics approach. As a result, the study aims (i) to develop a TT system dynamics model in a defence industrial participation context and (ii) establish a deeper understanding of the relevant factors and their interactions present in the system through analysing different types of scenarios. The research is based on a system dynamics approach, continuing with the same sampling and focus group as in Phase 2. Hence, every TT specialist involved in the TT operations (sample size = 8) are engaged in the research to achieve appropriate saturation within the case organisation. Due to the sensitive industry nature, the research is anonymously conducted where any identifying factors related to the organisation or the participants under the study are not released.

The data is based on the Phase 2 survey outputs and further individual unstructured discussions with the focus group participants conducted in 2020. The interview discussions extend the initial answers to the open-ended questions addressed in 2019 and involve unstructured interviews intending to elicit more specific views and opinions of the participants and provide a more in-depth examination of the initial survey data (Creswell &

Creswell 2018). The effort was focused on understanding the context, setting and culture within which the TT activities were taking place. During these interviews, the participants were asked for their opinions about the persistence of the identified problems and how to resolve and/or affect the issues emerging throughout the TT process. Similarly, the success factors and their impact patterns were discussed, and the participants' lessons were reflected.

5.4. The Technology Transfer System Dynamics Modelling Procedure

5.4.1. The Problem Articulation

Following de Pinho (2015), a causal loop diagram is established better to understand the complexity inherent in the TT process and to confirm further the key factors identified. The diagram presents the system at a particular time, representing the relevant elements, relationships and interactions to the issue under investigation. The diagram is based on the initial 'rich picture', including all the facts and perceptions based on the literature, research survey and interview results, and previously presented process information. As in line with the Straussian grounded theory approach, the baseline objective in this complex systems approach is to avoid over rationalisation of the problem and the situation but rather let the impressions express themselves through different steps and a more creative process, and the diagram is the accurate representation of the environmental complexity. Firstly, the key variables are identified, and their interactions and relationships are presented through the interrelationship diagram (IRD). The TT IRD presented in Figure 5.2 establishes all possible interactions between the different variables and forms the basis for identifying feedback loops. Notably, it would also be possible to 'shortcut' and create a causal loop diagram directly from the variables identified, but this would run the risk of only enforcing our theory and own ideas rather than fully exploring all possible relationships through conducting a comprehensive IRD approach. Figure 5.2 is constructed using VENSIM system dynamics simulation software, where the identified variables are set in a circle form. The connections between these elements are presented using influence arrows drawn from the element that influences the one influenced. It is important to note that the arrows are only possible to draw in one direction, and in the case of two elements influencing each other, the arrow is drawn to reflect the more substantial influence. Also, the relationship cannot be established through another element but must be a direct one. Both the short term and long term effects and any unintended consequences have been considered (de Pinho 2015).

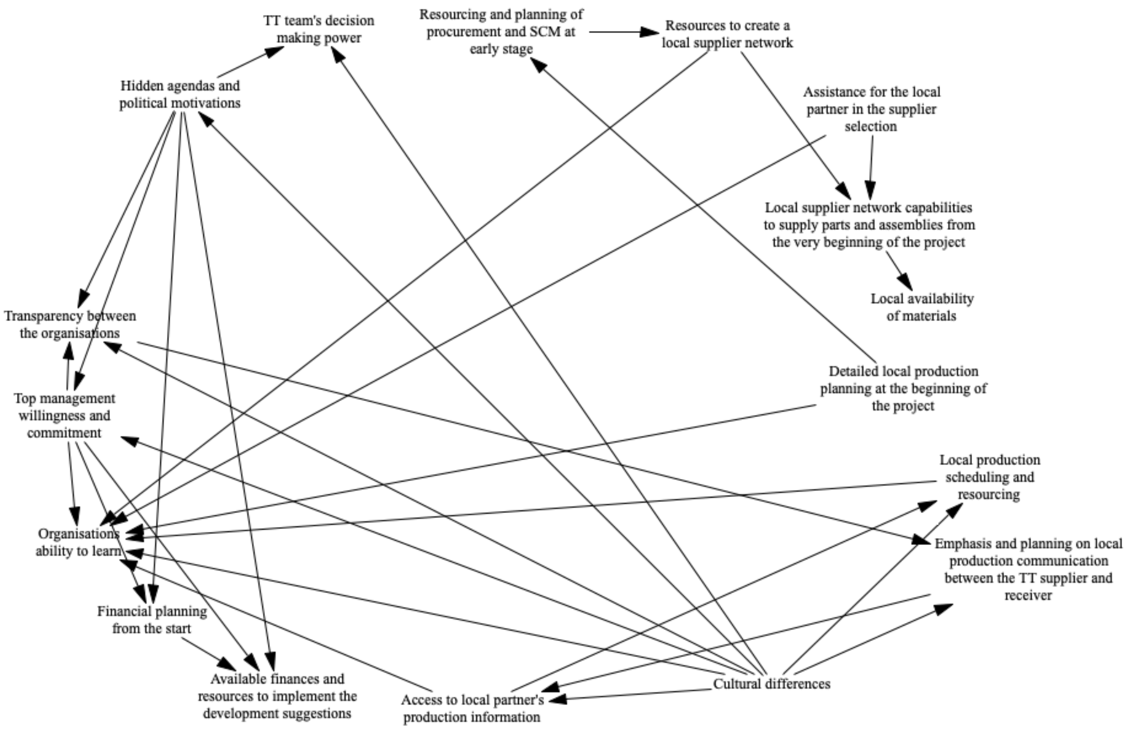

Figure 5.2: The TT inter-relationship diagram (IRD).

To conclude the diagram, the receiving organisation's ability to learn through TT is influenced by six elements: the top management's willingness and commitment to the contract and the related TT project, any possible previous experiences in TT, the overall corporate culture, cultural differences and the way of communication between the supplier and recipient organisations throughout the transfer. The top management's willingness and commitment naturally also impacts the operational TT team's level of authority given, the transparency of information between the organisations, and the financial resources made available for the project. On an operational level, everything is linked back to the quality of the initial local production planning.

Once all the possible relationships between the variables have been examined, the drivers and outcomes of the systems will be established by analysing the arrows (de Pinho 2015). As presented in Figure 5.3, the most outgoing arrows can be identified as the root causes or drivers, namely the top management willingness and commitment, cultural differences and the time and focus on detailed local production planning at the beginning of the project. The elements with the most incoming arrows are the key outcomes, namely the organisational ability with six (6) arrows, followed by several elements with two (2) ingoing arrows, namely the transparency between the organisations, TT team's decision making power, synchronising the schedules between the TT supplier and receiver, local production scheduling and resourcing, the local production communication, and the local supplier network capabilities to supply the parts and assemblies. These drivers and outcomes identified through the IRD align with the earlier reflective coding matrix results regarding the main factors of an efficient inter-organisational TT process. Firstly, the organisation needs to be open to cooperation and its goals to be aligned to facilitate learning. Secondly, a sound financial commitment understands that a successful TT requires long term investments and financial resources. Thirdly, cooperative supply chain strategies and collaborative product and process planning require building time, resources, and in-house capabilities. Fourth and lastly, the TT implementation success rate is directly linked to the quality of the initial planning phase.

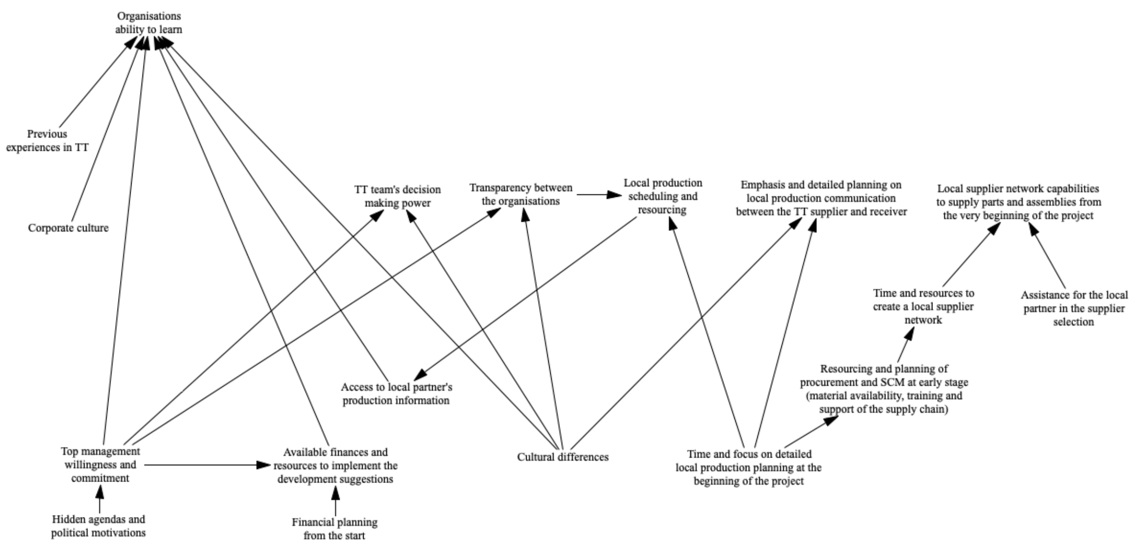

Figure 5.3: Identification of the divers and outcomes in the TT system.

Lastly, the IRD is transformed into a causal loop diagram (CLD) through an iterative process by exploring the dynamic relationships in the system. The objective is to establish a CLD that represents the complex reality without being overly complex nor too simple (de Pinho 2015). This transformation process must be mindful of the following considerations (Kim 1992): (i) CLD must be developed to address a particular issue that can be articulated in specific terms, (ii) there must be clearly defined boundaries set for the CLD model as the objective is not to try to illustrate the whole system but only a specific part impacting the set issue, and lastly, (iii) the level of intervention and sphere of influence through who are involved in the process to build out the model (Kim 1992).

The creation of a causal loop diagram presented in Figure 5.4 begins by using the IRD as a seed model: the primary outcome of interest is identified, and its main drivers of interest are selected. The variables linked to this outcome and drivers are added one by one (de Pinho 2015. In this case, the primary outcome of interest is the organisational ability to learn, driven by the management's willingness and commitment and the available finances and resources to implement the development suggestions. From this point forward, the model is built further by working between the IRD and the seed model, adding variables linked to the primary outcome and drivers (de Pinho 2015). Adding new variables that better explain the relationship between elements (de Pinho 2015). In this case study, a variable 'Government support' is added to reflect the environment better. In the end, the completed TT causal loop diagram illustrates different variables and how they are related to each other, representing the relationships between the key elements and their effect on the outcome of interest (de Pinho 2015). It is possible to identify four (4) sub-loops: (1) First formed by the recipient's internal elements: corporate culture - top management willingness and commitment - available finances and resources to implement the development suggestions - organisational ability to learn, (2) second formed by the local government factors: governmental support - hidden agendas and political motivation - top management willingness and commitment - available finances and resources to implement the development suggestions - organisations ability to learn, (3) thirdly the project-related elements, involving both the TT supplier and the local recipient, and (4) lastly from the time and focus on detailed local production planning at the beginning of the project to the resourcing and planning of procurement and SCM at an early stage of the project. It is important to note that the diagram's purpose is not to cover every detail of the system but to show the key elements of the feedback structure, leading to the observed pattern of behaviour (de Pinho 2015).

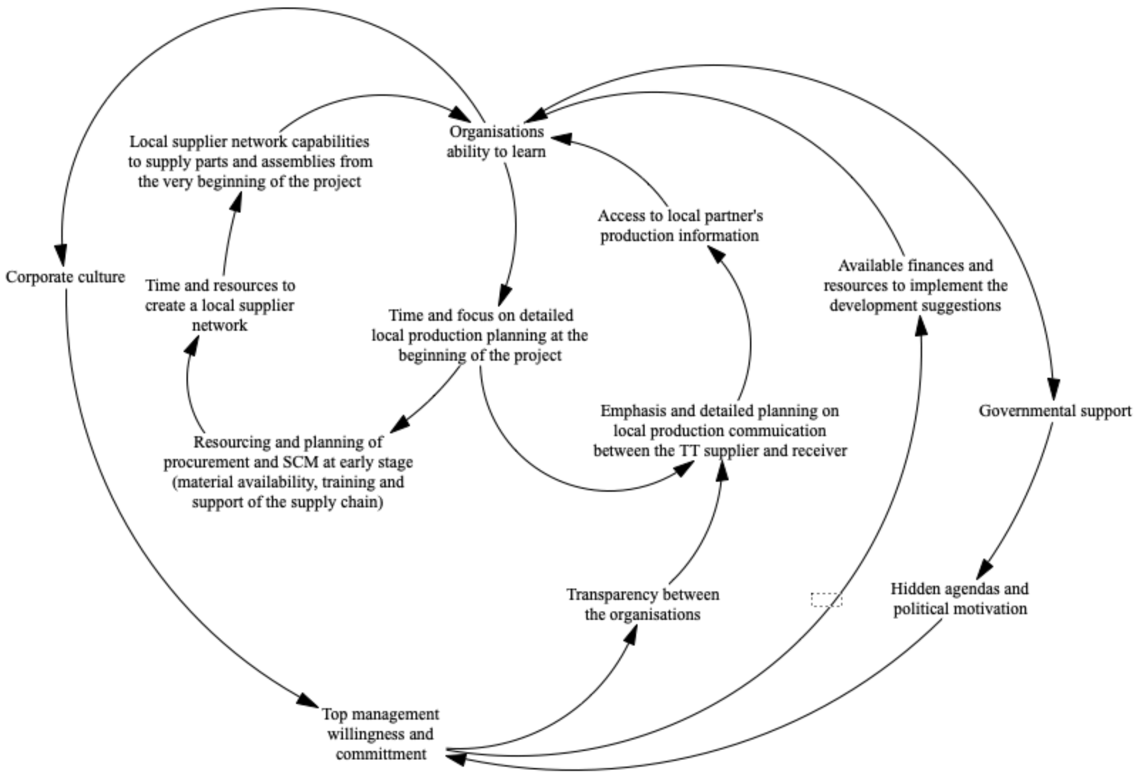

Figure 5.4: The TT causal loop diagram.

5.4.2. The Dynamic Hypothesis

The feedback loops are formed by variables linked circularly and can be identified as either reinforcing or balancing loops (de Pinho 2015). For reinforcing loops, all relationships are "+", or there is an even number of opposite "-" direction arrows, whereas for the balancing loops, there is an odd number of opposite "-" direction arrows irrespective of "+" arrows (de Pinho 2015). For this, the nature of the relationship between each pair of variables in the system must be assessed in terms of whether the arrows indicate a change in the same (i.e. increase "+") or opposite (i.e. decrease "-") direction (de Pinho 2015). Sometimes, it might be required to add an interim variable or indicate delays in the case of two mechanisms where one variable influences another, resulting in difficulty determining the nature of the relationship (de Pinho 2015). In a reinforcing loop, an action produces a result influencing more of the same action in terms of growth (i.e. virtuous cycles) or decline (i.e. vicious cycles) (de Pinho 2015). On the other hand, Balancing loops reduce the impact of a change, generating resistance and increasing stability (de Pinho 2015).

All the four (4) TT feedback loops identified and presented in Figure 5.5 are reinforcing:

- **Loop R1** from the corporate culture to the top management willingness and commitment to available finances and resources to implement the development suggestions to the organisation's ability to learn. Examining this in more detail, an assumption could be made that the top management's willingness and commitment increases the more the corporate culture emphasises and drives organisational learning and knowledge management as a strategic asset to the company. Consequently, there would be more finances and other resources made available due to the higher TT prioritisation, and hence the organisation's ability to learn would be improved.
- **Loop R2** from the government support to the hidden agendas and political motivations to top management willingness and commitment to the organisation's ability to learn. Examining this feedback loop in more detail, an assumption could be made that the level of government support directly correlates with the existing hidden agendas and the political motivations, having further negative impact on the top management's willingness and commitment towards optimising the organisational learning.
- **Loop R3** from the time and focus on detailed local production planning at the beginning of the project to emphasise detailed planning on local production communication between the TT supplier and receiver to access local partner's production information to the organisation's ability learn. Again, by examining this in more detail, an assumption could be made that an initial increased focus and effort would result in better communication and planning quality and more open access to the relevant production information, resulting in increased organisational learning.
- **Loop R4** from the time and focus on detailed local production planning at the beginning of the project to the resourcing and planning of procurement and SCM at an early stage (material availability, training and support of the supply chain) to the local supplier network capabilities to supply parts and assemblies from the very beginning of the project to the organisation's ability to learn. By examining this last feedback loop in

more detail, it can be assumed that the initial increased focus and effort would result in increased SCM resources (material availability, training and support of the supply chain), enabling increased time and resources to create a local supplier network. This would consequently increase local supplier network capabilities to supply parts and assemblies from the beginning of the project and enable better organisational learning.

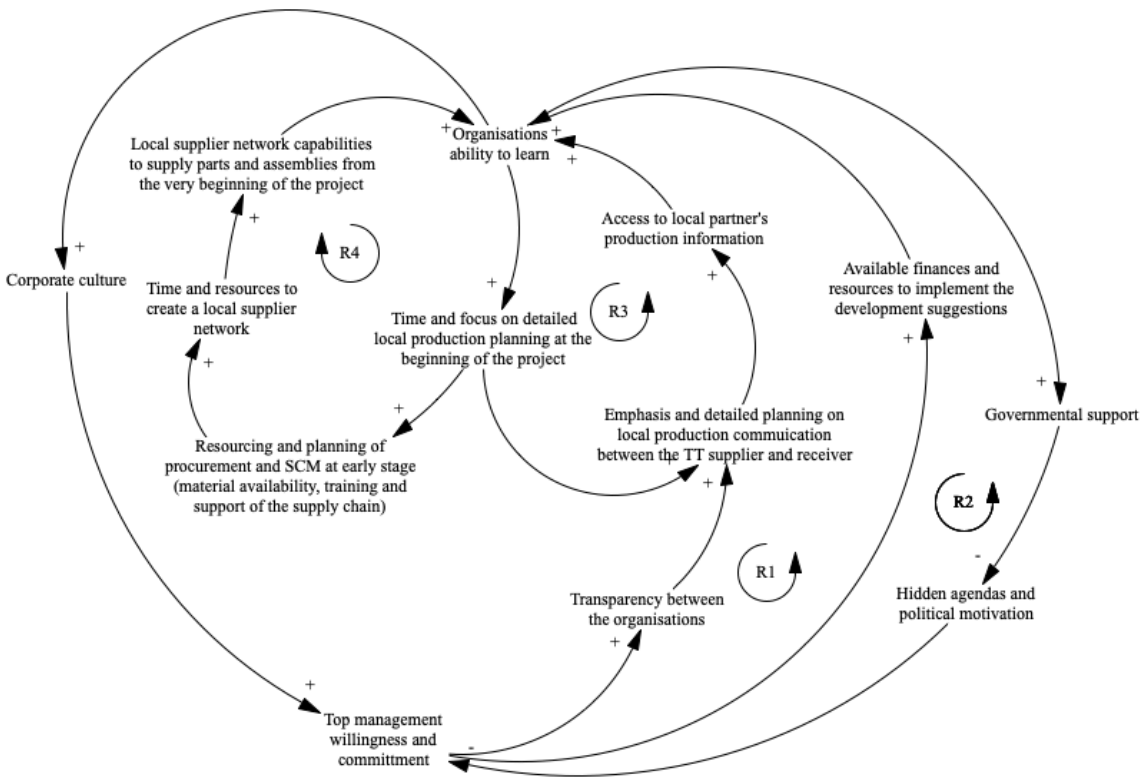

Figure 5.5: The feedback loops in the TT system.

5.4.3. The Behaviour of Model

Behaviour Over Time (BOT) graph, also known as the reference model, is an additional component to understand the TT system further. A BOT graph is a plot of variables illustrated on the y-axis over time on the x-axis (Calancie et al. 2018). In this study, the participants were asked to graph any and all key variables they considered important and capture the behaviour of the TT system over time. Typically building a BOT graph is a joint group modelling activity. However, due to the sensitivity of the topic and the requirement for participant anonymousity and the COVID-19 restrictions, the activity was conducted as an iterative process through individual interviews and discussions with each participant separately and by sharing the anonymous outputs with the other participants. After several iterative revision rounds, the BOT was considered completed when all participants finally received joint approval. A BOT graph is a tool to engage cross-functional and diverse organisational stakeholders to analyse and discuss complex system challenges and understand them from multiple perspectives, hence providing a holistic view of the phenomena under study (Calancie et al. 2018).

The typical data analysis tools for examining trends, interrelationships and system capability such as statistical methods are not applicable without an adequate dataset. On the other hand, it is seldom readily available for analysing a new problem or phenomenon (Kim 2010). The BOT graphs can break the data availability dilemma and assist in building causal theories and structures underlying the case before the actual access to any complex data (Kim 2010). Developing causal theories also reduces the risk of being limited to the data available (Kim 2010).

The study participants started working with their behaviour over time graphs by illustrating what is happening in a typical TT project in a local recipient company within a time horizon of five (5) years. This represents a conventional contractual TT timespan, bridging development to industrialisation, as illustrated in Figure 5.6. It is, however, typical that the defence projects exceed the set deadline due to various reasons, often two to three times over what is initially planned and agreed. This study nevertheless is based on the assumption of a standard five (5) years timespan.

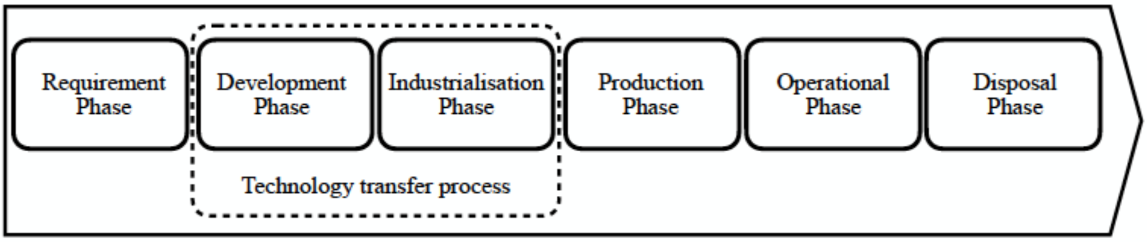

Figure 5.6: The main defence procurement project phases.

Through establishing the individual variables' behaviour, it is possible to examine the patterns of change over time. In the absence of exact project-related data and intending to draw out participants' mental perceptions of what factors are driving change, participants are encouraged to draw general trend lines (no change, increasing, decreasing, oscillation, etc.) of the variables over time as they understand them based on their experiences. The primary line graph shows the basic trend over time and assists in analysing how and why the trend occurs, especially where the pattern demonstrates unexpected behaviour (de Pinho 2015). The objective is for the behaviour over time (BOT) graphs to serve as a discussion and reflection point, inspiring hypotheses about what might determine the pattern over time (Calancie et al. 2018).

The project cost demonstrates a linear growth in Figure 5.7, where the local recipient's overheads are constant. On the opposite side, the milestone payables, i.e. payments, are linked to the project outputs that are scheduled deliverables. The initial planning is based on known overheads and a set schedule. The project would risk running uncontrollably out of money if any of these milestones were missed, resulting in slippage of overheads. Furthermore, if the timeline runs away, obsolescence becomes a problem as well. For example, if a stock item is purchased at the beginning of the project, this item must be resourced and re-designed back into the system due to obsolescence. It is notable that although we only examine the timespan over the development and industrialisation phase in this case, the project already starts occurring costs in the initial requirement phase. The most important factors to keep the TT project on schedule and costs under control identified are the detailed good quality initial planning and securing adequate resourcing throughout the project, resulting in efficient project execution without unnecessary resource-related delays.

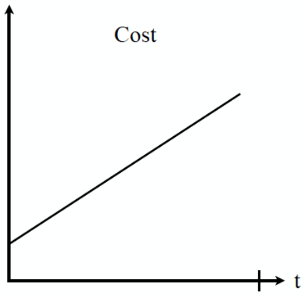

Figure 5.7: Project cost behaviour over time (BOT) graph.

The defence projects have higher profits embedded in the initial contract value with the understanding that the project time frame will typically be exceeded and that the project will face significant delays and issues during the execution due to its high technology, political and public procurement nature. The higher profit margin can be seen as contingency or risk cover included in the milestone payables. A typical defence project profit line is illustrated in Figure 5.8.

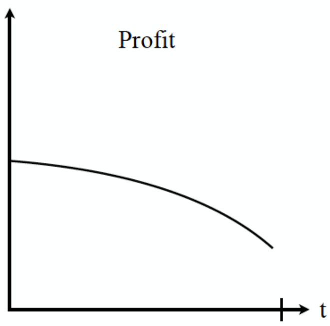

Figure 5.8: Project profit behaviour over time (BOT) graph.

The funds illustrated in Figure 5.9 are readily available from the beginning of the project, assuming that the funds exist and are allocated by the end customer, i.e. government. Throughout the contract period, the local partner's access to those funds is depended on their fulfilment of the milestones. In a case of slippage, the company would use these funds to cover its overheads. The basic assumption is that a defence procurement is a fixed term fixed cost contract. If the local partner does not use the contingency embedded in the contract, they can keep it and thus earn a higher profit. However, there are also typically penalty clauses written in the contract, such as coverage of the penalties regarding possible obsolescence during the project. The available finances are critical success factors, and the local recipient companies often struggle to secure adequate financial resources for the TT project.

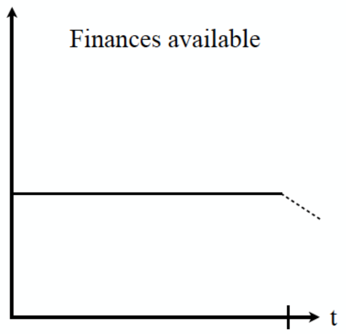

Figure 5.9: Project finances available behaviour over time (BOT) graph.

The number of people allocated for the project behaviour over time graph in Figure 5.10 demonstrates oscillation as the man-hours needed is not constant but differs for each milestone as the project progresses.

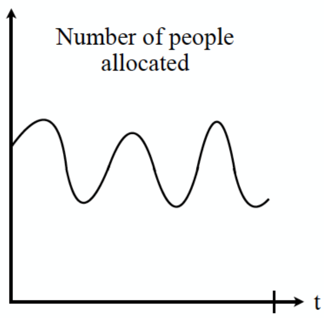

Figure 5.10: Number of people allocated to the project behaviour over time (BOT) graph.

Similarly, the number of TT specialised staff allocated to the project behaviour over time graph illustrated in Figure 5.11 demonstrates oscillation due to the same reasons as in the previous, as the man-hours needed is not constant but differs for each milestone the TT project progresses. At the beginning of the project, after signing the procurement contract and at the beginning of the development phase, the local production planning commences. After the planning has been finalised, there will be a gap in the operational TT activities as the development phase focuses mainly on the product and systems designing. The product design determines specifications and requirements for the overall production and supply chain set-up. The TT activities ramp up again as the project closes to the industrialisation phase.

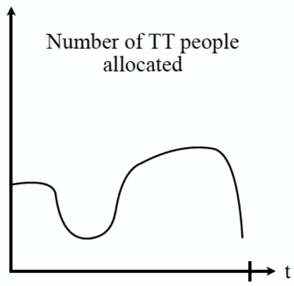

Figure 5.11: Number of TT people allocated to the project behaviour over time (BOT) graph.

The top management commitment to the project, as presented in Figure 5.12, is at its highest actually during the marketing, offer negotiations and contract signing, of which all take place before the actual operational activities. The management's focus and primary interest lie in securing the contract, after which the focus typically shifts to a new marketing project. The management might occasionally be involved in higher-level progress meetings, contract revision negotiations and/or problem/conflict solving requiring higher authority. Otherwise, the top management is not actively present in the operational activities. This is distinctive for the defence industry public procurement due to various reasons. The public defence procurement objectives range from social, economic, to financial objectives setting high barriers for possible cancellation of the contract, regardless of any performance issues. Also, the local producer options are limited, where the foreign suppliers are faced with one (1) to three (3) local options to partner with. Often the end customer, i.e. government, directly require collaboration with a certain specific local entity. As a result, the government is deeply committed to working with the preferred local participant once the contract has been awarded. The top management attention is naturally derived from the maintenance and the performance of the already existing contract rather than securing new projects. It is also notable that the defence industry contracts are lengthy, spanning tens of years. Typically, the top management involved in establishing the contract often is not in the house when the industrialisation of production starts. Top management individual performance awards are also often linked to the contracting rather than the operational performance. All this naturally shifts the focus and reduces the commitment behaviour over time.

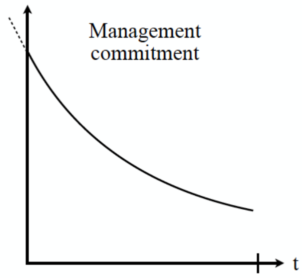

Figure 5.12: Management commitment to the project behaviour over time (BOT) graph.

The time and resources on planning supply chain management reflect s-shaped growth over time, as illustrated in Figure 5.13. Based on the typical scenario, the basic assumption is that the local partner's procurement department is adequately staffed and has standard skills and competencies. All the time and resources allocated for the SCM are ramped up to a point after which they will remain at the same level due to the local partner being the main contractor supplying the end client with spares throughout the product life cycle. It is important to note that the procurement performance assessment is typically based on the traditional view on how much the individual can save on a purchase. This drives the available funds towards bulk buying with bulk discounts, causing a possible later obsolesce risk. The defect procurement is still based on a traditional transaction-based approach rather than striving actively towards supply chain excellence and operations throughout the supply system.

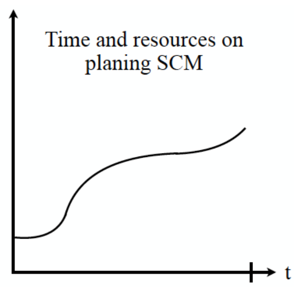

Figure 5.13: Project time and resources planning on the supply chain management (SCM) behaviour over time (BOT) graph.

The government policies typically force towards multi-sourcing with every procurement instance. Furthermore, the local partners do not typically represent the most modern supply approaches but are rather traditional. This results in a low drive towards building supplier network capabilities and partnerships. The potential supplier quoted against a data pack with very little support, resulting in minimal time and resources spent on building the local supplier network, as illustrated in Figure 5.14.

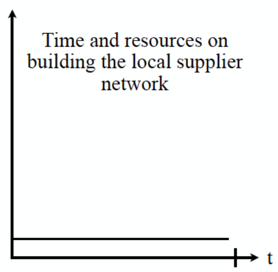

Figure 5.14: Project time and resources on building the local supplier network behaviour over time (BOT) graph.

The local production planning mainly involves the production and procurement functions. Figure 5.15 demonstrates how the local production planning takes place at the beginning of the project, right after signing the procurement contract and at the beginning of the development phase. After the planning has been finalised, there is very few, if any, revisions done.

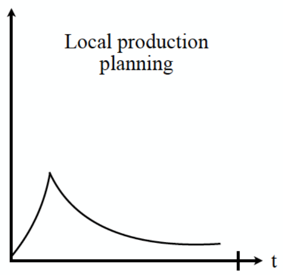

Figure 5.15: Project local production planning behaviour over time (BOT) graph.

The limited TT resources involved in the skills development focus on different functions and areas of operations, demonstrating an oscillation behaviour over time as presented in Figure 5.16. Ideally, the training should take only place in close proximity as the systems mature and are ready for industrialisation and start of the production to prevent any possible issues caused by the change of people and change of specifications that naturally occur over a more extended period.

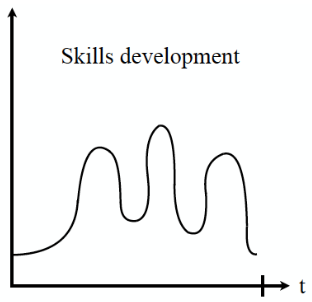

Figure 5.16: Project skills development behaviour over time (BOT) graph.

The communication trend also follows the oscillation pattern, as illustrated in Figure 5.17. Similarly to the previous skills development BOT graph, although the teams are set, the people within them tend to change over time, new priorities occur.

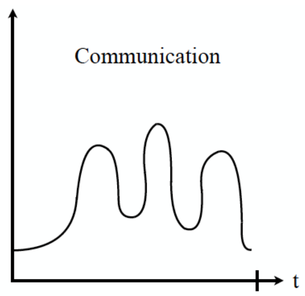

Figure 5.17: Project communication behaviour over time (BOT) graph.

The transparency between the foreign supplier and the local recipient is set at the beginning of the project, typically remaining at the same level throughout the rest of the project, as illustrated in Figure 5.18. The typical factors affecting the level of transparency in a TT project are culture, management decisions, operations and product-related confidentiality requirements and contracts, the overall trust between the different organisations and the participating organisations' role and location in the competing global defence industrial supply networks.

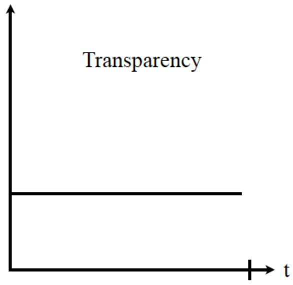

Figure 5.18: Project transparency behaviour over time (BOT) graph.

The skills development typically only involves the competencies related to the creation and production of the contractual product and excludes other local recipients' day-to-day operations and activities. Figure 5.19 illustrates how skills development does not start right in the beginning but only after finalising the local production planning and closer to the beginning of the development phase. The skills development takes place gradually in phases that are typically linked to the production sub-processes. The local recipient's performance is verified at the end of each phase, and hence the overall contract product-related performance gradually improves following the development phases. Although this BOT graph does not reflect improvement in the overall skills, it could be stated that there is probably a positive ripple effect to this dimension.

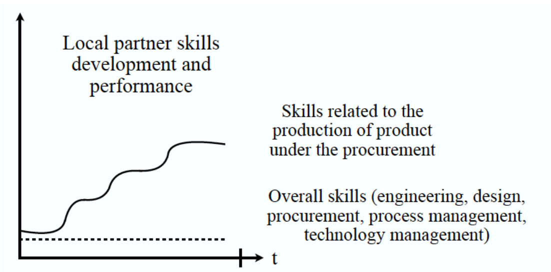

Figure 5.19: Local partner skills development and performance behaviour over time (BOT) graph.

When the individual modes of dynamic behaviours are studied as a whole, the management commitment and the building of the local supplier network arise as possible problem areas. The management commitment does not carry over the TT project, and the trend indicates no systematic approach and support to build the local supplier network. Also, although supply chain management seemingly has a positive growth trend, development can be identified when reflecting the activities and the general approach in more detail. It appears that the management does not identify or understand the value in the knowledge received through TT. It could be concluded that the management is not able the grasp the full potential of the attainable new knowledge as the TT is only seen short term benefit as an isolated specific project and/or product-related activity and not as an attainable increased overall competence development activity striving towards increased competitivity in the long term. For example, the local recipient's research and development department is rarely involved in the TT project. The new knowledge could establish a pathway to be utilised more broadly in the recipient organisation, outside the TT project scope.

Previously in Phase 2 in this study, the management, the financial resources and planning, the supply chain management and the local production planning were identified as the four main critical success areas resulting from the Straussian coding process. The emerging problem areas based on the behaviour over time analysis are lining with these critical success areas. As mentioned above, it is typical that the defence programmes and projects exceed their initial time frame and experience significant delays and issues throughout the project life cycle. The management focuses almost solely on marketing and securing the contracts, and the top executives are rarely present in operational activities or monitoring the TT performance. The local recipient, however, often struggle to secure and allocate adequate financial resource for the TT. Hence it could be argued that the role of the TT is not acknowledged nor understood as strategic and significantly value-adding, rather than just seen as an ordinary support activity. The supply chain management activities, on the other hand, focus solely on cost savings and provide minimal resources for the building and development of the supplier network. The procurement is seen to have a transaction-based approach rather than it would focus on the supply chain excellence development. Lastly, the local production planning is a once-off exercise done at the beginning of the project. The local recipient would utilise it as an active management tool that could maximise the knowledge transfer.

The consolidation of dynamics of multiple individual variables assists participants further to hypothesise mechanistic explanations for the behaviour, to develop measures and a principal impact approach (Calancie et al. 2018). A consolidated behaviour over time graph is generated based on the analysis, as seen in Figure 5.20. The consolidated graph provides a possibility to understand better the key elements affecting the successfulness of the TT process and the possible mechanisms and correlations affecting the local partner's skills and performance development. To begin to understand why the local partner's overall skills were not increasing and the overall performance was not significantly changing even as the product-related skills were increasing, the participants were asked to hypothesise about the relationship between the management commitment and the available finances as well as the relationship between the planning of supply chain management and the local supplier network building to the local partner's overall performance.

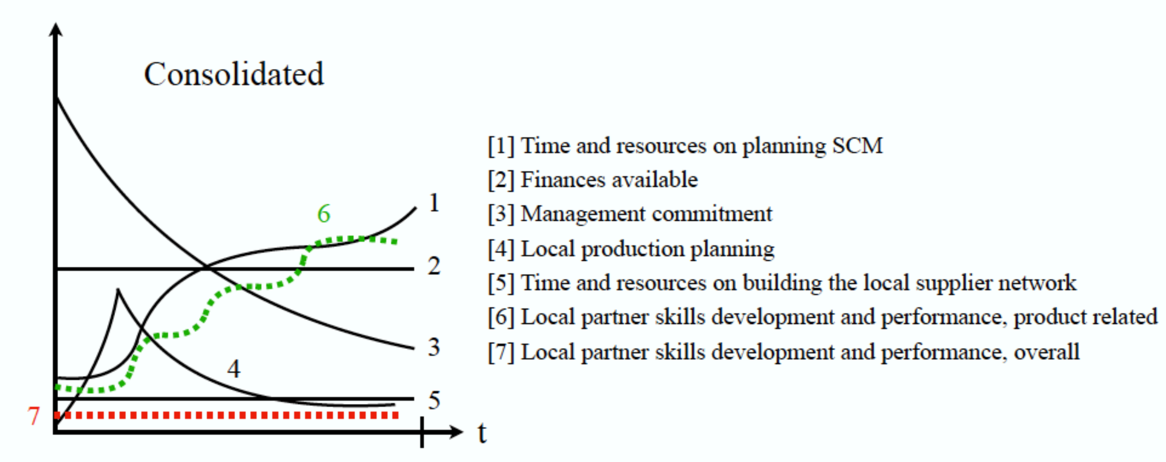

Figure 5.20: Consolidated behaviour over time (BOT) graph.

The current situation and business as usual scenario reflect a hypothesis where it seems that the management short-sighted does not identify or understand the strategic role of the TT in long terms capability and competitively development but instead treats it as an isolated project activity as discussed above. In the second hypothesis, the management would understand the strategic value of the knowledge. This could be driven either by the management themselves from commercial perspectives, or it could be driven by a government based policy related to the defence procurement, or both enforcing each other. (1) Firstly, in this scenario, management would not only be interested in securing the contract alone but also involved in the monitoring and management of the TT project outputs in the long term, such as how the research and development would apply the new knowledge in the broader product portfolio, and extend it to further possible other process and operational applications, new supply chain relationships and new supply chain management application in terms of increased integration, quality, reliability related to the management of the supplier network, and establishment of possible new global supplier relationships and replacement of the existing once. The management needs to actively drive and oversee these objectives, secure adequate resourcing and planning from the beginning. (2) Secondly, the governmental end customer perspective should emphasise the long-term benefits and attainable border benefits to focus on competitiveness development rather than just isolated product capabilities. (3) Thirdly, the lower the supplier network level, the more focused the relationship on integrating the product into the primary system. They are, however, highly motivated to deepen the relationship between the local main (i.e. the local recipient) and open to any possibilities to expand their market possibilities as the supplier network typically constitutes of private SMEs and hence compete solely on a commercial basis. Through the deeper relationship and with the objective of long-term efficient knowledge transfer, the local recipient could engage not just with the foreign supplier but also better access and utilise the existing supplier network and its technologies and research and development capabilities in their respective niche areas.

To conclude, according to Calancie et al. (2018), the BOT graphs are an excellent discussion tool that can develop a deeper understanding of a complex problem by sharing and reflecting different perspectives and through diagnosing a shared problem. The different stakeholders may voice their interactions within a system, leading to a more holistic view. Hence, this systems thinking approach enables holistic thinking rather than reducing an issue into a limited set of variables. This may assist the defence industry TT specialists to understand, describe and intervene within their complex system to address their respective industry challenges. The limitation of a defence industry sector may be that it does not fully allow the development of free creative thinking to address the issue due to the political nature and paradigm around the industry. However, the BOT graph activities could assist different stakeholders in understanding better and communicating how various evidence-based strategies could influence the defence industry TT process and its intended outcomes. As a result, it is possible to present effective interventions and new strategies (Calancie et al. 2018).

5.4.4. The Leverage Points

Leverage points are locations within a complex system where an intervention can be applied to produce a change (Anghelouiu & Tennant 2020, Birney 2021, de Pinho 2015, Ylén & Hölttä 2003, Sterman 2003, Meadows 1999). In the system analysis, the causal feedback diagrams are utilised to identify these 'power points' (Birney 2021, de Pinho 2015, Meadows 1999). Following Meadows (1999), as illustrated in Figure 5.21, the system's state is that system stock is essential. These system states can be based on both tangible or intangible stocks increased by the inflows and decreased by the outflows. The negative feedback loops, or correcting loops where one controls the inflow and one the outflow, causes the flows to change. It is important to note that the goal and the feedback connections are not visible in the system (Meadows 1999).

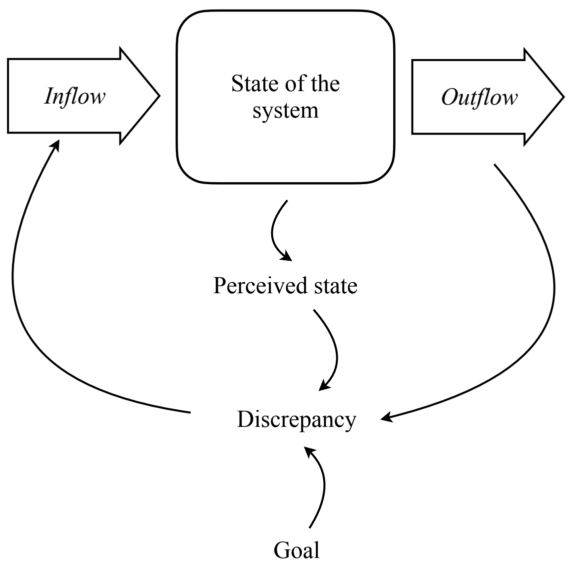

Figure 5.21: The state of the system diagram (Meadows 1999).

Meadows (1999) emphasises that a simple isolated stock and flow figure is relatively easy to establish and understand. However, when many simple individual systems are connected, it is often too complex to comprehend cause and effect relationships. Consequently, the system leverage points should not be based on intuition. However, people often know the leverage points intuitively but counterintuitively use them backwards, systematically worsening the problem. Alternatively, the parameter adjustments implemented to the feedback loops are not significant enough to create any impact (Meadows 1999). Based on rigorous analysis Meadows (1999) has identified twelve (12) most common places to intervene and, as a result, to cause a change in a system, presented in decreasing order of effectiveness in Table 5.2 (Meadow 1999).

Table 5.2: Places to intervene in a system (Meadows 1999).

	Points of Intervene [in decreasing order of effectiveness]	**TT Perspective**
	Mind Set Leverage (hierarchy levels 1-2)	
1.	**The power of transcend paradigms** *Being unattached to any paradigm, accepting a limited understanding, 'not knowing', no certainty in any view*	No certainty in anything
2.	**System paradigm** *The mindset or social paradigm out of which the system arises*	The common view of the world and the general consensus of the rules
	The Information and Control Leverage (hierarchy levels 3-8)	
3.	**System goals** *The goals of the entire system*	Political goals
4.	**Ability to self organise** *The power to add, change, evolve, or self organise system structure*	The ability to organisational learning
5.	**The rules of the system** *The rules of the system (such as incentives, punishments, constraints) define the scope, boundaries and the degree of freedom*	National offset policy, local production regulations, public procurement guidelines and regulations, related defence alliances
6.	**The structure of information flows** *The structure of information flows, who does and does not have access to what kinds of information and feedback*	Reporting frequency and quality, access to the information,
7.	**Positive feedback loops** *The source of growth around driving self-reinforcing positive feedback loops*	Technology access to the markets, technological adaptation
8.	**Negative feedback loops** *The strength of a self-correcting negative feedback loops, relative to the impacts they are trying to correct against, detecting excursions from the goal*	Quality control, assessment points
	The Physical Leverage (hierarchy levels 9-12)	

9.	**Delays** *The lengths of delays, relative to the rate of system change*	Access to information, learning curve and time
10.	**Structure** *The structure of stocks and flows and their physical arrangement*	TT process, operations, activities
11.	**Buffers** *The sizes of buffers and other stabilising stocks, relative to their flows*	Government subsidy or national procurement programmes to support the local production
12.	**Constants, parameters** *Numbers determining the discrepancy such as subsidies, taxes, standards.*	Cost and value of TT, job creation, quality standards required, IP rights, number of people involved, budget, overall local production policy

After establishing behaviour over time graphs, the participants were requested to reflect possible TT leverage points. Again, this would typically be a joint group activity. However, due to the sensitivity of the topic and the requirement for participant anonymousity and the COVID-19 restrictions, the activity was conducted as an iterative process through individual interviews and discussions with each participant separately and by sharing the anonymous outputs with the other participants. The outcome was considered completed when a joint approval was received from all the participants after several iterative revision rounds.

The Mind Set Leverage (hierarchy levels 1-2)

According to de Pinho (2015) and Meadows (1999), this leverage seeks to change the mindset or paradigm out of which the system arises. To affect this change requires challenging the assumptions about how things are, how the world is commonly viewed and exposing the anomalies and failures of the old paradigm. This comprehensive view will highlight a need for a fundamental shift in the behaviours driving the system. Strategies and interventions to shift paradigms include working with active change agents and inserting people with new paradigm mindsets in place of public visibility and power. Challenging social, economic and political norms and re-examining core values represent leverage at the highest level, resulting in the most significant change potential but will also face the most resistance from the existing system. When examining the system paradigm, a society shares a common idea of the common rules and level of acceptance. In other words, the great deep level of understanding anchored to the beliefs about how the world works is anchored to all common frameworks, doings, and activities in that society. These paradigms are the primary sources of any system reflecting the social agreements about the nature of the reality and directly linking how the system works (de Pinho 2015, Meadows 1999).

Defence TT is a highly complex, politically charged and sensitive military activity. The TT has become a competitive argument to support and develop the national defence industrial base and capabilities. Furthermore, the TT activities encompass a large spectrum of sectors and different procurement activities, taking the form of either tangible or intangible movement of know-how, knowledge or technical capabilities. Hence, even reaching an international consensus on what constitutes TT has proven to be impossible. With an increasing number of defence contracts, especially in emerging countries, governments attach TT requirements to the trade conditions under various forms such as development cooperation and joint ventures, creating access to new technical knowledge. An all-encompassing approach would cover all the technical and industrial steps required for creating a defence system from the development to the use, including scientific research and development and any industrial cooperation and related agreements. Despite the strategic national importance, the TT activities rarely result in real access to critical technologies or benefiting from the perceived degree of capacity and industrial potential due to their limited project scope and the recipient industry's degree of technological maturity. In all, to reflect the defence TT paradigm, it would be necessary to address the questions (i) why does the defence policy look the way it does, and on the other hand (ii) how this policy is related to the military and industrial capability? With an understanding of the policy and its link to the capabilities building. The traditional aim of defence policy is anchored on the effectiveness of a military mission in a crisis.

The mental framework of governmental policymakers drives international relations and defence policies. Traditionally the national power still has been linked to its military capacity and ability to engage in effective warfare, although there has been a steady decline of interstate warfare globally. At the level of international relations, war is no longer necessarily seen as an effective means to resolve political problems. Instead, there has been a growing increase of commercially based industrial battlefields where the military industries build capabilities and position themselves to survive in a global competition. Each nation's attitude towards warfare within its specific cultural context is reflected and expressed in its policy.

The national defence policy is directly linked to the logic that connects the state's security paradigm to its defence capabilities. As a result, the current globally applied defence procurement paradigm approach involves extensive TT elements mainly based on building the strategic military capabilities under the contract scope and less on broader commercial endeavours. The political decision-makers emphasise the importance of job creation and the value of the TT contract to the receiving local recipient. In other words, the policymakers derive the primary objective of defence TT from socio-political objectives rather than commercial aspirations. However, the changing global defence industrial environment provides reasons to re-examine this approach to build more sustainable and agile privately and fully commercially operating deference industry actors rather than subsidising the existing public or semi-public industry infrastructure. The development of national military capabilities is still very relevant. However, as the way of warfare is inevitably changing, it could be discussed if it is necessary to have fixed industrial infrastructure at a place at any cost nationally or could there be other ways to approach this strategic logistical support, such as belonging into a broader defence alliance network interdependent of each actor. This kind of policy approach may be equally secure while having attached considerably less limited national financial assets to maintain the national defence industry infrastructure.

It could be argued that paradigms are more complex to change than anything else about the system (Meadows 1999). This is especially hard with such an emotionally charged area as national security and defence contract values exceeding billions of taxpayers‘ money. According to the system thinking, you could, however, change the paradigm providing there is a way to see outside the system and force to see it as a whole, with its issues and anomalies (Meadows 1999). In order to emphasise more sustainable commercial objectives as part of the TT, it would be imperative that the current general failures be brought to a broad public discussion where active change agents with visibility and power should be involved. However, to conclude, it all comes down to the national objectives - is TT there to support the military strategy or further build the broader organisational capabilities? The hidden political goals are often not openly communicated in terms of what is publicly communicated often may be different from what the system then does.

The Information and Control Leverage (hierarchy levels 3-8)

de Pinho (2015) and Meadows (1999) further discuss the information and control leverage that recognises that systems can be stabilised and destabilised by the rate of change and information flows. Interventions at this level focus on reducing delays, optimising information flows, and managing relationships between feedback loops, creating new loops and connecting different system elements to speed up information flows. A complex system usually has numerous negative feedback loops to self-correct under different conditions and impacts. By understanding the ultimate goal of the whole system, it is possible to assess and understand how the overall system functions to conform to that goal. In all, intervening to shift the overall goal would affect change throughout the system. Most of the negative feedback loops within systems have their own goals that are critical leverage points for the subsystems. The strength of the negative loop, on the one hand, depends on its ability to keep its system stock at or near the set goal and the correctness of the response, and on the other hand, is relative to the impact it is designed to correct. Where a negative feedback loop is self-correcting, a positive feedback loop is self-reinforcing and a source of growth, explosion, erosion and collapse in systems. Reducing the benefits of a positive loop in slowing the growth usually holds more powerful leverage than strengthening negative loops in systems (de Pinho 2015, Meadows 1999). Meadows (1999), however, highlights the fact that humans have a profound tendency to avoid accountability, resulting in why so many of such feedback loops are missing. Missing feedback is one of the most common causes of system malfunction. Adding or restoring information can be a powerful intervention, usually much easier and cheaper than rebuilding physical infrastructure (Meadows 1999).

A system that can evolve and self-organise sustains the most potent form of system resilience (Birney 2021, Sterman 2003, Hölttä & Ylén 2005, Meadows 1999). Managers and economists alike often emphasise technology and disregard the power of self-organisation due to the more tangible, concrete nature of the former and the more intangible, abstract nature of the latter (Meadows 1999). However, complex patterns can evolve from simple algorithms, as hundreds of self-organising computer models have demonstrated. That does not mean that the real-world algorithms are simple but can be (Meadows 1999). In principle, as Meadows (1999) stated, self-organisation is just experimenting, selecting, and testing new possible patterns with a highly variable stock of information. For technology, this involves the knowledge people and organisation have accumulated. The source of variety is based on creativity, and the organisational selection mechanisms reward whatever meets the immediate need or a problem. Any insistence on a single culture and limiting experimentation prevents learning. Consequently, such a system cannot self evolve and innovate (Meadows 1999).

The system's rules are high-level leverage points that define the system scope, boundaries and the degree of freedom (Birney 2021, Sterman 2003, Hölttä & Ylén 2005, Meadows 1999). In all, the deepest malfunctions are embedded in the system rules, and the people have power over them (Meadows 1999). The power overrules a high leverage point. Hence, the local industry actors are actively lobbying the politicians setting these rules over the defence procurement, the related defence industrial participation policies and TT. There could be said that there is a fundamental issue with a system with rules designed by these industrial actors for the benefit of the same organisations. Most of these lobby meetings are typically closed to the public resulting in no information flow or feedback. These kinds of rules tend to lack any feedback from any other sector or even from society as a whole. For example, there is no feedback from the broader local supplier network or analysis of the recipient's ability to utilise the received technology and knowledge. Systems such as this tend to generate vast accumulations of power and centralised planning systems that, according to Meadows (1999), will end up destroying themselves for systemic reasons where the positive loops weaken the other safeguards in order to attract appropriate traditional investment and trade in their endeavour to shield themselves from uncertainty. It could be concluded that this has become the current state of many national defence industries globally that are on the verge of collapsing. These companies by default restrict their source of development potential by choosing the strategy of relying on governmental support.

A positive feedback loop is self-enforcing and, as such, a source of growth, or a collapse as a system with an unchecked positive loop will eventually destroy itself. Usually, a negative, self-correcting loop will engage in at some point (Birney 2021, Sterman 2003, Hölttä & Ylén 2005, Ylén & Hölttä 2004, Meadows 1999). Meadows (1999) argues that these leverage points can also be used by slowing them down where for example, the access and adaptation of new technology or to new markets has more time to adapt and function resulting in building competency, knowledge base and participation to the global networks (Meadows 1999).

In addition to the positive feedback loops, there are negative feedback loops ubiquitous in all systems, detecting excursions from the system goal together with a mechanism of responding (Birney 2021, Sterman 2003, Hölttä & Ylén 2005, Meadows 1999). The purpose of the negative feedback loops is for the system to self-correct under different conditions, and these loops may not be evident and inactive most of the time (Meadows 1999). However, their presence is critical for the long term system welfare, although they are not used often and are typically expensive to maintain (Meadows 1999). From the TT perspective, the typical negative loops are related to the production quality control and assessment points but the broader learning and innovation related control points are missing. The research focus groups suggest that in addition to focusing on the TT value, there should be an emphasis on the output value. In general, the governments and organisations are solely attracted to the price leverage point, causing them to push in the wrong direction with the related industrial participation subsidies and regulations. This results in the weakening of the feedback signal by twisting the system information favouring politicians and decision-makers. The real leverage would be greater transparency and the removal of national subsidies that distort the playing field.

Meadows (1999) suggests that perhaps delivering new information about the system would cause a behaviour change (Meadows 1999). According to the research participants, to support more efficient knowledge management and sustainable organisational learning, it would be essential to regularly report how the TT inputs have been used and what kind of outputs have been created. Currently, the reporting is solely focused on the value of the TT (i.e. an estimate of value received) and the job creation (i.e. the estimated numbers of jobs created during the local participation) of which do not provide a reliable reflection of actual knowledge transfer outputs. The TT value and the job creation are not entirely reliable and easily verifiable but instead based on inflated estimates for keeping the public, i.e. the taxpayers, happy.

The Physical Leverage (hierarchy levels 9-12)

As the name indicates, the physical leverage elements primarily focus on changing inputs and physical structures (de Pinho 2015, Sterman 2003). Most interventions are spent focusing on these elements. However, the physical leverage points have the lowest impact, and they are often most proximal to the outcome of interest (de Pinho 2015, Sterman 2003).

Meadows (1999) emphasises the system delays as an area of high importance and focus, although they might not be easily changeable. Delays in feedback loops commonly cause oscillation due to the inability to accurately respond with inadequate information or if the overall response is not timely in the first place. On the other hand, the delay may represent the time between introducing new technology and the broader applications (Meadows 1999). From the TT planning and implementation perspective, the local recipient typically restricts or slows down the access to the relevant information preventing an efficient TT execution. These delays are critical, causing oscillations in the TT teams response, and in the worst case, they cause chaos. However, overlong delays are not typical that would cause passing over an irreversible point of damage with a danger of collapse or extreme overshoot. It was nevertheless acknowledged that not all delays are avoidable due to the highly complex technological environment and bureaucracy related to the public procurements and decision making. However, in all, it is agreed that improving the information delays related to the TT between the supplier and the local recipient potentially may have a high effect providing the change takes place in the right direction. On the other hand, it would be essential to ensure that the local recipient has adequate learning time. Hence, there might be leverage in lengthening the time to learn instead of forcing the process to operate more efficiently.

The structure involving the stocks and flows and the overall arrangement significantly affects how the system operates (Birney 2021, Ylén & Hölttä 2004, Sterman 2003, Meadows 1999). It is a crucial system but rarely a leverage point when operational (Meadows 1999). Establishing a proper design in the first place is a leverage point (Meadows 1999). Once the structure is built, the leverage is more related to understanding the limitations, restrictions and retaining from fluctuations or expansions that strain the structural capacity (Meadows 1999). However, from a TT perspective, the stock and flow structure, in terms of the TT process, are often just unchangeable in terms of the operations and activities, planning and resourcing.

According to Meadows (1999), you can often stabilise a system through the use of a buffer. However, oversized buffers often result in an inflexible system that reacts slowly and is expensive to maintain (Meadows 1999). This would reflect government subsidies and targeted national procurement programmes to support local production from the TT perspective. As a result, this artificially created security reduces the industry ability to respond to the commercial market needs.

Lastly, the parameters determine how much discrepancy there is in the system (Birney 2021, Ylén & Hölttä 2004, Sterman 2003, Meadows 1999). The parameters are typically the most popular intervention points where approximately 90% of attention is managing them (Meadows 1999). Despite this, they also have the least leverage (Streman 2003, Meadows 1999). As Meadows (1999) emphasises, parameters are essential, and people care deeply about them. However, they rarely can change system behaviour unless they can initiate a change in a leverage point higher in the hierarchy (Meadows 1999). The TT process considers physically locked numbers such as the job creation and the overall value of TT as popular intervention points that are closely monitored and publicly communicated. The public is deeply interested in these aspects, and the defence contract negotiations fiercely focus on these. However, they do not impact the efficiency of the TT and the sustainable organisational learning point of view. Due to the overemphasised focus on the set parameters, the system has stagnated where any parameter changes cause any effect. In all, the research participants shared a unanimous view that the logic of the local production policy forcing to spend more on TT or/and local production does not directly result in improved competence if the parameters are not monitoring the correct outputs. That said, it is also understood that there is a possible political purpose why the TT parameters are designed to stay away from the critical areas, falling back to the paradigm of the defence policy in general.

To conclude, the participants suggest that to support more sustainable knowledge transfer and organisational learning from the commercial perspective, the industrial participation focus point should be adjusted from the foreign supplier activities to the local recipient activities, i.e. how the information is received and utilised. It is also imperative to acknowledge that the TT requires time to accumulate the recipient's technology and knowledge stocks. Looking at the TT process from a typical operational management point of view, emphasising efficiency and speed might be the wrong approach. The TT system is cracked to move the process in the wrong direction, and the control measures are more weak negative loops.

5.4.5. The Simulation Model Formulation

Next, each system and its interrelating and interconnected elements are analysed in more detail to generate a distinct behaviour, i.e. systems' dynamic, over time. This enhanced understanding of the system is illustrated through *stock and flow diagram*. Unlike the causal loop diagram, the stock and flow diagram differentiates between the parts of the system and provides further details about the different elements of the system (Aranson and Angelakis 2018). This process forces to analyse each variable to determine their units of measure, analyse the relationships between different variables to ensure the units combine correctly and discover all still possibly overlooked variables necessary for the overall diagram match (Aranson and Angelakis 2018). *Stocks* and *flows* are the fundamental language of system dynamics modelling. The stock and flow diagram enables building a computerised system under study and experimenting with different policies (Aranson and Angelakis 2018). In this model, stocks can accumulate or be depleted and are measured at one specific time.

The symbols for the stock and flow diagram are presented in Figure 5.22. It is important to note that flows are the only variables that can change the stocks and that there must be a unit consistency between a stock and the flows that affect it (Aranson and Angelakis 2018). In contrast, the flows are entities that make the stock increase or decrease and are measured over an interval of time (Aranson and Angelakis 2018).

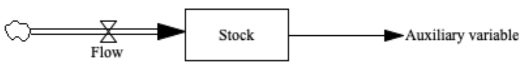

Figure 5.22: The stock and flow symbols.

The conversion from the causal loop diagram to a stock and flow diagram follows the Aranson and Agnelakis (1999) approach is presented in Figure 5.23. The units of all causal loop diagram variables in terms of stock and flow and their respective units are specified. During this process, also any additional variables can be added that are identified as missing. In all loops from R1 to R4, additional flow items were added, some overlapping, i.e. same flow items appearing in multiple loops. In loop R1, the available finances and resources to implement the development suggestion were added with both an in and outflow item regarding the allocated resources (people and finances) and the development activities turnover. In the loops R2, R3 and R4, the organisation's ability to learn was added with both an in and outflow item in terms of the local production problems and delays and the organisation's performance and innovation output. In loop R3, a new stock item in terms of the local production and an outflow item in terms of the efficiency and performance of the local production was added. Lastly, in loop R4, a new outflow item in terms of the efficiency and performance of supply was also added. The purpose of these variables added is to clarify and complete the model and its overall function. After all the stock and flow variables have been identified and linked, the remaining auxiliary variables are added. These auxiliary variables can be two (2) types: variables whose values do not change, i.e. constants, or variables representing calculations based on the stocks and flows. Lastly, the equations are specified for each variable, enabling the calculation of the value of a given variable providing its initial value. The value of other variables in the diagram is known. In all, the conversion process is iterative, often involving multiple revision rounds to reach and complete the final diagram and a calculable representation of the system (Aranson and Angelakis 2018).

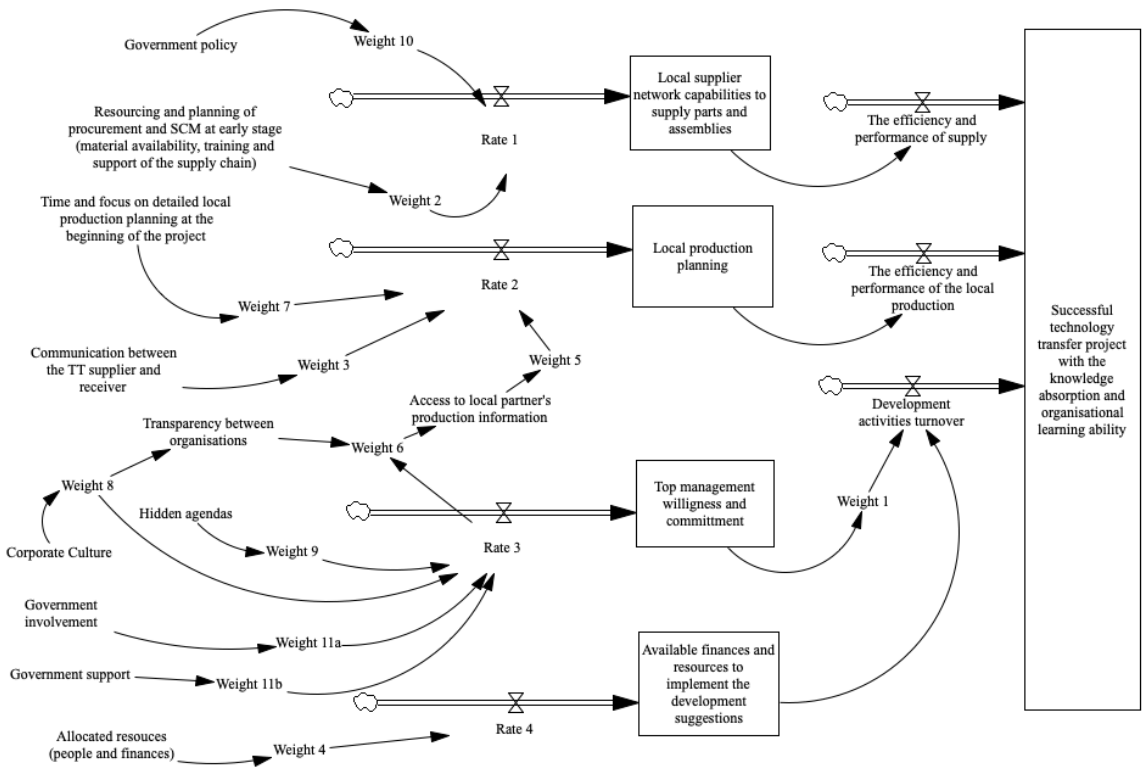

Figure 5.23: The complete conversion and the final version of the TT stock and flow diagram.

For the conversion, the participants were required to extend from simply visualising and analysing the feedback structure of a defence TT system through a causal loop diagram where it would be possible to distinguish between the different parts of the defence TT system and identify what causes these parts to change. This allows a more precise specification of the different system parts and their interrelation, providing a basis for simulating the behaviour of the TT system over time. In other words, the participants' responses were used to create a process prototype that allows the exploration of its behaviour and test the effect of changes to its structure and the possible policies governing its behaviour. Stock and flow diagrams allow specifying such a construct and the TT ecosystem elements, providing a richer illustration than causal loop diagrams alone.

According to Forrester's (1994) notation, a *stock* represents a part of a system whose value at any given time is dependents on the system's past behaviour. The stock value cannot be determined by measuring the value of the other parts of the system but by measuring how it changes and how these changes accumulate over time. The main stock is based on the accumulation of successful TT project with knowledge absorption and organisational learning ability. This main level is fed by the sub-stock levels, namely the local supplier network capabilities to supply parts and assemblies, the local production planning, the top management willingness and commitment, and lastly, the available finances and resources to implement the development suggestions (Forrester 1994).

The *flows* represent the rate at which the stock is changing (Forrester 1994). The flow either causes the stock to increase (i.e. the flow is into the stock), or the flow causes the stock to decrease (i.e. the flow is out of stock). The flows are represented by a small valve attached to a flow pipe that leads into or out of stock in the diagram. The main level stock (i.e. the accumulation of successful TT project with knowledge absorption and organisational learning ability) in-flows consists of the efficiency and performance of supply, the efficiency and performance of the local production, and the development activities turnover. The four sub-level stocks consist of the auxiliary Rates 1-4, respectively.

The rates are further fed by *converters* represent (i) the boundaries of the TT system where the converter values are not determined by the system behaviour itself, and (ii) parts that derive value also from other parts of the TT system. For rate 1, the independent converters are the government policy (i.e. the industrial participation requirements, guidelines and policies, public procurement policies that have a direct impact on the development of the local supplier network capabilities), and the resourcing and planning of procurement and SCM at an early stage (material availability, training and support of the supply chain). Rate 2 and rate 3 are part of interlinked converters representing broader parts of the TT system. Firstly, the rate 2 is fed by the time and focus on detailed local production planning at the beginning of the project in isolation. Similarly to rate 1, rate 4 is independently fed by the allocated resources (people and finances).

In contrast, the corporate culture affects the communication between the TT supplier and receiver and further the rate 2 (i.e. the local recipient's corporate culture is determinant of how open and efficient the communication between the organisations may be, are there restrictions in place due to cultural conflicts or cultural boundaries, and how the local recipient operates). One of the important aspects of communication is communicating the industrial participation and public procurement rules and regulations between the foreign supplier and the local recipient. Rate 3 also feeds the rate 2 through the transparency between the organisations and access to local partner's production information. The rate 3, on the other hand, is affected by any hidden agendas (i.e. hidden political motivations not publicly shared), the corporate culture in terms of the local recipient organisation's way of operating and managing its operations and the government involvement and support all individually. The local partner typically is a public entity, or there is the heavy involvement of a governmental actor in the background as a stakeholder in the company, for example. The governmental actors may choose to approach the directors of the local recipient with hidden agendas outside the execution of the initial defence contract (political power games, corruption, socio-economical aspirations, preferential rules, for example) that can lead, for example, to re-directing the procurement and the funds spending. The governmental actors may also not hold the relevant skills set for running an optimal industrial participation programme. Furthermore, unlike their private counterparts, the governmental actors have no personal stake in the business entities they are running. This would affect the overall industrial participation and TT process efficiency.

In general, the government policy aspect holds significant leverage. The TT system is typically governed by two central policies: public procurement policies and defence industrial participation policies. These two might not necessarily be in line with each other but cause obstacles to execution and application. For example, governments in South Africa may have a preferential procurement regulations policy in place. A business entity must comply if it wishes to engage with any governmental entity contractually. However, this preferential financial procurement policy can conflict with the overall local supply objective(s) related to the TT and local production capabilities. The South African Department of Trade and Industry overall offset and industrial participation objective is to gain the most non-defence related commercial benefit for South Africa from any defence procurement programme. The South African Army's objective is to purchase equipment suitable for their military strategy. The Armaments Corporation of South Africa (Armscor) represents the end customer, the South African Army, manages the direct industrial participation contract execution, including the local production and TT. The preferential financial procurement policy causes any order placed by Armscor to have a 6 to 8 months turnaround time, excluding the delivery period.

Furthermore, suppose the order is placed on any public entity, such as Denel Land Systems as a Level 5 overall system supplier operating as a local TT partner and recipient in South Africa. In that case, it will take an additional 6 to 8 months to be processed at their organisation, as each public entity in the supply chain must follow the preferential financial procurement policy. Let us assume that Denel Land Systems further orders its subsidiary, Denel Vehicle Systems as a Level 3 system supplier for the vehicle platform. Again, regardless of Denel Vehicle Systems being a subsidiary of Denel Land Systems, there will be another additional 6 to 8 months turnaround time for the order. To conclude, each order in the supply chain involving a public entity entails the order, quote and processing time of 6 to 8 months. The typical system may involve 40 orders, taking extraordinary resources and affecting the time and scheduling of the TT. It is important to notice that this timeline does not involve any change requests that are numerous in complex defence products. In a worst-case scenario, any conflicting policies might cause the entire contract to a standstill where the TT cannot progress.

The system *connectors* represented by the arrows establish how the different parts of the TT system influence each other. According to Forrester (1994), stocks can only be influenced by flows, which can be influenced by stocks, other flows, and converters. Converters either are not influenced at all as they are located at the TT systems' boundary or are influenced by stocks, flows and other converters (Forrester 1994).

The sources illustrated by the clouds lie outside of the TT system boundary, and their purpose is to demonstrate that the stock is flowing from a source outside of the TT model's boundary (Forrester 1994). The overall system dynamics notation system is presented in Table 5.3.

Table 5.3: The TT stock and flow diagram notation (Forrester 1999).

Element	Symbol	Description
Stock		Part of a system whose value depends on the past behaviour, measured based on changes occurred
Flow		The rate at which the stock is changing (in-flow causing increase, out-flow causing decrease)
Converter		Represent the boundary parts of the TT system (either that value is not determined by the behaviour of the TT system itself, or parts whose value can be derived from other parts of the TT system)
Connectors		Illustrate how the parts of a TT system influence each other
Source		Stocks that lie outside of the TT systems boundary

5.4.6. The Simulation Experiments

Three simulation experiments are conducted in order to observe and analyse the different TT system dynamics model hypotheses. An analysis of the TT system's dynamic structure and its causal links assists in improving the efficiency and effectiveness of the system (Forrester 1980). The three hypotheses are anchored to the main research questions: (i) how does the interaction of the key TT success factors change the behaviour of the TT system, and (ii) how do alternative policies result in better performance. The objective of the simulation is to test the different conditions in which the intra-organisational TT takes place, namely (1) the baseline (i.e. current state), (2) the application of success factors (i.e. the maximum state), and (3) the worst-case scenario (i.e. the minimum state). Each experiment is composed of several simulation runs that visualise the system's sensibility to the particular variables under examination and how they affect the behaviour of the whole system.

5.4.6.1. Developing Dynamic Theory Based on Qualitative Data

Traditionally system dynamics approach depends upon quantitative data to generate feedback models as a mathematical representation of problems and policy alternatives (Akcam et al. 2019, Luna-Reyes et al. 2003, Forrester 1994). However, as the classic system dynamics literature highlights, the qualitative data and its analysis also hold an important role as most of the information available is not numerical but is qualitative (Akcam et al. 2019, Turner et al. 2013, Kapmeier 2006, Laws 2004, Luna-Reyes et al. 2003, Forrester 1994). As Forrester (1994) suggests, the qualitative data mainly resides in a mental database or a written database of professional practitioners. It forms an essential source both in quantity and significance for the modeller (Forrester 1994). This view is shared by the mainstream authors (Sterman 2000, Wolstenholme 1990, Roberts et al. 1983, Richardson and Pugh 1981, Randers 1980). There, however, are no established protocols or formalised guidelines on how to incorporate this qualitative information into the modelling process (Akcam et al. 2019, Turner et al. 2013, Ackman et al. 2011, Luna-Reyes et al. 2003, Forrester 1994). The lack of procedures creates a gap between the problem under the study and the modelling. The links between reality and the assumptions in the model are not necessarily clear and easy to understand (Akcam et al. 2019, Luna-Reyes et al. 2003, Forrester 1994). This gap is even more noticeable when it involves soft variables, such as commitment, quality and engagement (Luna-Reyes et al. 2003). The uncertainty associated with quantifying qualitative variables may cause the simulation results to be misleading or fragile in some cases (Coyle 2000, Wolstenholme 1990). As a result, the typical archetype engineering mindset that lacks appreciation and acknowledgement for this mental database due to its 'qualitative' nature tends to ignore the qualitative process significantly because of these reasons.

Data gathering techniques such as interviews and focus groups and qualitative data analysis approaches such as the grounded theory methodology have a critical role in rigorous system dynamics efforts (Akcam et al. 2019, Kapainsky and Luna-Reyes 2008, Luna-Reyes et al. 2003, Forrester 1994). According to Luna-Reyes et al. (2003) study on the most suitable qualitative data techniques for the system dynamics approach, the grounded theory is perhaps considered one of the most exciting techniques for the modelling, through identifying themes and concepts and further linking these concepts to establish meaningful theories. Similarly, as the linking is an essential part of the system dynamics, these two approaches have a joint objective of drawing relationships among factors in a targeted system (Luna-Reyes et al. 2003).

A heuristic framework with low empirical content has a valuable role in providing a flexible idea about the problem. It can explore the empirical TT phenomena through the system dynamics analysis (Akcam et al. 2011, Kelle 1997). The TT model can be categorised as a theoretical notion or a common-sense concept with a low empirical category based on the falsifiability of the key concept (Akcam et al. 2011, Kelle 1997). According to Kelly (1997), the empirical content of theoretical notions is very low, limiting the deduction of falsifiable propositions from them. These notions lack precise reference and have no benchmarks as opposed to more definite concepts. They, however, serve a purpose by adding an essential theoretical perspective and guiding the research on a broader level. The common-sense categories are also heuristic concepts with low empirical content. These two categories can be identified to rely on theories of the members of the investigated culture and drawing on general knowledge (Kelle 1997). The use of more falsifiable concepts with a higher empirical content may risk forcing data into preconceived ideas (Akcam et al. 2011).

For this case study, there are no directly available quantitative data for simulation purposes. There are also no literature sources on quantitatively describing the key variables related to the established TT model. To quantify the TT conditions, the most important factors, i.e. the TT key success factors, are considered, and the research expert respondents determine their weights and the baseline values. The numerical data is limited in extracting the cause and effect relationships between the variables and can then be used as parameter values, system behaviours and time-series information for model output comparison (Akcam et al. 2019, Forrester 1980). In essence, Forrester (1980) argues building a general model or a theory first only after which a particular situation understudy would be modified to fit in (Forrester 1980). Hence, this supports the research approach to establish an initial conceptual, theoretical framework for the TT prior to further empirical research.

5.4.6.2. Hypothesis 1: The Baseline

The TT system dynamic modelling is incrementally approached where the first hypothesis establishes the baseline assumptions for the model variables. The baseline represents a prototypical TT system, reflecting a ‘regular’ TT environment with its problems and issues experienced. Hence the objective is not to create equilibrium conditions where the opposing forces are balanced and result in no change, growth or decrease in the value of the final stock level but somewhat to realistically mimic the current TT environment as it is operating now.

The standard model settings applicable to the baseline and all the different simulation experiments (hypotheses 1 to 3) are: Initial time = 0, Final time = 60, Time step = 0.25 (i.e. three months), Units for time = Month. In other words, the period starts from the contract signing and reflects 60 months of which is the typical TT process duration spanning over five (5) years.

The variables are not equal in importance; hence the variables have assigned different weights as represented in Table 5.4. The weights are set by using ranking question type where the participants are requested to rank a list of options based on the item they prefer most to the item they prefer the least in a Likert scale from one to five (1-5) where the one (1) represents the least and five (5) the most preferred options (Stevens 1946). In a ranking question, the more an individual prefers an option (i.e. the closer the option is to 5), the larger the weight associated with this selection (Stevens 1946). This results in the weight of importance: the more critical the option is to the respondent, the more weight is attributed to it, and vice versa. The normalised weight is a rescaled version of the survey weight and the variable sum that contains the normalised weight and corresponds to the exact number of units involved in the analysis (Field 2018).

Table 5.4: The normalised weights for the different TT system variables.

Rank Number *Highest weight first, lowest last*	**Variable**	**Mean Score (95% CI[a])** *Ranking 1-5*	**Weight** *Normalised/ standardised weights*	**Weight** [%]	**VENSIM Variable ID**
1	Top management willingness and commitment	3,88 (3,56-4,20)	1,30960	11,9%	Weight 1
2	Resourcing and planning of procurement and SCM at early stage (material availability, training and support of the supply chain)	3,70 (3,34-4,05)	1,24885	11,4%	Weight 2
3	Communication between the TT supplier and receiver	3,54 (3,30-3,78)	1,19485	10,9%	Weight 3
4	Allocated resources (people and finances)	3,25 (2,90-3,60)	1,09696	10,0%	Weight 4
5	Access to local partner's production information	3,22 (2,88-3,55)	1,08684	9,9%	Weight 5
6	Transparency between the organisations	3,22 (2,88-3,55)	1,08684	9,9%	Weight 6
7	Time and focus on detailed local production planning at the beginning of the project	3,03 (2,60-3,45)	1,02271	9,3%	Weight 7
8	Corporate culture	2,88 (2,53-3,23)	0,97208	8,8%	Weight 8
9	Hidden agendas	2,43 (1,88-2,98)	0,82019	7,5%	Weight 9
10	Government policy	2,11 (1,23-2,15)	0,71218	6,5%	Weight 10
11	Government involvement and support	1,33 (1,12-1,53)	0,44891	4,1%	Weight 11
Total		**32,59**	**11**	**100,0%**	
Average (the divider)	(total mean score / number of weight items)	2,96273	11,00000		

The baseline variable values presented in Table 5.5, similarly to the weights, are constant variables and set based on the respondent ratings. These are set by using rating question type where the participants are asked to rate each variable based on its effect on the current environment on a Likert scale of one to five (1-5) (Stevens 1946). The scale values represent the following effect levels: one (1) unfeasible/poor, two (2) unsatisfactory, three (3) neutral, four (4) satisfactory, and five (5) optimal (Stevens 1946). Each variable value goes through iterative rounds until a consensus between the respondents is reached on the best representative of a current baseline value for each variable.

Table 5.5: The baseline values for the different TT system variables.

Rank Number *Following the weight ranking*	**Variable**	**Value** *Rating 1-5*
1	Top management willingness and commitment	No set value, a stock item accumulating value based on input from other variables
2	Resourcing and planning of procurement and SCM at early stage (material availability, training and support of the supply chain)	2
3	Communication between the TT supplier and receiver	3
4	Allocated resources (people and finances)	2
5	Access to local partner's production information	Random uniform value (min 1, max 5, seed 3)
6	Transparency between the organisations	Random uniform value (min 1, max 5, seed 3)
7	Time and focus on detailed local production planning at the beginning of the project	3
8	Corporate culture	1
9	Hidden agendas	1
10	Government policy	2
11a	Government involvement	1
11b	Government support	2

The first variable (No 1), the management willingness and commitment, receives no set baseline value as it is a stock item that accumulates value from the other feeding variables linked to it. The second variable (No 2), the resourcing and planning of procurement and SCM at an early stage (material availability, training and support of the supply chain), receives a baseline value of two (2), reflecting that the variable typically affects negatively where the local recipient typically has no allocation of additional procurement and SCM resources for the TT process. However, the related tasks are handled as part of the everyday workload by the existing procurement organisation. Furthermore, the potential organisational learning and training aspect is not integrated and extended to cover the sub-supplier network. The local recipient typically treats all the procurement from the cost optimisation point of view rather than the partnership perspective, where there is deeper cooperation between the supply chain actors. The sub-suppliers typically receive the technical drawing package, and they are expected to respond with their most cost-effective quote. The third variable (No 3), the communication between the TT supplier and receiver, receives a baseline value three (3) as the communication between the foreign supplier and the local recipient can be seen to be at a neutral level and the local recipient typically actively engages to the communication. However, the respondents agreed that the communication performance is dependent on the level of organisation where the floor level is well engaged, but the higher the hierarchy, the less responsive the communication gets. The process stage also affects the performance, where the most active communication occurs around the contract signing and immediately after this. In contrast, communication declines as the TT process continue. The fourth (No 4) variable, allocated resources (people and finances), receives a baseline value of two, reflecting a typical negative effect where the local recipient has inadequate financial resources from the very beginning of the TT process and the local recipient is typically a completely or partially state-owned financially unstable enterprise, heavily relying on government support and subsidiaries. The local recipient's TT project team is commonly nominated in the beginning following the TT process. However, the team members are often not allocated extra time for the TT process but are expected to integrate the additional work into their daily workload. The fifth (No 5) and the sixth (No 6) variables, access to local partner's production information and the transparency between the organisations, have no set respondent rating based values. However, they follow the system's random uniform distribution and thus continuously take values within the given interval with an equal probability (Field 2018). As these two variables are located in the middle of the system, they need automatised variable values for the appropriate functioning of the simulation. Hence, the random uniform is the most suitable for this purpose. A random uniform distribution is a useful approach in situations as the TT case study where every outcome in a sample space is equally likely (Field 2018). Random uniform distribution is considered more suitable in cases where the exact rate is unknown but most probably to range between certain values, giving a wider window of opportunity to see how the system will behave should any of the given range values play out (Field 2018). The fixed random uniform function interval (1, 5, 3) provides a distribution between one (1) and five (5) with a simulation seed value of three (3) where the simulation starts from. At the beginning of the project, the seventh (No 7) variable, the time and focus on detailed local production planning, received a baseline value of three (3), reflecting a neutral effect where local production planning received close attention and focus during the contract negotiation phase. However, the plan is typically not updated regularly as the process requires changes. The changes are almost always ad hoc and not processed as part of any formal local production planning and management change management process. The eighth (No 8) variable, the corporate culture, only receives a value of one (1), reflecting a very negative effect where the local recipient is typically a fully or partially state-owned enterprise that does not operate under full commercial circumstances with advanced management approaches regarding the R&D, management, and overall processes and operations but rather relies on substantial government support and order backlog. The foreign supplier often is the polar opposite, a commercially operating global high technology enterprise broadly applying the latest and most efficient management approaches. This creates a conflict and friction between the supplier and recipient organisations; cultures are in a clash and not lined with each other for optimal cooperation. The ninth (No 9) variable, the hidden agendas, also receive a value of one (1), demonstrating a very negative effect as the political motivations have a negative, unpredictable impact on the TT execution. According to the respondents, the hidden agendas are, unfortunately, reality involving defence contracting. The tenth (No 10) variable, the government policy, receives a value of two (2), indicating a negative effect firstly due to the issues related to the preferential procurement policies that are often in conflict with the TT objectives and even the overall defence programme objectives, and secondly due to the industrial participation policy focus being fixed solely on the foreign supplier and lacking the local recipient and the local sub-supplier network perspective. The government policies should better manage, analyse and enable organisational learning from the TT recipient point of view. No matter how optimal and efficient the TT process would be, the TT supplier alone cannot force the recipient to receive and learn. However, learning is a two-way process where both parties must initially have certain characteristics. However, there must also be two actively participating parties in the process for it to be successful. The eleventh variable has been divided into government involvement (No 11a) and government support (No 11b). The government involvement receives a negative value being at the level of unsatisfactory where the government involvement typically increases when the defence programme activities and outputs do not satisfy or meet the hidden agendas discussed above where otherwise the government do not demonstrate an active involvement towards the operational activities taking place after the contract has been signed. This type of negative involvement hinders the TT process execution and forms obstacles for organisational learning. The government support receives the lowest level rating of unfeasible/poor. The support is restricted and limited to securing the maximisation of the foreign supplier industrial participation in the contract negotiation and the management of the offset claiming process. Ideally, the government support should be more reflected in supporting the local recipient and the local sub-supplier network in providing practical operational preparation and execution guidelines and organisational learning specialist advisory services.

The other Vensim TT system dynamics model equations are presented in Table 5.6 and are directly based on the causal loop diagram outputs. In addition to the constant variables discussed earlier, the other item types present in the TT model are the level, i.e. stock or an accumulation, and the auxiliary, i.e. a dynamic variable that depends on other variables (Vensim 2021). Before simulating, the model is checked and cleared for errors in equations and units.

Table 5.6: The TT model equations.

TT Model Item	Item Type	Equation	Input Description	Initial Value
Successful TT project with the knowledge absorption and organisational learning ability	Level	=INTEG(Development activities turnover+The efficiency and performance of supply+The efficiency and performance of the local production)	3 cause variables	0
The efficiency and performance of supply	Auxiliary	=Local supplier network capabilities to supply parts and assemblies	1 cause variable	N/A
The efficiency and performance of the local production	Auxiliary	=Local production planning	1 cause variable	N/A
Development activities turnover	Auxiliary	=(Available finances and resources to implement the development suggestions+Weight 1)/2	1 cause variable	N/A
Local supplier network capabilities to supply parts and assemblies	Level	=INTEG(Rate 1)	1 cause variable	0
Local production planning	Level	=INTEG(Rate 2)	1 cause variable	0
Top management willingness and commitment	Level	=INTEG(Rate 3)	1 cause variable	0
Available finances and resources to implement the development suggestions	Level	=INTEG(Rate 4)	1 cause variable	0
Rate 1	Auxiliary	=(Weight 10+Weight 2)/2	2 cause variables	N/A
Rate 2	Auxiliary	=(Weight 3+Weight 5+Weight 7)/3	3 cause variables	N/A
Rate 3	Auxiliary	=(Weight 8+Weight 9+Weight 11a+Weight 11b)/4	4 cause variables	N/A
Rate 4	Auxiliary	=(Weight 4)	1 cause variable	N/A

The baseline model is designed to establish typical TT process conditions, and the behaviour of the critical factors of a TT process is graphically illustrated in Figure 5.24. The main output, the successful TT project with the knowledge absorption and organisational learning ability graph illustrated with a blue colour, demonstrates almost an exponential growth from 0 to 8308.72 over the TT project duration. The top management willingness and commitment graph illustrated with a red colour demonstrate a negative linear decline from 0 to -4.4553 after the start of the project. The local supplier network capabilities graph illustrated in green demonstrates a linear increase from 0 to 32.2002. The local production planning illustrated with a grey colour demonstrates a linear increase from 0 to 182.719. Lastly, the available finances and resources to implement the development suggestions graph illustrated in black demonstrate a linear growth from 0 to 131.635. The yearly development of outputs is presented in Table 5.7.

The Critical Factors of a Technology Transfer Process

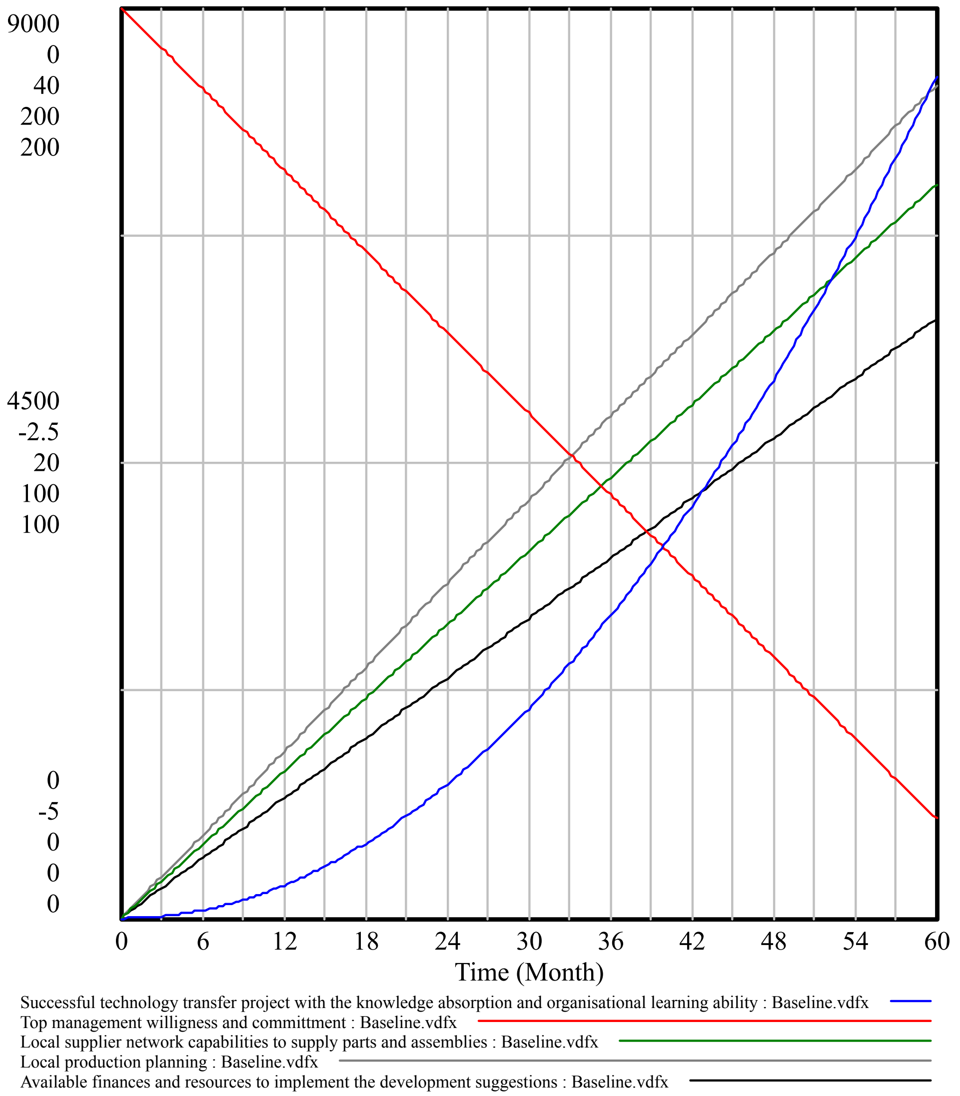

Figure 5.24: The baseline model showing typical TT process conditions and the behaviour of the critical factors of a TT process.

Table 5.7: The yearly development of the critical factor outputs for the baseline.

Item	Year 0 *[0]*	Year 1 *[12]*	Year 2 *[24]*	Year 3 *[36]*	Year 4 *[48]*	Year 5 *[60]*
Successful TT project with the knowledge absorption and organisational learning ability	0	324.648	1320.09	2985.97	5315.29	8308.72
Top management willingness and commitment	0	-0.89106	-1.78212	-2.67318	-3.56424	-4.4553
Local supplier network capabilities to supply parts and assemblies	0	6.44004	12.8801	19.3201	25.7602	32.2002
Local production planning	0	36.4325	73.5789	110.252	146.199	182.719
Available finances and resources to implement the development suggestions	0	26.327	52.6541	78.9811	105.308	131.635

5.4.6.3. Hypothesis 2: The Application of Success Factors

After setting the baseline conditions, the second hypothesis is examined by assuming a maximum application of the critical success factors and generating unconstrained growth in optimal TT conditions. In this scenario, Vensim SyntheSim mode is applied to synthesise the structure and simulation that superimposes the time graphs on top of the model diagrams to update these graphs as changes are made to the model variables through the slider bar mechanisms as illustrated in Figure 5.25 (Vensim 2021) The maximum application of the success factors is used to test the model under different condition and to test the impact that the changes in constants have on the TT model behaviour (Vensim 2021). The other simulation settings discussed previously remain the same.

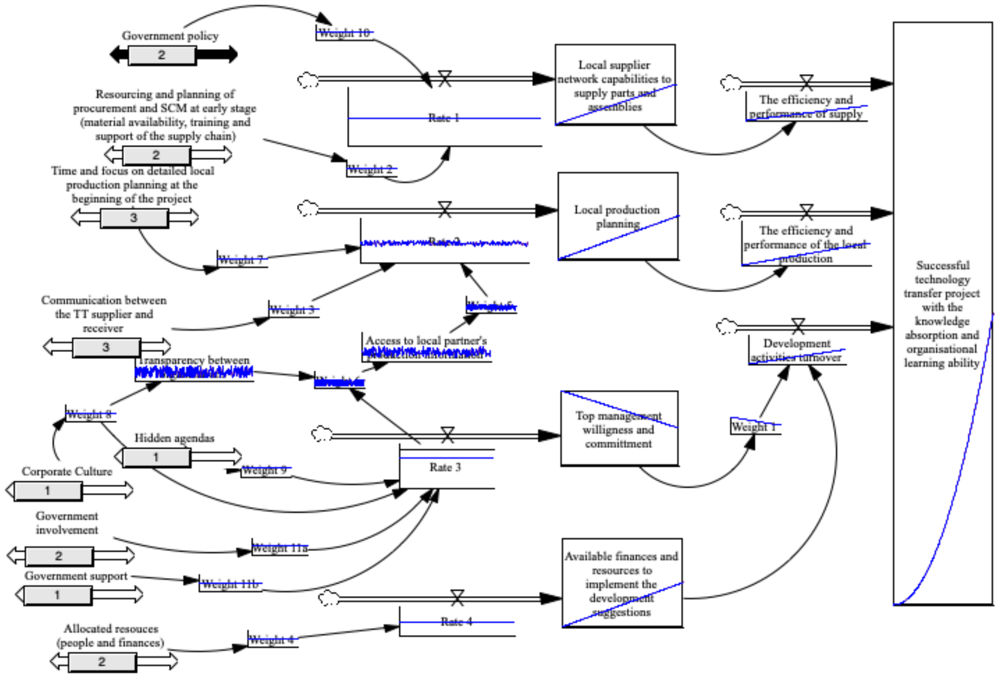

Figure 5.25: The simulation structure setup illustrating the SyntheSim variable sliders.

For this scenario, the system variables are treated to produce the maximum output. Hence, all the variables are set to the maximum value of five (5), as illustrated in Table 5.8.

Table 5.8: The second hypothesis values for the different TT system variables.

Rank Number *Following the weight ranking*	**Variable**	**Value** *Rating 1-5*
1	Top management willingness and commitment	No set value, a stock item accumulating value based on input from other variables
2	Resourcing and planning of procurement and SCM at early stage (material availability, training and support of the supply chain)	5
3	Communication between the TT supplier and receiver	5
4	Allocated resources (people and finances)	5
5	Access to local partner's production information	Random uniform value (min 1, max 5, seed 3)
6	Transparency between the organisations	Random uniform value (min 1, max 5, seed 3)
7	Time and focus on detailed local production planning at the beginning of the project	5
8	Corporate culture	5
9	Hidden agendas	5
10	Government policy	5
11a	Government involvement	5
11b	Government support	5

As illustrated in Figure 5.26, a graph is generated after the simulation run reflecting the behaviour of the stock. The maximum application of the success factors is designed to establish the optimal TT process condition. The main output, the successful TT project with the knowledge absorption and organisational learning ability graph illustrated with a blue colour, demonstrates almost exponential growth from 0 to 17758.2 over the TT project duration. The top management willingness and commitment graph illustrated with a red colour demonstrate a positive linear growth from 0 to 11.3917 after the start of the project. The local supplier network capabilities graph illustrated in green demonstrates a linear increase from 0 to 80.5005. The local production planning illustrated with a grey colour demonstrates a linear increase from 0 to 341.284. Lastly, the available finances and resources to implement the development suggestions graph illustrated in black demonstrate a linear growth from 0 to 329.088. The yearly development of outputs is presented in Table 5.9.

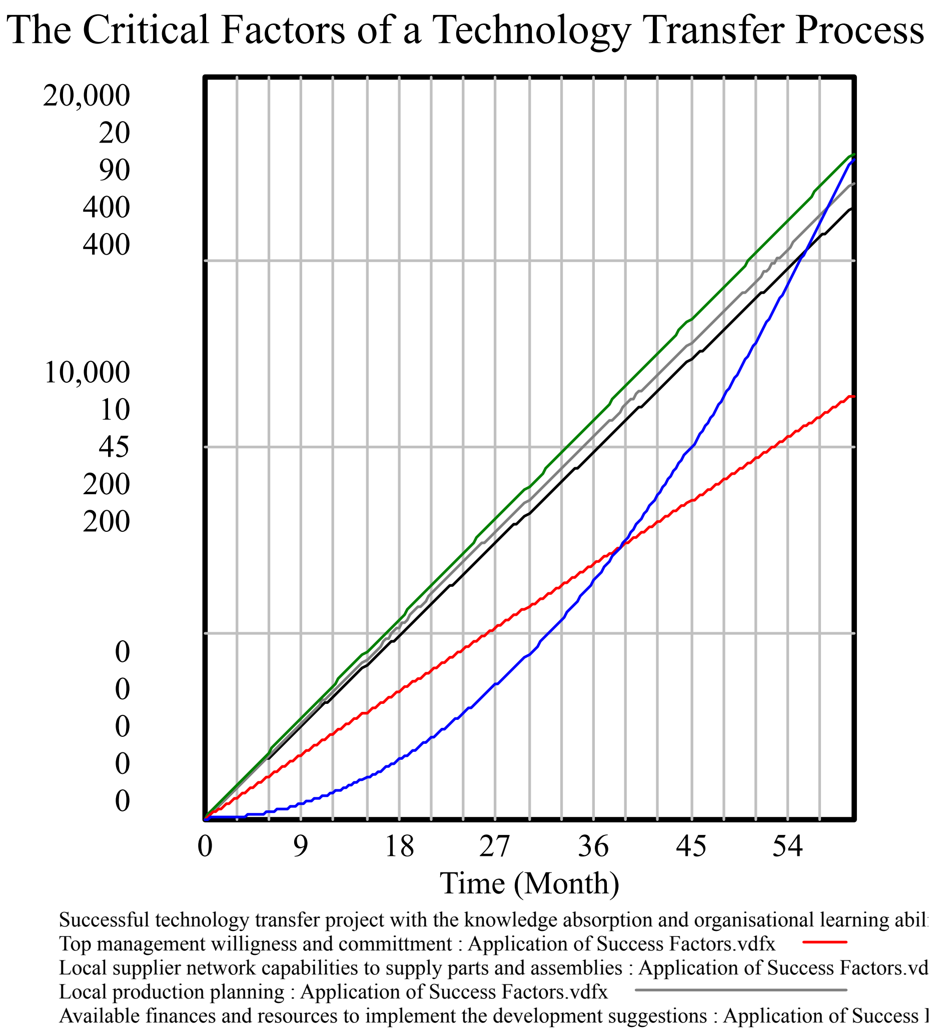

Figure 5.26: The graph showing the TT process conditions and the behaviour of the critical factors of a TT process when the maximum success factors applied.

Table 5.9: The yearly development of the critical factor outputs for the maximum success factors.

Item	Year 0 *[0]*	Year 1 *[12]*	Year 2 *[24]*	Year 3 *[36]*	Year 4 *[48]*	Year 5 *[60]*
Successful TT project with the knowledge absorption and organisational learning ability	0	695.662	2827.96	6388.24	11363.2	17758.2
Top management willingness and commitment	0	2.27835	4.5567	6.83505	9.1134	11.3917
Local supplier network capabilities to supply parts and assemblies	0	16.1001	32.2002	48.3003	64.4004	80.5005
Local production planning	0	68.3587	137.839	205.653	272.819	341.284
Available finances and resources to implement the development suggestions	0	65.8176	131.635	197.453	263.27	329.088

5.4.6.4. Hypothesis 3: The Worst Case Scenario

The third hypothesis is examined by assuming the critical success factors' minimum application and generating an unconstrained decline in the worst-case TT conditions. In this scenario, Vensim SyntheSim mode is applied to synthesise the structure and simulation through constant sliders, as illustrated in Figure 5.27. For this scenario, the system variables are treated to produce the assumed minimum output. Hence, all the variables are set to the minimum value of one (1), as described in Table 5.10.

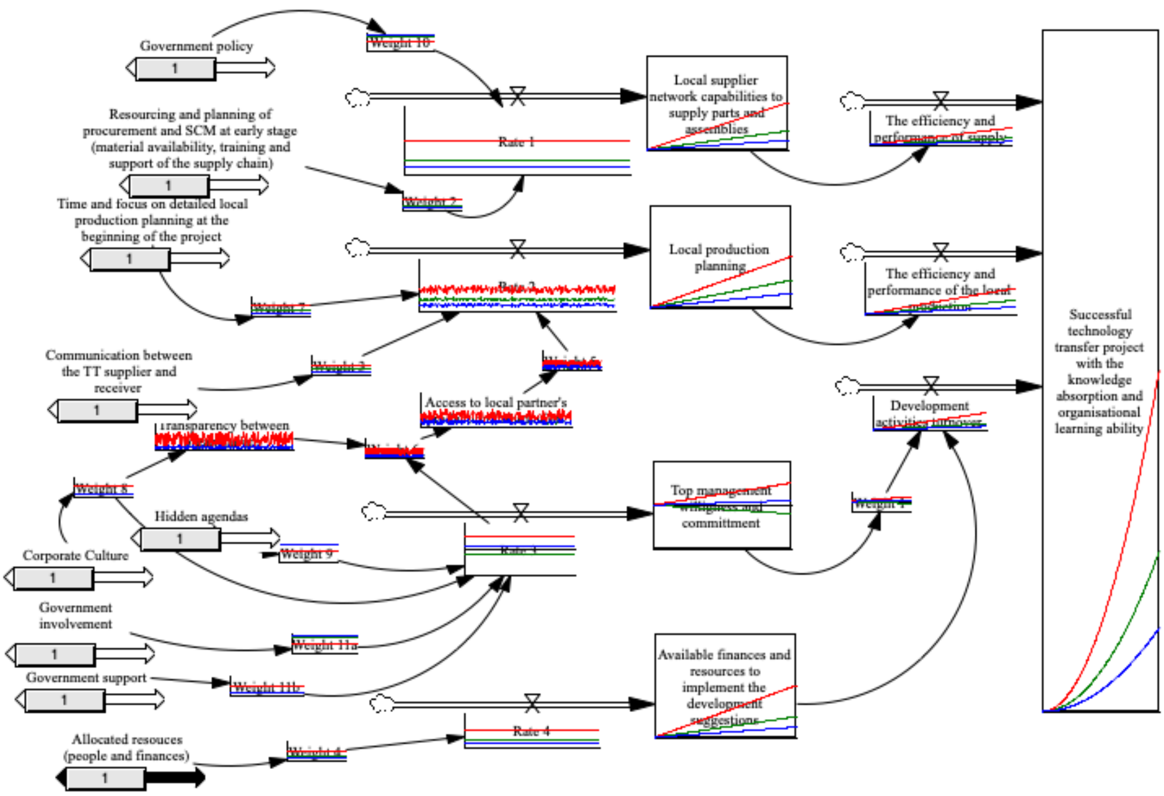

Figure 5.27: The simulation structure setup illustrating the SyntheSim variable sliders with minimum values and the related behaviour for all elements on the TT diagram.

Table 5.10: The third hypothesis representing the minimum values for the different TT system variables.

Rank Number *Following the weight ranking*	**Variable**	**Baseline Value** *Rating 1-5*
1	Top management willingness and commitment	No set value, a stock item accumulating value based on input from other variables
2	Resourcing and planning of procurement and SCM at early stage (material availability, training and support of the supply chain)	1
3	Communication between the TT supplier and receiver	1
4	Allocated resources (people and finances)	1
5	Access to local partner's production information	Random uniform value (min 1, max 5, seed 3)
6	Transparency between the organisations	Random uniform value (min 1, max 5, seed 3)
7	Time and focus on detailed local production planning at the beginning of the project	1
8	Corporate culture	1
9	Hidden agendas	1
10	Government policy	1
11a	Government involvement	1
11b	Government support	1

As illustrated in Figure 5.28, a graph is generated after the simulation run reflecting the behaviour of the stock. The minimum application of the success factors is designed to establish the assumed worst case TT conditions. The main output, the successful TT project with the knowledge absorption and organisational learning ability graph illustrated in blue, demonstrates moderate exponential growth from 0 to 4346.12 over the TT project duration. The top management willingness and commitment graph illustrated with a red colour demonstrate a linear small but positive growth from 0 to 2.27835 after the start of the project. The local supplier network capabilities graph illustrated in green demonstrates a linear increase from 0 to 16.1001. The local production planning illustrated with a grey colour demonstrates a linear increase from 0 to 94.6798. Lastly, the available finances and resources to implement the development suggestions graph illustrated in black demonstrate a linear growth from 0 to 65.8176. The yearly development of outputs is presented in Table 5.11.

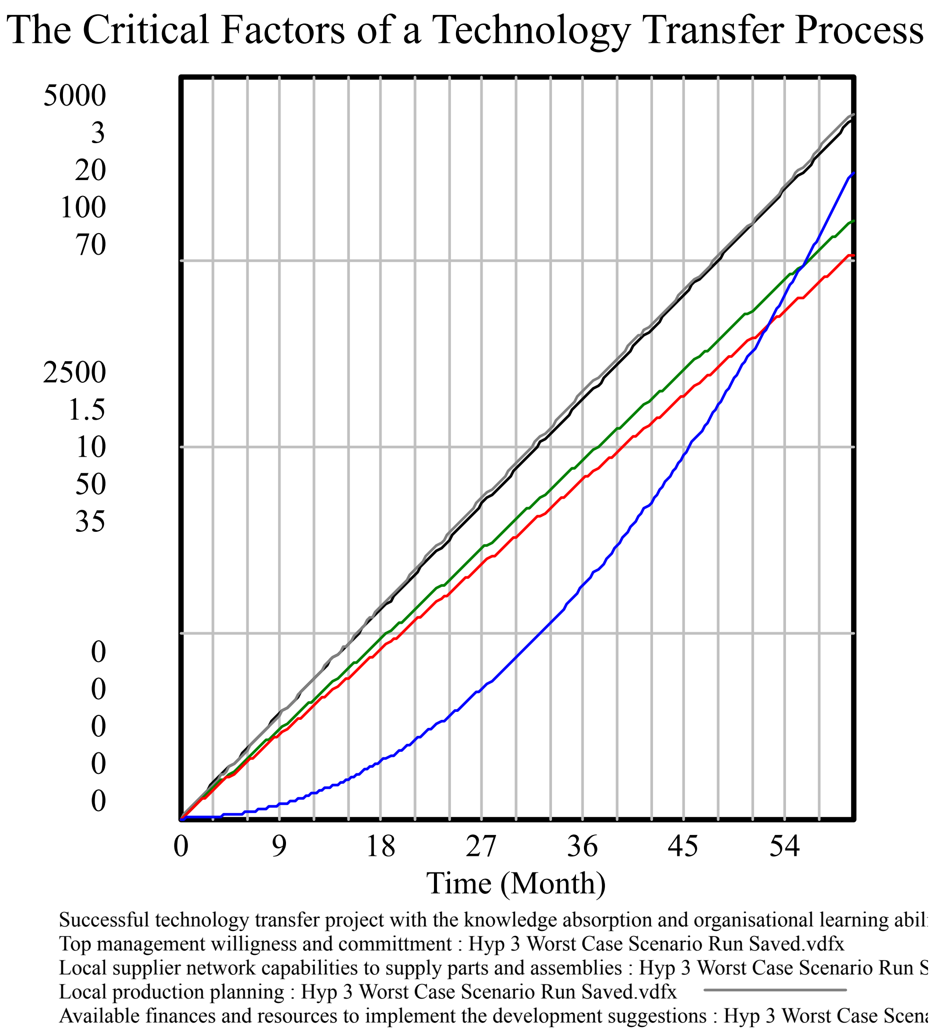

Figure 5.28: The graph showing the TT process conditions and the behaviour of the critical factors of a TT process when the minimum success factors applied, representing the worst case scenario.

Table 5.11: The yearly development of the critical factor outputs for the minimum success factors, i.e. the worst case scenario.

Item	**Year 0** *[0]*	**Year 1** *[12]*	**Year 2** *[24]*	**Year 3** *[36]*	**Year 4** *[48]*	**Year 5** *[60]*
Successful TT project with the knowledge absorption and organisational learning ability	0	168.797	690.053	1563.41	2781.88	4346.12
Top management willingness and commitment	0	0.45567	0.91134	1.36701	1.82268	2.27835
Local supplier network capabilities to supply parts and assemblies	0	3.22002	6.44004	9.66006	12.813	16.1001
Local production planning	0	18.8246	41.5136	57.4283	75.7672	94.6798
Available finances and resources to implement the development suggestions	0	13.1635	26.327	39.4906	52.6541	65.8176

5.4.6.5. Comparison of the Behaviour of the Reference Models

The different hypotheses outputs, namely (1) the baseline, (2) the application of success factors, and (3) the worst-case scenario, are next examined and compared. Table 5.12 presents the yearly development of the critical factor outputs for these different hypotheses, stating the TT yearly Vensim simulation values from the first year to the final fifth year. First, the development of the leading stock of the Successful TT project with the knowledge absorption and organisational learning ability is analysed. The maximum application of the critical success factors and generating an unconstrained growth in optimal TT conditions produces the highest total stock of 17758.2. In contrast, the minimum critical success factors generating the decline and the worst-case TT conditions produces the lowest total stock of 4346.12. When examining the total stock levels further, the maximum application of success factors' final stock level is two (2) times higher than the baseline and four (4) times higher than the minimum application of the success factors.

Similarly, the maximum application scenario reaches the worst-case scenario's maximum total stock level after the second year and the baseline maximum stock level after the third year of the TT process. The baseline scenario reaches the worst-case scenario's maximum total stock level after the third year of the TT process. Overall, in all the scenarios, the balanced stock growth of the successful TT project with the knowledge absorption and organisational learning ability is highest in the beginning of the project at the second year, decreasing steadily during the rest of the duration of the TT project as can be seen in the Table 5.13. The curves in Figure 5.29 demonstrate an exponential function, i.e. grows exponentially and increases quantity over time.

The top management willingness and commitment curves demonstrate a linear function that increases and grows proportionally throughout the TT process. Again the maximum application of the critical success factors and generating an unconstrained growth in optimal TT conditions produces the highest total stock of 11.3917. In contrast, somewhat surprisingly, the baseline produces the lowest total stock of -4.4553. The worst-case scenario application maximum stock value settles to 2.27835. When examining the total stock levels further, the maximum application of success factors' final stock level is five (5) times higher than the worst-case and almost fourteen (14) times higher than the baseline application of the success factors. Similarly, the maximum application hypothesis reaches the worst-case scenario's maximum total stock level at the first year and consistently exceeds the baseline stock level during the TT process. The baseline stock level never has a positive status.

The local supplier network capabilities to supply parts and assemblies curves demonstrate a linear function that increases and grows proportionally throughout the TT process. The maximum application of the critical success factors and generating an unconstrained growth in optimal TT conditions produces the highest total stock of 80.5005. In contrast, the worst-case scenario produces the lowest total stock of 16.1001. The baseline application's maximum stock value is 32.2002. The maximum application of success factors' final stock level is five (5) times higher than what of the worst-case and two and a half (2.5) times higher than the baseline application of the success factors. Similarly, the maximum application hypothesis reaches the worst-case scenario's maximum total stock level at the first year and the baseline maximum stock level at the second year during the TT process.

The local production planning curves demonstrate a linear function that increases and grows proportionally throughout the TT process. The maximum application of the critical success factors and generating an unconstrained growth in optimal TT conditions produces the highest total stock of 341.282. In contrast, the worst-case scenario produces the lowest total stock of 94.6798. The baseline application's maximum stock value is 182.719. The maximum application of success factors' final stock level is three and a half (3.5) times higher than what of the worst-case and almost two (1.9) times higher than the baseline application of the success factors. After the first year, the maximum application hypothesis reaches both the worst-case and the baseline scenarios' maximum total stock levels.

The available finances and resources to implement the development suggestions curves demonstrate a linear function that increases and grows proportionally throughout the TT process. The maximum application of the critical success factors and generating an unconstrained growth in optimal TT conditions produces the highest total stock of 329.088. In contrast, the worst-case scenario produces the lowest total stock of 65.8176. The baseline application's maximum stock value is 131.635. The maximum application of success factors' final stock level is five (5) times higher than what of the worst-case and two and a half (2.5) times higher than the baseline application of the success factors. The maximum application reaches the worst-case scenario's total maximum stock level in the first year and the baseline scenario's maximum total stock level in the second year.

Table 5.12: The comparison of the yearly development of the critical factor outputs for different hypotheses, presenting the TT yearly Vensim simulation values.

Item	**Scenario**	**Year 1** *[12]*	**Year 2** *[24]*	**Year 3** *[36]*	**Year 4** *[48]*	**Year 5** *[60]*
Successful TT project with the knowledge absorption and organisational learning ability	Baseline	324.648	1320.09	2985.97	5315.29	8308.72
	Max	695.662	2827.96	6388.24	11363.2	17758.2
	Min	168.797	690.053	1563.41	2781.88	4346.12
Top management willingness and commitment	Baseline	-0.89106	-1.78212	-2.67318	-3.56424	-4.4553
	Max	2.27835	4.5567	6.83505	9.1134	11.3917
	Min	0.45567	0.91134	1.36701	1.82268	2.27835
Local supplier network capabilities to supply parts and assemblies	Baseline	6.44004	12.8801	19.3201	25.7602	32.2002
	Max	16.1001	32.2002	48.3003	64.4004	80.5005
	Min	3.22002	6.44004	9.66006	12.813	16.1001
Local production planning	Baseline	36.4325	73.5789	110.252	146.199	182.719
	Max	68.3587	137.839	205.653	272.819	341.284
	Min	18.8246	41.5136	57.4283	75.7672	94.6798
Available finances and resources to implement the development suggestions	Baseline	26.327	52.6541	78.9811	105.308	131.635
	Max	65.8176	131.635	197.453	263.27	329.088
	Min	13.1635	26.327	39.4906	52.6541	65.8176

Table 5.13: The comparison of the yearly development of the critical factor outputs for different hypotheses, presenting the difference (%) between the consecutive TT execution years.

Item	**Scenario**	**Year 1** *[12]*	**Year 2** *[24]*	**Year 3** *[36]*	**Year 4** *[48]*	**Year 5** *[60]*
		Dif %	**Dif %**	**Dif %**	**Dif %**	**Dif %**
Successful TT project with the knowledge absorption and organisational learning ability	Baseline	n/a	307.0	126.2	78.0	56.3
	Max	n/a	306.5	125.9	77.9	56.3
	Min	n/a	308.8	127.0	77.9	56.2
Top management willingness and commitment	Baseline	n/a	100.0	50.0	33.3	25.0
	Max	n/a	100.0	50.0	33.3	25.0
	Min	n/a	100.0	50.0	33.3	25.0
Local supplier network capabilities to supply parts and assemblies	Baseline	n/a	100.0	50.0	33.3	25.0
	Max	n/a	100.0	50.0	33.3	25.0
	Min	n/a	100.0	50.0	32.6	25.7
Local production planning	Baseline	n/a	102.0	49.8	32.6	25.0
	Max	n/a	101.6	49.2	32.7	25.1
	Min	n/a	120.5	38.0	31.9	25.0
Available finances and resources to implement the development suggestions	Baseline	n/a	100.0	50.0	33.3	25.0
	Max	n/a	100.0	50.0	33.3	25.0
	Min	n/a	100.0	50.0	33.3	25.0

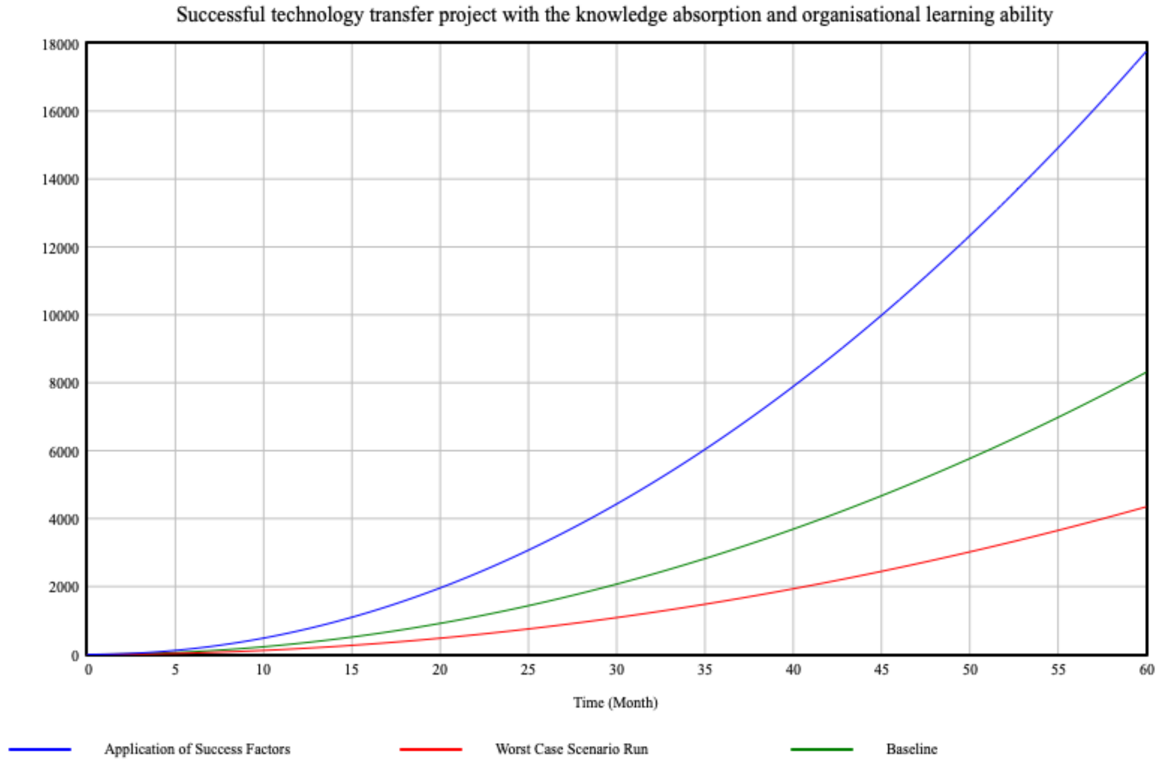

Figure 5.29: The exponential growth of the successful TT project with the knowledge absorption and organisational learning ability stock over the TT duration.

The slope value will establish the rate at which the graph simulated y value rises as the TT process proceeds. In other words, the slope is determined by the line generated by the (x,y) coordinates. For this purpose, Table 5.14 lists the x TT time values and the y values for the three different hypotheses. The slope function provides the slope of the linear regression line through the known y and x data points. Linear regression can be used even with relationships that are not inherently linear, such as exponential models, to model the relationship between y and x by creating a linear regression trend line. The slope function uses the following Equation 5.1:

$$b = \frac{\sum (x - \bar{x})\left(y - \bar{y}\right)}{\sum (x - \bar{x})^2}$$

Equation 5.1: Slope function.

The gradient, or the steepness of the successful TT project with the knowledge absorption and organisational learning ability stock over the TT duration, is measured by the value of the slope. The greater the value of the slope, the steeper the line whereas the sign of the slope, positive or negative, determines the direction. Slope is essentially a change in height over change in the horizontal distance and can be referred as a rise over the run. In the worst case scenario the slope/angle value is lowest at 55, the baseline value being 139 and the optimal conditions produce the steepest slope of 288 for the stock accumulation. Hence, the application of success factors produces a stock accumulation curve that grows five (5) times steeper than the worst case and two (2) times steeper than the baseline.

Table 5.14: The slopes of the knowledge absorption and organisational learning ability for the different hypotheses.

Item		**The Baseline**	**The Application of Success Factors**	**The Worst Case Scenario**
	x (time)	**y (value)**	**y (value)**	**y (value)**
Successful TT project with the knowledge absorption and organisational learning ability	0	0	0	0
	12	324.65	695.66	168.80
	24	1320.09	2827.96	690.05
	36	2985.97	6388.24	1563.41
	48	5315.29	11363.20	2781.88
	60	8308.72	17758.20	4346.12
Slope		139	288	55

When further examining the three inputs for the successful TT project with the knowledge absorption and organisational learning ability stock, namely the development activities turnover, the efficiency and performance of supply, and the efficiency and performance of the local production, it is identified that these three inputs greatly benefit from the increased efficiency of the related inputs as presented in Figure 5.30. The optimal TT conditions produce a significantly more significant impact than the baseline and the worst-case scenario. It is, however, notable that the development activities turnover grows exponentially when the two other inputs, namely the efficiency and performance of supply and the efficiency and performance of the local production, grow linearly.

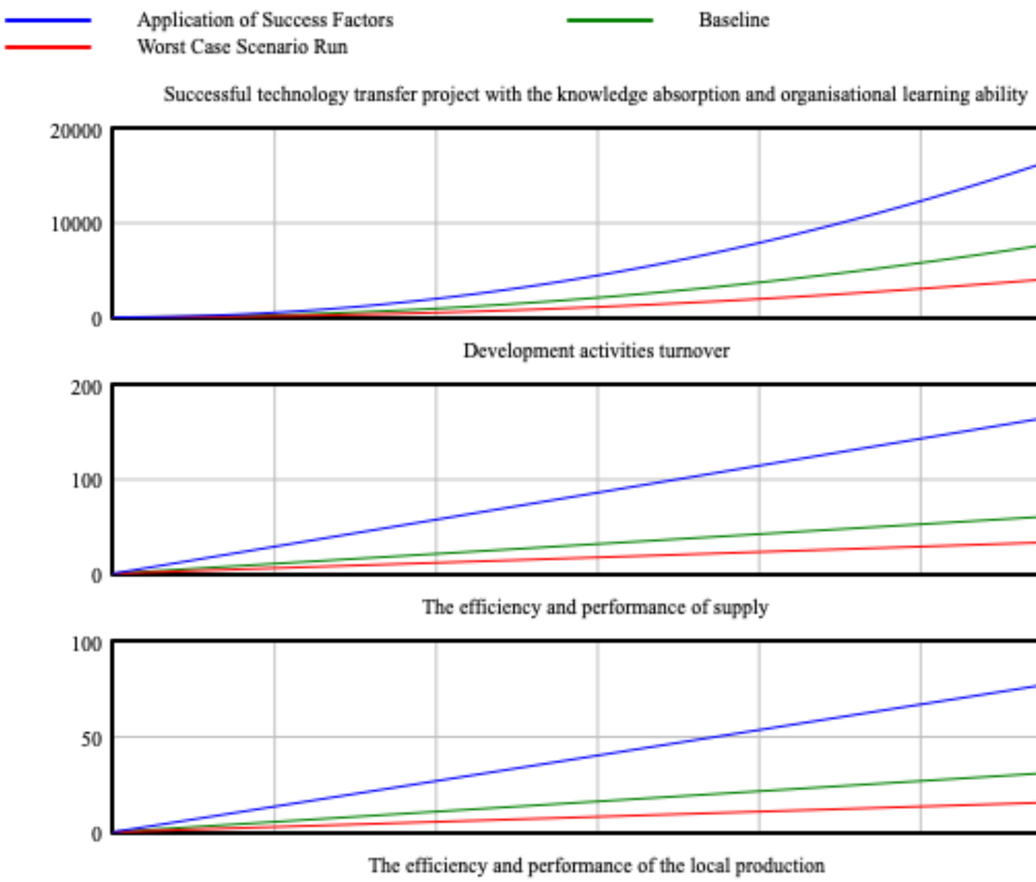

Figure 5.30: The three inputs for the successful TT project with the knowledge absorption and organisational learning ability stock.

5.4.6.6. The Model Validation

Several tests are run in order to build confidence in the TT simulation model under the study. Although this study does not apply a typical quantitative system dynamics approach, the model nevertheless needs to be tested to verify its consistency. However, the system dynamics validation does not follow the traditional statistical validation. The model is not anchored on the past behaviour but rather on the internal structure that creates its behaviour (Senge 1978). It is important to note that although the model is to be tested to provide reliable results, no model can genuinely be ever fully validated but rather tested to gain more confidence about the model consistency (Sterman 2000, Grosser and Schwaninger 2012). Forrester and Sage (1980) approach the validation by establishing confidence in the soundness and usefulness of the model (Forrester and Sage 1980). The validation approach combines two complementary elements: testing the structure and behaviour (Forrester and Sage 1980, Barlas 1996, Sterman 2000). As the name indicates, structural validity tests aim to assure that the structure of the built model is fit for the purpose intended and that every element has a real-world counterpart (Shreckengost 1985). To reflect this, the structure of this study is based on a natural system and hence does not contradict the knowledge about the existing system. From the simulation point of view, the correct structural elements prioritise the data, unlike so many other research methods (Shreckengost 1985). On the other hand, behavioural validity tests compare the model and the real-world system behaviour.

5.4.6.6.1. Structural Validity

The boundary adequacy considers the structural relationships related to the purpose of the set model and verifies that the variables are adequate (Shreckengost 1985). This is related to the boundaries defined by the modelling framework, the general TT process and the related variables defined by knowledge about the existing system. However, due to the complexity of the study phenomena and the fact that the TT process has not been modelled in detail before and hence lacks a scientific reflection point, there may be system sub-elements that remain unrecognised although the main critical elements have been identified. Furthermore, the study treats the TT actors as a homogenous group based on the literature findings and the study respondent expert opinions.

The parameter verification ims at verifying the validity of the parameters and constants used in the model (Shreckengost 1985, Forrester & Senge 1980). The parameters and constants are created based on and compared to the actual real-world knowledge in order for them to correspond conceptually and numerically to the actual study environment (Shreckengost 1985, Forrester & Senge 1980). However, there are no historical data available for this study that the parameters could be tested against due to the lack of relevant studies and since the conceptual model elements have not been quantified before.

However, the different variable relationships have been specified in detail, developed where they have not existed before and quantified. In all, the specified parameter values have been proven to be reasonable and consistent with the supporting data available.

The extreme conditions test verifies that the model is reactive when extreme values are defined and applied for the variables (Forrester & Senge 1980). The TT model is tested with maximum and minimum conditions that did not expose any structural faults or incomplete parameter values.

The dimensional consistency verifies that the units used in the model's variables, parameters, and constants are logical and well constructed (Shreckengost 1985, Forrester & Senge 1980).

The pool of structural validity tests proves that the overall TT model structure adequately reflects the aims and objectives set for the study.

5.4.6.6.2. Behavioural Validity

Each model/hypothesis validation is conducted by using behaviour tests. Typically where historical data would be available, the model would be expected to produce similar data and hence be parallel to the historical data as part of *the behaviour replication test*. However, the historical data is not always accurate nor perfect (Shreckengost 1985, Forrester & Senge 1980). In this study, no historical data is available to the model simulation data is analysed and tested in terms of reasonableness. For this purpose, the study respondents evaluated and assessed the TT system dynamics simulation outputs in terms of the model's purpose. The simulated results are compared with the assumed common sense expectation and discussed with the research participants to establish if the model behaviour makes sense. We can reasonably assume that the model is behaving appropriately and accurately.

As *the behavioural sensitivity test*, small changes are applied in the TT model’s parameter values resulting in no radical behaviour changes and demonstrating a stable behaviour and establishing confidence towards the model (Forrester & Senge 1980.

Dynamic simulation models are instrumental in predicting how a system would behave in implementing different policies and hence provide the basis for predictions for alternative approaches (Shreckengost 1985). Confidence is reinforced when the TT model successfully replicates the current behaviour.

The suprise behaviour test elates to identifying behaviour in the existing system that exists in the natural system but is unnoticed and unrecognised until modelled (Forrester & Senge 1980). This TT study also leads to such discoveries, for example, concerning the linkage of the top management commitment and related inputs to the overall stock accumulation, providing a new perspective to the overall TT ecosystem and building confidence in the model.

The pool of behavioural validity tests completed provides confidence that the TT model is consistent with the actual system behaviour.

5.5. Discussion

The second study phase explores a single global defence industry supplier's TT process perspective and experiences thereof where the holistic conceptualisation approach of the TT through the system dynamics aims to examine how the interaction of the identified key TT success factors change the behaviour of the TT system and how possible alternative policies result in better performance. The TT process, its pain points and key success factors were identified through the Straussian grounded theory approach in the previous first phase of this mixed methods research.

The results suggest that the industrial participation policies focus solely on requirements set on the foreign supplier with a low impact factor. In contrast, no requirements or elements govern or guide the local recipient's selection or activities with the highest impact factor. This study analysed the three main inputs for the successful TT project with the knowledge absorption and organisational learning ability primary stock accumulation, namely (i) the development activities turnover, (ii) the efficiency and performance of supply, and (iii) the efficiency and performance of the local production. Of these, the development activities turnover demonstrates the highest impact potential through the exponential growth, whereas the two are linear. Hence the development activities turnover could be assumed to be more critical for accumulating the main stock. Of these three, the development activities turnover is related to the local recipient and government associated activities (i.e. the top management willingness and commitment, and the available finances and resources to implement the development suggestions) and, as such, outside the foreign supplier's control. The two other inputs (i.e. the local production planning and the local supplier network capabilities to supply parts and assemblies) relate to the activities involving both the foreign supplier and the local recipient. Hence, the current policies and contracting could be misdirected to the wrong elements from the optimal learning point of view. The elements with the highest growth and the knowledge stock accumulation potential receive no attention, as illustrated in Figure 5.31. This is also in line with the system theory of leverage points where efficient interventions can only be produced at higher hierarchy levels (Meadows 1999). The main focus of the TT related industrial participation policies, i.e. the rules of the system, is currently directed to the lowest physical leverage level twelve (12) of constant and parameters determining the discrepancy such as governing the cost and value of TT, job creation, quality standards required, etc. Whereas the policy focus on the ability to evolve and self organise through organisational learning at a higher information and control leverage level of four (4) would potentially provide significantly better outputs.

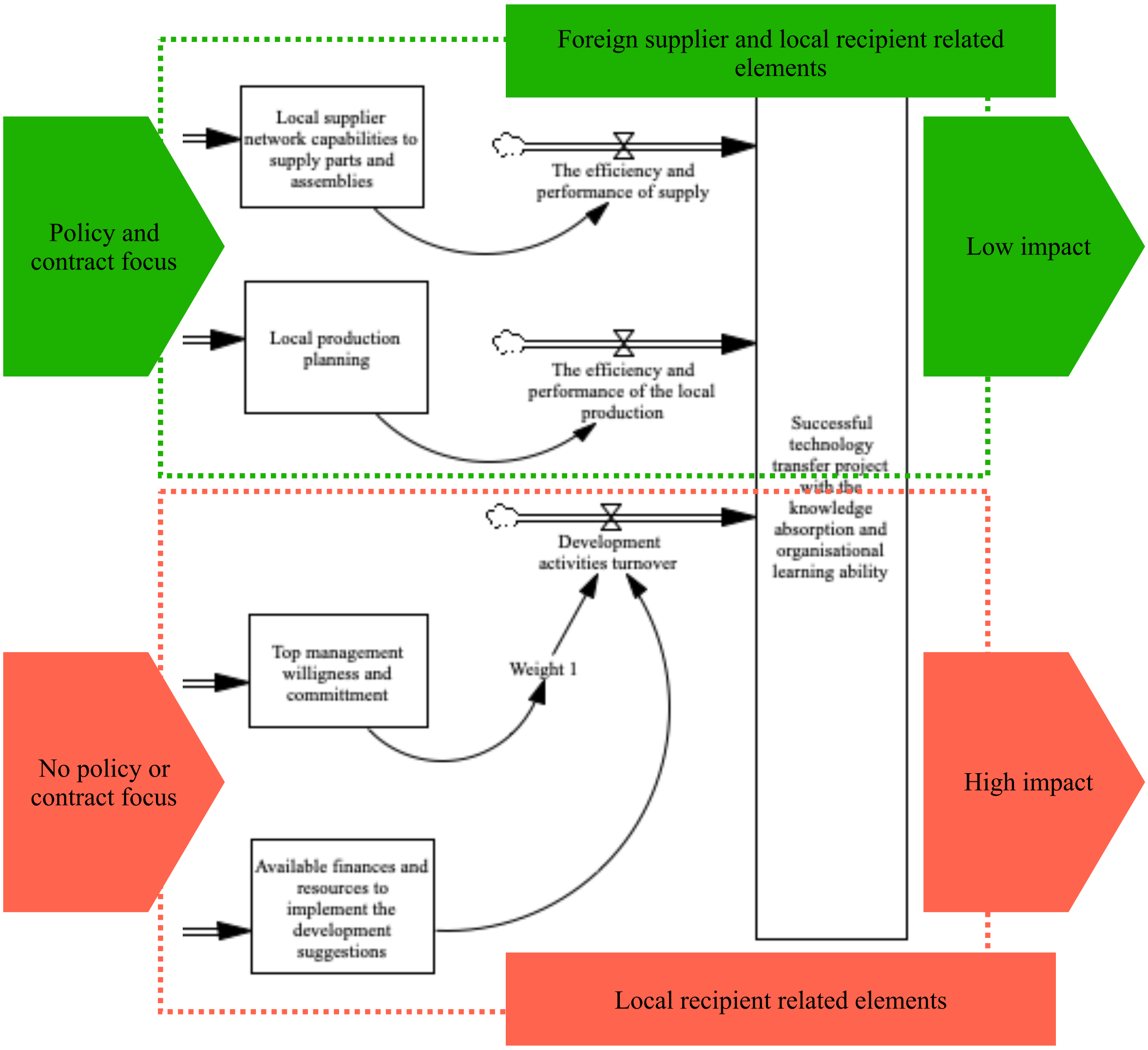

Figure 5.31: The industrial participation policy focus, associated actors and the activities impact from the optimal learning point of view.

Similarly to Kirchwehm (2014) and Winter (2012), the research data suggests that the TT process is currently focused on the contract product context (Kirchwehm 2014, Winter 2012). The local participation contract, the TT process and its output assessment is all set around the defence procurement product. The assessment of TT is based on the final product and how it complies with the set standards and the industrial participation claiming process. This approach misses the broader organisational learning benefits attainable through the TT. It is unlikely that the knowledge transferred will expand outside the contract scope or that the knowledge is received by the broader local audience, such as the supplier network. As a result, and supported by Kirchwehm (20014) and Balakrishnan (2008), this analysis implies that the TT as of now cannot produce a significant competitive advantage for the local recipient and the related local supplier network (Kirchwehm 2018, Balakirshnan 2008). Balakrishnan (2008) argued that TT and adaptation by itself will not be sufficient if the local companies cannot sustain their businesses or cannot utilise the skills acquired outside the contract context (Balakrishnan 2008). Instead of being successful in commercial markets, these companies focus on becoming experts at getting money out of government (Sköns and Dunne 2008, Kopac 2006). Furthermore, the government, as a significant stakeholder, a defence company is under pressure to support government goals rather than the profit as it would be in a purely commercial business environment (Sköns and Dunne 2008, Kopac 2006).

When analysing the high impact elements in more detail, the results indicate a correlation between the local recipient's top management performance in terms of the organisational knowledge absorption and utilisation, local governmental activities and the related political agendas. As per the study respondents comments, the local recipient's top management typically demonstrates willingness and commitment throughout the main defence procurement negotiations until the main contract is secured and finalised. This could imply that the local recipient's management does not experience significant pressure about the execution but instead focuses only on securing the contract. This can be typical in public or semi-public companies and/or companies that have government representatives in their boards participating in the strategic management of the business and/or companies that receive governmental support in the form of subsidiaries and/or orders. This analysis supports the theory that this type of organisation is naturally diverse from purely commercial interests and drivers and lacks related pressure. They operate in a monopsonistic market where the national government is often the single customer and regulates the exports (Sköns and Dunne 2008). When examining the TT systems dynamics simulation hypotheses, the data surprisingly suggests that the current baseline reflects the worst local recipient's management willingness and commitment stock levels. The management does not have the pressure after securing the business by delivering the procurement contract. The worst-case hypothesis has better local recipient's management willingness, and commitment stock levels due to the assumed higher pressure to perform. This can be further analysed by looking at the four (4) variable inputs for the top management commitment: hidden agendas, corporate culture, government involvement, and government support. In the worst-case hypothesis, it could be assumed that significant hidden agendas affect the defence contract and its execution resulting in simulation value one (1). The corporate culture would also be valued at the minimum level one (1), reflecting bureaucracy and hierarchically controlled management culture opposite to a performance-driven corporate culture. The government involvement would be restricted only to the local participation contracting and the claiming of related offset credits after the execution of the TT process; hence the value is set at the lowest level one (1). The government support would also be minimal at level one (1), focusing on securing the contractual TT but excluding any operational level support. These four (4) factors would have allocated 25% proportional input to the accumulation of the top management willingness and commitment stock with related weights of hidden agendas 7.5%, corporate culture 8.8% and the government involvement and support total of 4.1%, respectively. These input factors should not, however, be looked at in isolation as separate entities. However, the hidden agendas and the government involvement and support could be combined, resulting in higher weight and a significant influence on the top management willingness and commitment. This could imply that the less government involvement in any shape or form, the better the management performs in terms of commercial expectations and provides overall support to the learning and knowledge accumulation process. In other words, the more the local recipient company is dependent on the public support and subsidies and connect to the government, the worse it performs.

In contrast, the more the management of overall operations is based on commercial objectives, the better the organisation absorbs and accumulates knowledge. Hence, the better equipped the local recipient organisation is to build a sustainable commercial competitive advantage in the long term. These findings are in line with Hall et al. (2007) study on the role of the government, where they state the defence capabilities should not be retained in public ownership as designated sole sources. However, the process of privatisation should be fully completed (Hall et al. 2007). By contrast, the local industries typically demand more robust government participation to smooth the process of local companies acquiring technology from overseas suppliers through industrial collaboration (Balakrishnan 2008).

Lastly, in all the hypotheses, the proportional stock growth of the successful TT project with the knowledge absorption and organisational learning ability is highest in the beginning of the project at the second year, decreasing steadily during the rest of the duration of the TT project. This finding implies that the beginning of the TT process determines the final stock level. Hence, the emphasis on activities should be placed early in the TT process to maximise the accumulation of knowledge. Also, the study results indicate that the overall accumulation of the successful TT project with the knowledge absorption and organisational learning ability stock demonstrates exponential growth. Hence, it would imply that even a small change in the critical success variables could cause a significant impact over time. The existing TT related literature discusses other TT relationship-related drivers. However, it does not identify any time-related TT process impact factors (Kiss 2014, Vats et al. 2013, Dunne and Haines 2006, Searchy et al. 2004, Lorell et al. 2002)

5.6. Research and Policy Implications

Governments are spending billions annually on defence purchases (Mayne 2017, Kiss 2014, Willen et al. 2013, Stuys 2004). These purchases involve offset TT to support the self-reliance in defence technology in a wartime situation and to leverage the national capabilities, and to support the local defence industry economically (Kirchwehm 2014, Kiss 2014, Balakrishnan 2007, Dunne and Haines 2006, Dunne and Lamb 2003, Bachelor and Dunne 2000). Currently, over 130 countries have some form of offset policy for the domestic industry to benefit from the foreign defence suppliers. The offset programmes offered are typically given more weight than the quality, price or other parameters of competing products, having a 20-30% overall impact on decision making (Kiss 2014). Within the scope of offset, the role of TT and innovation have been more and more emphasised since the beginning of the 2000s (Kiss 2014). However, the current industrial participation policies are somewhat unfocused and do not typically enforce the organisational learning elements but rather focus on the lower physical system hierarchy level leverage points (Meadows 1999).

There is very little evidence of the benefits and the long term sustainability of the industrial participation and TT transactions (Kiss 2014, Willen et al. 2013, Antill and Ito 2012, Güvenç and Yanik 2012, Balakrishnan 2008, Dunne and Haines 2006). In general, defence offset performance is not easy to evaluate. Years later, it may be difficult to trace what has happened and evaluate the results, particularly the less direct benefits and results seem mixed (Kiss 2014, Willen et al. 2013, Güvenç and Yanik 2012 Dunne and Haines 2006). The impact of offsets is often found to be especially problematic in terms of job creation, the strengthening of backward and forward supply chain linkages, and technology enhancement (Dunne and Haines 2006).

Due to the nature of the TT in terms of the defence industry and national security confidentiality requirements, the high system complexity and the long project time span, it would be difficult to establish a standardised set of process performance measures. An industrial participation policy is an alternative response to the need to manage and improve the efficiency of the TT process as a good policy provides increased consistency of the execution, clarity on how to run the operations, effective execution, and enables better control of the overall TT operations. A well-defined industrial participation policy allows the government to efficiently guide the TT operations according to the selected strategic objectives and the different stakeholders to understand their roles and responsibilities better. Hence, the governments must constantly assess and develop their industrial participation activities and assess if their current understanding is accurate and up to date.

This research builds on the perspectives of the TT and the defence industry transformation success factors in the South African context together with the inter-organisational coordination development by Kiss (2014), Vats et al. (2013), Lorell et al. (2002), Dunne and Haines (2006) and Searchy et al. (2004) of which provide a theoretical framework and a reflection point for the study findings and the policy development. This framework is anchored to the research objective to understand the nature of strategic defence industry supply chain alliances and the conditions required for a successful local TT recipient development in terms of collaboration dynamics and technological capability accumulation in the offset context. The three perspectives of Lorell et al. (2002), Vats et al. (2013) and Kiss (2014) cover the whole process of a domestic defence company developing into international cooperation and partnerships, being able to actively and efficiently receive knowledge, capabilities and other benefits through an offset programme, and lastly transforming into a commercially successful corporation and away from being just a fully government subsidised nationalised asset (Kiss 2014, Vats et al. 2013, Lorell et al. 2002). In addition, Dunne and Haines (2006) expand the three perspectives with lessons learned from the South African defence industry transformation (Dune and Haines 2006).

The combined findings of this study's Phase 1 and Phase 2 suggest changes to a typical industrial participation management policy in terms of the local recipient selection, TT process management and control, and the management of the local supplier network as follows:

(1) Recommendation: A strategic partnership approach should be applied to identifying and selecting the local TT recipient, where the local recipient capabilities should be carefully assessed and mapped. There should exist complementary technological and operational capabilities between the local recipient and the foreign TT supplier. There should not be a too-wide gap in the two organisations management culture. The local recipient should also demonstrate the ability to absorb and integrate new knowledge, introduce measures to improve organisational efficiency, continuous investments in R&D and activity to join international production and trade circuits. Rationale: The efficiency and ultimately the success of the TT is based on a foreign supplier and local recipient relationship where the fit between the organisations will determine the gains of the project. Partnerships are strategic where the two organisations are expected to work closely together, so the more perfect the fit, the more efficient the execution, and vice versa. Industrial participation often results in the governments and the local recipients being left unhappy with the received TT and the resulting technological and process capabilities (Kiss 2014). However, in these cases, the barriers typically originated at the recipient end, such as the availability of suitable local partners and the limited capability of adopting and implementing new technology (Kiss 2014).

(2) Recommendation: The local recipient must have access to substantial financial capital and human resources to execute and complete the TT process efficiently and to implement the development suggestions in order to be able to absorb and adapt the technological knowledge and capabilities. The local recipient should not be financially unstable or regularly dependant on government funding or financial intervention activities. Rationale: Appropriate funding and adequate resources are required to support the TT project from the initiation through the execution to the completion to provide optimal results.

(3) Recommendation: The industrial participation contract and related TT should be extended to deliver and build capabilities within the broader local supplier network and not just with the local main recipient. Rationale: The TT could potentially have a more significant impact and broader economic benefits involving the local supplier network.

The sub tiers are acknowledged as a growing source of innovation and R&D partners. The development of supplier capabilities, improving processes, and identifying supplier weaknesses will increase the overall performance and efficiency of the supply chain. The development of capabilities and TT in the supply chain would require partnership-based relationships that are not common for public entities. The public procurement policies typically do not encourage partnerships. However, the transactions are rather more cost-driven, preventing the efficient formation of partnerships and the broader impact of TT by solely focusing on minimising the overall costs.

(4) Recommendation: The industrial participation contract and related TT should assess outputs of both the foreign supplier and the local recipient in terms of (i) the efficiency and performance of the local production, (ii) the efficiency and performance of the supply, and the local recipient in terms of (iii) the development activities turnover. Rationale: Currently, the industrial participation contract focuses solely on the foreign supplier TT outputs and deliverables, whereas the local recipient is seen as a passive receiver. Furthermore, one of the drivers for the TT is the potential impact on the local recipient that is typically related to increased productivity and new products through practical application of the knowledge received. The TT assessment is currently focused on the local recipient's ability to assimilate the contract product production. It does not include any elements of the local recipient's skills utilisation for further development.

(5) Recommendation: Industrial participation and TT should involve joint research and development activities, human resource talent pool generation, and high-tech manufacturing operations, not just focus on assimilating standard production processes. In general, the TT objective should be extended from just assimilating the contract production to building broader local capabilities in terms of innovation through long term R&D cooperation projects, commercialisation, forming new international defence supplier network partnerships, and having access to new foreign markets. Rationale: With a once-off, narrow contract manufacturing operations view, the TT misses its opportunity to utilise the attainable benefits beyond the contract scope. Balakrishnan (2008) stated that the TT and adaptation itself will not be

sufficient if the local companies cannot sustain their businesses or are unable to utilise the skills acquired outside the contract context (Balakrishnan 2008). Hence, facilitating activities that enable the commercialisation of the acquired knowledge should be considered an essential outcome of TT. These kinds of enablers are more anchored to the human 'software' capital, i.e. the know-how dimension in terms of design and creation of engineering solutions and production engineering skills, rather than the traditional technological 'hardware' (Pedone 2017).

(6) Recommendation: Government intervention and involvement should be minimised, and the privatisation of the local defence organisations should be considered. Rationale: The study results imply that the less government involvement in any shape or form, the better the local recipient's management performs in terms of commercial expectations and provides overall support to the learning and knowledge accumulation process. In other words, the more the local recipient company is dependent on the public support and subsidies and connect to the government, the worse it performs. In contrast, the more the management of overall operations is based on commercial objectives, the better the organisation absorbs and accumulates knowledge. Hence, the better equipped the local recipient organisation is to build a sustainable commercial competitive advantage in the long term. To add, the monopolistic state-owned defence enterprises often come with bloated resources and excess productive capacity, the overall industry typically struggling to keep pace with state-of-the-art production practices (Bitzinger 2011). Most of the national defence industries are heavily platform-centric and 'metal bashers', primarily just duplicating military systems that have been in production for 20 years or more as opposed to innovators (Bitzinger 2011). The heavy emphasis on self-reliance results in resources wasted on replicating the development and manufacture of systems already widely available on the global arms market (Bitzinger 2011). In general, the defence deals should be awarded based on open international competition, where the local suppliers would be left to find areas where they have competitive advantages. However, specific defence-specific capabilities cannot be sustained under free-market competition (Hall et al. 2007).

(7) Recommendation: The government should provide continuous operational support and guidelines to the local recipient and the broader local supplier network for the overall management of the TT process in terms of communication, coordination, and execution to maximise the possible benefits. Rationale: Defence industrial participation is one of the most complicated forms of business to governments (B2G) and business to business (B2B) involving various stakeholders where each of them are pursuing their interests in a complex high technology environment (Kirchwehm 2014). The local supply chain, and especially its lower-tier suppliers, typically have minimal experience or knowledge on industrial participation activities or how these activities could affect their business in the future. Furthermore, these are the companies in the participating industry that should benefit from the offsets. To effectively manage TT and organisational learning, knowledge of the TT process and related activities is needed.

Competencies, as industrial development and innovation capability, for example, are anchored in the technologies an organisation possesses. These technologies can systematically be built and acquired to improve an organisation's economic performance and enable technological upgrading and competitiveness. However, it is imperative to acknowledge that technology acquisition does not automatically lead to increased capabilities (Reddy and Zhao 1990). The policy directed activities should target the high impact TT system leverage points supporting and enabling organisational learning (Meadows 1999).

A multidimensional partnership approach is required for the development of these capabilities through TT. Partnering is an iterative and evolutionary learning process in which people interact in uncertain ways with other contextual elements such as power, culture, structure, financial resources and technology and needs to be led by a skilled buyer in the defence context, the government (Sanderson 2009). The local recipient and the related domestic supplier network should become a partner with the foreign supplier rather than just a passive receiver. Furthermore, the local main recipient should actively work up and down in its supply chain.

Ultimately, this study demonstrates a correlation between the industrial participation policy and the local recipient management's willingness and commitment variables, namely the hidden agendas, corporate culture and government involvement and support.

Hence, any industrial participation policy will not have an impact unless these variables act in accordance with the policy. In all, the policy in isolation does not have an impact. For the offset business to be successful it is not only the foreign supplier that has to see the business case of the TT but it is also the local TT recipient and the procuring government that has to focus not only on securing the business but also on following up the TT output and added value.

While not a comprehensive answer to all the multifaceted, complex challenges, the identified policy recommendations provide government guidance and direction for future research. This study is based on a conceptual TT domain representation, applying a qualitative system dynamics approach. Future research could build upon the findings of this study and address the observable domain of the defence TT ecosystem in an empirical study.

6. CONCLUSION

The first contribution of this research is the advancement of the understanding of defence TT through the construction of a TT process SCOR model and the identification of this process' pain points and critical success factors through a novel integrated case study and Straussian grounded theory approach. This process arose out of lessons learned from the best practices in a global defence TT supplier company. As a result, the defence industry organisations and economies involved in defence contracting can better plan and manage their related industrial participation TT activities. To date, the body of research has focused on the factors influencing the technology absorption (Malm et al. 2015, Knudsen et al. 2013, Simonin 1999, Grant and Gregory 1997, Szulanski 1996, Zander and Kogut 1995, Cohen and Levingthal 1990) and to identify meta mechanisms between the supplier and recipient organisations (Capasso et al. 2005, Stock and Tatikonda 2000, Albino et al. 1999, Lyles and Salk 2007, Lasserre 1982), providing very little insight into the actual TT process and activities taking place between the supplier and the receiver under a defence offset contract. This study sought to fill this gap by advancing the operational level understanding by presenting a systematically constructed best practices case study based TT SCOR process map as illustrated in Table 4.3 and identifying this process's pain points and critical success factors. As a result, this study also sought to assist the local recipients in better planning and managing their related industrial participation TT activities with the technology supplier. The participating local organisations typically do not have extensive prior experience on TT. Consequently, there are typically no effective routines to manage all the process aspects to the extent that the transfer often requires ad hoc solutions. As a result, the learning opportunities are not utilised effectively.

The general objective of defence industrial TT is two dimensional, firstly and mainly, to build the local ability to produce and maintain the contract product in a wartime situation. Secondly, to support innovation and organisational learning in the long run, the development of local defence industry sustainability through future capacity and capabilities for the local industry players to compete in a global marketplace. Based on the study findings, a local recipient can achieve this through having a management team that is open to cooperation and applying organisational goals that facilitate learning, through having a sound financial commitment and planning throughout the project life cycle, through the allocation of adequate time and resources for the development of the supply chain management, and lastly through thorough local production planning with a commitment to transparency between the supplier and recipient organisations. This receiving local partner’s ideal operating model is illustrated in Figure 4.7. The efficient management of these factors will lead to a successful project with added knowledge absorption and organisational learning capability. The role of the management through the commitment and openness to the inter-organisational learning as well as the resources and competence building of supply chain management and the establishment of the local supply network is identified as the most crucial, typically creating the highest barriers and obstacles for the TT execution and thus preventing the knowledge exchange. Hence, this case study advanced the theoretical position of local recipient’s management, financial planning, supply chain management, and local production planning as the main factors that the local recipient organisation can best influence to enhance the project's efficiency and success. The possible broader implications of the present research were that the governments setting the regulations and policies under which the defence contracts operate should engage in activities to enable efficient knowledge absorption and organisational learning and build future innovation capabilities. The key focus should be on ensuring that the local recipient has sufficient financial resources throughout the project and the necessary time for detailed pre-planning.

Considering the study problem, this study has several contributions to the advancement of the understanding of defence TT. In study Phase 1, a conceptual, theoretical framework was constructed based on the key concepts regarding the factors enabling a successful TT and their relations emerging from the literature. The theoretical contribution is in the perspective of the receiver of a TT and the prerequisites on both country, management and operational levels in order to achieve a sustainable TT. This study framework is built on several concepts and not a single theory due to the lack of robust critical literature linked to the phenomena under study. The defence industry-related TT literature does not provide a single well-developed theory. However, it is instead fragmented into the isolated case based concepts under the two macro viewpoints presented, the economy and industry. As illustrated in Figure 2.6, the conceptual, theoretical framework incorporates the key concepts from three main perspectives identified to provide the most complete theoretical foundation possible. Firstly, the accumulation of technological capability and the collaboration dynamics of the supplier and local recipient by Kiss (2014), Vats et al. (2013) and Lorell et al. (2002). Secondly, the study is anchored to the South African defence industry ecosystem, specifically through the findings of Dunne and Haines (2006) investigation. Thirdly, Searchy et al. (2004) methodological tool provide a perspective on inter-organisational coordination development. To summarise, the conceptual, theoretical framework incorporates the perspectives of the TT and the defence industry transformation success factors in the South African context together with the inter-organisational coordination development. This anchors the framework to the research objective to better understand the TT critical success factors and how they are linked and produce the behaviour of the entire TT system.

In Phase 2, a TT process level 2 SCOR model was constructed. The process's pain points and critical success factors were identified by applying a novel integrated case study and Straussian grounded theory approach. This study does not answer all the possible questions related to the defence industry TT process, nor does it attempt to. This study extends the few SCOR defence industry applications presented by Bean et al. (2009) and represents activities typical for global defence TT supply chains. While not a comprehensive answer to all the multifaceted challenges, the identified ‘Plan’ process key success factors provide practical field guidance and direction for future research. As a result, the theoretical position of local recipient’s management, financial planning, supply chain management, and local production planning was advanced as the main factors that the local recipient organisation can best influence to enhance the project's efficiency and success.

In Phase 3, a system dynamics TT model was constructed to test and compare the interaction of the critical success factors and how they change the behaviour of the TT system through different hypotheses. The combined findings of the system dynamics modelling and the process analysis in the study’s Phase 1 and Phase 2 respectively suggest changes to a typical industrial participation management policy regarding the local recipient selection, TT process management and control, and the management of the local supplier network. As a result, the defence industry organisations and economies involved in the defence contracting can better plan and manage their related industrial participation TT activities.

6.1. Research Contribution

To date, the body of research has focused on the factors influencing the technology absorption (Malm et al. 2015, Knudsen et al. 2013, Simonin 1999, Grant and Gregory 1997, Szulanski 1996, Zander and Kogut 1995, Cohen and Levingthal 1990) and to identify meta mechanisms between the supplier and recipient organisations (Capasso et al. 2005, Stock and Tatikonda 2000, Albino et al. 1999, Lyles and Salk 2007, Lasserre 1982), providing very little insight into the actual TT process and activities taking place between the supplier and the receiver under a defence offset contract. This study sought to fill this gap by advancing the operational level understanding by presenting a systematically constructed best practices case study based TT SCOR process map as illustrated in Table 4.2 and identifying this process's pain points and critical success factors. As a result, this study also sought to assist the local recipients in better planning and managing their related industrial participation TT activities with the technology supplier. The participating local organisations typically do not have extensive prior experience on TT. Consequently, there are typically no effective routines to manage all the process aspects to the extent that the transfer often requires ad hoc solutions. As a result, the learning opportunities are not utilised effectively.

The broader implications of this study are that the governments setting the regulations and industrial participation policies under which the defence contracts operate should engage in activities to enable more efficient knowledge absorption and organisational learning and systematically build future innovation capabilities. First, the TT strategic partnership approach and the selection of the local TT partner and recipient based on the initial existing capabilities should be prioritised. There should be complimentary technological and operational capabilities between the local recipient and the foreign TT supplier. There should not be a too-wide gap in the two organisations management culture. The local recipient should also demonstrate the ability to absorb and integrate new knowledge, introduce measures to improve organisational efficiency, continuous investments in R&D and activity to join international production and trade circuits. Second, the local recipient must have access to substantial financial capital and human resources to execute and complete the TT process efficiently and to implement the development suggestions in order to be able to absorb and adapt the technological knowledge and capabilities. The local recipient should not be financially unstable or regularly dependant on government funding or financial intervention activities as of now is most often the case. Third, the industrial participation contract and related TT should be extended to deliver and build capabilities within the broader local supplier network and not just with the local primary recipient. Fourth, the industrial participation contract and related TT should assess outputs of both the foreign supplier and the local recipient in terms of (i) the efficiency and performance of the local production, (ii) the efficiency and performance of the supply, and the local recipient in terms of (iii) the development activities turnover. Fifth, the TT objective should be extended from just assimilating the contract production to building broader local capabilities in terms of innovation through long term R&D cooperation projects, commercialisation, forming new international defence supplier network partnerships, and having access to new foreign markets. Sixth, the government direct intervention and involvement should be minimised, and privatisation of the local defence organisations should be considered. Seventh, the government should provide continuous operational support and guidelines to the local recipient and the broader local supplier network for the overall management of the TT process in terms of communication, coordination, and execution to maximise the attainable benefits. Hence, the government established and managed standardised procedures that should guide the local industries participating in TT.

In all, this study arose from lessons learned from the best practices in a global defence supplier company with extensive experience in TT projects with many local recipients and supply networks. It is argued that a global defence supplier with extensive TT experience with numerous projects and operating with multiple recipients has valuable insight and relative objectivity to assess and analyse such factors and identify general operational steps in a TT project. As a result, the defence industry organisations and economies involved in defence contracting can better plan and manage their related industrial participation TT activities.

6.2. Future Research

This study had several limitations, which also offer avenues for future research. The data was based on a single case study with small sample size, only reflecting the supplier view and did not capture the local recipient's views or the broader industrial participation environment. Therefore, future research could explore the other dimensions of the process and analyse them over time as a longitudinal study to better understand the interaction between the supplier and the recipient and other factors playing a role over time. Despite the limitations, this study reported actual experiences from a global TT supplier perspective, giving new insights to limited literature of inter-organisational TT in a complex high technology defence environment.

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Appendices

Appendix A - Questionnaire Template

Question: From supplier's point of view, the generic main phases of technology transfer (TT) in a local production and offset context is presented below. Please check the activities that you agree are part of the process based on your experience.

Marketing and negotiation phase (before the main supply contract is signed)
Preliminary study:

- ❑ Determination of person in charge and organisational responsibilities
- ❑ Collecting base data and information
- ❑ Analysis of industrial participation regulations and requirements
- ❑ Local partner survey and selection
- ❑ Preliminary industrial participation plan

Preparation:

- ❑ Contract preparation and preliminary industrial participation execution planning
- ❑ Cost analysis
- ❑ Risk analysis
- ❑ Determining work share and TT content
- ❑ Contract preparation

Negotiation and contract:

- ❑ Contract negotiation and signing
- ❑ Contract review (internal)

Contract delivery phase (after the main supply contract is signed)
Execution:

- ❑ Contract review
- ❑ Establishing the organisation and allocating the resources
- ❑ Establishing the industrial participation execution plan
- ❑ Training and support
- ❑ Production permit
- ❑ Industrial participation analysis and reporting
- ❑ Industrial participation claiming and crediting
- ❑ Analysis and review of possible additional support needs, and their planning and execution

Completion:

- ❑ Industrial participation analysis and reporting
- ❑ Claiming, crediting and reporting
- ❑ Possible corrective measures
- ❑ Industrial participation approval negotiations, or possible negotiations for extra time if not fulfilled on time
- ❑ Approval
- ❑ Final reporting and review to the planned
- ❑ Closure and lessons learned

Question: Based on your experience from the contract delivery phase, please list the activities that are the most problematic to manage and control with the recipient, and please elaborate the main reason(s) for the issues experienced.

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Question: Based on above question, what do you think should be done differently at recipient's end to decrease the problems experienced and to improve the efficiency of TT process?

Question: Based on above question, is there clearly a one activity that is causing most of the problems in the TT process?

Question: Based on your experience from the contract delivery phase, please name typically the most successful activities, in the TT process.

Question: Is there any form of evaluation taking place before the selection of the local partner (i.e. the recipient of the TT)?

- ❑ Yes
- ❑ No

If your answer is yes, are the evaluation processes and/or procedures standardised?

- ❑ Yes
- ❑ No

If your answer is yes, please also elaborate what kind of evaluation is taking place:

If your answer is yes, please check if any of the following factors is included to the evaluation:

- ❑ Global ability
- ❑ Management style
- ❑ Quality systems
- ❑ Logistics
- ❑ After-market services
- ❑ Current product and process competence

- ❑ Product development
- ❑ Finance
- ❑ Non of the above

Question: Is the local partner provided any suggestions how they could improve their operations before the TT takes place?

- ❑ Yes
- ❑ No

If your answer is yes, please provide some typical examples of the improvement suggestions:

If your answer is yes, based on your experience, how is local partner's attitude towards possible improvement suggestions received from the supplier (Patria) ? Are the suggestions for corrective measures and development ideas implemented?

If your answer is yes, based on your experience, on a scale from 0 to 5 how is local partner's attitude towards improvement suggestions received from the supplier (Patria)?

- ❑ 0 - not at all interested, negative attitude
- ❑ 1 - not at all interested, neutral attitude
- ❑ 2 - slightly interested
- ❑ 3 - somewhat interested
- ❑ 4 - very interested
- ❑ 5 - extremely interested

Question: Based on your experience, are the local partners typically committed and interest to learn and improve their operations?

Question: Is the local partner regularly evaluated by the supplier (Patria) during the TT phase?

- ❑ Yes
- ❑ No

If your answer is no, why do you think the local partner is not regularly evaluated by the supplier (Patria) during the TT phase?

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Question: Based on above question, if your answer was yes, is there any feedback and technological or other assistance provided to the recipient in identified problem areas?

- ☐ Yes
- ☐ No

Question: Please check if the local partner (i.e. the recipient of the TT) is involved in any of the following activities before the main supply contract is signed:

- ☐ Preliminary industrial participation planning
- ☐ Cost analysis
- ☐ Risk analysis
- ☐ Determining work share and TT content

Question: Is ad hoc solutions often required throughout the TT process?

- ☐ Yes
- ☐ No

Question: Based on your experience, do you think the recipients of TT typically have effective routines in place to handle all the aspects of a knowledge transfer and the collaboration with the supplier (Patria)?

- ☐ Yes
- ☐ No

Question: Please see the list below and check the problems you have encountered in the TT process.

- ☐ Knowledge codiafibility (i.e. the extent the supplier (Patria) could articulate the knowledge in a documents and softwares such as blueprints, procedural task descriptions, etc.)
- ☐ Knowledge complexity (i.e. technical complexity and technological sophistication of new features and concepts in a technology to be transferred)
- ☐ Knowledge ambiguity (i.e. the uncertainty or doubtfulness of the meaning of language, when the language is capable of being understood in more than one way by a user)
- ☐ Knowledge tacitness (i.e. the kind of knowledge that is difficult to transfer to another person by means of writing it down or verbalising it)
- ☐ Supplier (Patria) problems to identify local recipient needs
- ☐ Inadequate pre-transfer planning
- ☐ Inadequate post-transfer control
- ☐ Recipient's employee's teachability and absorptive capacity (i.e. the ease at the individual level by which knowledge can be taught to new workers and new technological practices can be adapted)
- ☐ Availability of qualified technical and managerial personnel with critical skills and know-how
- ☐ Recipient's lacking retentive capacity (i.e. ability to preserve the routine use of the new technological practices)
- ☐ Recipient problems achieving a satisfactory local production performance
- ☐ Recipient's lacking performance review and evaluation of their operations under the TT
- ☐ Recipient's lacking ability to analyse and evaluate their organisational performance

- ☐ Recipient's lacking ability to implement improvement suggestions received from the supplier (Patria)
- ☐ Recipient's lacking use of management methods
- ☐ The level of recipient employee's competence
- ☐ Recipient's management lacking motivation
- ☐ Recipient's floor level workers lacking motivation
- ☐ Recipient's lacking prior experience and understanding in the contract technology
- ☐ Recipient's lacking prior experience and understanding on the TT process
- ☐ Cultural differences
- ☐ Language differences
- ☐ Communication issues on management level
- ☐ Communication issues on floor level
- ☐ Geographical distance between the supplier (Patria) and the recipient

<u>Question:</u> Based on your experience, what are typical manufacturing start-up problems experienced with the recipient?

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<u>Question:</u> Is supplier's (Patria) manufacturing procedures adapted to local conditions?

- ☐ Yes
- ☐ No

<u>Question:</u> Based on your experience, please check what of the following categories of technological support, assistance and collaboration are typically offered to the local recipient.

Assistance related to product technology:

- ☐ Provision on product designs and technical specifications
- ☐ Provision, advice and/or financial assistance to obtain raw materials and components
- ☐ Regular feedback on product performance to improve existing production technology
- ☐ Technical consultations on product characteristics to master new product technology
- ☐ Organised R&D collaboration in product related areas

Assistance related to production technology:

- ☐ Provision, advice and/or financial assistance to obtain machinery and equipment
- ☐ Technical support to improve existing production technology
- ☐ Technical consultations on machinery operations to master new production technology
- ☐ Advice on production layout and organisation
- ☐ Assistance with quality assurance systems (e.g. ISO certification, TQM, etc.)

Training programmes for employees:

- ☐ In-plant training for managers and/or technicians at the recipient
- ☐ In-plant training for workers at the recipient
- ☐ In-plant training for managers and/or technicians at the raw material and/or component supplier(s)
- ☐ In-plant training for workers at the raw material and/or component supplier(s)
- ☐ In-plant training for managers and/or technicians at the supplier (i.e. Patria)
- ☐ In-plant training for workers at the supplier (i.e. Patria)

<u>Question:</u> What type of training is provided:

- ☐ None

- ☐ On the job (e.g. training provided at the workplace, practical training)
- ☐ Formal (e.g. classroom instruction, web-based training, e-learning, workshops, seminars, etc.)

Question: Based on your experience, check what type of training you think is the most important (i.e. has the highest impact on learning and competence development), and please elaborate your answer.

- ☐ On the job
- ☐ Formal
- ☐ Combination of both on the job and formal

Question: Which of the following range of techniques typically have been made available to the recipient?

- ☐ All techniques and manufacturing procedures controlled by the supplier (Patria)
- ☐ Only those techniques relevant to the broad range of activities undertaken by the recipient
- ☐ Only those techniques relevant to the delivery contract

Question: How it is identified/decided what activities, operations, and/or information is to be transferred to the recipient?

Question: Elaborate how is the typical organisational relationship between the supplier (Patria) and the recipient? What are typical problems.

Question: How could the recipient increase the success and adaptation of the TT within their organisation?

Question: Based on your experience, on a scale from 0 to 5, how probable you think it is that the local recipient of the TT is able to utilise the gained manufacturing capabilities in their future contracts?

- ☐ 0 - It definitely will not happen
- ☐ 1 - Not likely
- ☐ 2 - Neutral
- ☐ 3 - Likely
- ☐ 4 - Very likely
- ☐ 5 - I cannot say

Question: Based on your experience, on a scale from 0 to 5, how often does the local recipient end up being part of supplier's (Patria) global supply chain after the TT?

- ☐ 0 - It does not happen
- ☐ 1 - Not often
- ☐ 2 - Neutral
- ☐ 3 - Often
- ☐ 4 - Very often
- ☐ 5 - Always