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A Study of Performance Measurement & Management System Design in Collaborative Innovation

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Abstract

The research presented in this thesis investigates how organisations enable innovation through collaborative partnerships to maintain competitive advantages when resources such as manpower and finance are limited. Previous studies confirm that improving performance effectiveness of a Collaborative Innovation (CI) relationship needs to effectively manage multiple complex factors from various aspects.

As the performance outcome of the CI relationships does not always satisfy expectations with financial and other consequences, research asserts itself as an imperative for promoting knowledge on identifying gaps that need to be filled in the field of Performance Measurement and Management (PMM) and CI.

To improve efficiency and effectiveness of CI, PMM can be applied to support CI. The function of PMM is to improve the quality of CI and reduce the risk of possible failure. The aim of this research is to investigate how collaborative partners design PM systems for improving effectiveness of CI. The result of the research contributes to gaining a better understanding of designing and managing an effective PMM framework to achieve effective CI.

Qualitative research design with case studies as research method was adopted in this research. Seven case studies were chosen based on their potential for providing theoretical and practical perspectives. In the case studies, semi-structured interviews were conducted based on the reference model of designing a Collaborative Innovation Performance Measurement (CIPM) system. The requirements, characteristics and dimensions of the CIPM reference model are then compared and analysed, which leads to an enhanced reference model. Based on the reference model, a step-based construct for designing CIPM systems is presented.

The key findings of this research are: 1) a comprehensive list of the factors influencing the effectiveness of collaborative innovation was identified; 2) an improved understanding of performance measurement in collaborative innovation projects was provided; 3) a CIPM reference model was proposed; 4) a step-based construct for designing collaborative innovation performance measurement systems was developed.

The research contributes to the understanding, designing and managing of effective performance measurement systems for improving effectiveness of CI. Also, it can contribute to the analysis of factors which enable and constrain designing effective PMM systems in a collaborative innovation system in the context of academia-industry collaboration.

Academic researchers in operations management can benefit from the results of the present research. Practically, project managers can use the conclusion of the present research, as a reference model when designing their own effective performance measurement systems for achieving the objective of CI.

Chapter 1. Introduction

Today's global economy is developing beyond the levels achieved in the 20th century. Growing intensive competition, rapid technological development and increasing environment complexity are pushing organisations to establish sustainable competitive advantages through innovation. Innovation is a broad area with different aspects, such as product or service innovation, new production process technology, new structure or administrative systems, new plan or programme relative to organisational members (Keupp et al., 2012). Innovation can help organisations to reduce costs and increase efficiency of differentiating them from others.

Despite the benefits that innovation can bring to organisations, it is difficult for a single organisation or department to master innovation alone due to time limitations and the lack of sufficient internal resources. Innovation is generally considered to be the outcome of combining existing and new knowledge and expertise in various organisations: collaborative relationships have an interactive and complementary influence on innovation (Freeman, 1991). Therefore, more and more organisations tend to invest in innovation through active collaboration internally with other departments and/or externally with other organisations for achieving to higher levels of value creation.

Collaborative innovation has become an alternative or additional option instead of in-house innovation (Keupp, et al., 2012). In collaborative innovation, two or more organisations share knowledge, skills and risks with a common innovation purpose in mind. Collaborative innovation is increasingly treated as a critical success factor. It has been proven that such a collaborative innovation relationship enables participating organisations to get access to complementary capabilities and shorten development time while sharing innovation costs and risks (Sampson, 2007).

Practically, the success rate of collaborative innovation is not high (Keupp, et al., 2011). Effectively measuring and managing the performance of collaborative innovation can be an essential component of collaborative innovation success. It is crucial to continuously evaluate, monitor and manage the participants' performance during the collaborative

innovation process. There are various factors which influence the effectiveness of collaborative innovations. Business climates and environments influence the strategic alignment in collaborative innovation. Performance of a collaborative innovation partnership is influenced by the individual's organisational structure, strategy, technology, leadership, employee and experience. During the process of working on a partnership, the performance of collaborative innovation is influenced by trust and network building, decision making, conflict resolution, commitment, and contribution. At the stage of commercialising the innovation, quality and time to market is influential on the performance of collaborative innovation.

Performance measurement has been implemented in individual organisations for improving its own performance, e.g. Balanced Score Card is one of the most famous performance measurement frameworks based on four perspectives: financial, customer, internal business and innovation (Kaplan and Norton, 1992). Different from individual implementation, performance measurement in collaborative innovation should include the development of strategies and actions that all participating organisations need to take for improving performance based on the results provided by the collaborative performance measurement (Li *et al.,* 2009).

Previous research has presented that the complexity of implementing performance measurement in collaborative organisations consists in the management of the whole collaborative system, as a virtual organisation. The evaluation should include measuring the contribution of partners and the interaction amongst partners. However, there is not sufficient discussion on measuring performance implications to improve effectiveness of collaborative innovation (Bititci et al., 2012; Nudurupati et al., 2011; Franco-santos, 2012).

1.1 Research aim and objectives

The main aim of the research is to develop a theoretical model to support collaborative partners to design a PM system for improving effectiveness of CI. It involves exploring what affects effectiveness of CI and how collaborative organisations design performance measurement systems in the context of CI. In order to achieve such research aim, the following objectives will be achieved:

Objective 1: To have a deeper understanding of how collaborative innovation projects measure the CI performance and design CIPM systems.

Objective 2: To conduct a critical analysis of the factors affecting the development of effective CIPM systems.

Objective 3: To develop a process for designing CIPM systems.

Objective 4: To provide collaborative innovation organisations a step-based theoretical model and construct to support the CIPM systems.

1.2 Research structure

Figure 1 illustrates the structure of the thesis, displaying titles of each chapter and stages of research. It also presents logic flows between chapters, based on respective contents. There are eight chapters in this thesis.

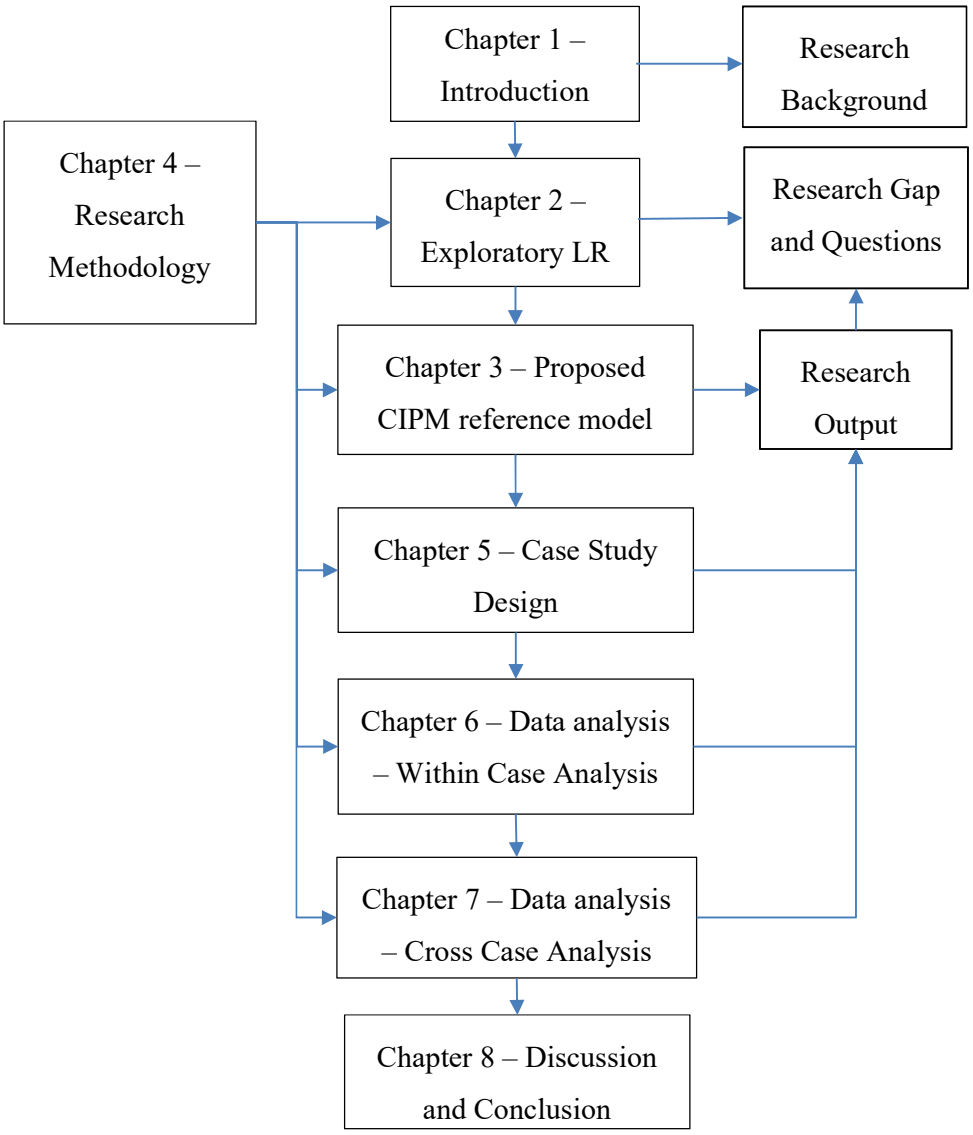


Figure 1 Research and thesis structure

The thesis is structured in eight chapters and the summary of each chapter are listed as follows:

Chapter 1 – Introduction – presents the background of the research, including introducing starting point and scope of the research, discussing research objectives, and displaying flowchart of thesis structure. The purpose of this chapter is to give readers a clear vision of what and how this research are conducted in relevant important topics and areas covered.

Chapter 2 – Exploratory Literature Review – presents an exploratory literature review with the purpose of building gap in existing knowledge. Theoretical definitions and understanding about Collaboration, Innovation and Performance Measurement and Management are discussed in this chapter. Also, research questions guided by knowledge gap are defined as the main outcome of this chapter.

Chapter 3 – Proposed CIPM reference model and construct – presents focused literature review on Collaborative Innovation and Performance Measurement and Management in detail. The CIPM Reference Model as conceptual framework and CIPM Construct as practical guideline are developed based on reviewing and critically analysing relevant literature. There is also an attempt to answer Research Questions 1 and 2 from theoretical analysis angle.

Chapter 4 – Research Methodology – presents review in methodology literature, including various research paradigms, critical philosophical positions and relevant research strategies. The purpose this chapter is to formalise the research and define appropriate philosophical paradigm and strategy for this research.

Chapter 5 – Case Study Design – presents discussion of research design issues being applied in this research. The purpose of the chapter is to display primary research strategy, case study design, and unit of analysis. This leads to confirming methods of how data would be collected and analysed.

Chapter 6 – Data Analysis (Within Case Analysis) – presents analysed data collected from the case studies. The findings of each case are displayed in the table as a summary of what has been identified and compared between theory and practice.

Chapter 7 – Data Analysis (Cross-case Analysis) – presents analysis about findings from different cases and comparisons about findings against the reference model developed in Chapter 5.

Chapter 8 – Discussion and Conclusion – presents the key conclusions which are drawn from this research. Contribution and limitation of this research to the theory and practice are also discussed. The final chapter also outlines the overall quality of the research and identify the areas for the future research.

1.3 Understanding the terms

In this research, some terms include abbreviations, which will be used a lot in the whole thesis when referring to the specific key word. Their specific meanings in the context of this research study will be explained below.

CI - Collaborative Innovation – is defined two or more organisations working together through exchanging, sharing and transferring knowledge, expertise, information and even risks, in order to generalise and commercialise the creative ideas in practice.

PM - Performance Measurement is defined as the set of metrics used to quantify both efficiency and effectiveness of actions. Performance measurement serves the purpose of monitoring performance, identifying the areas that need attention, enhancing motivation, improving communication and strengthening accountability (Ates et al., 2013).

PMM - Performance Measurement and Management is the process to evaluate organisation/project/process performance based on various criteria and improve the performance through appropriate approaches (Bititci, 2015).

CIPM – Collaborative Innovation Performance Measurement – a performance measurement system that enables the collaborative innovation organisations to monitor the collaborative performance during the project time, meanwhile, stimulate

improvements for the participated organisations' collaborative and individual's performance. In this research, it refers to the effective design process, not the implementation.

The above explanations only provide general understanding about the terms. There will be more detailed explanation about the terms in Chapter 2.

Chapter 2. Exploratory literature review

Although a significant number of studies have been conducted in the fields of collaboration, innovation, performance measurement, and performance management, systematic understanding in this area is yet to be established. Therefore, many scholars have attempted to critically review the links between business performance, collaboration and innovation (Ellwood et al., 2017). Attention has been paid to the impact of collaboration on product or service innovation, performance measurement on collaboration or innovation, and managing collaboration or innovation performance (Najafi-Tavani et al., 2018; Fenema and Keers, 2018). A systematic literature review based on analysing previous studies in this chapter presents a theoretical foundation and identifies a research gap.

2.1 Process of selecting literature

In accordance with previous scholars, this research applies a strategy which has been designed to understand collaboration, innovation and performance measurement in a systematic way (Pittaway et al., 2004). The systematic literature review process consisting of four steps from the methodological perspective (Denyer and Tranfield, 2009):

Step 1: Specifying the focus of the literature review and formulating research aim and question.

The purpose of the literature review is to achieve the research aim and objectives mentioned in Chapter 1; thus, the genera research question on the link between collaborative innovation and performance measurement and management.

Step 2: Locating the research

By running searches using different key words in various databases, a great amount of results were gained. The relevant key words used in the search are: performance measurement, performance management, collaboration, innovation, inter-organisational

relationship, collaborative network, strategic alliance, cooperation, coordination, partnership, clusters, globalisation, and internationalisation.

They key databases were Web of Science, Emerald, Science Direct and ABI/INFORM with the search area were “Title”, “Keyword” “Abstract”, and “Full Article”. The result from the first round was 1082 files.

Step 3: Research selection and evaluation

There were 243 files were duplicates. After deleting the duplicates, selection was implemented based on scanning Title and Keyword and that lead to 661 files. The criterion was that papers must have been published in peer reviewed journals, or presented at renowned, refereed academic conferences.

The next selection was based on skimming Abstract, which reduced the result to 472. The removed 189 were not relevant to the research.

After reading the full article, 332 files were removed, and the final result was 140 articles. The criterion was that the papers must show a clearly defined measurement of success. In the previous literature, a considerable number of papers have researched the use of collaboration and innovation under certain conditions, but a limited number have focused on the in-depth success process of collaborative innovation. This criterion can guarantee a certain level of quality. The independent check can assure the accuracy and reliability of the papers.

Step 4: Analysing and synthesising

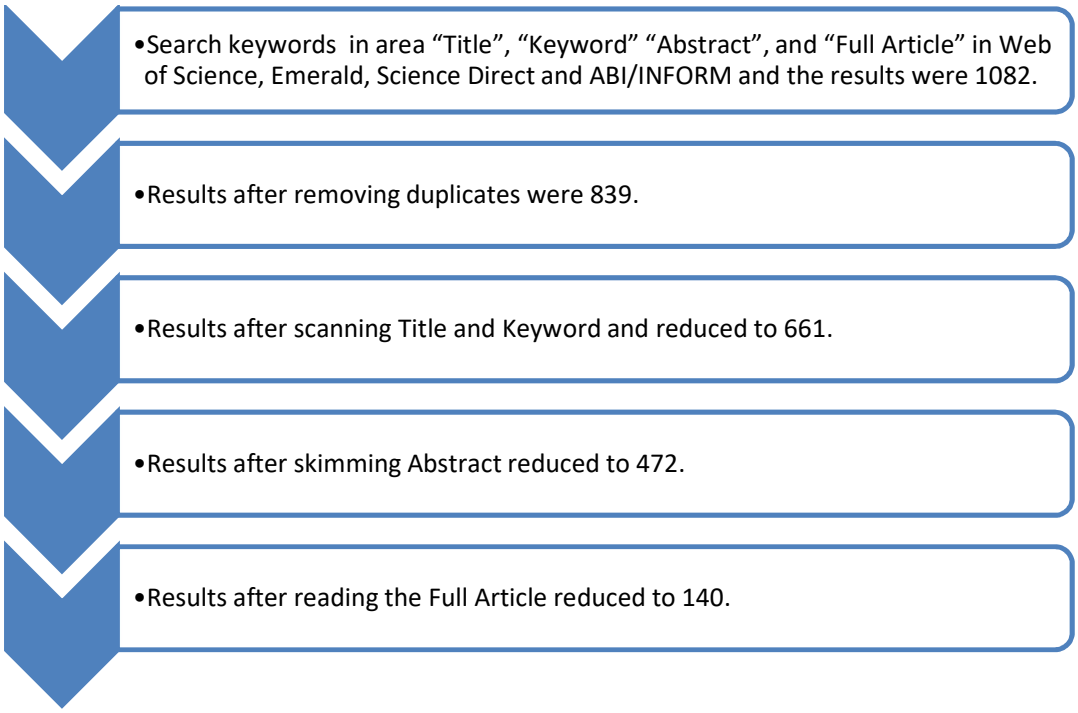
The 140 full articles were analysed based on the requirements as below:

- The innovation is defined narrowly as the performance outcome of collaboration. This narrow focus limits the scope substantially; therefore, well-founded conclusions about the topic of collaborative innovation can easily be drawn.
- Broad definitions of collaboration and innovation are included in this literature review. This research includes the entire spectrum, so both key areas and other

irrelevant aspects have been reviewed, such as licensing via R&D consortia, co-creation development, etc.

- Papers about the antecedents, processes, outcomes, and performance implications of collaboration and innovation are analysed deeply.
- Papers about performance measurement frameworks and processes in the context of collaboration or innovation are analysed deeply.

No criterion relating to the size of empirical studies was employed in this research, because it is not relevant in displaying general understanding. However, the scale of a case study can influence the generated insights and the conclusions of the research. The results of the systematic literature review (figure as below) provided guidance of achieving research aim and objectives from theoretical and methodological perspectives.



Flow diagram of systematic literature review

2.2 Collaboration

Nowadays, organisations are not treated as independent entities, as they are no longer operated in isolation (Spekman et al., 1998). Collaborations between two or more organisations are widely recognised to be an important source of innovation and competitive advantage in research to develop better or new results (Tether and Hipp, 2002; von Stamm, 2004; Bititci et al., 2003; Chapman and Corso, 2005; Tidd and Bessant, 2009). However, previous research has reported a high failure rate of collaboration (Bititci et al., 2009, de Man and Duysters, 2005). This section aims to provide a deep understanding about collaboration.

Collaboration is often used when individual organisations work together towards some common aims (Bititci et al., 2007). But it is not unique, because some other terms are often used to describe the phenomenon, such as relationships, partnerships or alliances (Bititci et al., 2004). No matter which term, they occur in situations where organisations cannot achieve their desired ends by working alone (Huxham, 1996).

2.2.1 Definition of collaboration

Some common definitions of collaboration given in the previous literature are as follows:

- Two or more organisations from the same or different countries join forces in order to implement a particular operation (Parker, 1994).
- Collaboration is a distinct mode of positive and purposive relationship, in which organisations still retain their autonomy, integrity and distinct identity, and may even possibly withdraw from the relationship (Cropper, 1996).
- During the process of collaboration, partners exchange information, alter activities, and share resources, risks, responsibility and rewards to enhance each other's capacity, gain mutual benefit and achieve a common purpose (Himmelman, 1996).
- Collaboration is a form of working in association with others for mutual benefit (Huxham, 1996).
- A number of organisations are linked to create and support a product or service for its service life, including final disposal (Jordan and Michael, 2000).

- Collaboration involves a number of autonomous organisations working together, pooling and sharing resources, information systems and risk for mutual benefit (Bititci et al., 2004).
- Collaboration is a system in which organisations, as relatively interdependent parts or subsystems, bring tangible and intangible resources to share, such as data, information, benefits and risks (Parung and Bititci, 2008).
- Within a single episode or series of episodes, two or more people engage in interaction with each other to work towards common goals (Patel et al., 2012).

Based on the process of shared creation or discovery, collaboration involves the creation of new value by doing new or different things. In the real world, collaboration is about resources being brought by different partners to transform and create different things or change (Thomson and Perry, 2006). As the purpose of organisations in entering into collaborative agreements is to achieve their own goals and self-interested expectations, the collaboration should arrive at the sympathetic implementation of shared preferences based on mutual understanding, collective will, and trust (March and Olsen, 1989). In summary, theoretically collaboration has been understood as various forms based on its existence differently in practice.

2.2.2 Collaboration in multi-disciplinary contexts

Collaborations vary depending on the different perspectives involved. From an early political point of view, collaboration often refers to two disputed dimensions, classic liberalism and civic republicanism. The former aggregates private preferences; while the latter's emphasis is a commitment to something larger than the individual (Perry and Thomson, 2004; Thomson and Perry, 2006). From the perspective of business and other areas, the relevant literature on collaboration mirrors this tension from the public administration area. However, Huxham (1996) and Bardach (1998) argue that collaboration needs a self-interest motive and meanwhile achieves organisational goals, usually by gaining better organisational performance or lower costs than would be the case if the collaborating partners acted alone. Moreover, Gray (1989) explains collaboration as an integrated process in which partners see their differences constructively explored by a problem, and search for solutions that go beyond their own

limited vision. This argument has been supported by Gray (2000), Huxham (1996) and Huxham and Vangen (2005). However, it is difficult to summarise these prior arguments, because collaboration should be considered as interdisciplinary, and its performance reveals the significant differences across different disciplines and different levels of collaboration (Qin, et al., 1997).

2.2.3 Co-operation, co-ordination and collaboration

All the above arguments provide a similar key concept in terms of the essence of collaboration: sharing. However, the different possible levels of sharing mean it is necessary to distinguish among the three stages of collaborative relationships: co-operation, co-ordination and collaboration (Spekman et al., 1998). Bititci et al. (2009) supported this argument and stated that different levels of collaboration are related to different levels of sharing of resources, risks and benefits. According to Spekman et al. (1998), the starting point for interaction is cooperation, in which organisations exchange essential information, and share resources with moderate mutual adjustments. Cooperation usually involves an informal and short-term relationship with low-intensity and little structure, in which each partner retains their own decision-making authority, identity, autonomy and responsibility for their own actions. This relationship is low risk, because only information and resources regarding the specific topic of cooperation are shared between organisations (Parkinson, 2006). The next level is co-ordination, in which specified workflow information, EDI (Electronic Data Interchange), and other mechanisms are intended to make traditional linkages between trading partners with little mutual adjustment. This level of relationship reflects the set of tasks that each partner expects the other to achieve, and their mutually agreed objectives. Partners share more information and resources to build a more formal and longer-term relationship. They play more specific roles, involve more responsibilities and risks, and even give up some autonomy and decision-making authority (Parkinson, 2006). As the third and highest level of partnership, collaboration requires a high level of trust, commitment, and risks and benefits sharing among partners. With the highest intensity, collaboration has been considered as the best form of partnership among the three partnership forms outlined here (Spekman et al., 1998). Each partner, in this relationship, is accountable to

the others, and to the whole partnership in terms of agreement. The risks are higher as well, since partners pool resources and information. However, they can gain better benefits and performance outcomes with making decision-making processes based on a common structure and goal (Parkinson, 2006).

As the above analysis shows, collaboration is the most difficult but, at the same time, the most effective governance mode to achieve mutual benefits. This research focuses solely on this most advanced form of integration.

2.2.4 Types of collaboration

Working in a collaborative relationship has a long-standing history, but it has taken different forms in different time periods. At the beginning of the last century, mergers and acquisitions began to increasingly take place, and peaks happen in the 1920s, 1960s and 2000s occurred in line with major periods of technological change. Before and during the 1980s, organisations gradually started new forms of collaboration, such as joint ventures, joint development agreements and various types of technology-sharing agreements. Over the past decades, the definition of collaboration has been gradually formed and has gained increased attention in the academic literature. The literature has provided rapidly growing and broad discussions of the use and structure of collaboration; however, studies addressing the relative merits of the mode of collaborations in terms of effectiveness have been scarce. A possible reason for this gap in the prior research is that one collaboration form is best suited to each particular situation (de Man & Duysters, 2005). Different forms of collaboration can have distinct impacts on the performance of the relationship. Based on level of complexity in the relationship, this research summarises seven common forms of collaboration found in the literature and discusses their respective characteristics.

- *Alliances*

Alliances, or strategic alliances, come in different forms such as licensing, joint ventures, publicly funded partnerships, etc. The prior literature defines an alliance as two or more organisations forming a team based on the co-operative agreements for sharing reciprocal inputs, while still maintaining their own organisational capabilities

(de Man & Duysters, 2005). This voluntary arrangement involves the partners in the exchange, sharing, and co-development of products, technologies, or services (Gulati, 1998). In modern times, although the average alliance success rate remains poor, it has become an important vehicle for maintaining competitive advantage in an era of turbulent technological change (de Man & Duysters, 2005).

The biggest advantage of alliances is that a number of transactional and contractual differences can be eased in the relationship through the use of a collaborative agreement (Hennart, 1998). Partner organisations, no matter how large or small they might be, can gain significant reductions in lead times, costs and risks in large projects, and a higher integration of complementary knowledge in alliances. In a particularly high-tech market, an alliance can aim at developing a specific promising technology, enabling organisations to rapidly bring products to the market and subsequently to competitive advantages and increased innovativeness. This is the radar function of alliances (Duysters & de Man, 2003). However, alliances can also have a negative impact on performance within a relationship, mainly because of the difficulties in knowledge transfer which may occur when partners have different organisational cultures with regard to sharing, or when partners are competitors in the same industry, aiming at absorbing each other's knowledge, skills and other assets (Lane and Lubatkin, 1998; Duysters, 1996). Therefore, the success of an alliance is associated with the operational, strategic and cultural differences between partners.

- *Mergers and Acquisitions*

Mergers and acquisitions encompass the combination of operations of two independent organisations into one entity. M&A can happen between two roughly equal organisations; alternatively, one organisation may take major ownership in another organisation (Hagedoorn & Duysters, 2002). The easy transfer of knowledge and technology from one organisation to another is the biggest advantage of M&A (Larsson et., 1998); so, organisations tend to seek acquisitions to avoid high transaction costs and solve tacit knowledge transfer problems (Bresman et al., 1999). Moreover, by spreading the risks and budget through M&A, organisations can reach economies of scale, engage in larger and more projects, combine strengths, and gain the advanced technological

development that each partner on its own would be unable to achieve (Gerpott, 1995; de Man & Duysters, 2005). However, mergers and acquisitions also have disadvantages, the most obvious being that much time and effort is needed to deal with complex change in the individual organisations involved, which may distract or divert management's attention onto one project (de Man and Duysters, 2005). Moreover, this form of collaboration may cause knowledge indigestibility, which means that a organisation may gain useless knowledge which goes beyond its requirements (Hennart & Reddy, 1997). These problems come from the same cause: M&A brings complex change in the entire organisation, but the knowledge exchange is limited to a small part of the partners involved (de Man & Duysters, 2005).

- *Supply Chain Collaboration*

Supply chain collaboration is 'an integrated process of designing, developing, optimizing and managing the internal and external components of the supply chain system (including material supply), transforming materials and distribution the finished products or services to customers in a way that is consistent with overall objectives and strategies' (Spekman et al., 1998). Christopher (1992) developed the definition that it is the network in which suppliers, manufacturers and distributors interconnect with each other in different processes and activities so that organisations can deliver value in the form of products and services to their end customers. Another interesting conceptualisation is provided by Parung and Bititci (2008), which is that this form of collaboration involves putting effort into working with the supplier's suppliers to deliver final products and services to the customer's customers. Normally, collaboration with customers and suppliers is dyadic, since it plays an important role in generating innovation. At the level of upstream collaboration with suppliers, organisations can find out what they have, such as specific resources and capabilities, and define what they demand. At the level of downstream collaboration with customers, organisations can find out what the specific market needs are, and understand what they can provide to satisfy customers. This beginning-to-end or end-to-end process provides organisations with all the necessary channels to share data, information and resources; however, it is not common to share risks and benefits with other partners in supply chain collaboration.

- *Extended Enterprises*

Childe (1998) defined extended enterprise as a business system in which purchasing organisations and suppliers collaborate closely to maximise the returns to all partners. Bititci et al. (2004) also contributed to the understanding of extended enterprise, stating that in this system, the members combine their core competencies and capabilities to create a specific competence. The advantage of extended enterprise is that organisations across boundaries participate in decision-making processes. Also, it is common that partners in an extended enterprise share data, information, resources and risks to achieve mutual benefits (Parung and Bititci, 2008).

- *Virtual Enterprises*

Virtual enterprise is defined as a temporal type of extended enterprise (Parung and Bititci, 2008). In this relationship, organisations do the same as other types of collaboration in that they share resources, information, data and risks. Moreover, members use their complementary capabilities, competencies and intellectual strengths in order to gain individual competitive advantages and maximise their overall performance (Bititci et al., 2004). In this dynamic relationship, partners share complementary competences for achieving specific business objectives within an agreed time period (Kochhar and Zhang, 2002).

- *Clusters*

Carrie (1999) defined a cluster as a network of organisations, including organisations, customers and suppliers, and even including their materials, components, equipment, training, finance, and so on. One of the common characteristics of clusters is the assembly or concentration of geographically linked organisations and institutions. Porter (1998) also identified that one advantage of clusters is that specialised inputs of interlinked industries and entities are included due to their competitiveness, e.g. the suppliers' components, machinery and services, and the buyers' requirements. It is common that partners share data, information, resources and sometimes risks to achieve this (Parung and Bititci, 2008).

Based on the understanding of theories from previous studies, collaboration, in the context of the research conducted in this thesis, is considered as a relationship entered into by two or more units with different cultural backgrounds to achieve common goals. Such relationship is mutually beneficial and well-defined. The partners share the knowledge, commitment, responsibilities, resources, rewards and risks, and authority to bring tangible and intangible resources into the relationship. In the relationship, partners make use of and absorb complementary resources in generating mutual and individual innovation.

2.2.5 Benefits of collaboration

Collaboration is considered as a strategic tool by organisations which they can use to increase their competitiveness, because it can bring various beneficial perspectives to organisations. Collaboration provides opportunities for an organisation to make improvements, since an organisation's capabilities are strengthened by the complementary resources contributed by its collaborative partners. The organisation also has the potential of creating dyadic and collective forces through collaboration, because resources tend to be a fluid entity. One of the fundamental ideas of this perspective is that collaboration offers an opportunity to maximise resources. Another key function of collaboration is that it improves a organisation's innovation capability (Beamish, 1988; Hagedoorn, 1995; Inkpen, 1996; Powell et al., 1996; Dooley et al., 2013).

The benefits from effective collaboration will vary according to the type of businesses or organisations involved, and can be categorised into three main categories:

- Operational benefits: collaboration helps to improve the efficiency of new product development by reducing the process cost, inventory cost (McLaren, et al., 2002; Parker, 2000, Holton, 2001; Hansen and Nohria, 2004), and transaction cost (Muller, et al., 2002; Lundin, et al., 2004), when organisations and their suppliers operate in close cooperation (Nolan, 2002). Moreover, collaboration is helpful in achieving attractive innovation (Arbonies and Moso, 2002), and decreasing the failure risk in new product development (Parker, 2000; Pittaway et al., 2004; Perks, 2000). When

the partnership cannot work well and the contract cannot be completed, collaboration can help organisations to safeguard their property rights (Pittaway et al., 2004).

- Market benefits: based on sharing their resources and knowledge about market and customers through a collaboration, organisations can enhance their customer service by better understanding their customers' needs (Stamm, 2004), improving the quality of their products (Lewis, 1990; Elmuti, et al., 2001), and minimizing customer complaints (Lewis, 1990). Collaboration is also believed to be an effective way to increase profits through sharing expertise across organisations (Hansen and Nohria, 2004), obtaining market intelligence (McLaren, et al., 2002), gaining market access (Parker, 2000; McCarthy and Golicic, 2002; Gonzalez, 2001; Elmuti, et al., 2001; Stamm, 2004), facilitating international expansion (Bitran, et al., 2002) and increasing market share (Lewis, 1990).
- Organisational benefits: Hamel and Prahalad (1989) state that collaboration helps organisations to make technological advances and gain market access at relatively low cost. Organisations also can gain improved decision-making and better insights from their partners' business practices and strategies, which can support them in efforts to develop benchmarks through an examination of their collaborative partners' practices. Moreover, collaboration can enhance organisations' capabilities, skills and knowledge based on integrating the resources of their partners (Bititci, et al., 1998; Stamm, 2004; Porter, 1998; Arbonies and Moso, 2002; Gonzalez, 2001), particularly the ability to pursue goals which involve distributed units or organisations (Hansen and Nohria, 2004). Among the most important motivations for organisations to collaborate is to exchange technology (Bitran, et al., 2002), to handle growing technological complexity (Marxt, et al., 2002), and to gain recognition of the value of intangible assets (Muller, et al., 2002).

Overall, in order to manage the collaboration effectively and achieve the benefits described above, an organisation should be aware of the potential disadvantages which can also arise. To sum up, there are a number of benefits could arise from collaboration. One of them, which is the topic of this research, is that it can support the generation of innovation.

2.3 Innovation

Collaboration has been discussed and presents in previous section. It helps organisations keep innovative and improve performance effectiveness (Najafi-Tavani el al., 2018). This section provides the theoretical knowledge of innovation, including definition of innovation and types of innovation.

2.3.1 Definition of innovation

In literal terms, innovation means introducing something new. Innovation in the business and organisational context is about management activities in the process of idea generation, technology development, manufacturing and marketing of a new (or improved) product, or the first commercial use of a new (or improved) manufacturing process or equipment (Trott, 2002).

Invention and innovation are often confused. One of America's most successful innovators, Thomas Alva Edison, thought that invention is as simple as coming up with new ideas, while innovation is the process of making the inventions work both technically and commercially. According to Trott (2002), invention is the process of converting intellectual thoughts into a tangible new artefact, while innovation is the process of inventing and subsequently exploiting the resources to convert the invention into a product or technology which improves organisation performance. Compared with invention, innovation requires various types of resources. Trott's concept has been supported by Edwards et al. (2004) who defined innovation as the 'commercial exploitation of ideas'. In more detail, innovation is not only purely invention or the creation of new ideas, but also involving diffusion and subsequent application of ideas in society (Trott, 2002). Therefore, innovation implementation has three main stages: theoretical conception, technical invention, and commercial exploitation.

Although innovation has been widely recognised by organisations as a powerful way to secure competitive advantage, its success is by no means guaranteed. Fagerberg (2006) concludes that an organisation normally needs to combine several different types of knowledge, capabilities, skills and resources in order to turn an invention into an

innovation. Innovation has been always seen as a crucial factor in strengthening the competitiveness of a business. Therefore, it is necessary to have a full understanding of the innovation process in order to be able to manage an innovation well.

2.3.2 Types of innovation

The categorisation of innovation is varied since it can be identified by form, outcome, process, or impact, for example on finance, process speed, etc. Smith (2009) categorised forms of innovation into product innovation, service innovation, and process innovation. They are explained in more detail below.

- Product innovation – products are tangible physical objects (Smith, 2009), for example, mobile phones, cars, or televisions, which customers use after purchase. Innovative products often persuade consumers to make a new purchase, and sometimes upgraded technology in an existing product attracts customer interest.
- Service innovation – in contrast to product innovation, services are intangible (Smith, 2009). Service innovation can have as much impact as product innovation on consumers; however, it can be difficult to identify in terms of tangible objects. Online banking, online shopping, PayPal, social media, etc., all are the good examples of service innovation.
- Process innovation – this category of innovation covers the innovative way of delivery or serving of a product or service. New equipment, new methods, and new systems are normally required for process innovation support. Quite often when process innovation is mentioned, people consider it as a manufacturing process; however, it also includes innovation in the service delivery process.

Product innovation, service innovation, and process innovation accelerate each other's development and implementation. As mentioned earlier, online services have become vital nowadays, as numerous organisations offer online transactions and online customer services to consumers due to the huge growth of the internet.

In addition to the types of innovation listed above, other criteria have also been used to differentiate innovations. Categorising types of products in terms of their degrees of novelty has been a widely-used approach. Freeman (1974) and Smith (2010)

categorised innovation into radical innovation and incremental innovation to distinguish between big-change innovation and small-innovation. Normally, innovations that involve new technologies, major breakthroughs, and major scientific advances would be categorised as radical innovations; while innovations that involve only product improvement would be categorised as incremental innovations.

This way of differentiating innovation into radical and incremental innovation has, however, been criticised as too limited. Henderson and Clark (1990) developed a more complex and sophisticated analytical framework, the key point of which was that products, services and process are considered as a system. In order to provide new innovative functions, the system should be made up by the right components that fit together in a particular way. Two distinct types of knowledge, component knowledge and core concept are normally required in making a product, service, or process. Based on the two types of knowledge, innovation is differentiated into four categories (Henderson and Clarke, 1990). The core concepts can be added based on existing or can be brought completely new. In order to categorise the innovation, it is important to clarify if the core concepts can be transformed to innovative outcomes based on using components in the organisations.

		Core Concepts	
		Reinforced	**Overturned**
Linkages between Core Concepts and Components	**Unchanged**	Incremental Innovation	Modular Innovation
	Changed	Architectural Innovation	Radical Innovation

Table 1 Types of Innovation

- *Radical Innovation*

Henderson and Clark (1990) defined radical innovation as 'radical innovation establishing a new dominant design, and hence a new set of core design concepts embodied in components that are linked together in a new architecture.' Normally, the

new components of this new architecture introduce a new technology into the marketplace or the industry. Not only is new technology generated, but a new business model may also be brought into the market.

Launching a completely new product or an existing product is a big, difficult and risky task for organisations. Radical innovations are relatively rare and have been estimated at a maximum of 10% by Rothwell and Gardner (1989a). Due to the huge changes it brings and the completely new nature of radical innovation, dramatic consequences are involved; for example, new market research, new technical support, probably completely new marketing and advising, etc. In order to secure the success of new innovation, right organisational capabilities are required. Launching a new innovation through new entrants is usual for radical innovations (Smith, 2006). The iPod is a typical example of this.

Radical innovation is a similar concept to Christensen's (1997) 'disruptive technologies'. The notion of disruptive technologies refers to technology which has significant changes by the markets and industries, often with high levels of uncertainty.

As Table 1 shows, overturned core concepts are reinforced in radical innovation and components are changed from core concepts. Radical innovation normally involves great changes, and has more dramatic consequences than other types of innovations for the organisations developing them. These great changes will lead an organisation into a period of higher uncertainty, and different organisational capabilities will also be required.

- *Incremental Innovation*

Smith (2006) defined incremental innovation as involving modest changes to existing products, services, or processes, and exploiting the potential of an existing design. The changes brought by incremental innovation cannot be major, and this kind of innovation is limited to the introduction of new components to existing products, services, and processes, making it distinct from radical innovation. The novelty of incremental innovation is low. Christensen (1997) defined incremental innovation as "a change that builds on a organisation's expertise in component technology within an established

architecture". This definition stresses that the important feature of incremental innovation is the product of existing practice and expertise associated with an existing technology, rather than a new technology.

Compared with radical innovation, incremental innovation is much more common. It is something that often happens in order to bring gradual improvements into a system, rather than a replacement. These changes exploit the potential of the current design using existing technologies (Smith, 2006). As Table 1 shows, incremental innovation's feature is that core concepts and components remain the same as core concepts reinforces. The architecture of the system is likely to remain unchanged; a new model of an existing and established product is refined in relation to particular components. For example, an organisation can improve the efficiency of an automatic washing machine by fitting more powerful motors to give faster spin speeds; this is a type of incremental innovation. As illustrated in Table 1, the components are reinforced, while the existing system/linkages are kept.

In terms of markets and industries, rather than creating a new market, the impact of incremental innovation tends to strengthen the position of the organisation, or to increase its market penetration, or to allow it to enter new market segments. In such case, the existing players continue to be the main bodies of incremental innovation.

- *Modular Innovation*

Modular innovation uses the architecture and configuration associated with the existing system of an existing product, but makes use of new components with different design concepts. It fits into the top-right box in Table 1.

Like incremental innovation, modular innovation does not involve a whole new design. However, it needs at least one significantly different component. The key feature of modular innovation is the use of new or different components, especially if the new components embrace a new technology, while keeping the system unchanged (Smith, 2006). The impact of modular innovation is usually more obvious than that of incremental innovation, and less dramatic than radical innovation.

- *Architectural innovation*

As Table 1 shows, architectural innovation does not feature changed components; however, the configuration of the system or linkage changes. Henderson and Clark (1990) explained that the essence of an architectural innovation is the reconfiguration of an established system to link together existing components in a new way. The focus of this innovation is applying the new system while keeping the components the same as in the past, or introducing only minor changes.

Although some research on innovation typology has been done before, it has not been possible to conclude which type of innovation is the best, since no innovation is perfect. Overlapping between innovation types are common, and hard to categorise. By using this innovation typology, organisations can evaluate the potential impact of a new and effective innovation, and decide on the right response to it.

Smith (2006) commented on innovation typology and pointed out its limitations. This categorisation is very product-oriented (Smith, 2006). When the innovation objective is service, it is harder to distinguish its system and components. Even when it refers to the innovation of products, it does not work under all circumstances; for example, it may struggle to describe innovations in chemicals or medicine. This typology focuses on technological impact, but overlooks the impact on society.

In the research presented in this thesis, innovation is understood as something that represents a new product, service, process or business model that is launched on the market or adopted as part of the production process in order to strengthen a organisation's competitiveness in the market. In order to gain good understanding of innovation, appropriate measures are needed. However, it is lack of knowledge about using performance measurement for innovation in existing research (Saunila, 2017).

2.4 Collaborative Innovation

The advantages brought by innovation have led to increased attention on the invention of novel products and on advanced technological production, such as investment in Research and Development (R&D) (Frosch, 2011; Hernandez-Espallardo et al., 2018).

However, traditional innovation models may not be sufficient to meet increased requirements. In addition, many organisations do not have sufficient financial, manpower, or research management resources to undertake effective innovation by themselves and are struggling to undertake effective innovation. As a result, they are increasingly entering into collaborative partnerships for innovation purposes.

In addition, innovation is about invention and change and quite often involves a high risk of failure. Therefore, organisations look for external opportunities in order to share the risks and secure the needed resources. Moreover, due to the pressure of optimising their capacity to innovate, organisations have to search beyond their organisational boundaries and collaborate with other organisations to achieve innovation (Rothwell, 1992; O'Sullivan and Dooley, 2008; Dooley et al., 2013). Activities like cooperating with external business can help an organisation to enhance and complement organisation-level innovation, and organisations which aim at introducing radical innovations are more likely to build collaborative relationships than organisations which practice incremental innovation (Tether, 2002; Weber & Heidenreich, 2017). However, Chapman and Corso (1995) argue that not only can radical or disruptive innovation be achieved by collaboration, but so can incremental innovation.

Organisations have concentrated on 'in house' product development for decades, but historically, many would-be innovators have been unsuccessful because it is not easy for organisations to innovate without new knowledge (Tether, 2002). The deeper reason is that most of them ignore the key source – collaboration - which would bring previously unconnected bodies of knowledge together (von Stamm, 2004). Therefore, external collaboration is critical for organisations intending to stretch their business boundaries and apply innovation in markets and business models.

2.4.1 Understanding Collaborative Innovation

Collaborative innovation is based on trust, reciprocal relations, and the time invested by the participating organisations in working together. Collaborative relationships have interactive and complementary influences on innovation (Freeman, 1991; Hagedoorn and Schakenraad, 1990). Von Stamm (2004) stated that collaboration brings a new body

of knowledge into organisations, and challenges their internal assumptions. In both product and service areas, collaboration can bring benefits through innovation: Bunduchi (2013) and Schiele (2006) provided evidence that collaborative New Product Development (NPD) is beneficial to the results of NPD, and Hsieh (2013) found that collaboration brings benefits to NSD (New service development) as well. NPD activities increasingly involve a range of collaborative arrangements with external partners across industries (Tapon 1989, Schiele 2006).

In collaborative innovation networks, the collaborative characteristics stand out in comparison to cooperation and coordination. Collaborative innovation involves higher levels of integration and interaction between participating organisations. Collaborative innovation involves mutual trust, in addition to the need for participants to work closely together and to share information, resources, responsibilities and risks to achieve common innovation goals (Ferreira et al., 2011).

The benefits of collaborative innovation are obvious; as has been discussed above, they include lower costs, lower risks, maximising complementary resources and knowledge, shorter development cycle, and improved product quality.

In summary, collaboration helps innovation mainly through the following ways:

- Reduced cost and risk: The most frequently given reason as to why innovators need collaboration is to share their costs and risks. Von Stamm (2004) also stated that accepting higher risk could be interpreted as being more innovative and open towards collaboration.
- Improving the speed of innovation: Innovation involves a competitive race, which is about time to market. It is important that an organisation can be the first to bring innovation into the market, but creation brings uncertainty, so delays usually happen. Von Stamm (2004) states that internal and external collaboration could resolve uncertainty and conflicts earlier. She also gave Ford as an example, which used the internet for collaboration between its own engineers and its suppliers. This collaboration in the supply chain involved downstream implications for design innovation before final decisions were made.

- Shared resources: Finding the required skills and resources in-house is not always possible: Collaboration can help organisations to access various sources of knowledge, expertise and specific organisational capabilities to achieve their innovation objectives (Chesbrough, 2003; Tidd et al., 2005; Dooley et al., 2013).
- Building strong relationship with partners locally and globally: organisations can identify required knowledge via making communication with collaborative partners locally and globally. The communication includes face to face and other high technological methods. Apart from that, close collaboration challenges existing assumption in organisations and partners together work on improving collaboration and innovation performance (Bathelt et al., 2004).

All in all, the benefits of effective collaborative innovation include increased market share, gaining new resources, cost reduction, reductions in development time and the risk of failure of new products, increased quality, etc. (Bititci et al., 2004).

2.4.2 Challenges of Collaborative Innovation

Theoretically, there are two major benefits in engaging external collaboration for innovation: organisation-internal perception is challenged; and the new body of knowledge or technology is brought to the organisation. However, there are also challenges for organisations in the innovation process, and collaboration can be useful to address these challenges:

- Collaborative innovation is risky and costly – how to assess and manage risk and cost. The common barriers to collaborative innovation are high levels of risks and costs, but risks and costs are directly linked. Thus, the most frequent motivation of an innovator to collaborate is the requirement to share risks and costs. It also seems that higher risk can bring more innovative elements, eventually creating openness towards collaboration (von Stamm & Riley, 2003).
- Dyer (1997) found transaction costs could be different when collaborative partners with commitments, scale and scope of exchanges are different, information sharing is different, and self-protection range is different. Refer to the role of trustworthiness, Dyer (1997) also found that greater information sharing would increase profitability, investments with relationship involved would make longer payback on return, and

the cost of investment on protecting collaboration would be less than gains so optimal levels of specific assets would be increasing (Ghoshal and Moran, 1996).

- Different bodies of knowledge need to be connected – how to manage the connection process. The value can be created by intra- and inter-collaboration, and the benefits of collaboration depend on the nature, evolution and dynamics of the relationship. Thus, the focus on collaboration shifts from building to governing process (Madhok and Tallman, 1998).
- The required skills and resources are usually not readily available 'in-house' – where to find resources. It is critical to get innovation to market first. Delays usually happen since creative novelty generates uncertainties, but these uncertainties and conflicts can be resolved by external collaboration. Upstream collaborations with suppliers lead to quick development and cost reduction, and downstream collaborations with customers reveal the implications of design innovation (Cowen et al., 2007). Moreover, organisations also gain resources through collaboration with suppliers or customers.
- Managerial roles disconnect different bodies of knowledge. Although the application of inter-organisational collaboration as a legitimate method for innovation is increasing, its success rate has been questioned (Spekman et al., 1996; de Rond, 2003; Dooley et al., 2013).
- At the beginning of collaboration is critical – lack of transparency before perceived benefits leads to low trust level and high mutual fear of opportunism. Collaborative partners need to be aware of connection between transaction cost of opportunism and defection. Early stage partners or lack of experience would rely on systematic and formal governance to achieve lower opportunism, reduced transaction cost, and improved efficiency (Parkhe, 1993).

The building of collaborative relationships with business partners such as customers, suppliers and universities has been widely accepted as a vital source of sustainability, innovation and competitive advantages for organisations (Pittaway et al., 2004; Tether and Hipp, 2002; Bititci et al., 2003); however, it is difficult to achieve successful collaborative innovation, and almost 50% of such relationships fail (Bititci et al., 2004).

In earlier research, the reasons for failure were not well known or explained (Keupp et al., 2011); although a high proportion of research and development efforts have been focused on collaboration or innovation. Therefore, it is necessary to investigate the reasons underlying the high failure rate and find methods to avoid potential risks when working in the collaborative partnership. One of the possible reasons is stated by Shaw and Burgess (2013), which is that collaboration and competition co-exist within and between partners. Moreover, Owen et al. (2008) conducted research about extended enterprise and provided another reason: as the trend is towards collaborating globally, it is more difficult to manage complex external partnerships involving different technologies, cultures, regulations and backgrounds to relations.

However, given the underrepresentation that most collaborative innovation actually fails to achieve and cannot successfully accomplish their objectives (Sadowski and Duysters, 2008; Keupp et al., 2011), it seems that performance of collaborative innovation needs to be improved.

2.5 Performance Measurement and Management

As a proven mature field in the research, Performance Measurement & Management (PMM) has been discussed by academic researchers, business consultants and industrial practical workers.

2.5.1 Definition of Performance Measurement

Neely (2007) defined performance measurement in basic terms as a process of assigning numbers to reflect the relationships of the attributes which are being measured. This means that the context and objective of performance measurement should be clearly defined in order to measure organisational performance.

In a previous work, Neely et al., (1995) defined performance measurement as including three interrelated elements:

- Individual measures that quantify the efficiency and effectiveness of actions;
- A set of measures that combine to assess the performance of an organisation as a whole; and

- A supporting infrastructure that enables data to be acquired, collated, sorted, analysed, interpreted and disseminated.

Traditionally, organisation performance was measured on the basis of financial accounting measures, such as return on investment and earnings-per-share; however, these can give misleading signals in today's competitive environment, so organisations must also evaluate their skills and competences to maintain continuous improvement and innovation. Therefore, in modern business world, instead of a single method focusing on the critical area of business, organisation managers want a balanced system of both financial and operational measures (Kaplan & Norton, 1992).

Performance management involves choosing appropriate indicators or metrics of critical success factors as well as defining criteria and areas of measurement. Performance measurement is a sub-process of performance management, which can aggregate sub-criteria and sub-indicators. Performance management covers performance measurement and other managerial aspects about maintaining performance effectiveness.

In previous work, relevant performance measurement factors have been identified as influencing the success of performance measurement: system maturity, organisational structure, organisational size and culture, management style, and information and communications systems. Performance measurement can include team measurement, and managerial measurement (Bititci et al., 2012). This research focuses on how to manage collaborative innovation measurement.

2.5.2 PMM and its evolution

Based on the results of performance measurement, a series of actions with proper performance management might be needed to improve performance. Performance management has been investigated most extensively and effectively as the process of quantifying the efficiency and effectiveness of action (Ferreira *et al.,* 2011). Although research into performance management has covered many areas, the key aim of performance management is to manage and improve individual and organisational performance through continuous adaption to the changing environment (Ates et al., 2013). A comprehensive performance management system in the context of

collaboration enables an organisation to proactively and strategically manage the collaborative business. Performance measurement is not enough to support the collaborative business, so both performance measurement and management must be considered.

The theory of performance measurement can be traced back to before the 13th century A.D., to the invention of bookkeeping systems (Mustafa & Saat, 2013). The basic early method of double entry bookkeeping remained unchanged until the Industrial Revolution (John, 1981; Bititci et al., 2012) in Europe in the 19th century.

Since the 1940s and 1950s, when Japanese organisations developed the theory of measuring performance, a great number of academic and industrial experts have developed different performance measurement frameworks (Mustafa & Satt, 2013). In the early 1950s, organisations focused on productivity management through quality control, time-motion studies, variety reduction, etc.

Performance measurement has gradually gained acceptance since Johnson and Kaplan published a seminal book in 1987 (Johnson & Kaplan, 1987). Neely (1999) reported that 3600 articles had been published on performance measurement between 1994 and 1996, reflecting the occurrence of a performance measurement revolution (Bititci et al., 2012). Since the late 1980s, increasingly complicated performance measure framework models have been developed in more and more fields (Folan 2005). Folan (2005) defined the term 'framework' as the active employment of particular sets of recommendations. A framework can assist in the performance measurement system-building process by clarifying boundaries, specifying its dimensions or views, and possibly also providing initial intuitions into relationships among the performance measurement dimensions (Rouse, 2003).

Thereafter, performance measurement theory developed from performance measurement (methods of measurement, objects of measurement, and reporting methods) into performance management, i.e. using measurement to manage the performance of an organisation (Ates et al., 2013). Nowadays, theories of performance measurement and performance management have been implemented in a variety of

areas (Bititci et al., 2012). The three main streams are: the operations perspective, the strategic control perspective, and the management account perspective. These streams can be further categorised into: operations management, manufacturing management, service management, strategic management, industrial engineering, facilities management, public sector management, psychology, human resources management and change management (Franco-santos et al., 2007, Morgan 1997, Stewart et al., 2007, in Bititci et al., 2012).

Earlier research has led to the conclusion that performance measurement should be integrated, balanced, and focused on customer/employee/stakeholder satisfaction (Bititci et al., 2012). Moreover, in terms of consideration of performance indicators, performance measurement can help organisations to measure whether or not their outcomes have achieved their objectives.

The evolution of Performance measurement and management discussed above is summarised in Table 2.

Table 2 Evolution of Performance Measurement

Early study	• 13th century, origins of performance measurement lie in double entry bookkeeping (Johnson, 1981)
Industrial Age	• Manufacturing models (Ford, 1922) and specialisation of labour (Taylor, 1911) • Transition from piecework payment to wage system to monitoring employee productivity (Johnson, 1981) • Organisational and managerial complexity keep increasing, leading to the delegation of power and control, and the emergence of divisional and departmental budgets (Bourne, 2001; Chandler, 1977)
1950s	• In its early stages, globalisation led to the development of productivity management methods such as quality control, time-motion study, and variety reduction. Productivity improvement is derived from the satisfaction of customers, employees, and stakeholders based on focused financial indicators (Johnson and Kaplan, 1987; Kaplan, 1983; Keegan et al., 1989; Neely et al., 1995)

1960-1980	• Economic emphasis changes from the supply side to the demand side, which leads to:
	  • A change of focus in performance measurement onto new dimensions such as quality, time, flexibility and customer satisfaction (Hayes and Abernathy, 1980; Kaplan, 1984; Slack, 1983)
	  • New recognition of performance measurement as a multidimensional domain (Dixon et al., 1990; Goldratt and Cox, 1986; Hayes and Abernathy, 1980; Kaplan and Norton, 1992; Keegan et al., 1989; Neely et al., 1995; Skinner, 1974)
	  • The development of more integrated and balanced approaches to performance measurement (Johnson and Kaplan, 1987)

1980-present	• To do the right things is more important to do things right (Drucker, 1994) - Focus of performance measurement was on whether the strategy could be implemented as intended and outcomes could be expected (Glueck and Jauch, 1984; Hax and Majluf, 1984; Wheelen and Hunger, 1983). This resulted in:
	  • An emphasis on integrated performance measurement on what to measure and how to measure, so that a strategy could be achieved (Bititci and Carrie, 1998; Dixon et al., 1990)
	  • Support of performance measurement frameworks to align business strategy and performance measures (Atkinson and Waterhouse, 1997; Bititci and Carrie, 1998; Bourne et al., 2000; Cross and Lynch, 1991; Dixon, et al., 1990; EFQM, 2013; Fitzgerald et al., 1991; Kaplan and Norton, 1992 and 1996; Neely et al., 2001; Keegan et al., 1989; Brown, 1996; Gunasekaran et al., 2001)
	• From performance measurement to performance management - Understanding that the management of organisational performance is facilitated by performance measurement (Adair et al., 2003; Bititci et al., 1997; Bourne and Neely, 2000; Haag et al., 2002; Kennerley and Neely, 2000; Nudurupati and Bititci, 2005).

2.5.3 Features of PMM

According to the literature on the development of performance measurement (Busi & Bititci, 2006), the major features of implementing performance measurement can be grouped as follows:

- From performance measurement to performance management: Measuring and managing overall performance based on measuring the actions involved in building collaborative relationships and achieving collaborative innovation. It is important for organisations to manage their performance based on measurements in different contexts.
- From individual to collaborative performance measurement: It is important for collaborative partners not only to measure individual performance, but also the

performance of their partnerships. This research gap has been identified by scholars (Pisano and Verganti, 2008; Bititci et al., 2012). This research would help organisations gain ideas about how to design their performance measurement based on the collaborative system.

- From lagging to leading performance management: This measurement will help collaborating partners to forecast the actions and implementation of the CI process (Ates et al., 2013). In order to achieve the expected results, organisations can make use of leading performance indicators to forecast future actions, rather than learning from previous lagging indicators.

2.5.4 Main PMM measure factors

What should be measured in performance measurement have been strategically identified in the literature. Time, quality, and flexibility are the most common factors that should be measured during the operation (Lynch and Cross, 1991; Kumar et al., 2018). Finance in various forms is also a critical factor that should be measured (Keegan et al., 1989). Apart from the above factors, customer satisfaction and human resources have been mentioned as important areas needed to be measured (Kaplan and Norton, 1992). Based on previous research (Kaplan and Norton; 1992, Lynch and Cross, 1991; Keegan et al., 1989; Hudson et al., 2002), the key measurable factors are listed below.

- Customer satisfaction: Service; Brand image; Market possession; Integration with customers; Competitiveness; Delivery reliability
- Direct outcomes – for example, the patents and publications (Perkmann et al., 2011)
- Finance: Cash flow; Market share; Overhead cost reduction; Inventory performance; Cost Control; Sales; Profitability; Efficiency; Product cost reduction
- Flexibility: Production effectiveness; Volume flexibility; New product introduction; Computer system; Future growth plan; Improvement on existing product or service
- Indirect outcomes – commercial exploitation of the innovation, and the follow-up opportunities that generated by the collaboration (Perkmann et al., 2011)
- Match between expected outcomes and the final achievements (Perkmann et al., 2011)

- Organisational resources: Employee relationships; Employee involvement; Workforce; Employee skills; Learning ability; Labour efficiency; Quality of work life; Resource utilisation; Productivity
- Quality: Product performance; Delivery reliability; Dependability; Innovation
- Time: Lead time; Delivery reliability; Process throughput time; Process time; Productivity; Speed of launch into market; Employee efficiency; Resource utilisation

In summary, after long-term development, performance measurement is set to maintain and improve organisational performance effectiveness via measuring specific and proper factors in various contexts. The current trend of implementing performance measurement is to measure and also manage influential factors from different angles achieving satisfactory performance effectiveness.

2.6 PMM applied to Collaborative Innovation

According to Bititci et al. (2012), the alignment between performance measures and business strategy can be supported through the use of appropriate performance models and frameworks. Therefore, it is important for the present research to investigate the extent to which performance measurement supports companies to achieve their innovation objectives through building collaborative relationships.

Depending on the organisation, one or several different measures of performance can be used at the same time. The prior literature shows that performance measurement includes the development of the strategies and actions that the organisation needs to develop and take to improve its performance based on the results provided by its performance measurement (Ittner et al., 2003; Li et al., 2009). This raises the question of how to decide which performance measures should be used to monitor collaborations. In fact, it is necessary to implement one or more methodologies or frameworks that can help to achieve a successful collaboration (Busi and Bititci, 2006; Ferreira et al., 2011).

Collaborative innovation, performance measurement, and performance management have been discussed in research in many contexts, including human resource

management, operations management, business strategy, marketing, finance, accounting, organisational behaviour, industrial economics, psychology, politics, and law, etc. (Smith and Goddard, 2002; Franco-Santos et al., 2007). According to Frost and Sullivan (2006) and Patel et al. (2013), collaboration, an organisation's strategic orientation, and market turbulence are three main drivers of business performance; and collaboration makes the most impact among the three driving factors. In this research, the achievement of an innovation objective through collaborative relationships is seen as the main driver of improving business performance.

The driving force of collaboration is to create a win-win situation between collaborative partners through creating valuable trust, strong commitment and improved performance (Ferreira et al., 2012). It is therefore vital to evaluate and continuously monitor the performance of the participants during the collaborative innovation process. Due to the complexity of collaboration, it is often quite challenging for organisations to decide how best to do so. Financial measures are the most common method used to assess the performance of participating organisations. However, according to the reviewed literature, evaluating and monitoring collaborative innovation performance using financial measures is not sufficient on its own (Johnson, 1983; Kaplan, 1984). The measurement criteria should be able to reflect the overall outcome of collaborative innovation in terms of financial and non-financial measures, internal and external measures, and efficiency and effectiveness measures (Keegan et al., 1989; Kaplan and Norton, 1992). Data regarding key performance indicators (KPIs), key success factors (KSFs) and key performance factors (KPFs) should therefore be gathered in relation to the collaborative process.

Prior literature shows that performance measurement includes the development of the strategies and actions that the organisation needs to develop and take to improve its performance based on the results provided by its performance measurement (Ittner et al., 2003; Li et al., 2009). Depending on the organisation, one or several different performance measures can be used at the same time. This raises the question of how to decide which measures should be used to monitor performance of collaborations. According to Bititci et al. (2012), the alignment between performance measures and

business strategy can be supported through the use of appropriate performance models and frameworks. Therefore, to support organisations to achieve their innovation objectives through building collaborative relationships, it is important for organisations to apply a suitable performance model.

With regard to performance measurement in collaborations between organisations, most performance frameworks still focus on a single organisation, and traditionally aim to measure the effectiveness and efficiency of actions using financial lagging indicators, i.e. variables such as cost, quality and time. With the development of performance measurement, non-financial leading indicators have been measured by many organisations, including customer satisfaction, product quality and innovation (Nudurupati et al., 2011). Collaborative innovation aims to help organisations to create and commercialise innovation in a timely and cost-efficient manner, as this has become a big challenge for organisations. In collaborative business, collaborative performance measurement and management depends on the performance of the individual partners in terms of their knowledge and capabilities (Evans et al., 2004; Chiesa et al., 2009; Yin et al., 2011; Ferreira et al., 2012).

A number of researchers have demonstrated that the complexity of implementing performance measurement in collaborative enterprises lies in the management of the whole collaborative system as a virtual organisation. According to Bititci et al. (2012), there is little prior grounded empirical research of performance measurement on collaborative systems. The authors asked 'how do organisations manage the performance of the collaborative organisation while also managing the performance of the participating organisations as a complete system?' The existence of this research gap is also supported by Nudurupati et al. (2011) and Franco-santos et al. (2012). However, Pisano and Verganti (2008) previously argued that choosing suitable collaboration options is more important in ultimately achieving the desired innovation results. Moreover, Holmberg (2000) stated that 'most organisations are unable or unwilling to measure and manage performance collaboratively with partners.' According to Neely et al. (2000) and Parung and Bititci (2008), organisations need be careful to evaluate their partners when the organisation wants to join in partnership. The evaluation should

include measuring the contribution of the partners and the interaction amongst the partners. However, measurement is not the solution to all the possible problems in collaborative relationships. Failure may occur for other reasons such as a lack of appropriate performance measurement in the collaborative system. However, some performance measurement frameworks in an inter-organisational context focus on 'extended process and attempt to measure the effectiveness and efficiency of inter-organisational actions and work flows' (Lethinen and Ahola, 2010; Bititci et al., 2012).

Collaboration can benefit innovation, but does not always do so. It is difficult to evaluate innovation within the whole collaborative system or process. Katila (2007) argued that innovation needs an integrated and balanced framework if it is to be measured and managed. Her study on biotechnology collaboration displays evidence of the negative effects of collaboration on radical innovation output. Therefore, it is necessary to build an integrated performance measurement framework to effectively measure and manage innovation performance, particularly in a collaborative system.

2.7 Evaluation of existing PM approaches

A number of performance measurement frameworks or approaches have been utilised for many years by organisations to define what measures can be used to assess the organisational performance. In the early period of early 20th century, the pyramid of financial ratios has been used by DuPont, but this and other similar purely financial measurement systems have been criticised by scholars; the systems overemphasise historical financial aspects and encourage short-termism (Neely et al., 2007). Therefore, managers keep updating and searching for better and more balanced measurement systems designed to enable adoption of non-financial measures to supplement the financial measures. As a development, performance measurement models can better capture the breadth of organisational objectives, and help organisations implement balanced sets of measures.

It is necessary to implement some methodologies or frameworks for measuring and managing the collaboration process (Busi and Bititci, 2006). This section aims to present the most common performance measurement approaches and frameworks. Each

of the performance management models was designed to serve specific purposes and support decision, in terms of a specific concept. It is helpful to identify an appropriate set of measures to evaluate CI performance.

2.7.1 Balanced Scorecard

Kaplan and Norton (1992) created the Balanced Scorcard (BSC) in 1992, based on a one-year research project. The main objective of this model is to provide top managers 'fast but comprehensive view of the businesses'. Balanced Scorecard is the most popular performance measurement framework. By 2001, 44% of organisations worldwide had adopted this performance measurement model (Neely et al., 2007). BSC is a simple, but an effective framework for performance measurement, and has had a significant influence on the development of performance measurement (Neely, et al., 2007; Bititci et al., 2005).

The BSC framework uses to identify financial and operational measures to four perspectives, including customer, internal, organisational innovation and learning, and financial perspective (Figure 2).

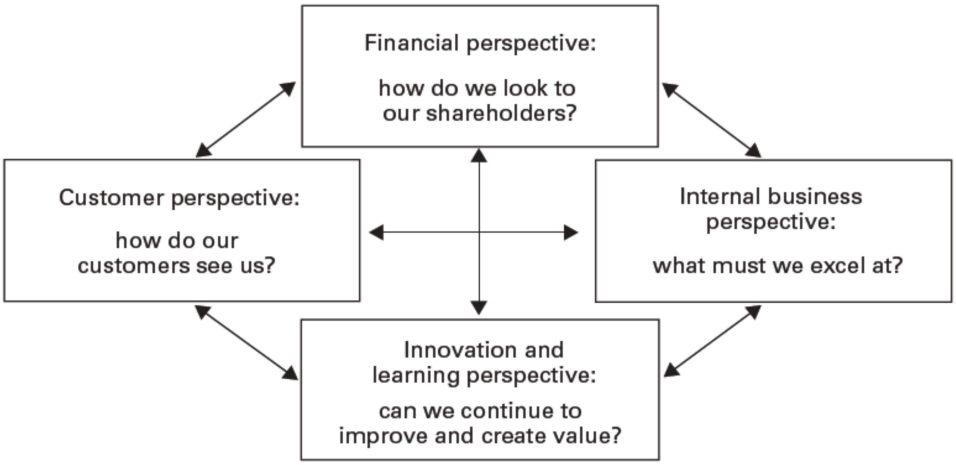


Figure 2 Balance Scorecard (Source: Kaplan and Norton, 1992)

Although BSC can be reflected in many attributes of measurement, it is not appropriate for Collaborative Innovation, because: 1. It pays attention to limited perspectives, based

on financial perspective and the driving factors around it (Neely et al., 2007); 2. It is linked more explicitly to organisational strategy (Kaplan and Norton, 2007); 3. Its full potential cannot be realised unless an organisation clearly links its performance divers and measurements (Kaplan and Norton, 1996c); 4. BSC cannot cover competitiveness dimension; 5. It cannot display the customer perspective and the organisational performance of competitors; 6. BSC omits the perspectives on human resources and employee satisfaction, supplier performance, product-service quality and environmental/community consideration.

2.7.2 Performance Prism

Performance Prism (Figure 3) focuses on the importance of stakeholder satisfaction. This is a stakeholder-oriented view performance measurement framework. In this framework, the stakeholders receive more consideration, rather than shareholders. Stakeholder group includes customers, employee, suppliers, regulators, and legislators.

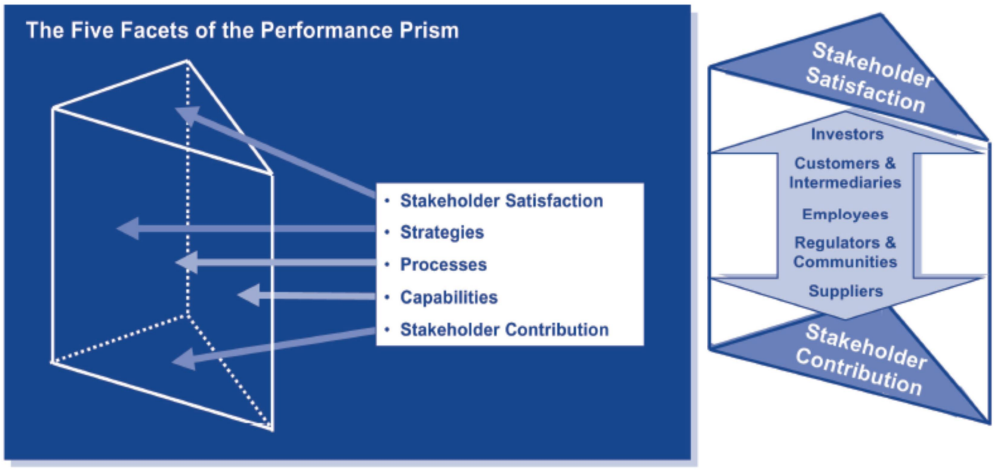


Figure 3 The Performance Prism (Source: Neely et al., 2001)

2.7.3 SMART pyramid – Strategic Measurement and Reporting Technique

The SMART (Strategic Measurement And Reporting Technique) pyramid is also supposed to support the internal and external needs for performance measurement. This

framework owns the characteristic of cascading measures through the organisation, so that the strategy and business unit objectives can be reflected by departmental and central measures (Lynch and Cross, 1991). However, this framework has limitations for collaborative innovation because this framework focuses on the individual development, rather than the collaborative system. In addition, any innovation outcome cannot be measured in this framework.

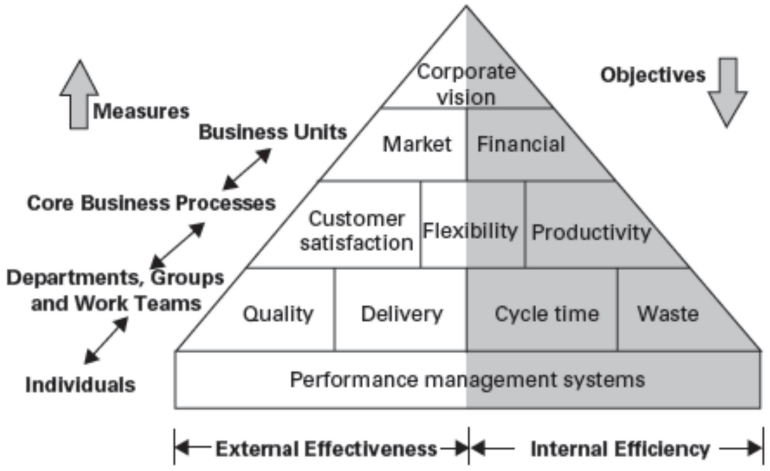


Figure 4 The SMART pyramid (Source: Lynch and Cross, 1991)

2.7.4 The Performance Matrix

The performance measurement matrix is one of the earliest frameworks, and it has gained widespread recognition. The measure is categorised as cost and non-cost, which is supposed to reflect the need for balanced measurement, and accommodate the flexibility of measurements (Neely et al., 2007). However, it is not suitable for CI because: 1. it provides limited sets of measurement, although it is supposed to be balanced and integrated; 2. it is not available to implement at different stages of CI process; 3. focus is progress for individual organisation, not collaborative partnerships.

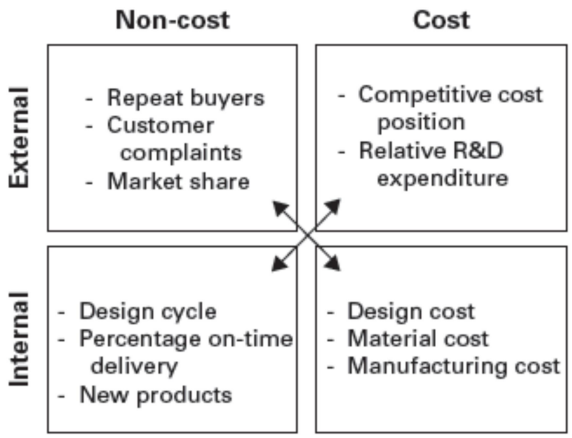


Figure 5 The Performance Measurement Matrix (Source: Keegan et al., 1989)

2.7.5 Results and Determinants Framework

The results-determinants framework has been established based on the study of performance measurement in service industries.

Results	Competitiveness
	Financial performance
Determinants	Quality
	Flexibility
	Resource utilization
	Innovation

Figure 6 The results-determinants framework (Fitzgerald et al., 1991)

As Figure 6 shows, the measures in this framework are classified into two basic types. One type contains competitiveness and financial performance, which are related to results. The other type contains quality, flexibility, resource utilisation and innovation, which are related to determinants of the results. The results-determinants framework can particularly reflect the concept of causality between input and output of collaborative innovation. The advantage of this framework is that it can explicitly exhibit that current results come from the past business performance. However, the framework cannot be applied to CI due to the following reasons:

- The framework cannot specifically identify the desired drivers of performance in order to achieve the desired performance outcomes;
- The framework cannot provide how to improve the result quality based on measuring innovation as one of the determinants;
- The framework cannot provide influence associated with collaborative partnership.

2.7.6 Input-process-output-outcome framework

Brown (1996) developed the input-process-output-outcome performance measurement framework based on cause and effect relationships. This framework reflects the theory of linking and measuring through five stages, i.e. inputs, processing systems, outputs, outcomes, and goals.

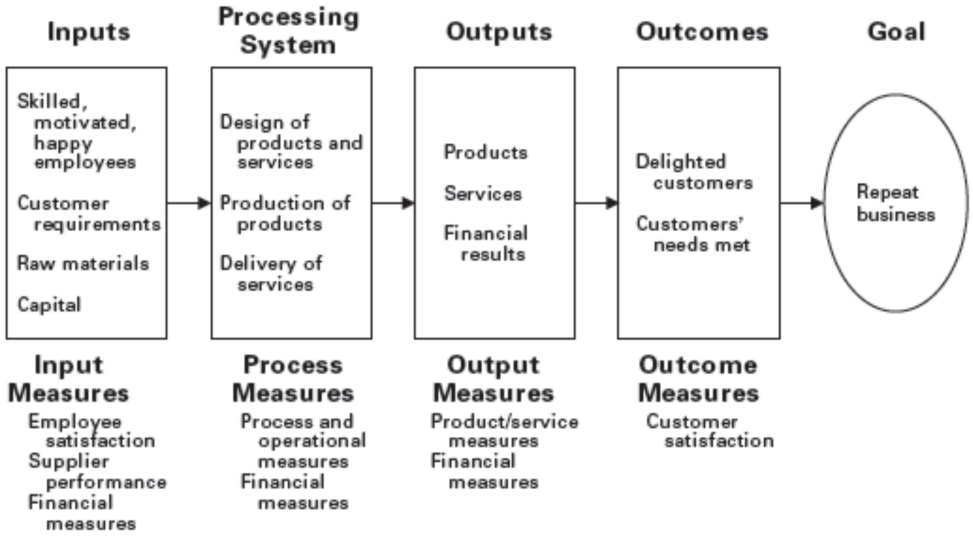


Figure 7 The input-process-output-outcome framework (Source: Brown, 1996)

Although the framework cannot provide all the detailed performance measures, the five stages reflect the link between business process and performance measures. Moreover, the distinction between output and outcome measures is useful for this research. However, the framework is not suitable for CI due to the reasons listed below:

- this framework is oversimplification, although it is a useful way of distinguishing between different categories of measures;

- the framework has not differentiated the requirements between individual organisation and collaborative system.

2.7.7 European Foundation for Quality Management model

Criteria of European Foundation for Quality Management (EFQM) model consist of 5 enablers and 4 results, which addresses broad view of performance. This framework clearly highlights the enablers of performance improvements and indicates the results which should be measured. However, the reasons of this framework is not suitable for this research are: 1. this framework is a self-assessment rather than an objective or a collaborative framework; 2. the categories for measurement are too broad to make sure every single result can be measurable simultaneously (Neely and Adams, 2001).

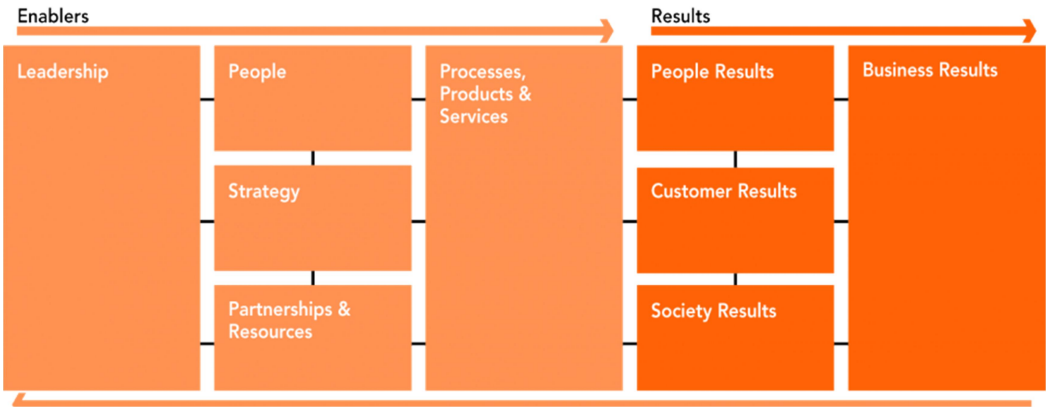


Figure 8 The European Foundation for Quality Management framework (Source: EFQM 2013)

2.7.8 Supply chain PM framework

In order to improve the effectiveness of management with both financial and non-financial metrics in a supply chain, Gunasekaran et al (2001) provided a balanced approach which is classified at strategic, tactical, and operational measures. However, this framework cannot simplify the decision-making procedures. In addition, this framework does not pay attention on innovation as the outcome.

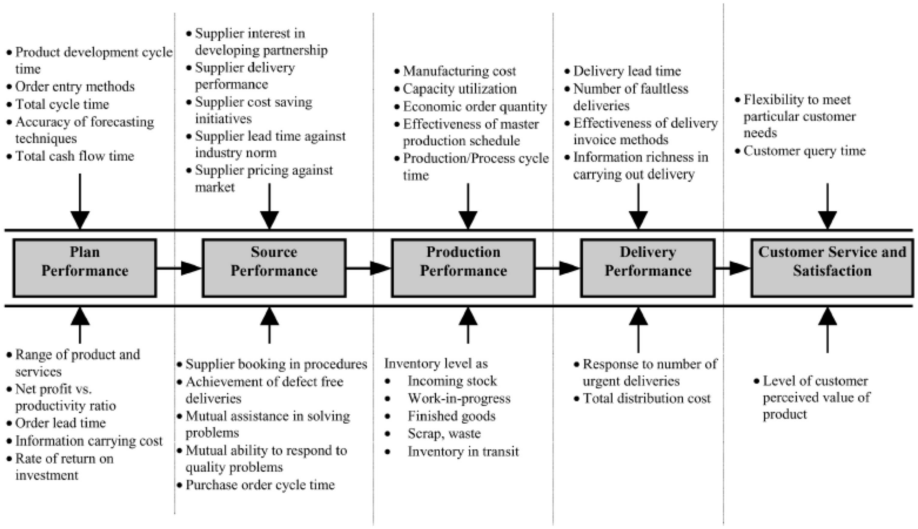


Figure 9 Supply Chain Performance Measurement Framework (Source: Gunasekaran et al., 2001)

Based on the critical analysis on existing performance measurement frameworks, the existing frameworks are designed for individual organisations with different purposes. The frameworks partially or cannot fully provide comprehensive framework to implement performance measurement at the collaborative innovation level. This leads to research gap and research questions presented in next section.

2.8 Research gap and research questions

In collaborative innovation networks, the collaborative characteristics stand out in comparison to cooperation and coordination. Collaborative innovation involves higher levels of integration and interaction between participated organisations. Collaborative innovation involves mutual trust, in addition to the need for participants to work closely together and to share information, resources, responsibilities and risks to achieve common innovation goals (Ferreira et al., 2011). The benefits of effective collaborative innovation include increased market share, gaining new customers, cost reduction, reductions in development time and the risk of failure of new products, increased quality, etc. (Bititci et al., 2004; Kumar et al., 2018). Therefore, a number of evaluative measures are needed and an infrastructure to measure and manage performance is

required for CI. It is evident that the existing research on PMM of CI has provided limited findings relating to measurement and management of CI performance.

However, there is still a gap with regard to a comprehensive theory on PMM in the context of CI. In addition, no available study has investigated collaborative innovation performance measurement or management as a holistic system. In summary, current research fails to do the following:

- Identify the factors which enable and/or constrain the achievement of effective collaborative innovation;
- Explicitly address how performance measurement and management supports collaborative innovation.

Therefore, further research is required to tackle the above gaps. It is also important to contribute to the current understanding of the characteristics of effective collaborative innovation. Having reviewed the existing literature, weaknesses in the current research examining PMM and CI have been discovered.

First of all, no existing research has clearly integrated the three research disciplines in performance measurement and management of collaborative innovation. Most of the existing research focuses on collaboration and performance measurement (Busi and Bititci, 2006; Ferreira et al., 2011), or measuring innovation performance (Adams et al., 2006; Hernandez-Espallardo et al., 2018). In order to help collaborative organisations to improve the collaborative innovation performance, focus has to be placed on clarifying the effectiveness and efficiency of collaboration in order to improve innovation performance. Secondly, the existing research has discussed how to improve collaborative innovation by managing the key factors which influence performance of collaborative innovation (Bunduchi, 2013), but more research is needed on the implementation of performance measurement and management to support and improve collaborative innovation. Thirdly, there is little evidence that sufficient empirical research has been done in the existing Collaborative Innovation Performance Measurement (CIPM) research.

Based on the gaps identified above, two research questions arise, with associated areas of investigation:

- **Question1.** What are the factors influencing the performance effectiveness of collaborative innovation?
- **Question 2.** What should be considered for collaborative organisations to design their PM systems for CI?

To investigate the above questions, this research will first, identify a comprehensive list of factors that influence the performance of collaborative innovation. Second, provide a reference model to facilitate collaborative organisations to design effective performance measurement and management systems in the context of collaborative innovation.

Due to the exploratory nature of this study, the research questions are left open to revision and development in the light of the qualitative approach (Miles and Huberman, 2004).

2.9 Chapter conclusion

An exploratory literature review has been given in this chapter. Fundamental concepts of this research are presented, which covers collaboration, innovation, collaborative innovation and performance measurement and management. In addition, performance measurement and management being applied to collaborative innovation was discussed. Moreover, existing performance measurement approaches were evaluated, which led to the research gap and research questions identified in the chapter.

In the next chapter, a detailed literature review will be presented and the conceptual framework of this research will be demonstrated.

Chapter 3. Proposed CIPM reference model and construct

It is important to establish strong and good working relationships between collaborative partners, and ensure strong involvement by each partner (Bititci et al., 2009). To facilitate building such relationships, scholars have investigated how to improve the success rate and performance outcome of collaboration. Some of them have distinguished the collaboration in stages, antecedents, process and outcomes (Thomson & Perry, 2006; Vanpoucke & Vereecke, 2007); and some of them have made analysis in terms of groups or attributes (Macedo & Camarinha-Matos, 2017; Bititci et al., 2004; Prajogo et al., 2018). In each stage of collaborative process, there are factors involved which influence the success of collaboration and innovation. The factors or attributes have gained much attention in the literature.

In this chapter, the process of synthesising the information (Rousseau, Manning and Denyer, 2008) is **Step 1: Question Formulation** – To answer two research questions presented in Section 2.8, it needs to analyse the questions with clear purposes, which are to explore the literature related to factors which influence collaborative innovation and designing performance measurement systems. **Step 2: Comprehensive Identification of Relevant Research** – The systematic review in the previous chapter has finalised the research gap and questions based on clear inclusion and exclusion of relevant literature. In this chapter it would capture and analyse all relevant studies thoroughly to find material for looking for answers to research questions. **Step 3: Organising and Interpreting** – In order to achieve the research aim, a frame of designing performance measurement systems has been confirmed in terms of performance measurement literature (Hudson et al., 2001). It includes requirements of PM design process, characteristics of performance measures and dimensions of performance measures. In this research, PM systems designed for CI organisations are required to measure and manage factors that enable and inhibit the process of collaborative innovation; thus, requirements of CIPM design process, characteristics of CI performance measure, and dimensions of CI performance measures are formed by such factors. **Step 4: Synthesis**

- A conceptual CIPM reference model and a practical construct will be proposed based on the theoretical findings. The limitation and constraints cannot be avoided, due to the dynamic nature and scope size of the subjects.

3.1 Factors of collaboration

As discussed in the previous chapter, effective collaboration can help organisations to improve organisational performance, increase profit and enhance innovation through sharing insight, knowledge, ideas and expertise. From reviewing the literature of collaboration, it was found that there are many factors influence effect of collaboration. Organisations should be aware of the potential disadvantages and weaknesses of the factors. In order to manage them effectively, groups of factors will be discussed in this section, such as environmental, organisational and process.

3.1.1 Environment related factors

Basically, the environment involves the conditions and areas where organisations operate actions. Involved factors can be divided into two dimensions. The first dimension is physically the space people work in, such as organisation space, light, temperature, noise and safety. The second dimension includes socio-cultural aspects, such as time pressure, competition, stability, rapid change, etc (Détienne, 2006; Devine and Banahan, 1999; Dix et al., 2004).

- ***Environment:*** The collaborative partners may work in a co-located or distributed setting even across different time zones. Cross-national collaboration may make the partners from different time zones to co-locate. Different locations and time zones lead to increasing demand on multi-national collaboration. In such collaboration, partners normally invest in more effort on building trust and synchronous communication. 'Breed linking' and geographical proximity can facilitate building collaborative work amongst partners, because it is easy for individuals to work together with similar language, and cultural background, etc.(Edwards and Wilson, 2004; Espinosa and Carmel, 2003). However, for partners without geographical proximity, it is better to co-locate. Co-locating can facilitate informal communication, maintain awareness on

sharing, and achieve a tight relationship (Galve Górriz and Ortega Lapiedra, 2000; Hinds and McGrath, 2006). Based on these, co-location can help improve group effectiveness and productivity and solve problems (Hockey, 1996; Kiesler and Cummings, 2002; O'Driscoll and Cooper, 1996). The negative impact of environment, such as poor working conditions can badly affect organisational performance, physical and mental wellbeing, willing to collaborate, and possibility of collaboration, etc. (Neale et al., 2004; Olson and Olson, 2000; Salas et al., 2005a).

- ***Business climate:*** Due to differences in location, country or environment, business climate can be different. Generally speaking, if the business climate is more stable, the organisations can have more business opportunities and effective organisational performances; and vice versa (Wilson et al., 2003). The business climate can influence an organisation's strategy whether to collaborate and how to build a partnership. In detailed, partner participation is impacted by business climate through explicitly and implicitly encouraging and discouraging. In the global or multi-national collaboration, both overall business climate and national or regional climate make an effect. Therefore, organisations need to implement the appropriate strategy for achieving objectives (Hackman, 1990; Unsworth and West, 2000).

3.1.2 Organisation related factors

The nature of organisations makes critical role in the process of making collaborative partnership. The attributes inside of organisations are important factors to influence the organisational action (Seymour and Cowen, 2006; Sheehy and Gallagher, 1996). These factors are organisational structure, technology, resources, strategy, leadership/management style, employee, organisational culture, and experience.

- ***Organisational structure:*** Normally, organisational structure offers formal and informal roles for individual and teams, based on organisational foundation and boundaries (Buchanan and Badham, 2008; Burton et al., 2005). In detail, organisational culture separates and defines organisational aspects, such as functional responsibility and authority, departments, tasks, processes, policies, culture, norms, power relation, trust, learning and incentives participation. Individual or team's participation in

collaborative decision-making is influenced by organisational structure (Campion et al., 1993; Conger and Kanungo, 1988). Besides, organisational structure can also influence on other factors, such as level of autonomy for various teams to structure, conduct or implement their tasks and responsibilities (Edwards and Wilson, 2004; Frost & Sullivan, 2006; Hackman, 1990). Higher level of autonomy is associated with improved work productivity and employee satisfaction, although it is stated that team effectiveness is more related to team structure and higher task interdependence (Hinds and McGrath, 2006; Igbaria, 1999). In other words, rather than traditional organisation, decentralised workplaces with flexible response to change and concentration on employee's influence can gain better performance Langfred, 2000; Mannix and Sauer, 2006; Parker and Wall, 1996; Suchman, 1987). The decision maker normally well understands decentralisation rather than rely on hierarchy of authority. The decentralisation usually helps leaders increase political skills, through gaining resources and support for further personal, team and organisational goals (Payne, 1996; Pettigrew and McNulty, 1995). Overall, organisational structure can be influenced and influence collaborative relationship, so organisations should design the organisational structure and work conditions supporting and facilitating collaborative work. Effective power and influence arranged for employees can lead to effective collaboration, by influencing communication, decision making, organisational learning, conflict resolution and overall performance. (Tyndale, 2003; Weiseth et al., 2006; West, 1996; Wilson et al., 2003).

- ***Technology:*** Technologies can offer some mechanisms for organisations working together physically, or virtually when they cannot co-locate (Warner et al., 2003; Weiseth et al., 2006; Wilson, 2006). The technological tools include emails, online conferencing, and other knowledge management tools. All the technological tools support the partners from different locations and time zones to work towards a common purpose. The common recognition between collaboration and technology is: the simpler is better; but, some more complex 3D engineering model is needed for a specific project (Bolstad and Endsley, 2005; Cramton and Orvis, 2003; Daft and Lengel, 1986). The main benefit of collaborative technology is to improve the effectiveness and efficiency of collaborative work, the end product with high quality, work processes, organisational relationships, and participants' satisfaction, reduce the costs, reduce social distances and maintain common ground (Dix et al., 2004; Eason and Olphert, 1996). However, the

advantages of technological tools can be limited depending on the way they are implemented to be used. They should be supported by formal and informal communication, function-oriented strategy, and appropriate tasks (Edwards and Wilson, 2004; Frost & Sullivan, 2006; Graham et al., 2004; Hambley et al., 2007; Hammond et al., 2001, 2005). Collaboration technology can be used for achieving organisational goals and values, but can also be limited by cost, availability, technical limitation, and compatibility with existing system (Harford, 2008; Harvey and Koubek, 1998, 2000; Herbsleb et al., 2000; Igbaria, 1999; Klein, 2001; Knutilla et al., 2000; McNeese and Rentsch, 2001; Monk, 1996; Nunamaker, 1997). Although collaborative technology offers benefits for making efficient meeting, face-to-face meeting cannot be removed from collaboration process. Normally technology helps collaborative partners increase the chances to exchange and create new knowledge. (Pinelle et al., 2003; Rogers, 1995; Sheldon, 2007; Skovholt and Svennevig, 2006; Sonnenwald et al., 2001; Sproull and Kiesler, 1986; Talbot, 1999;).

- ***Resources***: The reason why the researcher separates resource from technology is that technology above all focuses on technological tools used for communicating and collaborating; while resources here include tangible and intangible adequate aspects, such as finance, time, physical space, materials, equipment, tools, experts, capability, and so on (Johnson and Hyde, 2003; Mattessich and Monsey, 1992; Robertson, 1996; Steiner, 1972). Rapid technological change and scarce resources with risings devolution and organisational interdependencies can drive increasing collaboration (Thompson and Perry, 2006). Apart from these, to build successful collaborative relationship, much work and time are needed; however, many organisations underestimate the resources requirement (Mentzer, 2000). Vanpoucke and Vereecke (2007) have stated that investment is high for cross-functional teams and specialist training. Therefore, any lack of commitment of required resources can inhibit building collaborative relationship. More importantly, resources are not unlimited, so utilisation of resources has to be anticipated and managed according to demand (Cramton and Orvis, 2003; Hackman, 1990, 1998; Waugh, 2005).
- ***Strategy:*** It is important for collaborative partners to complement structured and proven methods, such as with finding available partners, ensuring goal congruence, sharing each other's problems, completing written agreements, understanding each

other's roles, competencies and limitation, ensuring the pace of collaboration to be suitable for partners, and optimising the outcome of combination (Bititci et al., 2009; O'Driscoll and Cooper, 1996). The strategic vision of collaboration should be routine and predictable, so that partners can achieve it easily, but some are complex, due to the different natures of strategic vision, as cognitive or behavioural. A different vision requires a different level of support and demands which influence on participants' wellbeing and relationship. The partners should make the strategic tasks more appropriate to demands, and provide structural and clear measurable boundaries which engage all participants as being responsible for (Van Fenema, 2005). The ideal structure can avoid the duplication of work. Tightly coupled vision and tasks involve more collective activities, such as input from individuals and teams, coordination and communication, etc. (Edwards and Wilson, 2004) In order to prevent negatively affected performance, collaborative partners choose to promote back-up behaviour. An organisation can help overloaded partner with back-up behaviour, which needs high levels of sharing, for example, work progress, roles, conditions, responsibilities, etc. (Kyzlinková et al., 2007; Salas et al., 2005a, 2005b).

- ***Leadership/ Management Style:*** The manager's ability is crucial to lead the organisation in the collaborative relationship (Russell, 2004), because nothing significant can be completed, unless the manager makes the collaboration move forward (Mentzer et al., 2000). Management support is related to improved work productivity, team effectiveness, employee satisfaction, and plays an important role in the success of promoting collaboration (Cordery and Soo, 2008; Campion et al., 1993). Good leaders should provide clear direction and guidelines to employees, make communication effective, set up appropriate expectations, inspire collaborative work, bridge disciplinary boundaries and estimate potential constraints and weaknesses. The management of a collaborative project also needs to plan, implement appropriate methods, monitor the progress, and ensure work outcome can be delivered based on required quality and performance (Salas et al., 2005b; Devine and Banahan, 1999). It is important for collaborative management to monitor and review the change, and make the organisation fit into the changeable environment (Tyndale, 2003; Parker and Wall, 1996; Katzenbach and Smith, 1994). During the process of collaboration, management also requires to provide feedback on individual and team performance, to manage conflict, and to

provide consistent management. Some scholars argue that a semi-autonomous work environment can be helpful for improving work productivity and employee satisfaction, so that collaboration may be enhanced. According to the nature of leadership, there are two types of leaderships, 1.transformational leadership, which tends to motivate for working together for common goals, and 2.transactional leadership, which tends to reward or punish with reference to reward or punish performance. Both leaderships can be effective for improving collaboration performance, depending on context (Edwards and Wilson, 2004; Guest, 1996; Hackman, 1990; Unsworth and West, 2000).

- ***Employee:*** In the whole collaboration process, employee is the main factor to implement collaboration. Effective employees should be able to complete the tasks, utilise collaboration tools and implement collaboration (Edwards and Wilson, 2004; Hackman, 1990, 1998). Training for gaining effective employees is important to manage change and development within the organisation. Organisations should ensure personal and professional development happen in the organisation, so that individual employee satisfaction and productivity can be improved (Weiseth et al., 2006; Anderson, 1993; Campion et al., 1993). Thus, the whole organisational effectiveness can also be improved. The employee can gain new skills or improve existing skills through training (Cooke et al., 2001; Stammers, 1996). Organisational managers can make use of training to help employees gain specific skills for collaboration tasks (Cordery and Soo, 2008; Salas et al., 2008; Tesluk et al., 1997; Warr, 1996b;).
- ***Organisational Culture:*** Culture includes national, organisational, or professional culture. Organisational culture represents the attitudes, beliefs and values which are shared by the employees (Bornemann et al., 2003; Devine and Banahan, 1999; Dooley, 1996). At the same time, the organisational culture impacts behaviour and morale of people in the whole organisation. Organisational culture usually comes from the organisation's overall objective and vision, thus the management should be well placed to change organisational culture for adapting and achieving the objective. It is important for collaborative partners to be aware of and overcome difficulties from different culture, since cultural differences always exist. It is also vital for organisations to build an early understanding of cultural differences and work with partners to mitigate cultural differences (Bititci et al., 2009). Culture can influence the openness of communication channels, willingness of changing, types of social interaction between people,

organisational trust and organisational effectiveness (Weiseth et al., 2006). According to some attributes, culture can be different. The first attribute is strength, which is members' acceptance to culture; the second is content, which is the main direction the organisation focuses on; the third is pervasiveness, which is organisational behaviour or value the organisation focuses on influencing (Edwards and Wilson, 2004; Frost & Sullivan, 2006; Guest, 1996; Marttiin et al., 2002; Payne, 1996; Tyndale, 2003; Unsworth and West, 2000). Culture can influence on other factors, so as to influence on organisational main objective.

- ***Experience:*** Experience refers to shared history of working together (Wilson et al., 2003). Past experience can be a driver for effective collaboration. The reason is that partners understand each other, so they can provide what the partner needs, share the relevant information, and reduce the cost, such as communication (Mannix and Sauer, 2006; Marttiin et al., 2002; Mattessich and Monsey, 1992). The positive effects of experience also include completing mutual trust, and improving satisfaction of decision making process, based on individual and team's familiarity (Flanagin et al., 2004; King, 2006; Van Fenema, 2005; Warr, 1996b;).

3.1.3 Process related factors

A collaboration process involves a high volume of exchanging and sharing information in order to provide benefits for organisations. Therefore, participating partners need to be aware of the effect of factors (Hansen and Nohria, 2004; King, 2006). They are trust, networks, knowledge management, error management, goals, team, learning, coordination, communication, decision making, conflict resolution, incentives, performance, commitment, responsibility and contribution, level of process thinking and clarity of expectations.

- ***Trust***

Mayer et al. (1995) defined that trust was based on positive estimation about another's intention or behaviours. The positive estimation leads to the willingness to accept vulnerability (Bunduchi, 2013). In the context of business collaboration, trust has been differentiated: goodwill trust focuses on partner's intention; and competence trust refers to a partner's ability which can perform according to expectations (Sako, 1992;

Nooteboom, 1996; Bunduchi, 2013). Trust can be built depending on partners' experience, reputation, interaction, communication behaviours, and geographical proximity (Bunduchi, 2013).

According to the nature of trust, it is considered to have two forms by McAllister (2005): one represents reliable role performance, cultural-ethnic similarity, and professional credentials, while the other represents citizenship behaviour and inter-action frequency. The existence of trust is a key feature of collaboration. It is critical to understand the formation of collaborative inter-organisational relationships and inter-organisation R&D collaboration. Trust has been considered as an important factor of collaboration, since it creates greater information sharing, reduces the costs and risk, increases partners' commitment and involvement, and improve the overall performance of the organisation. Trust is a multilevel construct that exists at personal, organisational, institutional and international levels (Das and Teng 2001). According to Smith Ring and Van de Ven's research in 1992, trust between collaborative organisations is based on individual experience, common history, and interaction with partner. Consequently, the existence of a history of interactions between partners is an important condition for trust development. If such history did not exist, then organisation's reputation will become an important indication to estimate organisation's ability to perform according to expectations, or have the intention to do so in an open and supporting manner (Gulati, 1995).

Apart from reputation, another indication that can be used for building trust is communication behaviour (Sako, 1997). The partners are willing to share information through timely, accurate and adequate communication, as considered to be a key predictor of trust in New Product Development (Bstieler, 2006). Geographical proximity is a factor that supports the communication and building the trust (Bonte, 2008).

Trust supports learning and continuous improvement in collaboration, and encourages greater information sharing and improved coordination between partners. Due to this, learning supports collaborative technology transfer between partners (Dodgson, 1993), while greater information sharing leads to better collaborative innovation outcomes

including lower costs, faster development and improved product quality (Petersen *et al*. 2003). Trust helps organisations to increase suppliers' commitment and involvement in collaboration, which are associated with more successful innovation (Ragatz et al., 1997).

- ***Networks***

Social networks in modern economy make a significant effect (Edwards and Wilson, 2004; Campion et al., 1993). Formal and informal, personal and professional networks form the platform to share information and generate new ideas, e.g. forum, and web pages, etc. Informal networks help the effectiveness of formal daily work, e.g. the people can clarify the target person and relative responsibility to accelerate the progress on tasks. Social support in networks is beneficial to establish informal contacts and open communication, increase employee satisfaction, wellbeing and work productivity, and promote adoption of innovation (Wilson et al., 2003; Devine and Banahan, 1999). However, networks are easily established in co-located collaboration rather than distributed working environment. (Galve Górriz and Ortega Lapiedra, 2000; Krackhardt and Hanson, 1993; Johnson and Hyde, 2003; O'Driscoll and Cooper, 1996; Sheehy and Gallagher, 1996;).

- ***Knowledge management:***

Knowledge is considered as one of the most important resources, whereas learning is regarded as the most fundamentally important process. Collaboration gives organisations the best opportunity to learn knowledge through collaborative partners' knowledge contributions (Weiseth et al., 2006). Collaboration can make partners access to new resources and knowledge cross organisation's boundaries (Mohr and Speaksman, 1994; Bunduchi, 2013).

In the organisations, individuals and teams require to get access to the necessary knowledge to complete their tasks. Managing and using knowledge well is beneficial for individuals, teams and organisation to gain better understanding of their past and current activities and relevant outcomes, and further improve future performance (Edwards and Wilson, 2004; Bornemann et al., 2003; Carneiro, 2000). Organisations

which are ready to collaborate should make sure knowledge can be available and utilised as necessary. A trust environment and sharing culture is necessary for collaborative partners to exchange and utilise the knowledge for achieving organisational goals (Détienne, 2006; Hackman, 1990; Inkpen, 1997; Kelly, 2007; Marttiin et al., 2002).

Alexander and Childe (2013) stated that a success factor of knowledge transfer is using rich media channels to transfer tacit knowledge. The tacit knowledge means inexplicit knowledge, which owns the ability to be dynamic. In the context of collaborative innovation management, the essential component, tacit knowledge can be used to make sure whether innovation can be achieved from exploitation of new knowledge. In Alexander and Childe's (2013) research in the frame of collaborative innovation, they conclude the selection of appropriate channels can improve innovation through knowledge transfer between organisations. The knowledge transfer between collaborative partners in the business and higher education sectors has been proved to be an excellent source of collaborative innovation (Perkmann and Walsh, 2007).

- ***Error management***

Errors during collaborative work derive from ineffective coordination of individuals within teams. Inappropriate normative and informational influences may affect collaborative decision making, the quality of leadership, and high workload. Error management involves identifying and managing the errors and violations which may influence collaboration, productivity and cost (Salas et al., 2005a, 2005b; Reason, 1990). The violations are deliberate deviations from formal rules, due to ignorance of rules. Violations may be related to collaborative procedure and culture, and in particular, be relevant to individual group thinking (Edwards and Wilson, 2004; Hockey, 1996). An appropriate error management culture should apply when an error occurs, the organisation should report and identify the error and communicate with partners for assisting to detect and manage the error. So, error management may promote organisational learning for achieving organisational goals. Mutual performance monitoring is related to effective collaborative partners, and involves each partner's work performance. Collaborative partners should help each other prevent or quickly

correct any errors, by sharing an understanding of each other's roles, mutual trust and common ground (Van Dyck et al., 2005; Rasmussen, 1986; Viller et al., 1999).

- ***Goals***

Setting up clear visions and objectives is important for achieving successful collaboration via providing clear guidelines for implementing strategy and goals (Marttiin et al., 2002; Mattessich and Monsey, 1992). Benefits of clear goals include providing effective understanding for better communication and structure, and making measurable performance targets (Tyndale, 2003). Underspecified goals can have negative effects on collaboration effectiveness. The conflict between individual and collaboration goal in collaborative work is a critical factor to influence on success of collaboration (Cohen et al., 2000; Devine and Banahan, 1999). If the people make collaboration goal fit in their own beliefs and demands, then they can adapt well in work (Johnson and Hyde, 2003; Katzenbach and Smith, 1994). One of the types of collaboration, collaboration with competitors makes organisations partially share. And in this trend, organisational factors and other social factors can impact participants focus on working for maximising team or individual outcomes (Breazeal et al., 2004; Edwards and Wilson, 2004; Hackman, 1990; Howes and Payne, 2005; Klein, 2001; Pfeffer, 1992).

- ***Team***

Collaboration is supported when individual roles is coordinated to achieve team goals. The difficulty is that inter-organisational collaboration needs effort of participant partners to have an understanding of roles and responsibilities between teams in different organisations (Salas et al., 2008; Hackman, 1990, 1998). Collaboration can be enhanced if team relationship is good and motivated in the working environment, which leads to lower demand communication and coordination, e.g. enabling team members to predict and fully understand colleague's behaviour. Highly effective collaboration can involve 2-4 team members, while teams normally involve 4-20 persons; an optimum number is 6-8. Building a team involves internal training, like communication and assertiveness, and also external social activities from workplace. The latter activities can contain working on a project more effectively, improving motivation, boosting morale, increasing commitment, overcoming cultural barriers, and build trust, etc. To understand

current issues about team can help achieve goals and overcome the barriers to effectiveness. Post-collaboration evaluation can help teams review the performance and make future performance more consolidated. Building effective team is more beneficial for organisational process than simply technical training (Edwards and Wilson, 2004; Anderson, 1993; Bradley et al., 2003; Katzenbach and Smith, 1994).

- ***Learning***

Learning can help individuals and employees achieve their goals and improve response to change (Edwards and Wilson, 2004; Hackman, 1998). The collaboration gives informal and formal opportunities for learning among individuals, teams, and process. Individuals can learn from each other within a team, including improving the skills, increasing knowledge, and experience of success and failure (Unsworth and West, 2000; Wenger, 1998). The forming of informal learning can help organisations improve future learning lessons; on the other hand, formal specific-task learning can improve the quality of working environment, form the organisational learning atmosphere, and increase the team's flexibility (Bornemann et al., 2003; Hockey, 1996; Ilgen et al., 2005; Kyzlinková et al., 2007; Stammers, 1996).

- ***Coordination***

Coordination is needed for achieving shared objectives. In order to optimise collaborative performance, coordination between cross different and multidisciplinary teams and organisations require clear communication (Weiseth et al., 2006). Besides, coordination involves other activities, such as setting goals, managing information and people, managing time schedule, planning and managing labour, monitoring work progress, managing resources and offering feedback on performance (Gutwin and Greenberg, 2000; Hackman, 1990). The overall purpose of coordination is to assist effective collaborating (Girard and Robin, 2006; Devine and Banahan, 1999; Klein, 2001; Neale et al., 2004).

- ***Communication***

The collaboration will dissolve as a result of doubt and mistrust without making effective communication and implementing frequent performance feedback between

partners. Therefore, it is important for collaborative partner to make organised and clear communication based on the trust built by all possible communication channels. Effective communication makes partners willing to share information, and cultural difference may negatively affect communication quality (Bititci et al., 2009). As an important part of communication, negotiation, which involves an interaction between formal bargaining and informal sense making, influences the partners for building commitment and agreements (Thompson and Perry, 2006). Mentzer (2000) stated that effective communication not only requires the attributes about relation and people, but also other three sub-factors, high-quality information exchange (Petri, 2005), participation, and partners' openness. Firstly, high quality can be achieved when the information is exchanged accurately, adequately, timelessly and credibly (Daft and Lengel, 1986; Huber and Daft, 1987; Stohl and Redding, 1987). This exchange is believed to generate benefits for the collaboration (Petri, 2005). Secondly, it is beneficial to improve collaboration performance if the organisations are willing to engage in planning and goal setting, and discuss their practices and process with other partners (Mentzer, 2000). Thirdly, in the openness atmosphere, organisations are comfortable to make the information sharing and this consequently lead to synchronised beliefs and better performance of collaboration. The openness range can be partners' competences, technology roadmaps, information on latest developed technologies, and production process and capacities (Vanpoucke and Vereecke, 2007).

- ***Decision making***

Much decision making is practically not a formal or structural process, but in the process of decision making, information collection, alternative exploration and choice should be supported technically, to ensure real contribution from all participants (Weiseth et al., 2006; Devine and Banahan, 1999). Group decision making is subject to individual decision making. Employees joining in decision making process can increase employee satisfaction and commitment. In any hierarchical structure, team members may be less motivated or confident to work for innovative ideas. However, use of computer is helpful to generate new ideas compared to face-to-face meetings (Hammond et al., 2001; Klein, 2008; Steiner, 1972; Unsworth and West, 2000; Viller et al., 1999; Montiel-Overall, 2005; West, 1996).

- ***Conflict resolution***

Problems are always present, due to different partners' goals, values, ideas, and individual differences with high level of uncertainty, ambiguity and high stakes; however, blaming each other is destructive to the collaborative relationship. Therefore, partners should be able to forecast possible problems in advance; moreover, after problems take place, partners should identify problems and focus on solution (Bititci et al., 2009; Denise, 1999). Normally, the reasons for them in the collaboration process include poorly setting up common ground at the beginning, lack of shared understanding of each other's skills, knowledge, and perspectives, poor social dynamics within teams, in particular the collaborative partners are multidisciplinary and multinational, and difficult to be managed (; Waugh, 2005; Katzenbach and Smith, 1994). Conflict can threaten effectiveness, efficiency and working relationship, but conflict is impacted by collaborative context, trust, and support for collaborative system. Therefore, conflict can be controlled by managing effectively different opinions, so as that conflict do not limit progress, reduce quality of performance, lower morale, and create bad feeling, etc. However, conflict itself is not necessarily bad as it can lead to more creativity, wider discussion, and increased participation (McNeese and Rentsch, 2001). Therefore, making use of divergent views based on conflict can be beneficial generating high performance (Détienne, 2006; Anderson, 1993; Devine and Banahan, 1999; Edwards and Wilson, 2004; Eisenhardt et al., 1997; Mattessich and Monsey, 1992; McNamara, 2003).

- ***Incentives***

In order to encourage collaboration, organisation should motivate collaboration goals rather than individual goals, based on rewards biased towards collaboration rather than individuals (Edwards and Wilson, 2004; Hackman, 1990, 1998). If a group of people refers to team, but it is managed by individuals, the effectiveness of the team should be lower (Salas et al., 2005b; Shea and Guzzo, 1987). Motivation of collaborative work could be financial rewards, contribution recognition, enhancing viability or improving status in marketplace, shared responsibility, shared risks, personal relationship, or achieving potential targets (Bergman and Baker, 2000; Bohen and Stiles, 1998). To be opposite, lack of confidence can result in demotivation. The particular thought is needed

for supporting motivation to participate in collaborative relationship (Détienne, 2006; Katzenbach and Smith, 1994; King, 2006; Mattessich and Monsey, 1992; Unsworth and West, 2000; Willaert et al., 1998).

- ***Performance***

Evaluating collaboration effectiveness involves assessing how collaborative partners work together to achieve outcomes and whether the partners will be able to work together in the future. Working together can increase team cohesiveness (Wilson et al., 2009b; Howes and Payne, 2005). Performance relevant to collaborative working includes maintaining budgets and deadlines, profits, saved time, meeting requirements, quantity and quality of product/service, improving work progress, innovation, achieving goals, improving relationships, extending professional network, generating new business, learning, individual and team satisfaction and wellbeing, trust and commitment to improve, reduce errors (Cordery and Soo, 2008; Salas et al., 2005a; West, 1996; Steiner, 1972), level of safety, level of absenteeism, and staff turnover. The complex measures reflect that both collaborative and individual performances are important to influence overall performance; and both should be involved in assessment. Collaborative performance is influenced by types of task, levels of trust between partners, training, and quality of management (Delgado Piña et al., 2008; Edwards and Wilson, 2004; Hackman, 1990; Tesluk et al., 1997; Warr, 1996a).

- ***Commitment***

Commitment is about whether the collaborative partners are willing to exert the efforts in the relationship. The efforts concern asset resources, such as organisation's time, money, facilities, etc., which are often directed specifically towards to the collaborative partners (Vanpoucke and Vereecke, 2007). Bititci et al. (2009) also added that commitment is about if partners in a team are able, capable and skilled to invest effort in collaboration. Thus, both willingness and capabilities are important in commitment.

- ***Responsibility and contribution***

Balancing the contribution of partners in the areas of outcome development, manufacturing, and marketing is necessary so that no one partner dominates the

collaboration (Tyndale, 2003; Viller et al., 1999). Absence of such balance may result in takeover of the weaker partner by stronger partner, short-term relationship, or failure of collaboration without achieving its full potential.

- ***Level of process thinking***

During the working with collaborative partners, it is required for organisations to maintain thinking in terms of not only function, but also the process of the collaboration, via the liaison devices like structures or cross-functional teams (Vanpoucke and Vereecke, 2007). Lack of process thinking has negative effect on performance of collaboration practices (Croxton, 2001).

- ***Thorough planning / Clarity of expectations***

Clearly defined, shared, and reasonable goals and objectives should be set up. The opportunities may be lost and the challenge may remain if the collaborative partners do not share a common goal and vision. Therefore, partners should measure whether the expectation is understood by all partners in the relationship (Mentzer, 2000).

3.2 Factors of innovation

Regardless of types of innovation, the benefit of innovation has been widely discussed. In its practical business world, fulfilling organisation managers' inspiration for innovation can lead the business to achieve the potential it has (Alexander and Childe, 2013). Innovation helps organisations maintain competitive advantage and sustainable economic growth through generations, diffusion and adoption of innovative products, services and production technology (Grossman and Helpman, 1994). In Shaw and Burgess's research (2013) about utility organisations, they state that innovation can help reduce cost and increase operating efficiencies.

Due to the internet technology innovation, all sorts of organisations including insurance organisations, banks, supermarkets, etc. are providing online facilities for customers to complete the purchases or benefit from the online service. Business efficiency has been increased dramatically with much less staff resources involved. In order to encourage

the customers to use the online facilities, and also due to the reduced cost of online business, the organisations offer discounts to customers.

Innovation has been widely recognised as a key to the economic performance of organisations. The organisation with stronger innovative ability grows faster. In the last two decades, much literature on innovation success factors has been published. Panne, Beers, and Kleinknecht (2003) concluded from the SAPPHO-study (Scientific Acivity Predictor from Patterns with Heuristic Origins) that the characteristics of innovation process that discriminated between success and failure are related to the innovator's ability to understand customer needs, marketing capabilities, the efficiency of the development process, management skills, and the organisation's adequate ability to absorb external information.

In 1980s, based on 200 Canadian innovations, Cooper summarised that viability is determined by three factors. The first one is the degree to which the product is unique and superior compared with existing ones. Second, it is the innovators' understanding of marketing development. The final one is the product's synergy with the organisation's overall technological and manufacturing resources. Cooper (1980) pointed out that these three factors determine 50 percent of the product's viability.

A single magical factor does not exist, some common factors have been considered as crucial factors in most of the studies, while some other unusual factors have also been researched and analysed. According to the reviewed literature, the factors have been classified into three groups as shown in **Figure 10**, and will be explained in details below.

- Organisation related factors
- Product related factors
- Market related factors

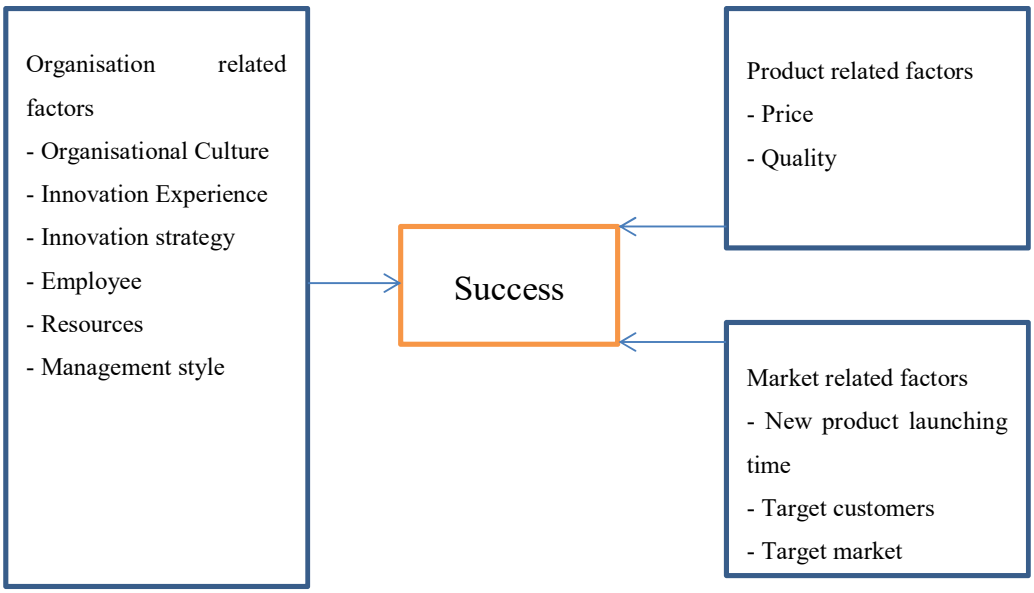


Figure 10 Critical factors for successful innovation (van der Panne, 2003)

3.2.1 Organisation related factors

Four factors have been considered relevant to the technological viability of an innovation project, which are the organisation's culture, experience with innovation, the research and development (R&D) team, and the organisation's strategy.

- ***Organisational culture:*** A culture susceptible to innovation has been considered crucial to the organisation's technological capabilities in the long term, because the culture related to innovation will affect the organisation to decide the necessity and time to innovate (Ekvall & Ryhammar, 1998; Lester, 1998). The entrenched routines and interpretative barriers may cause cultural resistance to innovation to proceed. If the employees focus solely on their own tasks and responsibilities, innovation barriers are incurred when team work is needed much more than individual responsibilities. Interdepartmental cooperation affects technological viability has also been approved (Souder, 1988). Rochford & Rudelius (1997) pointed out that a high percentage of innovative organisations report that interdepartmental cooperation is hampered, mainly due to lack of mutual trust. Adequate interdepartmental communication is necessary to overcome resistance as an impediment to innovation success.

- ***Innovation experience:*** Previous innovation project experience is a treasure for the organisation's technological capabilities as an organisation improves various existing skills through the innovation project process. The more similar innovation projects that an organisation engages in, the more improved technology, production, and marketing skills can be gained (Stuart & Abetti, 1987; Bessant, 1993). In addition, the time-to-market may be reduced, if the organisation has more innovation project experience.

- ***Innovation strategy:*** A well-defined innovation strategy is considered as another important success factor. The benefits are obvious, innovation strategy provides a clear guideline for dealing with strategic issues, such as selecting the right markets, and the right time to enter the market, to develop the necessary skills, etc. (Lester, 1998) Numerous empirical studies have proved that innovation activities must be coordinated with and directed by the innovation strategy, which additionally help the organisation to maximize the benefits from innovation.

Pro-active strategy and re-active strategies will lead to different outcomes. The organisation who adopts pro-active strategy will guide the organisation to launch the new product into the market and to obtain product leadership in the market, while a re-active strategy organisation will use product development to compete in the market. Although innovation strategies have been considered as crucial to an organisation's technological capabilities, there are still no common practices. According to Page (1993) only half of the innovative organisations have a clear innovation strategy.

- ***Employees:*** The personal characteristics of employees and the motivation of employees will affect the organisation's innovative ability (Smith et al., 2006).

- ***Resources:*** The resources that the organisation has and can be used for innovation, and how the organisation manages the resources will have an impact on organisation's ability to manage innovation (Smith et al., 2006).

- ***Innovation management style:*** Normally, an organisation treats each innovation process as a project. No doubt, management style is an important factor to affect project's development and result. According to Cozijnsen et al. (2000), 60percent of the innovation viability is determined by appropriate management time, project funding, information, and decision-making. In order to manage the project better, most of the organisations will split the innovation project into phases according to the attributes of the project. In most cases, the project consists of six phases, which are (1) planning phase, (2) brainstorming phase, (3) screening phase, (4) evaluation phase, (5)development phase, and (6)market research phase, (Panne, et al., 2003), all ending with market launch phase. Different researchers have brought up this idea in different periods. In 1987, Cooper & Kleinschmidt pointed out that the organisation is more successful if it can keep the innovation project process to this track. In 1988, Wind & Wahajan showed that one of the main failure reasons is skipping any of the phases. In 1993, Calantone et al. pointed if the innovation project is split up, it is easier for an organisation to manage the crucial factors.

Planning and evaluation are the two phases that have been more emphasized in the reviewed literature. At the planning phase, tasks and responsibilities need to be clarified and well-defined, which benefits strategies made and implemented later on. The evaluation phase is emphasised because appropriate evaluation helps an organisation to know the innovation project better, maximize the results of the project and minimize the risks and uncertainty related to the project.

Regarding the relative importance of the planning and evaluation phases during the innovation project process, different researchers have argued on them. Cooper & Kleinschmidt (1987) think that planning and evaluation phases are more important in the earlier stage of the innovation projects, since an appropriate innovation project proposal project idea) based on market demands, market preferences, etc. help the innovator to make the proper strategies on time.

3.2.2 Product related factors

Although there are only a few studies mentioned with reference to the impact of product price on competing products or substitutes (Panne, Beers, and Kleinknecht, 2003), one view has been widely acknowledged is that when an innovation is successful, it meets customer demands on difference factors at the same time. These factors include, for example, product quality, product price, product total-costs-of-use, convenience-of-use, after-sales services, and backward compatibility (Maidique & Zirger, 1984; Panne, Beers, and Kleinknecht, 2003). In contrast, the innovations that focus only on the reduction of total-costs-of-use are less successful. In general, product quality has been considered unanimously as a prerequisite for success; some researchers even consider product quality as the only 'real' determinant success (Roure & Keeley, 1990).

3.2.3 Market related factors

Early market launch can be a competitive advantage, and inversely, late market launch may affect financial returns. John and Snelson (1988) pointed that the financial returns can be reduced by half if the market introduction time was delayed by six to twelve months. Therefore, it is important that an organisation shortens the innovation process and quickens the market launch time to gain the expected market share. It seems it is the earlier the better to launch new products to the target market; however, the market response needs to be measured. Moreover, early market launch may lead to lower product quality (Hultink, 1998). Although many innovators have realised that early market launch may result in failure, most of organisations attempt to be in the market as early as possible to gain enough market shares. According to Page's reports (1993), over 40 percent of innovators try to shorten the time-to-market.

3.3 Various factors influence Collaborative Innovation

According to the literature review, both collaboration and innovation are broad areas which have been researched widely in many scopes. The focus of the research is Collaborative Innovation - collaboration is a process and innovation is one of the outcomes. And the purpose of this section is to find main factors affecting collaborative

innovation which can be considered into performance measurement in the context of the research.

The logic of concluding the factors are: a. factors affecting collaboration meanwhile affect innovation, i.e. quality of innovation is depending on effectiveness of collaboration; b. the factors affecting collaboration are more general and the factors affecting innovation are relatively more specific. Therefore, after removing duplications and summarising the critical analysis based on the logic as above, factors influence Collaborative Innovation is listed in the following section.

Various factors which influence collaborative innovation are listed in Table 3.

Table 3. Various Factors influence Collaborative Innovation

Factors	Positive	Negative
Physically political and social environment	1.Collaboraion is supported by social resources controllers, political leaders, national government; -national policy makers decide the possibility and scale of collaboration, and impact the progress and scope of collaboration 2.Parners utilise the support out of relationship to gain collaborative success.- Utilising the resources out of relationship, can extend the vision and scope of collaboration (Kagan et al., 1990; Harbin et al., 1991; Holtzman & Anderberg, 2011)	1. Policies inhibit the growth of collaboration; -if national development planning is not open to global market, the collaboration cannot be carried out. 2.Lack of professionalism in local government leads to reducing efficiency of government support -professional people are needed in national government to ensure effectiveness of collaboration (Atherton, 2008; Zhang & Si,2008; Su & Adams, 2010)
Experience in Collaborative innovation	1.Previous collaboration experience in industry promotes potential organisations to understand and trust collaborative process -previous experience can motivate further collaboration; alignment of self-experience and other's experience can make collaboration more effective 2.Previous engagement improves skills and technological capabilities decisive for innovation; allow for reducing time-to-market; 3.In product learning cycle, experience makes organisations capitalise upon effects of learning-by-doing to improve R&D efficiency, and learning-by-failing to expose weaknesses (Kagan et al., 1990; Siu, 2005)	1.Learning from previous experience is risky, since each team is likely to be unique in its organisation;-previous experience may be lower level of collaboration for short-term benefit 2.Generic experience cannot be suitable for every situation 3.The experience is insufficient to assure good results; 4.Resources cannot match the experience (Kor & Mahoney, 2000; Siu, 2005)
National Culture	The knowledge providers and recipient from similar cultural context can make knowledge transfer efficiency and effective -Affinity exists between two units with similar background. Partnership with diverse cultures, personalities, or other demographic variables exhibit higher levels of innovation than homogeneous units; Low power distance, high individualism and low uncertainty avoidance easily generate innovation (Bhagat et al., 2002; Gonzalez et al., 2006; Lucas, 2006)	1. Lack of common language on knowledge sharing; -different languages lead to different understanding, although translation helps a lot 2. Different thinking logics, like collectivism/individualism influences people's cognitive styles; -different value, norms and perspectives impact decision-making leaders to make different direction of organisations, e.g. Profit-oriented, and service-oriented. Different levels of uncertainty avoidance influence different perceived credibility of what is shared -partners should have similar level of uncertainty avoidance. 3. Common language is barrier to knowledge transfer; 4. Factors limit adoption of innovation, like risk-taking and long-term orientation; 5. Individuals in high uncertainty avoidance organisation are uncomfortable for change (Pelokorpi, 2006; Wei, 2007; Wei, 2010)

Factors	Positive	Negative
Technology & Resources	1.Web-based technology helps organisations capture, transfer and manage information;2.information are shared and learning through collaboration; 3.different types of skills can improve efficiency and quality; 4.Through knowledge management, technologies transfer knowledge to employees to gain knowledge which can be used in the process of new idea development and implementation; 5.Technology is used to facilitate useful idea generation and supports various stages of innovation process(Griffiths et al., 2001; Kagan et al.,1990; Smith et al., 2008)	1.Disparity in partners technological capabilities leads to low efficiency and failure of exchanging information -the level of technology can decide to the success of collaboration2.Lack of capacity to absorb new ideas;3.The feature-based approach tend to dominate customer-based approach, since salesman focus on technological improvement, rather than customer needs (Gupta, 2006; Ramesh et al., 2010; Kwan, 1999)
Employee	1.Employee own expertise, knowledge and skills for collaboration -and it's important that employee tend to collaborate; 2.Recruitment to ensure missing talent and appropriate competencies are present; 3.Employee build external interaction to bring professionalism to manage innovation; 4.Employees feel comfortable in their role in their work environment to be innovative (Holtzman & Anderberg, 2011; Kagan et al.,1990)	1. Lack of education and training organised by organisation about awareness of collaboration -employee plays a key role in organisation, so they need to know the meaning of collaboration 2. Homogenous group of employee is not easy to achieve innovation; 3.Employee cannot receive management support, sufficient resources, time, materials and finance to innovate (Mostafa, 2005; Ramesh et al., 2010)
Management	1.Leaders provide resources to support and promote learning and knowledge sharing between partners; -managers tend to collaborate 2.Leaders capture opportunity to collaborate; -assertiveness and sensitiveness are important for leaders 3.Evaluate strengths and weaknesses of team in the organisation; -self-recognising helps build appropriate collaboration 4.The leader own organising and interpersonal skills to carry out collaboration with fairness -The higher level of capacity leaders own, the better effectiveness of collaboration 5.Leaders position the organisation for change; 6.Improve time to market; 7.Make validation-driven planning converts uncertainties into a clear tasks and responsibilities, thereby streamlining course of innovation project; (Allen & Taug, 2006; Gupta et al., 2006; March, 1991)	1.Internal management focus on detailed problems of collaborative relationship, but ignore main objective and value proposition of collaboration; -focusing on short-term value normally limits development of majority organisations 2.Lack of top management commitment(credibility of commitments); -the higher levels of leaders commitment, the more important 4.Lack of top management support to R&D leads to lack of product champion' devotion; 5.Lack of attentiveness leads to uncertainty to radical innovation 6.Lack of understanding benefits of collaboration makes managers focus on their own; -the vision of top leaders should focus on long-term relationship (Ramesh et al., 2010; Liao & Welsch, 2003)

Factors	Positive	Negative
Organisational Culture	1.Culture influence on all organisational factors to generate innovation; 2.Willing to learn and generate knowledge with learning orientation culture (Subramanian an Youndt, 2005; Smith et al., 2008)	Culture impact on corporate strategy with higher level of risks (Veugelers & Cassiman, 1999; Cravan et al., 2002)
Organisational structure	1.flexible structure conditioned for change; ways of team organising and degree of formality influence employee to innovate; 2.Organically organised organisations develop superior technical and marketing capabilities; 3.Organisations can focus on customer needs and technological feasibility in matrix structure (Griffiths et al., 2001; Smith et al., 2008; Anderson & West, 1998; Rothwell, 1992)	1.Pronounced levels of formalisation and control in functional organisations are contradictive to trail-and-error character of innovation process; 2.Matrix or Venture-team still remains consensus (Johne & Snelson, 1988; van der Panne et al., 2003)
Strategy	1.Organisations make formal strategy development process, and partners assessment and selection process to ensure alignment of respective culture and capacity; -compatibility is important, makes partners smoothly collaborate 2.Partners set up strategy in an appropriate pace of development, so as to avoid overwhelming partners' capacity - speed of development cannot be too fast or too slow, should be fit to organisational capability 3.Strategy drives organisational culture to innovate; 4.Strategy makes employees understand nature of their jobs 5.all other organisational factors mediate effect of innovation process to impact organisation's ability to manage innovation (Monczka et al., 1998; Gulati et al., 2000; Smith et al., 2008)	1.Lack of collaborative and strategic planning leads to waste of resources and missing the opportunity; 2.Partners establish unclear strategic visions and paths -unclear paths in planning makes low efficiency of collaboration 3.Lack of reflection of developing innovation in strategy leads to innovation is ignored by employees; 4.Innovation process does not function without ideas (Ramesh et al., 2010; Paladino, 2008; Smith et al., 2008)
Communication	1.open and frequent communication can rapidly capture, transfer and manage information; -Smooth communication 2.Two-sided communication behaviour bring depth and breadth of information sharing; -one-sided communication cannot gain collaboration3.Informal communication leads to cohesive collaborative relationship; -necessary4.Increased levels of communication bring better commitment -high level of communication themes, methods and standards through top management (Griffiths et al., 2001; Monczka et al., 1998; Mohr & Spekman, 1994; Morgan & Hunt, 1994)	1.Lack of communication leads to failure of information sharing; 2.Failure to communication disrupts partnership; -blocking transferring information may destroy collaboration (Mentzer et al., 2000; Park et al., 2002)

Factors	Positive	Negative
Trust & commitment	1.Build trust through great task coordination and agreement with clear tasks; -trust is the important antecedent 2.Partners share visions to build trust at the outset of relationship; -trust makes partners share information, resources, and risks.(Monczka et al., 1998; Rothaermel & Deeds, 2004)	1.Dynamics of organisational trust and distrust cause obstructions to mutual learning capacities of partners; -learning problem is caused by information transferring and communication blocking 2.Lack of trust leads to failure of relationship; -no trust, no collaboration 3.Lack of commitment leads to problems with trust and failure of relationship (Arnulf et al., 2005; Ramesh et al., 2010; Cetindamar et al., 2005)
Understanding & respect	1. Partners need compromise, since realistically collaboration cannot always fit preference of every member perfectly -to accept request from partner, and make appropriate sacrifice can gain better outcome of partnership 2. Understand each other's cultural norms and values, limitations, and objectives, and respect each other; -understanding is to identify and accept everything (Aganoff & Lindsay, 1983)	1.Lack of understanding each other's expectations, common ground, internal and external value proposition leads to fail to fulfil partners needs and lack of commitment -need to understand the goal of collaboration (Greve, 2007)
Partners Attitude	1.Partners own responsibility to generate high sense of ownership and pride to contribute in the whole success; 2.Treat collaboration as self-interest; -inter-organisation is of similar characters as inter-person's relationship 3.Believe benefit will be larger than costs, such as loss of autonomy; -pursuing value is motivated driver for collaboration 4.All levels of each partner (upper & middle management, operations) participate in collaborative initiative 5.Diverse forms of collaboration make organisations become open to new thoughts and learn from others; 6. inter- and intro- organisation forms (info, like market trends, and skills) can bring heterogeneous expertise; 7.Allowing members to focus on respective expertise can improve efficiency and quality (Holtzman & Anderberg, 2011; Rist et al., 1980; Holman & Arcus, 1987)	1. Lack of ethics leads to poor performance of partners and they only focus on self-profit. - in fact, it is difficult to keep always focusing on long-term benefit; and internal management style impacts organisational performance 2.Lack of innovative partnership leads to lack of external resources and capabilities for organisations to innovate; 3.Lack of resources for continuing R&D, production, marketing, and management capabilities, SMEs are difficult to overcome internal and external restrictions for innovation (Ancona et al., 2001; Rothaermel & Deeds, 2004)

Factors	Positive	Negative
Goal of Collaborative innovation	1.Goals of collaborative relationship are clear, concrete, realistic, and aligned with respective organisational goal to deliver value; -the goal of collaborations is more clear and detailed, the effect of collaboration is better2.Partners are committed to and contribute to achieve collaborative goals; -commitments help achieve the collaboration (Holtzman & Anderberg, 2011; Cetindamar et al., 2005)	1.Lack of understanding collaboration visions leads to distrust collaboration; 2.Unshared and inexplicit expectations of each partner leads to unrealistic objectives of collaboration -communication is vital to avoid confusion, distrust and misunderstanding (Ramesh et al., 2010; Henderson & Clark, 1990)
Structure of collaborative relationship	1. Collaborative relationship should be well-structured; -The structure is concrete 2. Collaborative R&D Team: -Improves equilibrium of organisation's technological capabilities & marketing skills; -Configuration of team adds interdisciplinarity to viability; -Enables attendance of a product champion as efficient technological gatekeeper. (van der Panne, 2003; Holtzman & Anderberg, 2011)	1. Lack of commercial and operational business model to identify each other's competencies and contribution; -the content in structure is not reasonable, which influences process of collaboration 2.Lack of an operational system to manage collaborative enterprise -it is better set up a institution for coordinating 3. Collaborative R&D team needs top management support, but this requirement leads to official nomination which disrupts intrinsic motivation and dedication (Liao & Welsch, 2003; Gupta et al., 2006)
Adaptability, Flexibility & Conflict Resolution	1.Partners are open to use different methods to organise respective work and collaborative work; -Learning capability, innovation initiative and acceptance 2.Partners always clearly understand and carry out their roles, rights and responsibilities in the changing conditions; 3.Partners sustain collaboration even if goals and members change-this is critical, researcher doesn't agree, since it is too difficult to sustain as major change happens (Isles & Auluck, 1990; Rist et al., 1980)	Avoidance techniques of addressing conflict lead to failure of collaboration -this techniques or systems need to set up at the beginning (Monczka et al., 1998)
Risk & Value	Sharing risk and rewards between members -compatibility and agreement of high value and low risks (Mentzer et al., 2000; Sahay & Maini, 2002; Kaufman et al., 2000; Kotabe et al., 2003)	1.Focus on short-term benefits rather than long-term benefits; 2.Unfair distribution of benefits; 3.Lack of competitive advantages to be gained -high risks and low value leads to collaboration problems (Benner & Tushman, 2003)
Performance Measurement	Performance expectancy motivates people to use system to share knowledge - better performance management is to adjust and evaluate the performance (Li, 2010)	1.Lack of appropriate performance metrics leads to conflict; -management problems leads to collaboration problems 2.Partners focus on improving own performance metrics rather than the whole partnership performance metrics (Fawcett & Magnan, 2001; Ramesh et al., 2010)

The relationship of the factors presented in Table 3 is illustrated in Figure 11, which shows the influential relationship between factors and collaborative innovation. The figure also shows interactive relationship between factors. '+' means positive effect and '-' means negative effect. The most influential factors are trust, communication, information and knowledge sharing, and commitment. The important factors also include trust, culture, management style, partner selection, risk and cost sharing, and finding key performance indicators which have strong relationship with collaborative innovation.

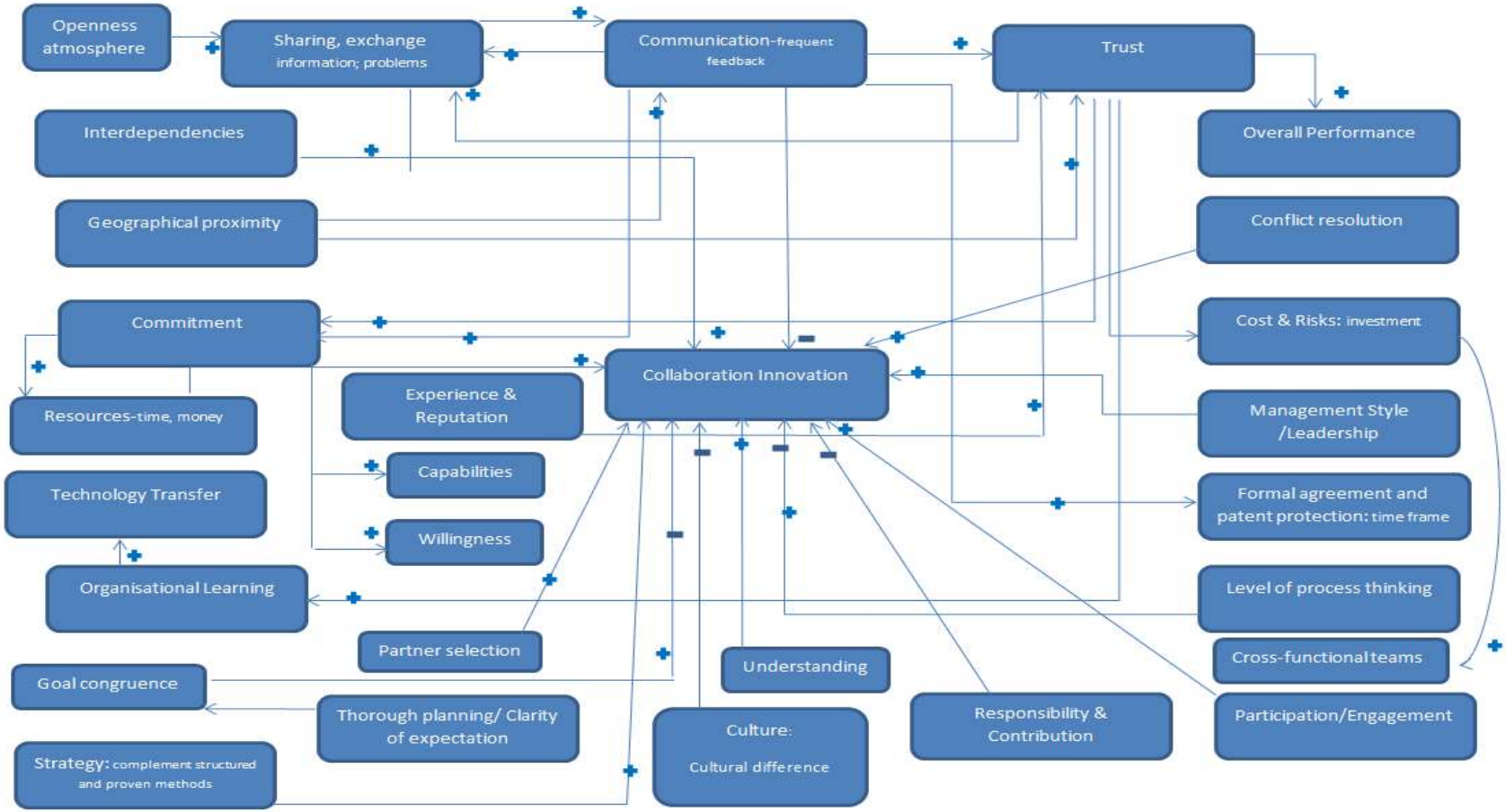


Figure 11. List of Collaborative Innovation factors

After grouping and categorising the factors, more detailed and coherent relationships among them have been presented in Figure 12. With CI-oriented management style, organisations spend effort on selecting appropriate partners based on making communication and building trust. Afterwards, partners work for mutual benefits via exchanging and sharing information, minimising costs and risks and commercialising innovation. The significant part is to set up key performance indicators at the early stages of building partnership. To measure and manage the appropriate factors makes vital effect on performance effectiveness of collaborative innovation.

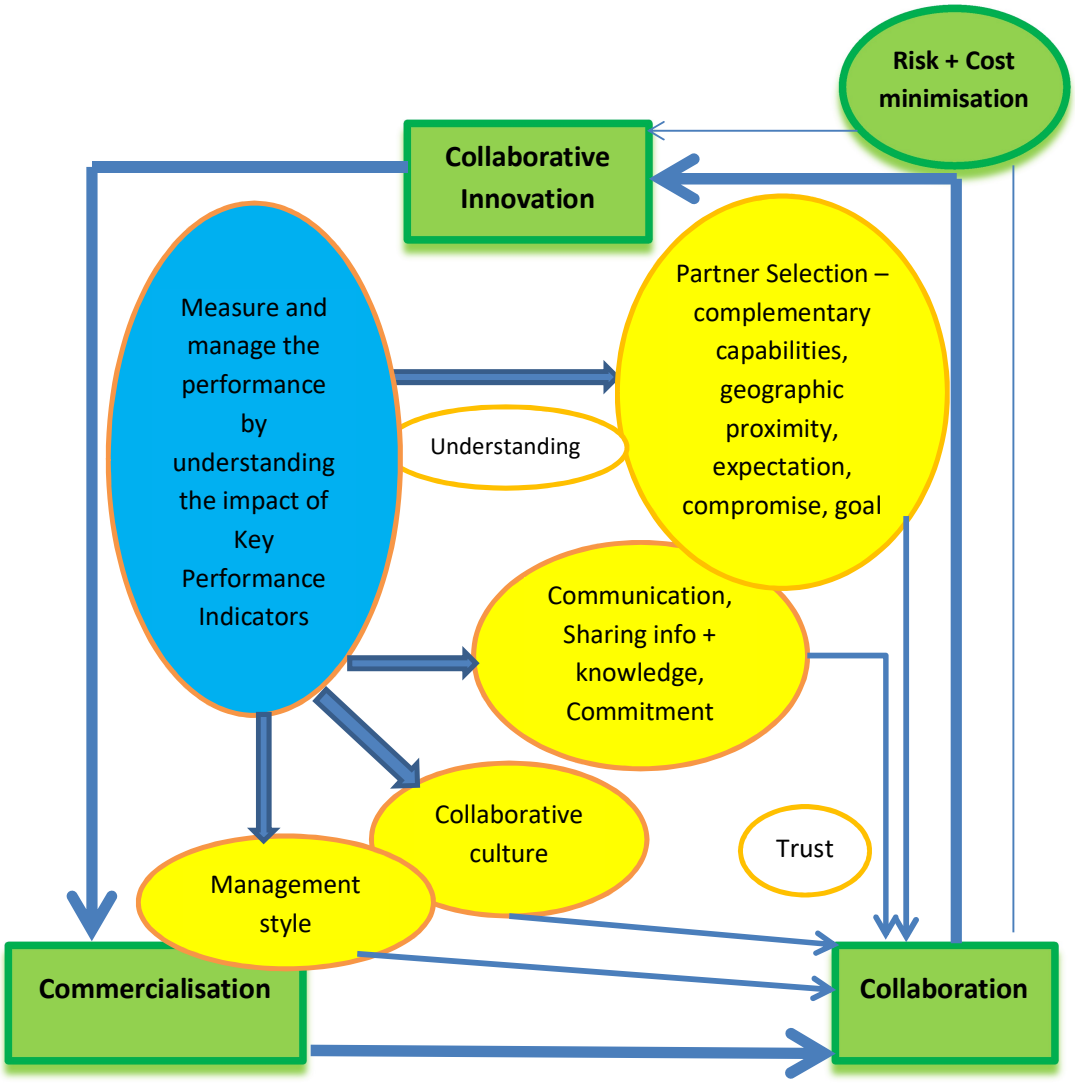


Figure 12. Relationship between PMM and factors of CI

Answer to Research Question 1: What are the factors influencing the performance effectiveness of collaborative innovation?

This research started from exploratory and systematic literature review in collaborative innovation for the purpose of looking at current literature to understand the relationship between collaboration and innovation. The focused research helped the researcher to identify the important factors which improve performance in collaboration and innovation. The detailed review by the researcher points to the conclusion that the five main groups of factors promote success in collaborative innovation. This includes environmental influence, organisational own capabilities, activities during the process, output of collaborative innovation, and market response. In order to identify the variables which affect collaborative innovation performance, the researcher found that a large variety of factors are related to collaborative innovation performance. Some of the factors have been discussed in literature on both collaboration and innovation; and some factors belong to collaboration or innovation.

One finding from this review is that the factors which influence collaborative innovation from different perspectives can be categorised into different groups. Another finding is that based on the nature of the factors, they could be used to form criteria to evaluate existing knowledge in the next section.

3.4 Evaluation of existing Performance Measurement Frameworks based on factor analysis

Based on the critical analysis on existing performance measurement frameworks in Chapter 2, the existing frameworks are designed for individual organisations with different purposes. The frameworks partially or cannot fully provide comprehensive framework to implement performance measurement at the collaborative innovation level.

Collaborative PM has been neglected, but it benefits from the performance measurement literature in the pair of PM and collaborative performance measurement (Folan, 2005). Designing a CIPM system specifically needs to consider the requirements, characteristics and dimensions of collaborative innovation. The

measurement systems should extend competitive strategy into the areas of various partners (Fawcett et al. 1997). Moreover, factors involved in product development, quality, and the environment have been considered as important requirement for adequate performance measurement (Lockamy 1998; McIntyre et al., 1998; Ragatz 1997).

Existing PM development approaches were reviewed in Chapter 2. The critical parts are: demonstrate a clear link to theory of CI and PM; define explicit collaborative innovation purpose; select partners with specific requirements; and consider measurement of leading and lagging indicators. A detailed evaluation on all existing PM development approaches in the context of CI is needed. The evaluation was implemented and the evaluation criteria were based on the factors influence CI concluded in this chapter and fundamental theories of PM in Chapter 2. The objective of this evaluation was to have an even understanding of existing approaches. Table 4 shows the analysis outcome and illustrates that while most of the approaches covered a wide aspects of performance, few of them mapped to the requirements and characteristics of an effective development process of performance measures.

Table 4. Evaluation of existing performance measurement frameworks

	BSC	**IPMS**	**PP**	**SMART**	**PM**	**R&D**	**IPOO**	**EFQM**	**SC**
The CIPM should (Leading-Input)									
Demonstrate a clear link to theory of CI and PM	x	x	x	x	x	x	x	1/2	1/2
Clearly define explicit collaborative innovation purpose	1/2	1/2	x	√	1/2	√	√	1/2	√
Clearly define the frequency of measurement	x	1/2	x	√	x	x	√	√	x
Select partners which									
>have complementary capabilities	1/2	1/2	1/2	1/2	x	1/2	1/2	√	√
>have the same expectations and goal	1/2	1/2	1/2	1/2	x	1/2	1/2	√	√
>have compromise capability	1/2	1/2	1/2	1/2	x	1/2	1/2	√	√
>have experience of collaborative innovation	x	x	x	x	x	x	1/2	√	1/2
>are willing to share									
>>technology	1/2	1/2	√	1/2	1/2	√	√	√	√

>>information	1/2	1/2	√	1/2	1/2	√	√	√	√
>>knowledge and know-how	1/2	1/2	√	1/2	1/2	√	√	√	√
>>expertise and skills	1/2	1/2	√	1/2	1/2	√	√	√	√
>>innovation risks	x	x	x	1/2	1/2	√	√	√	1/2
The CIPM process should (Leading-Process)									
Identify conflict resolution capabilities	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Build open, transparent and honest communication	√	√	√	√	√	√	√	√	√
Ensure partners tending to build collaborative innovation culture	1/2	1/2	1/2	1/2	x	1/2	1/2	1/2	1/2
Have top management support	√	√	√	√	√	√	√	√	√
Have trust between partners	1/2	1/2	1/2	1/2	x	1/2	1/2	√	√
Have mutual understanding between partners	1/2	1/2	1/2	1/2	x	1/2	1/2	√	√
Identify requirements									
>Delivery speed of innovative products	x	x	x	√	√	1/2	√	x	√
>Delivery reliability of innovative products	1/2	1/2	x	√	√	1/2	√	1/2	√
>Percentage of on time deliveries of innovative products	1/2	1/2	x	√	√	1/2	√	x	√
>Number of new products with relevant supportive service	1/2	1/2	x	√	√	1/2	√	1/2	√
The CIPM should measure (Lagging-Output)									
Effectiveness of collaborative innovation should be measured	1/2	√	1/2	√	√	1/2	1/2	1/2	√
Efficiency of collaborative innovation should be measured	√	√	1/2	√	√	1/2	√	1/2	√
Learning and growth of partners should be measured	√	1/2	√	√	√	1/2	√	1/2	√
Customer satisfactions should be measured	√	x	√	√	√	1/2	√	√	√
The measure should (Lagging-Outcome)									
Be relevant to collaborative innovation and easy to maintain	x	x	1/2	1/2	1/2	x	1/2	1/2	1/2

Be simply understood and utilised by participating collaborative partners	√	x	√	√	1/2	x	1/2	√	√
Be able to provide feedback quickly and accurately	1/2	1/2	1/2	√	√	1/2	√	√	√
Be reliable, valid and acceptable	√	√	√	√	√	√	√	√	√
Clearly define methods of data collection and measuring the level of performance	√	√	√	√	√	√	√	√	√

Notes: BSC=Balanced Scorecard(Kaplan & Norton, 1992, 1996c & 2007); IPMS=Integrated Performance Measurement Systems (Bititci & Carrie, 1997); PP=Performance Prism (Neely et al., 2001); SMART=Strategic Measurement and Reporting Technique (Lynch & Cross, 1991); PM=Performance Matrix (Keegan et al., 1989); R&D=Results-determinants Framework (Fitzgerald et al., 1991); IPOO=Input-output-outcome Framework (Brown, 1996); EFQM=European Foundation for Quality Management Framework (EFQM, 2013); SC=Supply Chain Performance Measurement Framework (Gunasekaran et al., 2001).
√=Yes; x=No; 1/2=Partially

Due to the complexity of collaborative performance evaluation, it is possible to obtain satisfactory information and knowledge as a model acceptable to all the partners (Wognum et al., 2002). None of the methods of performance measurement and selected performance indicators is exclusively supportive to collaborative innovation. In order to have a successful collaborative innovation, continuous PMM for the participating partners is crucial for supporting collaborative innovation. Adequate technologies and support infrastructures, proper management tools and performance measurement solutions are required to help the individual partners in the collaborative systems (Ferreira et al., 2011). It is therefore extremely important to have a proper performance framework that can be used to generate the expected collaborative innovation outcomes.

Performance measurement and management in a collaborative relationship for innovation is a complicated subject and different aspects that influence the choice of metrics are involved in it, such as the evaluation of performance objectives, evaluation levels, criteria choice, the type of collaborative relationship, available and accessible data sources, the collaborative management model, collaborative governance, power differences between members of the collaboration; evaluation time frame, times of collection of information, the frequency of data collection, etc.

Due to the diversity of collaborative innovation and the number of influencing elements, none of the existing performance measurement and management models is supportive. Therefore, a phenomenological and constructive approach is needed as a valid option that can be used in a specific collaborative innovation case with a specific timeframe.

According to Bititci et al. (2005), since mid-1980s the need of performance measurement system has been identified to for a better-integration, more relevance, balanced, strategic and improvement-oriented approach (Johnson & Kaplan, 1987; McNair & Masconi, 1987; Kaplan, 1990; Druker, 1990; Russell, 1992). Many researchers have created and developed the performance measurement systems. There have also been numerous attempts to describe the design processes in a performance measurement system. According to Bititci et al. (2015 B), although the phenomenon of maturity models for PMM has been well recognised, there is still a clear gap in how these models can add value, compare to those more traditional ways of diagnosing organisation's performance improvement. Therefore, a new construct of performance measurement for CI needs to be created.

The criteria and indicators to measure performance should follow the constructivist logic and should be taken account into the vision of participated organisations' individual performance systems and the common tools. The created tools can be used by other collaborations (Ferreira et al., 2011). A CIPM reference model will be developed in the next section.

3.5 Proposed CIPM reference model

The purpose of this part is to present the proposed reference model for collaborative innovation's performance measurement. According to the definitions in the reviewed literature, performance measurement is a process of assigning numbers to reflect the relationships of the attributes which are measured. A performance measurement framework, generally, describes the interrelationships of various performance indicators referring to their participating partners. Figure 13 shows the different tasks related to performance measurement and management as a framework in collaborative innovation systems (Ferreira 2012). This research uses this model as the starting point of developing the CIPM reference model.

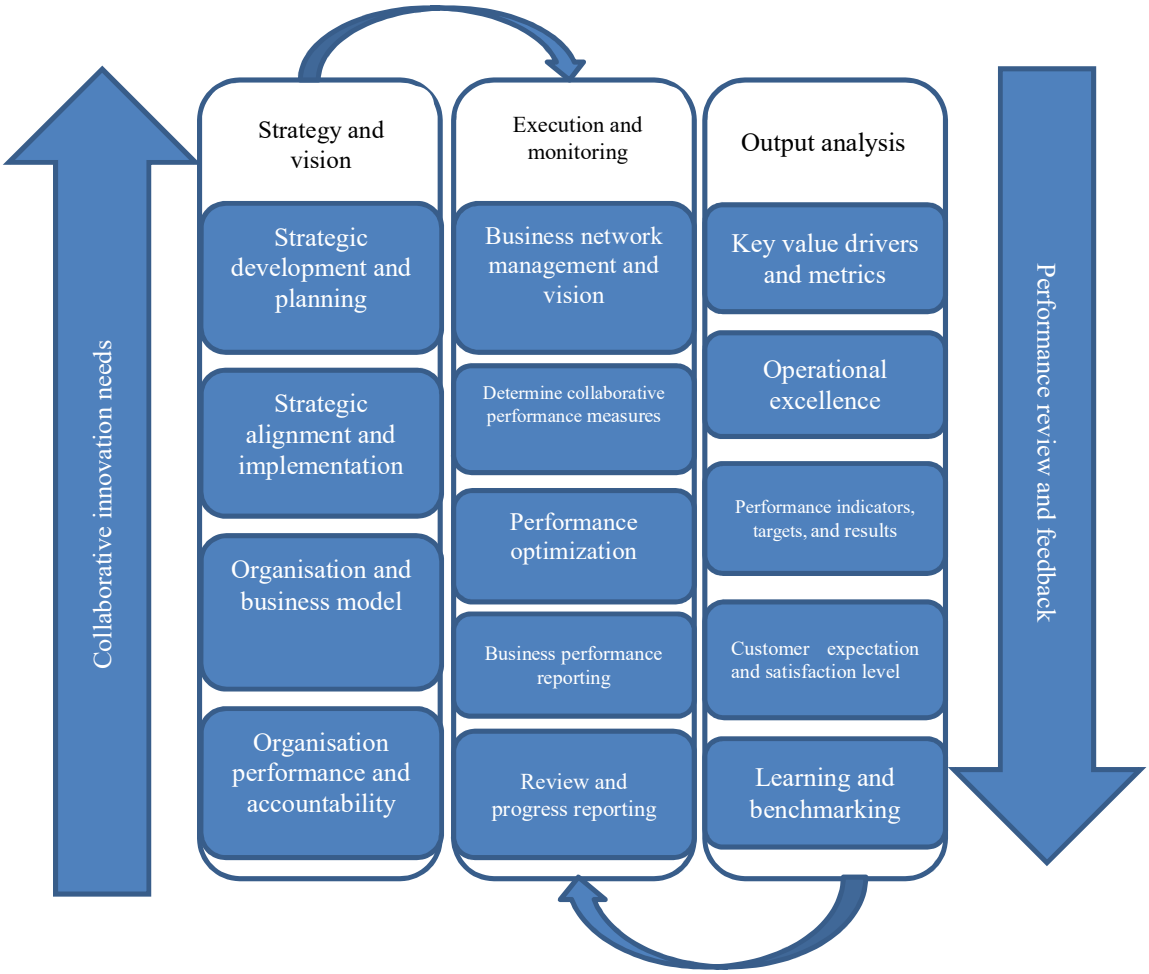


Figure 13. Collaborative innovation performance measurement and management model (developed from Ferreira et al., 2012)

Traditionally, PM systems are financially driven and historically focused (Kaplan and Norton, 1993). However, according to Neely et al. (2000), non-financial measurement has been considered more than before. Since then, theoretical constructs and guidelines which attempt to explain the characteristics of strategic PM have been proposed. Trend of development of the related theoretical models is to cover financial and non-financial aspects; but the ultimate purpose of different frameworks is to design an effective PM system based on aligning strategic purposes. There is a demand to develop a conceptual framework in the context of collaborative projects, based on gaining a clearer and deeper understanding of PM design for CI. In order to develop an effective PMM system, it's very important to identify the features of an effective development process.

Different researchers have developed different theoretical models of designing PM systems. The functions of the models are different, including recommendations (Neely et al., 1997), needs, and specifications (Hudson et al., 2001; MacBryde & Mendibil, 2003). The common purpose of the model is to cover and present details from various angles about process of designing and building PM systems. The following section will review the previous developed models, in order to identify general principles of effective development.

In 1997, Neely et al., presented a list of recommendations (Table 5) with regard to the design of performance measures, based on reviewing and analysing the themes about designing PM system in 21 papers and books. Recommendations include PM's transparency, links between strategies, actions and measures, calculation, data, control, monitor, information and implementation. This recommendation list was extended and used to construct a framework covering the elements for achieving designing effective performance measure. The elements consist of the following elements: title, purpose, relates to, target, formula, frequency, who measures, source of data, who acts on data, what they do, and notes and comments. The recommendations for performance measures can provide particular selection mechanisms. Normally, the performance measures selection is decided by the company's top management board. Therefore, it can be a subjective process.

Table 5. Recommendations with regards to the design of performance measures (Neely et al., 1997)

Recommendation
1 Performance measures should be derived from strategy
2 Performance measures should be simple to understand
3 Performance measures should provide timely and accurate feedback
4 Performance measures should be based on quantities that can be influenced, or controlled, by the user alone or in co-operative with others
5 Performance measures should reflect the 'business process' – i.e. both the supplier and customer should be involved in the definition of the measure
6 Performance measures should relate to specific goals (targets)
7 Performance measures should be relevant
8 Performance measures should be part of a closed management loop
9 Performance measures should be clearly defined
10 Performance measures should have visual impact
11 Performance measures should focus on improvement
12 Performance measures should be consistent (in that they maintain their significance as time goes by)
13 Performance measures should provide fast feedback

14 Performance measures should have an explicit purpose 15 Performance measures should be based on explicitly defined formula and source of data 16 Performance measures should employ ratios rather than absolute numbers 17 Performance measures should use data which are automatically collected as part of a process whenever possible 18 Performance measures should be reported in a simple consistent format 19 Performance measures should be based on trends rather than snapshots 20 Performance measures should provide information 21 Performance measures should be precise – be exact about what is being measured 22 Performance measures should be objective – not based on opinion

Hudson et al. (2001) disagreed with Neely's necessity of all 22 recommendations; instead, some repetitive ones have been found it was necessary to be removed. It has also been identified that previous research focusing on contents of PM, but lack of identification about requirements of effective process for developing PM and lack of clarifying features of PM development process which supports increasing success rate of implementing PM. With the purpose of evaluating previous PM approaches, a typology, as shown in Table 6, has been developed by categorising and synthesising features of PM process methodologies.

Table 6. Typology for the evaluation of strategic PM development approaches (Hudson et al., 2001)

Development process requirements	**Performance measure characteristics**	**Dimensions of performance**
Need evaluation/existing PM audit	Derived from strategy	Quality
Key user involvement	Clearly defined/explicit purpose	Flexibility
Strategic objective identification	Relevant and easy to maintain	Time
Performance measure development	Simple to understand and use	Finance
Periodic maintenance structure	Provide fast, accurate feedback	Customer satisfaction
Top management support	Link operations to strategic goals	Human resources
Full employee support	Stimulate continuous improvement	
Clear and explicit objectives		
Set timescales		

In order to evaluate existing approach for PM design in the context of team, MacBryde and Mendibil (2003) developed the typology as below (see Table 7). The key areas are:

development process, characteristics of performance measures and dimensions of performance. The team-related typology have added concentration on stakeholders' satisfaction, areas teams are accountable for, team's strategic purpose, requirements and achievements at team level, and identification and definition of drivers for team performance.

Table 7. Typology for TPMS design (MacBryde and Mendibil, 2003)

Development process requirements	**Team performance measure characteristics**	**Dimensions of team performance**
Review and evaluate TPM system	Derive from the stakeholders represented within the team membership	Team effectiveness (process outcomes)
Enable identification of company's strategic objectives	Clearly defined/explicit purpose	Team efficiency (internal team processes)
Enable identification of team's stakeholders' requirements	Relevant and easy to maintain	Team learning and growth
Enable development of performance measures	Simple to understand and use	Team member satisfaction
Focus on areas that the team is accountable for		
Enable goal prioritisation		
Involve key users of the TPM system		
Enable identification of the team's purpose and strategy		
Provide a maintenance and review structure		
Top management support		
Full team members support		
Clear and explicit objectives		
Set timescales for design and implementation of TPM system		
Facilitate the identification and definition of measures for key drivers of team performance		
Assign individual responsibility for the measurement, communication and improvement tasks associated with each goal		
Distribute or rotate individual responsibilities for measures across multiple team members		

The previous models and typologies provided general aspects related to designing strategic PM systems; however, they are not most suitable for CIPM system design. Due to CI's unique features, CIPM system design calls for an integrated and specific process. There is no appropriate typology in the current research to address the characteristics of

a comprehensive CIPM design process. According to the reviewed literature, a reference model of CIPM design will be described in the following sections.

3.5.1 Requirements of CIPM system design process

According to concept of strategic PM, it is vital to identify the properties of effective development processes. This action also brings practical value from generalising theories of strategic PM into practice. Besides, principles of effective development and implementation are vital to be clarified in specific context. Platts (1990, 1994) identified key principle: point of entry (highlighting weakness areas and indicate improvement needs, based on evaluating previous PM systems); participation (including staff as key users of PM development); procedure (identifying procedure for developing strategic purposes and PM systems); project management (proposing a method for developing measure, along with procedure to the new PM system).

Hudson et al. (2001) summarised four key principles of effectively managing PM development process: support of top management; everybody is on board; set up clear and explicit objectives; set up time framed project management. Based on the requirements from literature reviews, and the unique features of collaborative innovation, the requirements of CIPM system design process as below:

- Performance measures of CI must be chosen from the organisational strategy and purpose
- CI-related strategic objectives must be clearly and explicitly identified
- Performance measures of CI should gain top management support from collaborative organisations
- CI-related goals should be prioritised
- Being responsible for communicating with participated organisations should be clearly defined
- Existing PM systems related to CI should be reviewed and evaluated
- Performance measures of CI should be designed and decided based on discussion with partners in the CI project
- Data collection and methods related to calculating the level of CI performance should be defined clearly

- CIPM should be able to measure non-financial aspects alongside financial aspects
- CIPM should gain support from participants
- Time scales for designing and implementation of CIPM system should be set
- Key factors of CIPM should be identified
- Individual participated organisations' responsibility and measurement should be clearly identified
- Causal relationship between performance measures should be understood
- CIPM should be maintained and reviewed

Apart from identifying the properties of an effective development process, it's also very important to conceptualize the performance measure characteristics and appropriate dimensions of performance.

3.5.2 Characteristics of CI performance measures

Since 1980s, different researchers identified rules of guidelines of characteristics of performance measures. Later Neely *et al.* (1997) identified a more comprehensive set of 22 characteristics, according to the previous research. Based on all the identified characteristics from the reviewed literature, a list of characteristics for CI performance measure has been extracted as below:

- The purpose in each performance measure of CI is clearly defined
- Data is available and accessible for constant review
- Performance measures of CI are related to CI process and outcome
- Performance measures of CI are easy to understand, use, and maintain
- Performance measures of CI are applied at collaborative and individual level
- Feedback regarding performance measures of CI is provided accurately and on time
- Performance measures of CI are reported periodically
- CIPM is cost-effective
- CIPM stimulate continuous improvement rather than only monitoring performance

3.5.3 Dimensions of CI performance measures

Regarding the dimensions of CI performance measures, there were a variety of terms in the literature. Some of them are replicated, although different terms have been used. Finance is cited in most of the literature, and is considered as a critical dimension of

performance. Time, quality, and customer satisfaction are repeatedly cited as critical performance measure areas as well. In addition, efficiency, effectiveness, and speed are the common ones that have been cited for measuring performance. These dimensions can be seen to cover most of aspects of various businesses, and can be used for measuring CI performance. Keegan *et al.* (1989) gave five generic measures as the best approach to measure, which are quality, customer satisfaction, speed, product/service cost reduction, and cash flow from operations. Based on these holistic considerations, and combined with the CI features, the dimensions of CI performance measures have been summarised as below:

- Efficiency
- Effectiveness
- Finance
- Quality
- Speed
- Stakeholder satisfaction
- Innovation

3.5.4 Proposed CIPM reference model

Collaborative organisations should pay more attention of their measurement efforts to incorporate evaluation of their performance among the collaborative participants and stakeholders (Nudurupati et al., 2016). The synthesis of the requirements of CIPM systems design process, the characteristics of CIPM systems design process, and dimensions of CI performance measures provide a reference model that may be used to evaluate the current approaches for collaborative innovation performance. The model is listed in Table 8.

Table 8. Proposed CIPM reference model

Requirements of CIPM systems development process	**Characteristics of CIPM performance measures**	**CIPM performance measures**
Performance measures of CI must be chosen from the organisational strategy and purpose	The purpose in each performance measure of CI is clearly defined	Efficiency
CI-related strategic objectives must be clearly and explicitly identified	Data is available and accessible for constant review	Effectiveness
CI Performance measures should gain top management support from collaborative organisations.	Performance measures of CI are related to CI process and outcome	Finance
CI-related goals should be prioritised	Performance measures of CI are easy to understand, use and maintain	Quality
Being responsible for communicating with participated organisations should be clearly defined	Performance measures of CI are flexible which can be changed as circumstances change.	Speed
Existing PM systems related to CI should be reviewed and evaluated	Performance measures of CI are applied at collaborative and individual level	Stakeholder satisfaction
Performance measures of CI should be designed and decided based on discussion with participants in the CI project	Feedback regarding performance measures of CI is provided accurately and on time	Innovation
Data collection and methods related to calculating the level of CI performance should be defined clearly	Objective performance criteria are preferable to subjective ones	
CIPM should be able to measure non-financial aspects alongside financial aspects	Performance measures of CI are reported periodically	
CIPM should gain support from participants.	CIPM is cost-effective	
Timescales for design and implementation of CIPM system should be set	CIPM stimulate continuous improvement rather than only monitor performance	
Key factors of CIPM should be identified		
Individual participated organisations' responsibility for measurement should be clearly identified		
Causal relationship between performance measures should be understood		
CIPM should be maintained and reviewed		

3.6 A construct to support PMM system design in CI

In order to have a win-win collaborative innovation result between partners, it is crucial to evaluate the participated partners' performance within the collaborative innovation projects. Due to the diversity of collaborative innovation and the number of influencing elements, none of the existing performance measurement and management models is totally supportive. What are the conditions and challenges that the collaborative organisations have to cope with? It is difficult to manage the inter-organisational networks, so it is beneficial for the organisations to know which dimensions need to be considered (Monsted, 2011; Fenema and Keers, 2018). To identify the factors that affect the design of performance measurement and management framework for collaborative innovation is also crucial. Therefore, a phenomenological and constructive approach is needed as a valid option that can be used in a specific collaborative innovation case with a specific timeframe. According to Bititci et al. (2005), since mid-1980s the need of performance measurement system has been identified to for a better-integration, more relevance, balanced, strategic and improvement-oriented approach (Johnson & Kaplan, 1987; McNair & Masconi, 1987; Kaplan, 1990; Druker, 1990; Russell, 1992). Many researchers have created and developed the performance measurement systems. There have also been numerous attempts to describe the design processes in a performance measurement system. However, the above analysis displays that the existing frameworks cannot be appropriate to measure collaborative innovation performance. Therefore, it is crucial to design a new construct of performance measurement and management that can be used to improve the effectiveness and efficiency of collaborative innovation.

The performances of a collaborative business usually measured and evaluated through the collection process in terms of key performance indicator (KPI), key success factor (KSF), and key performance factory (KPF) among the participated organisations. The criteria and indicators to measure performance should follow the constructivist logic and should be taken account into the vision of participated organisations' individual performance systems and the common tools. The created tools can be used by other collaborations (Ferreira et al., 2011).

The fundamental step for the development of collaborative innovation model is the selection of the required indicators, which leads to the need of defining a method for organizing and classifying the indicator groups (Ferreira, 2011). The purpose of the performance information classification is for organizing the set of indicators into categories and to allow research of performance measurement information with the collaborative networks. In the process of performance management, it is necessary to make compromises between the indicators that have conflicts potentially. For example, the higher requirement on quality, the higher cost is needed. As mentioned before, the choice of performance measurement indicators is usually determined by the objectives of the collaborative innovation. These objectives will also determine the areas of performance measurement criteria.

Back to 1980s, Globerson (1985) and Maskell (1989) categorised the performance measurement system design principles into *the process of designing a performance measurement system* and *focus on the output of the process.* Neely (2000) categorised the principles into *desirable characteristic of a performance measurement system design process* and *desirable characteristics of the output of the process,* according to the principles that have been identified previously. Based on the principles proposed by different researchers, the requirements for the process of designing performance systems and requirements if focus on the output of the process, as shown in Table 9. This can be used not only to support the performance measurement and management system design, but also can be used for informing the design process.

Table 9. Desirable characteristics in the process of designing effective PM systems

Requirements for the process of designing PM systems	***Requirements if focus on the output of the process***
Performance measures should be gained from the company's strategy	Performance measures should accelerate benchmarking
The purpose of each performance measure must be defined clearly	Ratio based performance measures are preferable to absolute numbers
Performance measurement system should be unique, which should be specific to business units	Performance criteria should be directly under the control of the participate organisations
Data collection and methods of methods of calculating the level of performance must be	Feedback from Performance measure system must linked cross-functionally to

Requirements for the process of designing PM systems	*Requirements if focus on the output of the process*
defined clearly (graphs is preferable)	ensure it supports strategy implementation, but not inhibit it.
Data should be available and accessible for constant review	Objective performance criteria are preferable to subjective ones
Performance criteria should be decided by the involved parties	Should be able to measure non-financial aspects alongside financial aspects
The performance measures should consider other organisation	Performance measures should be simple, cost-effective and easy to use
The performance measures should be flexible that can be changed as circumstances change	Performance measures should be able to provide feedback on time
Should be based on multi-criteria	Performance should be reported daily or weekly
Performance measurement system should extend competitive strategy into the areas of upstream and downstream.	Performance measures should foster improvement on performance rather than monitoring performance
The performance should be able to evaluate group performance not individual work	Performance measurement systems should be able to reflect customers' needs and if their expectations are satisfied effectively
Performance measurement systems should be supportive and consistent mutually with the business's goals, objectives, critical success factors and projects.	Performance measurement system be integrated, which should provide understanding of relationship between various measures.
Performance measurement system should be balanced, which should include the requirements of various stakeholders (shareholders, customers, employees, society, environment).	Deploy strategy – It should disseminate and translate strategic objectives and missions throughout the company, particularly to the crucial parts of the company
Inform strategy – It should provide an input to strategy, although it should not be driven by strategy	Include competencies – It should include competencies and capabilities which can determine how the value is created and sustained
Deliver value – It should focus on business processes that deliver value	The specific innovation outcomes and results should be clearly defined
Include stakeholder contribution – It should clarify the role of stakeholders and contain the contribution they make to the success or failure of companies	

The process guideline covers both who should be involved and what procedure should be adopted during each phase of the process, based on review existing procedures of designing performance measurement systems from Neely et al. (2000) and Mendibil (2005). The process guidelines and the principles of performance measurement and management system design for collaborative innovation that shown in Table 9 are fundamental basis to develop a construct to support performance measurement and management system design in collaborative innovation. This construct consists of 10 phases as listed in Table 10.

Table 10. A construct for Collaborative Innovation PMM system design

Phases		**Purpose**	**Actions**	**Outputs**
Phase 1:	clarify CI organisations' strategies, purposes, objectives and requirements	to clarify clear and complete CI organisations' strategies, purposes, objectives and requirements	1a. identify CI organisations' strategies, purposes, objectives and requirements 1b. compare and analyse CI organisations' strategies, purposes, objectives and requirements	List of CI organisations' strategies, purposes, objectives and requirements
Phase 2:	identify existing performance measures in CI organisations	to obtain a clear and complete understanding of CI organisation existing performance measures and purposes	2. compare and analyse existing performance measures in CI organisations	Summary of existing performance measures in CI organisations
Phase 3:	refine and develop CI-related and strategies and goals	to refine and develop specific CI strategies and goals	3a. assess CI strategies and goals against CI organisations' requirements 3b. clarify the roles of partners in collaborative innovation 3c. develop CI objectives	Updated strategies and goals of CI project
Phase 4:	define measurement strategy for CI projects	to define measurement strategy and assign responsibility over individual measures	4a. define data sources, methods of data collection and calculation, and relevant time scale for each measure 4b. agree how to collect data between/among CI partners	Summary of data collection core areas and methods for CI performance measures
Phase 5:	identify key factors of CI performance measures	to identify the key factors affecting the collaborative innovation objectives	5. define key CI performance factors and interrelationship among the factors	Summary of key factors and their interrelationship
Phase 6:	develop CIPM system(s)	to design CI performance measures and complete CIPM system (s)	6a. define financial and non-financial measures according to CI objectives 6b. identify causal relationships between CI performance measures 6c.design and check quality of each performance measure 6d. prioritise measures according to requirements 6e. agree on designed performance measures	Formalisation of CIPM system(s)
Phase 7:	define CIPM system(s) review structure	to define an appropriate plan and structure for performance review and a system which can be used for reviewing CIPM system(s)	7a. agree on defined CI performance review plan 7b. agree on defined CI performance review structure 7c. agree on defined CI review procedure 7d. design structure and format of phased progress reports	Structure of CIPM system(s) review including records sheet with on-time feedback
Phase 8:	ongoing maintenance of CIPM system(s)	to update the CIPM system(s) accordingly	8. remove inappropriate ones 8b. introduce necessary new ones	Regularly updated CIPM system(s) which can stimulate continuous improvement

3.7 Chapter conclusion

The factors influence collaboration and innovation were analysed and discussed in detail in this chapter. The first research question was answered in the chapter. A theoretical model, CIPM reference model has also been presented in this chapter, based on detailed analysis on existing performance measurement frameworks and previous performance measurement system design approaches. Finally, a construct of CIPM system design with stage-based procedure as a practical guideline has been presented.

Chapter 4. Research methodology

A correct methodology is important for any research as it helps to ensure an appropriate research strategy, based on philosophical and epistemological assumptions.

It is widely accepted that valid knowledge should be generated based on a rigorous process. Before carrying out the research, it is essential to establish a research methodology. The main objective of this chapter is to discuss the nature of the research and define research methodology appropriate to the research topic. To implement appropriate research strategy, the nature of specific relevant phenomena is described and an integrated discussion of scientific research and philosophical assumptions is presented in this chapter. In particularly a critical review of philosophical literature is also presented for choosing one specific research paradigm.

4.1 Research methodology

A good research standard is dependent on a clear research objective, a logical relationship between research questions, literature review, data collection, data analysis and conclusion report. Research methodology plays an important role in connecting and justifying links between the stages of a research project. Indeed, relationships between all of the research stages of a project exist (Clough and Nutbrown, 2002).

In the earlier literature, the meaning of research methodology has discussed by many scholars, and is differently depending on the context of the research and researcher's views. Research methodology in this research is defined as the process of discovering and justifying the philosophical paradigms, positioning the research questions, explaining the specific the research strategy and methods. The research strategy means approaches of investigation, which include surveys, experiments and case studies, etc. (Long et al., 2000). Research methods in this research means the investigation tools or instruments utilised in the process of research study. In general, the process of data collection and analysis in particular needs clear methods, such as documentation, interviews, questionnaire or observation.

4.2 The nature of the research

The main areas of collaboration, innovation and performance measurement and management have been discussed over 100 years, and have contributed in the peak time of research in the recent 20-30 years. The focus of this research is on improvement of business performance in innovation management, and applied research can help researchers in identifying a solution to problems. It is very valuable to improve our fundamental understanding of the characteristics of management research: 1). managers need to adopt a cross-boundary approach for effectively combining multi-disciplinary knowledge; 2). the contribution to case study organisation needs to be clear as a return of research; 3). the risks of research methods should be taken into consideration when implementing research (Easterby-Smith et al., 1991). The characteristics of the research presented in this thesis require bringing knowledge across different disciplines and areas, identifying the research strategy and methods, and making a clear contribution.

4.3 Philosophical assumptions

Discussions on research paradigms are often built on two differentiated extremes positivism and interpretivism. Positivism is also known as objectivism, traditionalism, or main stream. Interpretivism is also known as phenomenologicalism, hermeneutics, and subjectivist. Both ontological and epistemological assumptions exist in each of the paradigms. In positivism, knowledge is considered as objective and external. People usually focus on causal explanations, developing and testing hypothesis by taking large samples (Easterby-smith, 1991), and using quantitative methods to measure the phenomena. Researchers with interpretivist assumptions believe the world is subjective and socially constructed. Knowledge is considered as being subjective and driven by human interest and individual perception. The researchers need to get involved in a given situation to understand the historical or contextual characteristics (Long et al., 2000). In this paradigm, researchers use qualitative methods in small samples and in-depth methods to understand the phenomena.

Ontological and epistemological foundations of the research are concerned about philosophical assumption in management research. Ontology is the study of nature of

the reality. Epistemology is about how to know the nature of the reality. Epistemology is affected by the nature of ontological assumptions. In research, the nature of knowledge and how knowledge can be generated is linked to epistemological assumptions (Easterby-Smith et al., 1991).

The positivist and interpretivist paradigms in relation to ontology and epistemology are listed in Table 11.

Table 11. The characteristics of positive and phenomenological paradigms (developed from Easterby-smith et al., 1991)

	Positivism paradigm	**Interpretivism paradigm**
Ontological assumptions	The world is external and objective; Observer is independent	The world is socially constructed and subjective; Observer is part of what observed
Epistemological assumptions	Knowledge is objective and value-free; Knowledge is accessible to all	Knowledge is driven by human interest and individual experience
Researcher should	Focus on facts; Look for causality and fundamental laws; Reduce phenomena to simplest elements; Formulate hypothesises and then test them	Focus on meaning; Try to understand what is happening; Look at the totality of each situation (i.e. historical-contextual characteristics); Develop ideas through induction from data
Preferred methods include	Operationalising concepts so that they can be measured; Taking large samples; Quantitative methods	Using multiple qualitative methods to establish different views of phenomena; Small sample investigated in depth or over time;

The argument on research philosophy is often related to epistemological characteristics of the paradigm and the impact of epistemology on a research design. The identification of positivist/interpretivist epistemological distinctions is related to quantitative/qualitative methodological distinctions (Rolfe, 2006). Quantitative research uses methods which are looking for numerical data and statistical analysis, and quantitative research tends to use interpretative data analysis.

The objective of this research is specifically to look for how organisations manage and measure the performance for achieving collaborative innovation. The researcher tends

to believe that the people are part of the knowledge in the research of understanding the phenomena of collaborative innovation performance measurement and management; therefore, this research's orientation is towards interpretivism paradigms. In the study of performance measurement and management an understanding of history and context is important. To gain a better understanding of the problem, the researcher tends to apply subjective interpretation; this may involve the use of case studies and in-depth interviews for collecting and analysing data.

The method of case studies is suitable for empirical and applied nature of this research, because focusing on case studies helps the research to achieve its purpose: exploration and theory building. Another reason for using case studies is to ask the question 'how' and 'why' as a main focus in this research, e.g. how do organisations measure and manage performance, and why some organisations are successful with CIPM but others are not. This method helps to focus the research on interconnected and interrelated relationships and processes of factors and collaborative innovation (Kumar, 1999), and understand the reasons why some factors are more important than others. Moreover, it helps this empirical research to be close to the practical business world to understand complex relationship in depth.

The relationship between research purpose and methodology is presented in Table 12.

Table 12 Matching research purpose with methodology (Voss et al., 2002)

Purpose	Research question	Research structure
Exploration Uncover areas for research and theory development	Is there something interesting enough to justify research?	In-depth case studies; Unfocused, longitudinal field study
Theory building Identify/describe key variables	What are the key variables? What are the patterns or linkages between variables? What should these relationships exist?	Few focused case studies; In-depth field studies; Multi-site case studies; Best-in-class case studies;
Theory building Test the theories developed in the previous stages; Predict future	Are the theories we have generated able to survive the test of empirical data? Did we get the behaviour that was predicted by the theory or	Experiment; Quasi-experiment; Multiple case studies; Large scale sample of population

Purpose	Research question	Research structure
outcomes	did we observe another unanticipated behaviour?	
Theory extension/refinement To better structure the theories in light of the observed results	How generalisable is the theory? Where does the theory apply?	Experiment; Quasi-experiment; Case studies; Large-scale sample of population

4.4 Key features of quantitative and qualitative research

Qualitative research usually involves the investigation using descriptive data. Quantitative research usually looks for numerical data. Traditionally, researchers in operations management conduct quantitative research (Voss et al., 2002), so this research tends to provide more qualitative data in operations management. Stake (1995) states the key difference between qualitative and quantitative research is the way researchers to look for knowledge: qualitative researchers focus on understanding complex relationships in phenomena, while quantitative researchers focus on looking for explanation and control.

Quantitative research uses the deductive or confirmatory or "top down" scientific method; it is used primarily for description, explanation, and prediction. It is based on quantitative data, in particular on the analysis of variables. The results are statistical and a goal is to generalize the results. In qualitative research, in contrast, the "bottom up" or inductive exploratory method is used; it is used primarily for the purposes of description and exploration and to gain an understanding of how people think and experience their lives. It is based on qualitative data which during analysis are examined for patterns, themes, and holistic features. A narrative report is presented and generalization is usually not a goal because the focus is on the local, the personal, and the subjective.

Quantitative research focuses on measurement of quantity, amount, intensity or frequency (Denzin and Lincoln, 2000), while qualitative research focuses on the qualities of explanation and meanings. There is another key feature of qualitative research, the contextual or integrated view (Lanning, 2001). In order to understand the

deep relationship based on the researcher's personality, this research tends to use empirical materials, including case studies, interviews, documentation, and observation. Additionally, using triangulation (interconnected interpretative methods) utilised in qualitative research helps researcher gain better understanding of phenomena (Denzin and Lincoln, 2000).

4.5 Constructive research

This research uses constructive research theory as a methodological framework, because using constructive research is helpful to provide a solution to an existing research problem (Kasanen et al., 1993; Kelale, 2001), and is associated with creative constructivism (Meredith et al., 1993; Kaplan, 1998). Using such a methodological approach is valuable for providing new solutions to relevant practical problem, based on grounded theory building. The important part of constructive research is that when constructing the solution, the research can generate creative knowledge and learning. This research should achieve the characteristics (Kasanen et al., 1993): relevant to practice, useful in practice, linked to grounded theory, creation, and available to be used in different environments (Figure 14).

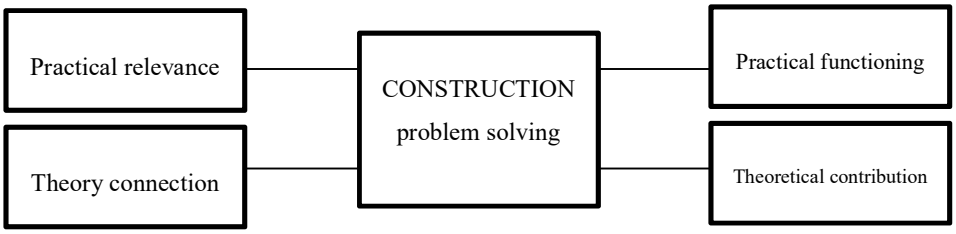


Figure 14 Elements of constructive research (Kasanen et al., 1993)

Constructive research is different from other basic research methods, such as technological development or model building; because constructive research is recognised as a kind of applied study, with unique criteria standing for usefulness. In constructive research, researchers are required to demonstrate the practical relevance, identify the application of research in practice and ensure an accurate feedback.

As one of the observational research methods, case study uses nominal or ordinal scales of measurement. Case study often has no clearly defined research problem, and research

questions may arise during the research process. For example, the researcher may keep asking 'Why' or 'What is happening?' Case study is heavily used in social science, behavioural studies or anthropology. It offers unique insights, and will advance human knowledge.

Theoretically, case study can be classified into two types (Stake, 1995):

- Intrinsic case studies, focusing on one particular case without reference to general research problem;
- Instrumental and Collective case studies – both are multiple case studies (Eisenhardt, 1989; Yin, 1994; Voss et al., 2002).

In order to gain a holistic understanding of the phenomena, it is widely agreed that case studies can contain qualitative and quantitative data collection methods, such as interview, observation, archives (documentations), and questionnaire (Eisenhardt, 1989; Stake, 1995).

To achieve the research objective and answer research questions, this research needs to develop and test the CIPM construct, through evaluating the existing performance measurement frameworks, developing a new construct based on existing knowledge and testing the construct as applied by a number of users.

Table 13 Summary of research strategies (modified from Lanning, 2001)

Qualitative research		
General characteristics • Case and field oriented • Issues are progressively focused • Closed to the real phenomenon • Researcher's personal involvement • The emphasis on observations, including the observations by informants • Includes description with author's	***Purpose*** • To understand a phenomenon, not to explain cause and effect relationship • Research problems are related with cases or phenomena	***Quality of research*** • Triangulation • Emergent and responsive research design • Sensitivity to the risks of human subjectivity • Disconfirming own interpretations

interpretations • Reporting provides vicarious experience • Knowledge is constructed, not discovered • Phenomena studies in its natural setting • Personality of the scientist is a key research instrument • Contextual and holistic assessment of the phenomena		
Quantitative research		
General characteristics • Numerical • Documentation-making understanding based on organisation reports • Questionnaire • Sampling size should be in sufficient size and representative of population	**Purpose** • Understanding dimensions such as on-time delivery rate, total processing time, reliability, quality and cost	**Quality of research** • Valid research results • Developing a model to explain a process
Case study research		
General characteristics • Descriptive or normative in nature • Both quantitative and qualitative methods used • Hard to separate analysis and interpretation from data gathering • Analysing and interpreting subjective procedures • Knowledge is rather constructed than discovered or found • Generalising on the	***Purpose*** • When a contemporary phenomenon within its real-life context needs investigation to gain a better understanding of complex phenomena • When a 'what, how or why' question is being asked about a set of events, over which the investigator has little or no control • To build theory and to test it • To produce a description	***Quality of research*** • Quality of research • The use of triangulation • Proper research design • Rigorous and accurate representation of empirical data • Finding rival explanations • Do pattern matching • Use a case study protocol • Develop a case study database • Use replication logic in multiple case

basis of very limited number of cases • Generalising is not making statistical inferences from the sample but to generalise through deep understanding of the phenomena • Interviews adapt to the changing situations and requirements • Captures the core meaning and feelings of the informant		studies • The reader is offered a chance independently to judge the merits, the validity, and the reliability of the analysis • Significant research outcome
Constructive research		
General characteristics • Normative in nature • Typically includes case studies • Both quantitative and qualitative methods used • Produces an innovative and theoretically grounded solution for a relevant problem • Uses a limited number of research objects	***Purpose*** • When there is a need for an innovative and theoretically grounded solution for a relevant problem • When there is a concern about 'how things ought to be in order to attain goals', not 'how things are'	***The research outcome*** • Relevant, simple, and easy to use • Practical relevance • Practical utility • Proved to be useful • Theoretical novelty • Link to theory • Also appropriate in other environments

In this research, to understand the designing PMM systems for CI and the research trend in a performance measurement area, and to achieve the research aim, multiple sources of evidence are needed. These requirements match the definition of case study (Yin, 1994). The benefits of using case studies (Eisenhardt, 1989: Meredith, 1998; Yin, 1994) are: 1) Researchers can study the phenomena, and generate and test the new theories with end users in mind. This process helps researchers gain more valid and acceptable research at the end. 2) Case study improves the understanding of nature and complexity of the studied phenomenon, and helps research to generate new ideas to answer what, how or why as questions. 3) When variables are not well known and a phenomenon is

not well understood, case study encourages exploratory investigations. However, it is like a coin with two faces. While implementing case study research strategy, the researcher needs to be aware of several potential challenges: insufficient time, difficulties of cost and access, lack of control, need for triangulations and good interview skills, and generalisations to information difficulty (Eisenhardt, 1989; Meredith, 1998; Yin, 1994). Moreover, study involving multiple cases is not to just make a list of similarities and differences between the cases (Miles & Huberman 1994), but also to identify any emerging patterns across cases and any underlying arguments (Eisenhardt & Graebner 2007).

4.6 Chapter conclusion

Discussion on clarification of the research methodology and related implication in angle of management research has been presented in this chapter. Research paradigms, their characteristics and relevant philosophical positions have also been described and the appropriate ones have been selected for this research. Appropriate research strategy can be identified in terms of appropriate research paradigm. In this research, case study has been justified as the most appropriate strategy to achieve the research aim and find the answers to research questions.

Chapter 5. Case Study Design

How the case studies were chosen and conducted will be presented in this chapter. Data collection methods and data analysis methods have been chosen based on confirmation of philosophical and research methodologies options in the Research Methodology chapter. Some factors influencing the design of the research in details are considered and discussed as well, including the background of researcher, starting point of the research, and source of available data. The results from Case Study will be provided and discussed for answering the research questions in the next coming chapters.

5.1 Academia-industry collaboration

Organisations need to maintain innovative to remain competitive and sustainable in the marketplace. In order to overcome the pressure from competitors and optimise the capacity, organisations are encouraged by policy-makers as an advantage to search across the boundary to collaborate with other organisations, e.g. universities. Academia-industry collaborations gradually have become a more and more common phenomenon (Etzkowitz and Leydesdorff, 2000; Dooley et al., 2013; Yan et al., 2018), because collaboration enables organisations to gain effective diverse ranges of knowledge. The transfer of knowledge between commercial enterprises and higher educated organisation is the important source of collaborative innovation (Perkmann and Walsh, 2007; Lockett et al., 2008; Alexander and Childe, 2013). Knowledge management (exchange, generation and learning) plays an important role in the collaboration between life and science organisations; therefore, in order to achieve the success of delivering the value to partners, the phases should be managed effectively with explorative, institutional, strategic and operational phases (Dooley et al., 2013). Alexander and Childe (2013) developed the understanding of tacit knowledge, which is opposite to explicit knowledge and derives from the ability to know and act. Their research confirmed that effective transfer of tacit knowledge using appropriate channels can help collaborative organisations improve the knowledge transfer and improve innovation between academia and industry.

5.1.1 Background of academia-industry collaboration

Academia-industry collaborations gradually have become a more and more common phenomenon (Etzkowitz and Leydesdorff, 2000; Dooley et al., 2013). Normally, academia-industry collaboration works in an informal and decentralized manner (Link et al., 2007; Perkmann and Wash, 2009). However, commercial companies gradually find it is important to adopt a more strategic approach to the collaboration with university (Bercovitz and Feldman, 2007). Meanwhile, universities are trying to find some ways to streamline and reinforce their industry collaborations by establishing centres specialising in certain subjects with single or multiple companies (Webster and Swan, 1991). Rolls Royce is a famous example for academia-industry collaboration. Rolls Royce has established about 30 Academia-Technology Centres in different universities for gaining more expertise in more specific subjects. Academia-industry collaboration is also popular in pharmaceutical industry (Kleyn et al., 2006; Garnier, 2008).

Some official figures have shown that academia-industry collaboration has gained the attention of industries, and plays an important role in innovation. Nearly half of the UK engineering and Physical Sciences Research Council (EPSRC) involve formal collaboration with third party (HEFCE, 2007; Perkmann, 2011). In EU and the United States, the situations are similar. In 2002-2003, for EU15, 6.6% of R&D in higher education and government laboratories was business funded; for the United States was 2.9%; this refers to federally funded R&D activities only – capital expenditures are not included.

As of 1990, there were already over a thousand academia-industry R&D centres in the United States, and total £2.9 billion has been spent on these centres; while National Science Foundation only spent less than half of this £1.3 billion on academic research (Cohen et al., 1994).

5.1.2 Companies' motives for academia-industry collaboration

- Collaborate with academia may help companies to gain more funding from government
- Companies would like to access basic scientific knowledge
- Academia can provide advice and assistance to improve companies' problem-solving skills, and benefits ongoing R&D programmes
- It is possible for the companies to gain more generic benefits than programme objectives through collaborating with universities.

5.1.3 Challenges of building academia-industry collaboration

The academia-industry collaboration is complicated, and there are always some problems that need to be solved. Challenges have been analysed and discovered in different stages during partnership (Dooley et al., 2013).

Although the organisations need to face these challenges, academia-industry collaborations are still popular, as mentioned earlier in this section. A lot of research has been done on evaluating on how participated organisations overcome the problems and gain success in the collaboration. The researcher Grimaldi and von Tunzelmann (2002) made some contributions on this topic based on the UK government's LINK programme. They suggested that the performance measurement on collaboration should consider direct outcomes, indirect outcomes, and the degree of matching between the collaboration's initial objectives and its final outcomes. Direct outcomes include patents and publications; and indirect outcomes include its commercial exploitation effects and the opportunities that generated by collaborations. The matching degree between the initial objectives and the real achievement needs to be measured.

Academia-industry collaboration differs from other types of R&D activities and other alliances in the following aspects, because the biggest challenge which is rooted in relationship: organisational structure and purposes. University tries to pursue academic science, which can be long-term research; while companies are output oriented in short-term or medium term (Perkmann, 2011).

First of all, academia-industry collaborative innovation projects normally focus on generating scientific knowledge that cannot be used for commercialization; therefore, it is hard to measure the outputs and the value of the collaborated project. If the academia-industry collaborative innovation can resolve technical problems in practice or result in innovation, then probably the value of the project will be higher. As other R&D activities, academia-industry project comes with risks as well. Thus, one of the biggest challenges for performance measurement on collaborative innovation is to define measures that can be used for measuring the value of the intangible outputs (Perkmann, 2011).

Secondly, academia-industry collaborative innovation is normally more complicated. Normally, the companies' objectives try to seek more benefits from the collaborative innovation, from the basic knowledge, get access to talented graduates and university postdoctoral researches (Perkmann, 2011). Thus, performance measurement should consider of the company's multi objectives.

Third, some of the project benefits may not be realised in a short term (Voytek et al., 2004). Researcher Kerssens-van Drongelen and Bilderbeek also stated that many of the benefits deriving from academia-industry collaboration might only be realised after a certain time. Therefore, performance measurement will require the use of prospective indicators that can predict the long-term benefits from the collaboration (Lander et al., 1995).

Fourth, it is important on deciding on the standards of the performance. According to Perkmann et all. (2011), academia-industry collaboration is different from one area to another area, the collaborative objective, inputs, outputs, organisational set-up, company size, etc. This makes it difficult to decide the metrics should be used. The metrics is often made with past performance (Kerssens-van Drongelen and Bilderbeek, 1999), but it may not be suitable for all the collaborations.

5.1.4 How to make academia-industry collaboration successful

Cyert and Goodman (1997) and Yan et al. (2018) argue that effectiveness measures have been overemphasised in previous research and practice, but neglecting the

'learning' perspective. Their opinion is that the academia-industry collaboration may bring concrete, directly commercially relevant outcomes, but overlooks the important role of stimulating inter-organisational learning. They advise that collaboration should have the same objectives, pursue team-based collaboration and create multiple relationships and tasks throughout the life of the alliance.

Previous research provided the existence of trust, predefined objectives, quality of communication, commitment, and similar organisational structure would make the successful collaboration between university and industry. However, it is needed a measurement framework with specific performance indicators (Perkmann et al., 2011). Therefore, it is important to provide framework with specific measurement indicators.

5.2 Case study design for the research

The aim of the research is to investigate how collaborative organisations design a PM system for improving effectiveness of CI. In practice, it is to explore more specific details which the collaborative partners need to deal with when they design the PMM system for CI and to understand the factors which impact the designing an effective PMM system for CI. The theoretical framework developed in Chapter 3 has also guided identification of research design. Moreover, the exploratory research questions presented in Chapter 2 have influenced choice of research design. Additionally, in nature this is an exploratory research, because there is lack of in-depth understanding in the research area. To sum up, case study is chosen as the research design, which can bring appropriate data and subsequent analysis. According to the theory of case study design, single case study has been rejected for this research. It is because single case study focuses on unique and typical case based on testing a well-formed framework (Yin, 2009). Therefore, multiple case studies have been used in this research. Seven case studies based on academia-industry collaboration have been chosen.

5.3 Case study selection

All seven case studies in this research are mainly from KTP project and normal university-company collaboration. The background of knowledge Transfer Partnerships

(KTP) is the European leading programme. The purpose of KTP is to help businesses to improve their competitiveness and productivity through using knowledge, technology and skills. The main sponsor of the KTP project is TSB (Technology Strategy Board), which is the UK's national innovation agency. Each KTP project is sponsored by the participating business, TSB as co-sponsor and other public sector agencies.

University of Strathclyde has a major commitment to KTPs and hosts the West of Scotland KTP Centre, which is the largest centre in Scotland and one of the premier centres in the UK. The aim of KTPs is to achieve the organisational core strategic need and identify innovative solutions to help other businesses grow. The outcome of KTPs is increased profitability for businesses, based on improving quality and operations, increased sales and access to new markets, and social contact.

5.4 Case study design

The implementation of case study design is to plan the ways to find appropriate position of the research study, collect appropriate data and gain conclusion. There are three significant stages need case study researchers to work through: selecting case, collecting data and analysing data (Yin, 1994).

At the beginning, potential 20 interviewees involving 9 university-company collaboration projects were contacted by phone or email in this research. After being rejected and re-considering, 7 cases involving 7 projects were studied in this research.

5.4.1 Overview

In order to ensure the reliability and validity of data collection and documentation, a case study protocol has been developed to make a structured approach. Collected data will be used to answer, empirically, the following research questions:

RQ1. What are the factors influencing the performance effectiveness of CI?

RQ2. What should be considered for collaborative organisations to design their PM systems for CI?

Data is collected through interview with various participants in the collaborative projects. In addition, secondary documentation was collected internally from the company and externally through media and academic documentation.

In this research, there are four stages in the data collection and documentation process, including setting up, conducting interviews, documents analysis and validation of the reports (Figure 15). In the coming sections, description of these steps will be presented.

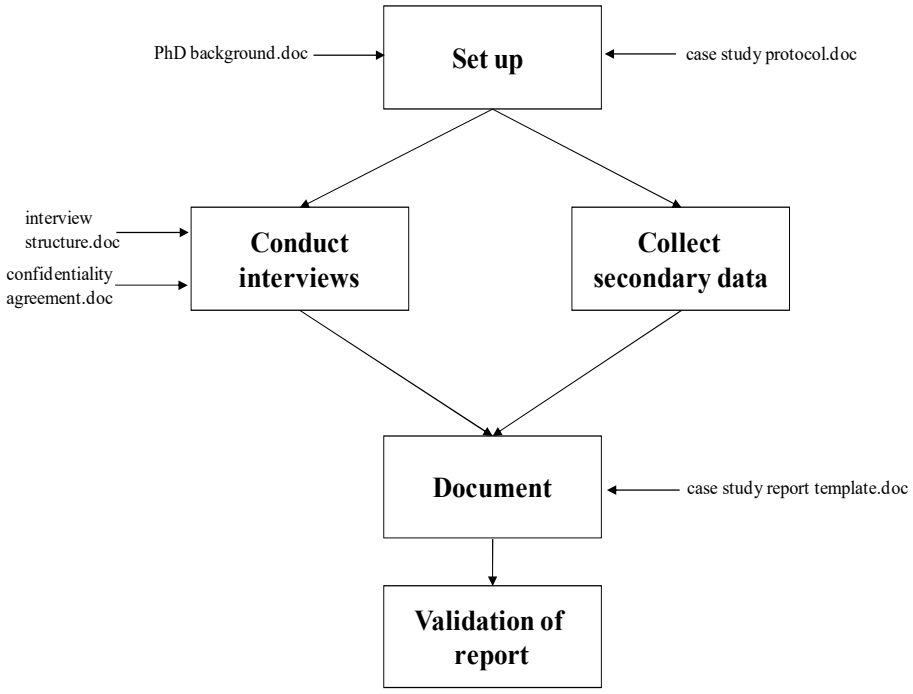


Figure 15 Phases of data collection and documentation

5.4.2 Set up

Identification and selection of case study company

The research focuses on designing effective CIPM systems, thus potential case organisations must fulfil a number of criteria:

- According to definition, the organisation should work or tend to work with partners for achieving innovation.

- The organisations would like to use PMM construct for improving collaborative innovation performance.

Both interviews and secondary data collection methods will be used in this research, so the organisation must be willing to make available relevant personnel for interview, as well as provide the researcher with relevant documentation.

Desk research

In order to determine if the potential organisations can be selected for developing interview strategy, some desk research should be carried out. This should start from reading organisation website and other published sources of information which are freely available. And the purpose of desk research is to understand the company history and background.

First contact

The first contact aims at introducing the main contact in the organisation about the research and creates opportunities to arrange a face-to-face meeting to discuss the data collection process.

In the process of initial interviews with the organisation contacts, this research will follow the steps as below:

- Interviewees
    - Relevant personnel – managerial level; PM leader; participating employees
    - Timescales – approximately 1 hour per interview
- Confidentiality – It is necessary to maintain confidentiality for case study organisation and individuals participating in the interview during the whole process of research. It is important to ensure the company and all others understand this fact at the outset. The emphasis of this point is that data gathered from any individual person or the company will not be used in any way in any research report or publication which may incriminate them or identify them as an organisation or an individual without their express permission. Refer to special requirement, a formal

confidentiality agreement can be available to be provided and signed by the research team and the company or the individual.

- Overview of the organisation – try to understand the company more in detailed
    - Brief history of the business – when the business started, ownership change, significant changes, etc.
    - Size and ownership – number of employees, governance
    - Product and service provided (previous, current and future)
    - Markets – including: customers, competitors, and suppliers
    - Future direction and plans
    - Organisational structure and management team
    - Organisational culture

- Site visit – To gain a greater understanding of the organisation's operations and make some observations on things like:
    - How organised and how smoothly things be running
    - What the atmosphere is like – talk to people about the progresses
    - How new and updated facilities are available to staff

5.5 Conduct interviews

5.5.1 General interviews

In order to understand the stories about performance measurement and management in the organisation, the researcher adopts a semi-structured interview approach, which is not of prescriptive set of detailed questions, but a series of guide questions. According to the questions in the guideline a below, interviewees are guided to discuss a certain topic or elaborate on specific points, and thus in-depth interview should be implemented with semi-structured interview. However, in order to triangulate the collected data, the researcher is aware of ensuring to cover the general points for each interviewee.

The interview strategy for each interviewee can be different, because of various data from desk research and interaction with other interviewees. However, it is necessary to

cover the general scope of the topics as the guideline. The following table shows the case study selections:

Table 14 Case Study design in this research

	Interviewee	**Methods**	**Duration**	**Information gained**
Case Study 1	*Research Fellow* Her role in the main CI project is Researcher from the academic partner	Interview and discussion Documents review Observation	2 and ½ hours for interview	Designing PM for CI from academic perspective
Case Study 2	*Managing Director* His role in the main CI project is industrial partner	Interview and discussion Documents review Observation	2 hours for interview	Designing PM for CI from industrial perspective
Case Study 3	*Professor* His role in the main CI project is Principle Investigator	Interview and discussion Documents review Observation	2 hours for interview	Designing PM for CI from project manager and academic perspective
Case Study 4	*Business Improvement Manager* His role partner in the main project is Industrial Supervisor from industrial partner	Interview and discussion Documents review Observation	2 and ½ hours for interview	Designing PM for CI from industrial perspective
Case Study 5	*KTP associate* His role in the main project is KTP associate	Interview and discussion Documents review Observation	2 and ½ hours for interview	Designing PM for CI from project associate perspective
Case Study 6	*Knowledge Exchange Fellow* His role in the main CI project is Academic Supervisor of academic partner	Interview and discussion Documents review Observation	2 hours for interview	Designing PM for CI from project manager and academic perspective

	Interviewee	Methods	Duration	Information gained
Case Study 7	*Senior Engineering Consultant* His role in the main CI project is Senior Engineering Consultant	Interview and discussion Documents review Observation	3 and ½ hours for interview	Designing PM for CI from industrial, engineering consultant and academic perspective

5.5.2 Interview guidelines

Orientation

- Interviewee information – name, position in the company and main responsibilities.
- Company information – size, age, turnover, products, lifecycle position, etc.
- Interviewee and Company – the overview or history of the company since the interviewee has been there.

CIPM story

- Do you think the company measures and manage the performance for achieving collaborative innovation, and if so, how?
- What are the main drivers for design CIPM systems?
- Who was involved in the various performance measurement and management?
- How was the objective achieved through PMM?
- What were the barriers to measure and manage the performance in context of CI?
- What made the collaborative innovation performance measurement and management system effective?
- Do you think it was necessary to measure and manage the performance for achieving collaborative innovation?

5.5.3 Collect secondary data - Questionnaire

This phrase may happen prior to semi-structured interviews. The purpose of this phrase is to gather the understanding based on feedback. The researcher would request to see

the documentation (keep a copy if allowed), once the interview is related to the documentation as the evidence from the company.

5.6 Document

5.6.1 Interview notes

Any written notes and digital records can be used to produce a mind map of discussions in the words and connections of the interviewee. In order to keep the anonymity, there is no name or job title to be displayed in the statements.

5.6.2 Case Study report

The researcher would complete case study report based on the report template and interview notes. And the researcher would make sure the anonymity of both interviewee and case.

5.6.3 Cross-case analysis

In case study research the critical step is to implement the systematic search for cross-case patterns (Voss et al., 2002). The process of cross-case analysis is to study cases individually, identify patterns in different cases and generalise conclusions (Yin, 2011). Eisenhardt (1989) state that in order to generate more reliable and accurate theory, researchers need to investigate far away from first impressions. In details, case-oriented strategy and variable-oriented strategy are recommended to be implemented. The earlier one focuses on using conceptual framework among cases, and the latter one promotes shortcut to find emerging themes among cases (Miles and Huberman, 1994). In this research, findings from each case based on the using the conceptual framework are compared. This is case-oriented strategy. On the other hand, emergent themes are generated from different variables and their relationships. This part is variable-oriented method. Then, analysis results from the cross-case analysis are used to answer the second research question.

5.7 Validation

It is important for every research to provide confident findings. The confidence comes from reliability and validity of the research. According to Yin (2009), construct validity, internal validity, external validity and reliability are popular to examine the quality of research (Table 15). Firstly, accurate evaluation implemented for the theories and interviews is in this research, which proves construct validity. Secondly, a logical and causal relationship is built in this research, which proves internal validity. Thirdly, extensive case selection in this research proves external validity. Lastly, results of this research can be the same if this research repeats by the same collection methods, which prove reliability. To sum up, Confidence in this research finding has been built by maximising these aspects.

Sampling strategy of the case study design in the research is to cover as many kinds of university-industry relationship as possible, including 1-2-1 projects (1 academic partner and 1 company) and clusters (more than 1 academic partner and more than 1 company). However, the limitation exists because it may not be possible to cover all kinds of collaboration because every project is different and partners may differ during the collaboration process. It would be valuable for the future research to explore and study cases based on different kinds of relationships.

Table 15 Case study tactics for research quality tests (Yin, 2009)

Test	Case Study Tactic	Phase of research in which tactic occurs
Construct validity	• Use multiple sources of evidence • Establish chain of evidence • Have key informants review draft case study reports	Data collection Data collection composition

Internal validity	• Do pattern matching • Do explanation building • Address rival explanations • Use logic models	Data analysis Data analysis Data analysis Data analysis
External validity	• Use theory in single-case studies • Use replication logic in multiple-case studies	Research design Research design
Reliability	• Use case study protocol • Develop case study database	Data collection Data collection

5.8 Chapter conclusion

Case study, as the appropriate research design for this research has been discussed and identified in the chapter. Three key steps in case study research design have been presented: selecting case, collecting data and analysing data. In details, multiple-case strategy has been adopted because it can bring multiple-range evidence and resources for getting research conclusions. The main data collection method has also been confirmed to be interview. At last, in order to build comparative and comprehensive explanation, cross case analysis has been confirmed as data analysis method.

Chapter 6. Data Analysis – Within Case Analysis

The aim of this chapter is to present the data collected from each of the selected seven case studies. The case analysis phase started with the transcribed interview audio, and then grouped the interview contents for a narrative discussion. Each individual case was analysed independently, and in-depth within case analysis of each case will be given in this chapter. Cross case analysis will be presented in the next chapter.

It is essential for a collaborative innovation project to have an effective process for strategic PM development, in order to improve the effectiveness of the collaborative innovation. This research consists of seven case studies based on different collaborative innovation projects (Please refer *to Table 14. Case Study design in this research* in Section 5.5.1). The data was collected through interviews, in order to investigate whether these projects measured their performance strategically. The empirical data from the interviews provided relevant data to evaluate the validity of CIPM reference model and the proposed construct.

The cases were analysed by their formal and informal performance measures during the collaborative innovation process. The data from the case study is analysed using CIPM reference model criteria: requirements of CIPM system development process, characteristics of CIPM performance measures, and CIPM performance measures. CIPM reference model has been applied in every case to validate the model.

6.1 Case Study 1

A European Commission project funded through FP7 framework was studied in Case Study 1 (CS1). The project ran from 2009 to 2012, and had 26 partners in the project which included 13 SMEs and 13 academic partners. University of Strathclyde was the coordinator of the project. The aim of the project was to improve manufacturing companies' competitiveness through helping them to have access to research outcome, and let them use the tools that developed by the university to make their business better. As a result, the business sustainability was maintained, and the performance was improved. In return, the university obtained the input needed from industrial perspective

in order to reinforce the impact of the research. There was no formal PM system applied when this CI project started, however, different measures were used for measuring the performance.

An analysis was carried out to compare the identified characteristics from CS1 against the CIPM reference model that was developed from the literature review.

6.1.1 Requirements of CIPM systems design process

- CI-related strategic objectives must be clearly and explicitly identified

In CS1, when the proposal of the project was developed, the aim of the project was to help make manufacturing companies more competitive. When the university showed the project proposal to the potential partners, the strategic objectives were clearly explained. During the project, the university helped the partners to get access to the research result, and any tools that the university developed with focus on making business more competitive. The partners' objectives were to make the business better, maintain sustainability and improve business performance. The objectives were satisfied at the end of the project. The university also gained benefits from the collaboration, for example, the university got the input they needed from industrial perspective in order to reinforce the impact of the research they did better.

This evidence shows that CI-related strategic objectives must be clearly and explicitly identified.

- Performance measures of CI should gain top management support from collaborative organisations – confirmed and extended

Top management support from collaborative organisations to performance measures of CI is crucial. In CS1, the managing director from one of the participated partner who had a MBA degree was very glad to be involved in the project, and he preferred to have the university to do the performance measures and give feedback to them. The director was very proud that his father founded the company, and was quite forward thinking.

Compare to another collaborative partner, their managing director had been working in the industry for 40 years and was very knowledgeable about the industry; he was a bit

more sceptical about working with university. It's hard to get him work with the university to implement performance measures. The company was owned by a small group of investors, and the company did not have long term planning.

This confirms the literature explaining that performance measures of CI should gain top management support from collaborative organisations. In addition, this evidence also indicated that management style has impact on CIPM.

- Being responsible for communicating with participated organisations should be clearly defined.

There were 13 SMEs and 13 academic partners from seven countries involved in the project, and there were meetings held in every six months. In order to let the partners know clearly what was happening, a researcher from each country was assigned to be the liaison person. These people were required to contact the participated companies regularly to make sure they were updated on the project progress, and meanwhile collect comments and feedbacks from them. The partners were happier with the country coordinators because it meant that they had direct contact with somebody from the project academic side, and they knew what was happening. It was important to make sure this kind of communication was happening among all the participated organisations.

This evidence confirms existing literature explaining that being responsible for communicating with participated organisations should be clearly defined.

- Existing PM systems related to CI should be reviewed and evaluated

In CS1, the first part of the project was to conduct a performance review and a current state analysis of what participants did according to a set of criteria for measuring company performance.

A diagnostic tool, strategy tool, and lots of different things had been developed during the project. The SMEs were supposed to use the dashboard to give feedback. However, sometimes it was quite a challenge to get the collaborative partners to use it without actually sitting and going through with them. In order to achieve the best results, the researcher from the university went to all the participated companies, and used the tools

to measure the performance. Based on the diagnostic results, a set of recommendations were given to the collaborative partners.

These findings confirm that existing PM systems related to CI should be reviewed and evaluated.

- CIPM should be able to measure non-financial aspects alongside financial aspects

In the case, there was a finance person who just dealt with money, which shows that the financial aspect has always been measured. In addition, The project manager, who was in charge of keeping on top of all aspects of the project, made sure that the project was not overspend; the deliverables were met; and the people were doing what they were supposed to do.

This finding is consistent with that CIPM should be able to measure non-financial aspects alongside financial aspects.

- CIPM should gain support from participants

In this case, not every participant was willing to be engaged to the performance measures. The university did a business diagnostic for the partners, and gave recommendations to them. However, there were participants did not make any changes or act based on the diagnostic results or recommendations, which made it difficult to implement performance measures. Some of the companies were more engaged, they used the other tools that were developed, and made changes in order to improve company performance.

This evidence confirms that it's important to gain supports from participants.

6.1.2 Characteristics of CIPM systems design process

- Data is available and accessible for constant review

The university had developed a system to collect participants' feedback, some partners got very engaged, which was very helpful for the project. However, some partners just did the very minimum that they had to do as a participant, which heavily affected the data collection for PM.

This shows that it's important to have data available and accessible for constant view.

- Performance measures of CI are easy to understand, use, and maintain

A website, a diagnostic tool, and a strategy tool, and other different things were developed for measuring performance during the project time. Some of the partners got very engaged, and followed the requirements of PM. However, some of the companies did not want to be involved that much, which were not good for performance measure database collection. Although every participant was using the same system, different participants treated the system totally different due to their attitudes.

This shows that it's important that performance measures of CI are easy to understand, use and main, in order to get

- Performance measures of CI are flexible which can be changed as circumstances change

The milestones and deliverables were the main things to check performance outcomes, which were normally decided at the beginning of the project. Sometimes, the decided milestones and deliverables did constrain things slightly. Sometimes, after a particular task was done, and the staff realised actually that was not the best way to do that, and they wanted to change it. However, the manager could not agree to change, because he did not want to change the agreed deliverables. The staff found it was very frustrating to have a strict list. The project manager's performance measures to check everyone's work. However, they felt they were trying their best to the best job and sometimes came up with the better solution, which did not always match with deliverables. Normally, the deliverables were written at the start of a four year project, and did not really know what it's going to happen, so sometimes there is a bit of a mismatch.

This confirms that performance measures of CI should be flexible which can be changed as circumstances changes.

- Performance measures of CI are applied at collaborative and individual level

In this case, performance measures were used to measure the participants' performance during the project. The participants submitted deliverables according to agreed schedule.

These confirm that performance measures of CI were applied at collaborative level. However, performance measures of CI to individual level have not been mentioned.

- Feedback regarding performance measures of CI is provided accurately and on time

In CS1, it was only the six monthly meeting that actually involved everyone. Some partners had the feedback that they were unsure about what was happening exactly. So in order to update everyone on time, a researcher from each country was assigned to be the SME liaison person. Their job was to contact the participated companies regularly to make sure they got the updates on what was happening with the project, meanwhile, collected any comments or feedback that they had. It's important to make sure that kind of communication was happening.

There were 13 SMEs and 13 academic partners involved in the project, and there was a monthly meeting, which was called technology board. All of the academic partners and one SME representatives attended the meetings. These meetings were also to update everyone what was happening in terms of the technical developments in the project and collected feedbacks.

A virtual meeting was arranged for SMEs every month, however, they were not interested in doing that, and did not think it was worthwhile. After they reported this problem, the country coordinators were arranged, which made the SMEs much happier. Because the performance measures were being implemented in different ways in different places by different people, it's hard for them to get a coherent, true, and full feedback picture.

These findings show that feedback was provided accurately and on time through various ways. A full feedback system will be needed to get the completed feedback information.

- Performance measures of CI are reported periodically

There was a big meeting with all the partners involved every six months. A performance review of what work could be done against the deliverables that the partners had to do was done. Then, future work was being proposed. The details of how the deliverables were not always there. So at the meeting, the details of what all the partners need to do

and who would do that were discussed. It's also the time to see any improvements can be done.

This finding confirms that performance measures of CI are reported periodically.

- CIPM stimulate continuous improvement rather than only monitoring performance

At the beginning of the project, a current status analysis of what the company did, according to a set of criteria that was for measuring company performance. Based on the analysis results, some feedbacks were given to the company. A business model for SMEs was developed, and also specific tools for different aspects of the business were developed.

This confirms that CIPM does not only monitoring performance, but also stimulates continuous improvement.

6.2 Case Study 2

Case Study 2 (CS2) is a project between a Scottish whisky bottling company and a university. The company provided contract packing for whisky companies, and the market was extremely volatile. The university did a strategy review for the company, and found that the business was very low skilled. The university built the academic models and came up with proposals to test it out. In this project, the university was in the dominant position.

6.2.1 Requirements of CIPM systems design process

- CI Performance measures should gain top management support from collaborative organisations

Top management's personality, attitudes and supports have huge impact on collaborative innovation performance measures. In CS2, the new manager is a very outgoing and extrovert type person. He is good at building a good relationship with customers. If giving him a framework to follow and ask him to put down the performance measures, he's less comfortable doing that kind of thing.

The university did a performance review for the company, and found out that the staffs within the company were not communicating the strategy through the business. However, the principle owner and the senior managers did not make any changes on it, after they got this performance review result. The company did not really want to tell the staff about the strategy, because they did not want their competitors to know what their strategy is.

These evidences confirm that without top management supports, it's hard to implement CI performance measures.

- Being responsible for communicating with participated organisations should be clearly defined

During the project time, there were two main people from the university that the company needed to communicate with, and regular meetings were held between those two people and the company. This confirms that the people that were responsible for communicating with the participated organisations should be clear defined.

- Existing PM systems related to CI should be reviewed and evaluated

In CS2, at the beginning, the university did a four segments performance review for the company. The company was satisfied with that review, they found that the objects and everything that needed to be done with the projected were clear defined, and the review also helped them to set up the targets for improvement. The company had a really good strategy through that review.

The company did a comprehensive questionnaire that was developed by the university, and identified their principal weakness. After the analysis, the university found out that the company was scoring low on strategy; the company did not communicate the company's strategy through the business.

The manager thought it is really important to keep re-evaluating and justify how appropriate the system.

These findings confirm literature in the sense that existing PM systems related to CI should be reviewed and evaluated.

- CIPM should be able to measure non-financial aspects alongside financial aspects

A remarkably simple spreadsheet was used in the company for financial measures. From that spreadsheet, the company could easily see, how much money was going out each month, how much money was coming in each month, what the sales were, what the targeted sales were, where the company was running out of cash, where the company were likely to have surplus cash, if the customer paid the company on time, etc. The manager thought this financial measurement was critical to their business survival.

The person who was running the plant could monitor the staff efficiency. If he/she saw difficulty in the line, they would tell that staff and modified the plan.

These findings confirm non-financial aspects should be measured alongside financial aspects.

- CIPM should gain support from participants

In CS2, the manager thought that it is necessary to know the individuals, and see what things are positive for them and what things are negative for them before implementing performance measure. It would be difficult to get everyone to do the full range of what you believe needs to be done.

The manager though that people do not like being measured. So any measurement system that the company put in, the company needed to be very careful how it's going to be implemented.

These evidences show that CIPM should gain supports from participants.

6.2.2 Characteristics of CIPM systems design process

- Feedback regarding performance measures of CI is provided accurately and on time

The university gave suggestions to the company, and the factory made the judgement, and told the university the suggestions were not going to work, if they found the suggestions were not suitable. Based on the feedback, the university would go away and think about it, and either modify the suggestions or come back to discuss with the

factory to find out what the problems are.

The company would get an update when they had the major project meeting. Meanwhile, the university would give the company some feedback, which the company thought it was great and on time.

These confirm that feedback regarding performance measures of CI is provided accurately and on time.

- Performance measures of CI are reported periodically

There were two major progress meetings a year. At the meeting, the business partners had always to do a presentation on what their progress with the project was. It's also the time to see how the progress aligned with the project's objectives for that particular phase of the project.

There were targets to meet for all the business partners during the project time. The deliverables were submitted at the annual meetings. Feedbacks were provided for the partners as well.

These were consistent that performance measures of CI are reported periodically.

- CIPM stimulate continuous improvement rather than only monitor performance

At the beginning of the project, a performance review was done for the company. The company found the review was good for them, because the objectives and everything that needed to be done were clarified, and the targets for improvement were set. A good company strategy was also conducted through the review.

This finding is consistent with the study from the literature that CIPM not only monitor performance, but also stimulate continuous improvement.

6.3 Case Study 3

Case Study 3 (CS3) is based on a 2-year project which aims to design and deliver a uniquely integrated and flexible cake manufacturing production system with new developments in mechatronics. This collaborative innovation solution is capable of

handling specific materials to customise cakes whilst making the new product lines available at profitable levels. This is a generic and cost-effective innovation for maintaining business sustainability.

Two participating partners have been involved in the project, including a university and a company. The company is based in Scotland, and it is a professional supplier of premium and celebration cakes to the UK market. The change of the company has been promoted in the early 1990s' by the demand of supermarkets and other retailers. At the moment, company's business has been transferred from bakery retail with one hundred-year history to supplying the celebration cakes to retailers.

The company has had experience of working with university for refining their processes with objective of increasing shelf life and improving consistency. Strong collaborative working relationship has been built, and successful result has been achieved completely by the end of the previous project.

The interviewee is the Primary Investigator (PI) of the project. PI is generally a lead researcher or research group leader for a particular well-defined project. In this project, responsibility of PI includes writing project proposal for applying for funding to support the project, providing technological inputs to direct product production, and managing project in terms of project progress, project deliverables, project finance and tasks.

Analysis has been carried out to compare the identified characteristics fromCS3 against the theoretical CIPM reference model.

6.3.1 Requirements of CIPM systems design process

- CI-related strategic objectives must be clearly and explicitly identified

In CS3, project proposal was designed by Primary Investigator and agreed by industrial partner based on clear strategic objectives. According to agreement between two partners, main objective was to design innovative and smart solution to handle the cake. The benefit company partner could gain was the effectiveness improvement on cake automation handling system design. Moreover, all tasks related to strategic objectives were agreed by both partners and listed in the planned schedule. Overall, understanding

objectives clearly and working for them has made positive impact on progress of the project.

- Performance measures of CI should gain top management support from collaborative organisations

In CS3, professor from university partner was PI, who proposed project proposal, applied for project funds, found collaborative partner, built research team, designed measurement details and managed project progress. Manager from company partner side was keen to give support, provide platform and technologies to make project move forward, discuss about milestones. So, details about project progress and measurements were proposed by PI and then agreed by managers of company partner.

- CI-related goals should be prioritised

Plans were designed at the beginning of building collaboration. Tasks were agreed by both partners, ordered and then listed in Gantt Chart. However, it can be too fragile to make innovation. It needs freedom or some space for solutions for making innovation. So not everything needs thoroughly pre-defined and prescribed. Collaborative partners need to prepare for and face challenges, and then find solution.

- Being responsible for communicating with participated organisations should be clearly defined

Many reasons may affect aims to achieve or fail. Participants try to use different resources to cover circumstance. If lack of funding support, partners should talk to them and persuade them to involve more. At the beginning of and during the project, there are rounds of meetings for collaborative organisations to discuss about details on the project progress and updated plan.

- Existing PM systems related to CI should be reviewed and evaluated

Collaborative organisations have not formally implemented PM with a specific framework in this case, but there are simple frameworks including Gant Chart, lists of deliverables, and tables of targets and deadlines. However, previous experience has

made impact on this project, e.g. PI has used formal PM framework in previous project, called facilitated input.

- Performance measures of CI should be designed and decided based on discussion with partners in the CI project

Based on frequent communication, details of PM in the project can be discussed and agreed by all partners. In this project, rounds of meetings by employees from both organisations have been made to monitor progress and plan for achievements.

- CI should be considered when designing and deciding the performance measures of CI

In this case, protection has been taken into consideration. University partner understood importance of keeping IPR (Intellectual Property Rights) of company partner. Understanding mutual benefits is also crucial, particularly for collaboration between university and company. Different organisations have different gaining from the project, but when university publish papers or make presentations, it needs protection for company partner from competitors.

These evidence shows CI should be considered when designing and deciding the performance measures of CI.

- CIPM should be able to measure non-financial aspects alongside financial aspects

In this case, funding, as one of the most important aspects, has been monitored and measured as the project moves on. Moreover, other aspects have also been carefully monitored and measured, including project deliverables, project tasks and so on.

- Timescales for designing and implementation of CIPM system should be set.

Although collaboration in this case involves a company and a university with different benefits, the same purpose exists in the collaboration, which is to build long term relationship. It is important to achieve good performance when partners intend to build long-term relationship.

- Key factors of CIPM should be identified

Some factors should be elaborated, e.g. organisational culture. 'Plans need to be concrete for achieving what are proposed.

- Individual participated organisations' responsibility and measurement should be clearly identified

In this case, PM is about defining project proposals, achieving deliverables, and further refining them in the future every specific period. It also involves clearly defining on the basis about responsibilities of partners in the project, time, and deadlines. Also, project needs to prepare contingency plan with clear responsibility, because unexpected problems may happen.

At the beginning of project, purposes and responsibilities in documents are made very clear. This is the key to the success of the project. This clarifies characters of partners, responsibilities, financial use, and IPR, etc. Sometimes it can be risky and time-consuming to agree on contents and regulations on documents, but it is crucial and useful.

- CIPM should be maintained and reviewed

Keeping updates about performance measures is important and useful for collaborative partners to achieve effective performance.

6.3.2 Characteristics of CIPM systems design process

- The purpose in each performance measure of CI is clearly defined

In this case, PI proposed purposes and details of project, and then after discussing, they were agreed by partners. Measurement in this case included deliverables, project progress, and further refining them in the future every specific period. It also involved clearly defining on the basis about responsibilities of partners in the project, time, and deadline. The purpose of PM is not to push the pressure, but also ensure to gain effectiveness of performance.

- Performance measures of CI are related to CI process and outcome

In this case, progress and deliverables were measured. And as the project moved forward, performance of machine with advanced design was tested.

- Performance measures of CI are flexible which can be changed as circumstances change

It always needs to be flexible about what can get and what can achieve. In this case, partners have prepared contingency plan for unforeseen situations and outcomes. During the process of changing design of machine, relevant functions were affected.

- Performance measures of CI are applied at collaborative and individual level

In this case, measurement about deliverables, progress and functions of machine were related to performance of individual and collaborative organisations. Partners respectively provided contribution and collective outcome about idea and design were measured.

- Feedback regarding performance measures of CI is provided accurately and on time

PI in this case clearly presented importance of feedback about CI, 'It must be valuable to keep informing updates to all partners.' In particular, both quality and efficiency of feedback is important for the project.

6.4 Case Study 4

A project between a newspapers/magazines logistic company and university was studied in case study 4 (CS4). This company is the second largest distributor of newspapers and magazines in the UK, and employs just fewer than four thousand people across the UK. The company has 45% market share, which is about 26000 customers need to get deliveries every day. The core purpose is to deliver newspapers and magazines on time, in the right quality, to each retailer. Although the company has a big market share, the market is in declining by about 5% per year because of the increase use of smart phones, iPads, and other digital technology. The younger generation do not necessarily need to buy a newspaper; even international papers are

widely available on the web. In order to look at new ways, new services, new products, even in new areas to make more profit, the company joined this collaborative project.

6.4.1 Requirements of CIPM systems design process

- Performance measures of CI must be chosen from the organisational strategy and purpose

In CS4, the company identified primary metrics and secondary metrics for measuring company's performance. The manager gave an example, primary metrics was to reduce transport bill by four hundred thousand pounds; and the secondary metric was not to have any impacts on the delivery time to the customers. The manager explained that the company wanted to achieve something from each project, so each project would have its main objective and then would have some secondary objectives. Normally, the primary objective was what the company trying to achieve; and the secondary objective was to make sure that the company did not create a new cost or a new problem because of achieving primary objective. The manager said that, quite often, people took the benefits when they put a project in place, but the costs were transferred somewhere else. So the company needed to manage the process properly. The company use performance management all the time in what the company does, so it's necessary to identify the measure is what the company want to achieve.

This evidence shows that performance measures of CI must be chosen from the original strategy and purpose.

- CI-related strategic objectives must be clearly and explicitly identified

There were a few points from CS4 shows that CI-related strategic objectives must be clearly and explicitly identified.

Before the collaborative project started, the company would like to know what benefits they could get from the project. Once the benefits were agreed, they were defined in the contract.

The manager said that the company used performance management all the time in what the company did, and the performance metrics were set according to the company's primary and secondary objectives.

Although this project was considered to be successful, the manager thought it could be more successful if they got a more defined set of objectives. The company thought they were quite woolly at the beginning of the project, because the problems and the objectives were not defined clearly.

The manager said that if the company was doing the collaborative project again, the benefits and success criteria should be defined more clearly. By fulfilling the success criteria, the target to aim for will be set clearly as well. It would be beneficial for the company to set up the primary objective and other objectives by analysing the previous or current state, and the future state detailed.

These findings confirm literature in the sense that CI-related strategic objectives must be clearly and explicitly identified. The manager also suggested that the benefits and success criteria should be more clearly defined.

- CI Performance measures should gain top management support from collaborative organisations

In CS4, there was support structure within the company. There were a board of directors, and each of those boards of directors had got people who fulfil different directorial roles. When an idea for potential savings was generated, the business improvement department would work up a benefits case, cost invested benefits model, and then they would propose to the responsible director. The potential outcome of the project would be discussed with the directors, and once it's agreed that it was a viable project, it will be moved to next step.

This evidence confirms existing literature explaining that CI performance measures should gain top management support from collaborative organisations.

- Existing PM systems related to CI should be reviewed and evaluated

In CS4, normally, at the end of each project, a review of the success of the project would be done to see how realistic the project was; if there were too much money been spent for the project; if the project took too long; if the actual deliverables met the target.

This evidence confirms existing literature explaining that existing PM system related to CI should be reviewed and evaluated.

- CIPM should be able to measure non-financial aspects alongside financial aspects

In CS4, there was a progress meeting every three months. There was a checkpoint to see if the project still on track, and if every participant was still happy with the way things were going. If someone was not happy at any point in those three months, someone could say stop. So there was a definite control mechanism there.

- CIPM should gain support from participants

Once the project got approval, the participant moved to the next stage to build a competent project team depending on what the skill set required. The team members could come from IT support, from depot network, from a distribution centre, etc. These persons would get involved in performance measurement in terms of were the branches complying with contractual requirements, were the branches complying with the targeted budgeted performance, were the company performing ahead of wages and salaries, how was the stock control, or any involved in kind of the order and the control of the operating system and the process.

Quite often, the collaborative was going to affect the company's retail customers, so the company embedded one of the relationship managers with the retail team. These managers got involved into the project, and they checked what the new process was going to be and took some responsibilities and got feedback for the rest of the team.

These findings are consistent with the study from literature review that CIPM should gain support from participants.

- Timescales for designing and implementation of CIPM system should be set

Performance management has been used all the time in CS4, and the time scale for implementing PM was set when the target was set. One example was given the company wanted to measure how accurate the delivery is in six month time. The staff

then knew that they needed to spend more time getting the delivery accurately, rather than focusing on delivering on time in the following six month.

A timeline would be created based on the project team's thoughts on how quick to deliver the project result.

These evidences confirm that timescales for implementing CIPM system should be set, however, the evidence of time scales for designing CIPM system has not been founded in this case.

6.4.2 Characteristics of CIPM systems design process

- Data is available and accessible for constant review

During the project time, the collected data were fed back to the team to get feedback. This confirms that data is available and accessible for the team to have constant review.

- Performance measures of CI are flexible which can be changed as circumstances change – confirmed and extended

In CS4, the performance measures were used all the time in the company. The measurement was decided by the company's prioritised objective. The manager gave an example, if the delivery on time to the retailer was the number one priority, then that's the measurement they were going to go by, and other performance in that area would be improved as well because they focused on it. Meanwhile, the company would have a look at what was affecting performance, and how could the company improve it. Probably in six months, the number one objective was not about the delivery on time to the retail any more, it's about how accurate the delivery, then the performance measures would be changed accordingly.

During the project time, it could end up with five measures of the same metric, and how the participants measured the metric could be variant. The manager gave an example on people's thinking about how the unsold newspaper been processed. For a publisher was probably more interested about making sure the unsold are collected and returned on

time, so he could hit his sales figure. For a retailer, he did not really care how quickly the unsold ones been processed, as long as he got money at the end of the bill.

In the CS4, the manager said that it was not always five or six metrics for all measures. Normally, the company tried to have a very simple metric, but when the company was not achieving that metric, the company needed to go back to the process and analyse the process from start to the end. After analysing what causing that to fail, then the company needed to take it apart to rebuild it, or to repair it, or try and get better performance metrics. Sometimes, the company realised that the metric that they had got was not the metric they should have. In that case, the company needed to redefine the goals and metrics.

For the same metric, different people can have different point of views. The manager gave an example that they delivered 99.7% of the newspapers on time; the company was very impressive with this figure. However, from a customer's point of view, the 0.3% of the customers who did not get the delivery on time was the customers who got less volume.

The finding is consistent with the literature review that performance of CI should be flexible which can be changed as circumstances change. In addition, the evidence also shows that one measure could have a few metrics, and the metrics should be adjusted according to the target's needs.

- Feedback regarding performance measures of CI is provided accurately and on time

At the quarterly review, the company checked if the company going to achieve what they need to achieve by end of the project; and also reviewed the timeline and make sure everything was actually going to be on track to deliver.

Normally, at the end of the process, the company would do a review of the success of the project, and judged on how realistic the project had been in terms of the cost. The typical case was when the projects run over; it would be the company spent too much, or the company had taken too long; or the company did not deliver half of what they were supposed to deliver.

Based on the associate's report every three months, the company-based supervisor and the academic supervisor would clarify exactly what they have been seeing was same as what he reported. Then the supervisors would discuss how things were going just in general, how the project was going, and if there was any issue that needed to be resolved. The issues could be about the associate, the project, financial aspects, etc.

These findings were consistent with the study from literature that feedback regarding performance measures of CI is provided accurately and on time.

- Performance measures of CI are reported periodically

During the project time, the associate did a presentation and summarised what he had been doing in the last three months to the supervisors from participated partners. A financial summary will be submitted as well. The associate would produce a Gantt chart as to what his plans are going to be forward for the next three, four, five, or six months.

These show that performance measures of CI are reported periodically.

- CIPM stimulate continuous improvement rather than only monitoring performance

In CS4, the manager mentioned that there were various metrics across been used. However, in this collaborative projective, it's more difficult to narrow down, so the 360 feedback was probably the biggest barometer of performance. They used it to check how well the KTP associate has been integrated into the company's society, and used it to improve his performance.

The supervisors from the company and the university would discuss how the project was going in general, and also discussed if there were any issues that need to be resolved. There was that element of control or checkpoint to see if everything was still on track, and if the participant was happy with the way the project was going. If one of the participants was not happy at any point in those three months, then someone could say stop, and judgements and improvements could be made.

These evidences confirm the literature explaining that CIPM stimulate continuous improvement rather than only monitoring performance.

6.5 Case Study 5

Case Study 5 (CS5) is a collaborative project between the government, a company, and a university. The associate was from university, and worked in the company during the project time. The purpose of this project was to understand where to fill the skills what the company hadn't found enough, and also to improve the operational efficiencies across the supply chain from the expertise of what KTP associate had, and what the university could bring to the company. The associate's title was Implement Engineer during the project time, and his main responsibility was implementing the performance measurement framework. He needed to make sure that the right framework was used to measure the performance in the company. It's not only the company's requirements need to be filled with, also the requirements of the partnership and the university. When the objective of the company changed, the university needed to change the working way according to the project needs. During the project time, the associate focused on driving the efficiencies, improving the efficiencies with the company.

An analysis was carried out to compare the identified characteristics from CS5 against the CIPM reference model that was developed from the literature review.

6.5.1 Requirements of CIPM systems design process

- Performance measures of CI must be chosen from the organisational strategy and purpose

When the initiatives were discussed between the associate and the company managers, they made sure that those initiatives were aligned to what the business needs and strategies. It's only when the initiatives met the business needs or the board needs, the projects could be driven.

This finding confirms literature in the sense that performance measures of CI must be chosen from the organisational strategy and purpose.

- CI-related strategic objectives must be clearly and explicitly identified

The purpose of the project was to understand where to fill the skills that the company had not found enough, and also to improve the operational efficiencies across the supply

chain from the expertise of what the university and the associate can bring to the company. This purpose was clearly and explicitly identified, according to the associate. This evidence confirms that CI-related strategic objectives must be clearly and explicitly identified.

- CI Performance measures should gain top management support from collaborative organisations

During the project time, the managers from the company and the supervisors gave a lot of supports to the associate. He had chance to talk to the business manager early every day, and got to know a lot of details about the business. The supervisors from the university also gave him a lot of supervisions during the project time. The associate thought the success of the project was because of the good managers.

This confirms that CI performance measures should gain top management support from collaborative organisations.

- Being responsible for communicating with participated organisations should be clearly defined

In this case, the associate was from the university; however, he was mainly based in the company. He got supervisions from the university's supervisors and work closely with the company managers. It was clear from the beginning of the project that the associate was the person to help the company to find the skills what the company had not found enough and also to improve the operational efficiencies across the supply chain from the expertise of the university and the associate.

This evidence shows that the person who is responsible for communicating with participated organisations should be clearly defined.

- Performance measures of CI should be designed and decided based on discussion with participants in the CI project

During the project time, the associate did the first round analysis based on the collected data, and then identified the gap in that particular process. The gap would be shown to

the manager, and the managers would discuss with the associate to see what could be changed for improving the performance of the company.

The associate's role was to identify the implement initiatives across the business, and discussed about the initiative with the company's managers to see what benefits it could bring for the company.

These evidences confirm that performance measures of CI should be designed and decided based on discussion with participants in CI project.

- CIPM should be able to measure non-financial aspects alongside financial aspects

The company distributing newspaper and magazines to the retailers, so there were many aspects that need to be measured. During the project time, there were a few matrixes been used for measuring the performances, for example a few matrix for checking the quality, and a few matrix for checking how the company delivered the products to the customers. The associate gave more detailed on what they actually measure, like if the company has taken the right quantities for packing within the company's distribution, if every customer got what they should get, if the driver packed the right parcel and delivered to the right retail. Some mistakes happened sometimes, and customer would phone up to complain, which was extra cost for the company. Through the matrix, some of the errors or mistakes could be found before the customer complained. There was a relation between everything in the company's operation, so different matrixes were created for measuring.

This shows that CIPM should be able to measure non-financial aspects alongside financial aspects.

- CIPM should gain support from participants – confirmed and extended

The people who worked in all the depots all participated into the performance measure process and helped to collected the data on time. Without these staff's supports, the data could not be collected properly.

According to the associate, sometimes it's hard to know if the results of performance measurement were correct or not. Because it could be the employees tried to perform better when they knew the measurement were ongoing.

It is necessary to let the participated staff fully understand the PM process. Because it's possible that the staff got a wrong figure, and still thought it's the right number, if people did not understand the thesis behind fully.

This shows that CIPM should gain supports from participants, however, it is important to make sure that people do not change their working way when they know there is ongoing measurement, and they go back to their normal working. It's necessary to let the staff have the full understand of the performance measurement.

6.5.2 Characteristics of CIPM systems design process

- The purpose in each performance measure of CI is clearly defined

The purpose of this project was to understand where to fill the skills what the company had not found enough and also to improve the operational efficiencies across the supply chain from the expertise of what the university and associate can bring to the company. This purpose was clearly defined right at the beginning of the project.

This confirms that the purpose in each performance measure of CI is clearly defined.

- Data is available and accessible for constant review

The associate changed a few matrixes, decided to have a close look on the quality control. There was a lot of number crunching needed for understanding what was happening. The associate needed to use the data more effectively, in order to identify the best way to analyse it. Once the gap was identified in that particular analysis, the associate would explain to the manager and discussed what changes could be made for the company.

This evidence shows that the data is available and accessible for constant review during the collaborative project time.

- Performance measures of CI are reported periodically

There was a meeting with the funder, operations director, and line manager for reporting work process. The associate explained to them what have been done in the last four months, and discussions involved about the progress and the deliverables. The main purpose of the meeting was to make sure that the project as on track and the partners were going to achieve what they were supposed to achieve.

This evidence shows that the performance measures of CI are reported periodically.

- CIPM is cost-effective

The associate gave an example on CIPM should be cost-effective. He suggested the company to implement framework into the business, however, the company rejected to do that after he explained to the managers. The manager thought it's too massive for the company to take at that time.

This evidence shows if CIPM is not cost-effective, it's hard to implement.

- CIPM stimulate continuous improvement rather than only monitoring performance

In CS5, KTP associate thought that it is important to quantify something, in order to improve it. The company could do the performance management better, based on the performance measure result. Performance management is an ongoing process and is the key thing for company's continuous improvement.

During the project time, all the depots' performances have been monitored, and a weekly report was done. Based on the report, the managers could compare every depot and see which depot was better each week. These also became a competition among the depots, which drove to improve the process. Although the report was a quantitative thing, it did not give ranking. The investigation would be done for those performances got worse.

These evidences show that CIPM stimulate continuous improvement rather than only monitoring performance.

6.6 Case Study 6

Case Study 6 is a project funded by the government and the company, and the work was mainly done by the associate who is a member of university and working in the company. The interviewee's role in the project is KTP supervisor, which is the supervision of the KTP associates. He provided guidance throughout the project and supervised the development. The project was about continuous programme, which was how they can make supply chain better.

The university works based on the assumptions from company. The company has lots of expertise and experience in this area. They have made profits on selling their machines, providing services, and doing activities around machines to the people all over the world. They think that the existing machines can have new different components which they could not have, and they hope to create something through the collaboration with the university. It is a 2-year project, covers many areas, such as Mechanical Design and Control System Design. The company hope to end with a prototype of the designed machine at the end. The key in this project is from the beginning to make clear understanding about the clients' requirements. The project was very sensitive to the company, which could make the company very rich or very poor. That was why it was essential that they have frequent meetings and have open communication to understand each other.

An analysis was carried out to compare the identified characteristics from CS6 against the CIPM reference model that was developed from the literature review in the following sections.

6.6.1 Requirements of CIPM systems design process

- CI-related strategic objectives must be clearly and explicitly identified

In CS6, the CI-related strategic objectives were clearly and explicitly identified. According to the interviewee, they spent lots of time on the project plan. A 2-3 years high-level project plan with clear idea of miles stones, and deliverables for both

company and university wanted to achieve have been written down. In the interviewee's opinion, the project plan is very important.

- CIPM should be able to measure non-financial aspects alongside financial aspects

The chairman or usually the CEO of the company gave updates about company's financial things. The updates could have impacts on the project progress. There were financial reports to look at the expenditures, and if there was anything needed to be adjusted. There were a few budgets of the associate to look after, which are training, personal development, travel, subsistence and consumables. It's easy to know if the project still had enough money to spend on for the project.

Apart from the financial things, the non-financial things also been inspected during the project time. The associate gave the presentation at the meeting; he showed the progress to the needs from the previous meetings. The associate would discuss what things happened according to the plain; what things changed and why; more details of his development in terms of the project. The collaborative project was a partnership and it must work for everybody, according to the interviewee. The benefits were discussed at the meeting as well, for example, what benefits the project were creating for all individuals; any outstanding academic outputs; the personal development outputs of the associate; and the project progress.

The skills of individuals for the project progress were measured. There were very effective tools like skills metrics been utilised. Based on the metrics, the strengths of people could be known, and what areas they could develop.

6.6.2 Characteristics of CIPM systems design process

- Performance measures of CI are reported periodically

Formal meetings with the funders of the project were held regularly. The meetings were well organized, and one of the most important meets was every four months. At the meetings, the local management committees (LMCs) did the sense checking and assessed the progress. This was the time that the company and the university worked together to make decision to make the direction of the project and try to find out the solutions.

This shows that performance measures of CI are reported periodically.

- Performance measures of CI are flexible which can be changed as circumstances change

As the situation of the company changed, the measures were adjusted accordingly.

This evidence shows that the performance of CI can be changed as circumstances change.

6.7 Case Study 7

In Case Study 7 (CS7), the main project is an EU-funded one with different partners, including universities, research organisations, SMEs and large companies from different countries. The objective of this project was to build an effective platform for different organisations to find collaborative partners. However, CS7 also looked at experience from one expert with academic knowledge and practical experience in marine engineering for over 40 years. The interviewee has worked as a consultant in different projects, which normally involved two or more partners. The purpose of most collaborative projects is to design and deliver new or improved marine technologies and machines.

Analysis was carried out to compare the identified characteristics from Case Study (CS7) against the CIPM reference model that was developed from the literature review.

6.7.1 Requirements of CIPM systems design process

- CI-related strategic objectives must be clearly and explicitly identified

In this case, according to interviewee's experience, objectives of project and way of working relationship were based on nature of the project. Some of collaborative relationships did not focus on innovation, e.g. one project was set up because of short of resources and staff. In this project, unclear mutual understanding made partners confused and delivered unsatisfied outputs. In another project, wrong expectation was put in when designing project plans. During the process, one partner was trying to refine the expectation; but it was too late to do so. Eventual outputs were not made to achieve

very original expectations. Thus, it is important for collaborative organisations to make refinement at the very early stage.

- Being responsible for communicating with participated organisations should be clearly defined

In all of the successful projects from the interviewee, regular meetings and formal communication were conducted to make more benefit for the projects, rather than informal and social communication. And all formal meetings and communications were formally recorded and utilised. The interviewee realised that verification and validation about the information were formally maintained when communication was made in the process of these projects.

- Performance measures of CI should be designed and decided based on discussion with partners in the CI project

From the interviewee's experience, in one of the successful projects about electricity power supply for fitting submarine design, 7 partners built strong working relationship, based on early designing PM, regularly meeting and discussing together. At the very early stage of project, the partners designed dimensions of measurement as detailed as possible. The partners also made clear understanding among each other about what would be going to do, what requirements would be, and what benefits could gain from each other.

This evidence shows that performance measures of CI should be designed and decided based on discussion with partners in the CI project.

- CIPM should gain support from participants

In one of projects about Virtual Reality, all employees joined and used the technology for improving the related function. Participation from all partners makes project and implementation of PM work effectively.

- Timescales for designing and implementation of CIPM system should be set

At the beginning of the project, collaborative partners should clearly define sets of measurements, targets, progress review, detailed plans, requirements and way of measurements.

- Individual participated organisations' responsibility and measurement should be clearly identified

In this case, it is confirmed that clearer defining of responsibilities & tasks makes positive impact on improving performance effectiveness of collaboration.

The relative and respective responsibilities from different levels to the senior or main level may be related to full participation of staff from different departments of the project. The accountability of managers will feed up to the whole project manager.

In submarine projects, responsibility, skills, measurement and understanding are considered. Different sections or relative staff with these should be considered.

In mobile phone or aircraft projects, measurements are designed from small to big bits, because jobs collaborated from small bits to big bits, and relative managers are responsible for each and to tie them up.

Reports to different levels can be in different sizes. Sub-levels managers gets what he needs and reduces size of reports to higher level, so report to main manager may be very simple and straightforward about time and schedule.

In PM, problems are not clearly displayed in the report. In this case, it may say to need more staff or night shifts for completing tasks. So, based on PM, when problem is there, manager needs very clear understanding and work out with relevant team to meet to discuss if being fixable and how to fix problems.

- CIPM should be maintained and reviewed

Some problems are unforeseen, especially when keeping innovative all the time and measuring tasks. It needs to keep alert and find what negatively influence (hamper) performance. In this case, collaboration may cause delay of making product.

6.7.2 Characteristics of CIPM systems design process

- The purpose in each performance measure of CI is clearly defined

In one of interviewee's submarine design projects which includes one government, two main companies and three universities, standard of tasks and measurement targets were not set clearly at the beginning. It caused that measures were very difficult to achieve. After first month, project manager realised the problem and re-defined the measurement and standard of tasks. The set of tasks were called Gates and were built in life cycle management. The change made significant improvement in the project. The partners measured the right things with detailed targets and eventually achieved satisfied outcomes.

This evidence shows that purpose is clearly defined in each performance measurement.

- Data is available and accessible for constant review

In this case, the interviewee has worked in many marine and submarine projects. In most projects, data was the most important issue. Tiny mistake could make significant failure. At each stage of gates, collaborative partners organised review about the progress of the project. Numbers and progress were formally recorded and evaluated. This shows the importance of availability and accessibility of data for constant review in the CIPM design.

- Performance measures of CI are related to CI process and outcome

In one project about designing battery, two partners measured details about battery, including measure its size, how long it would take to charge, how long it would take to discharge, what would happen about discharge when it was not hooked up, how it would work with new battery, and others related to battery technology.

This proves PM of CI is related to CI process and outcome.

- Performance measures of CI are flexible which can be changed as circumstances change

The interviewee mentioned that dimensions of measurement could not be designed thoroughly at the planning stage. In most of marine projects the interviewee joined, it

might take 7-15 years to complete a product; so some of plans might be obsolete. Therefore, participating partners always maintained innovative and updated to their tasks as the collaboration process went on.

This is the evidence about importance of flexibility for performance measures of CI when circumstances change in the complex CI process.

- Objective performance criteria are preferable to subjective ones

Confirmed in CIPM reference model - Measurement should be not too objective or too subjective – The interviewee said some measures are too subjective or too objective.

- Performance measures of CI are reported periodically

Every period, it is called gates in this case, as the milestones for stages of a long project. In order to make sure the performance is at the right level. At particular stop or gates, needs to set up right time to check completeness level.

Participation of different levels of managers, but frequency of meetings varies in different levels of managers, weekly for lower level and monthly for upper level- The interviewee said in big project, lower level managers edit report and submit to upper level.

- CIPM is cost-effective

Time and Cost-effective, because the interviewee said he monitors progress of some people in short time. He needs to spend not long time and big cost to help solve a problem in a project.

- CIPM is reliable, valid and acceptable

Keeping process move should be put into consideration in the collaboration process - the interviewee said not to stop the overall project, but not let poor data go through, or poor design go through at all stages.

6.8 Chapter conclusion

Although every collaborative innovation project used performance measures, none of the project had formal PM system covering all the areas identified in the proposed CIPM reference model. Moreover, little empirical evidence currently exists which describes current PM practice in collaborative innovation projects or evaluates the appropriateness of current processes within this context.

Following the aim, Chapter 6 has presented the individual case analysis of seven cases, and CIPM reference model has been applied in every case in order to validate the model. A great amount of data has been collected and investigated based on qualitative case studies. After being categorised in terms of theoretical CIPM reference model developed in Chapter 3, the data was analysed based on narrative discussion and justified for the existence of contents about requirements of CIPM system designing process, characteristics of CIPM system design and relevant dimensions. The next chapter will conduct and present cross-case analysis of all the seven cases.

Chapter 7. Cross Case Analysis and updated CIPM reference model and construct

In the previous chapter, each individual case was analysed independently. In order to identify any emerging patterns across cases as well as any underlying arguments, cross case analysis will be conducted in this chapter.

According to the suggestions from Yin (2011), the majority of contents in this chapter are the results from interpreting data and drawing conclusion for carrying out data analysis. Due to the iterative process of the data analysis, results from previous analysis were referred to during interpreting data and drawing conclusion.

The aim of this chapter is to explore where the multiple cases are diverging or converging as well as finding out the comparison between emerging patterns in collaborative innovation performance measures. In order to achieve this objective, the researcher will compare and contrast the cases versus research questions and the reference model developed through the literature review (chapter 2 and chapter 3). The cross-case analysis involved in this chapter is to answer research question 2, while research question 1 has been answered in chapter 3.

The updated CIPM reference model presented at the end of this chapter was resulted from the within case analysis's key points and the cross case analysis result table (Table 15 and Table 16).

7.1 Empirical findings

The CIPM reference model, which was summarised from the related literature reviews and presented in Table 8 in Chapter 3, has been used to analyse cases individually and comparatively. According to Eisenhardt (1989), it is possible that new constructs could

emerge at this stage. Even though the reference model has been identified in the literature review and been used in case analysis, new contents related to the model may emerge, because the relevant knowledge is flexible. With this flexible approach, it is possible to have a new model, and therefore will contribute to the original theory (Eisenhardt 1989).

In order to facilitate identification of specific patterns, it is important to convert the large amount of data obtained from within case analysis into more understandable format. A failure to condense the useful data can lead the research to unsound conclusion (Miles & Huberman 1994). To facilitate this, the data from within case analysis in the previous chapter has been summarised in Table 15 and Table 16. Next, comparison among the cases is implemented. As shown in in Table 16, the analysis results were categorised into confirmed group, unconfirmed group, additional group, confirmed and extended group: confirmed group represents clear evidence was found in cases; unconfirmed group represents no evidence was found in cases; additional group represents new point was found from cases; confirmed and extended group represents clear evidence and further opinions were found.

Table 15 Cross Case analysis of requirements of CIPM systems design process – case projects – result of analysis (Confirmed - ✓; unconfirmed-✖; Confirmed and Extended-☑)

Requirements of CIPM systems design process	**Key findings from cases**	**CS 1**	**CS 2**	**CS 3**	**CS 4**	**CS 5**	**CS 6**	**CS 7**
Performance measures of CI must be chosen based on the organisational strategy and purpose	Only the interviewees from CS5 & CS7 mentioned clearly that the performance measures of CI must be chosen based on the company's strategy and purpose. Although other interviewees did not mention it clearly, this point has been approved by the other researchers in previous studies that PM must be chosen from the organisational strategy and purpose.	✓	✖	✖	✖	✓	✖	✓
CI-related strategic objectives must be clearly and explicitly identified	6 out of 7 interviewees confirmed that CI-related strategic objectives must be clearly and explicitly identified. The interviewee from CS4 pointed that the collaborative partners should define the benefits and success criteria more clearly, and set the targets to aim for clearly, in order to have a more successful project.	✓	✓	✓	✓	✓	✖	✓
Performance measures of CI should gain top management support from collaborative organisations	5 out of 7 interviewees confirmed that top management support from collaborative organisations was important. The evidence from case 1 also shows that the management style has huge impacts on CIPM.	☑	✓	✓	✓	✓	✖	✖
CI-related goals should be prioritised	Only interviewee from CS3 mentioned that the tasks and goals were designed at the beginning, agreed by all the partners, prioritised, and listed on Gantt chart. However, this has been confirmed by other researchers that it's important to prioritise CI-related goals.	✖	✖	✓	✖	✖	✖	✖
Being responsible for communicating with participated organisations should be clearly defined	5 out of 7 interviewees confirmed that someone was taking responsibilities for communicating the project time. The other two interviewees did not answer clearly that if they had assigned at least one person for taking responsibilities for communicating.	✓	✓	✓	✖	✓	✖	✓
Existing PM systems related to CI should be reviewed and evaluated	In CS1, CS3, and CS4, the interviewees described that the existing performance measure systems related CI had been reviewed and evaluated.	✓	✖	✓	✓	✖	✖	✖
Performance measures of CI should be designed and decided based on discussion with partners in the CI project	Interviewees from CS3, CS5, and CS7 all confirmed performance measures of CI were designed and decided based on discussion with the partners in the project. The other interviewees did not mention clearly about this.	✖	✖	✓	✖	✓	✖	✓

Requirements of CIPM systems design process	Key findings from cases	CS 1	CS 2	CS 3	CS 4	CS 5	CS 6	CS 7
Data collection and methods related to calculating the level of CI performance should be defined clearly	Although none of the interviewee confirmed that data collection and methods related to calculating the level of CI performance should be defined clearly, according to the previous researcher's study, it's important that data collection and methods of CI performance been defined before project starts.	×	×	×	×	×	×	×
CIPM should be able to measure non-financial aspects alongside financial aspects	All the interviewees confirmed that both financial and non-financial aspects been measured during the project.	✓	✓	✓	✓	✓	✓	✓
CIPM should gain support from participants	Although two interviewees did not confirm this, it's important to gain support from participants to makes sure that CIPM can implement smoothly, it's always quite a challenge to get all the involved employees to follow the system exactly. The evidences from the cases show that without the participants' support, it's hard to collect data and fully implement the CIPM system.	✓	✓	×	✓	☑	×	✓
Timescales for designing and implementation of CIPM system should be set	3 out of 7 cases confirmed that timescales for designing and implementation of CIPM system should be set. Although other interviewees did not mention, it has been approved by previous researchers.	×	×	✓	✓	×	×	✓
Key factors of CIPM should be identified	Only the interviewee from CS3 mentioned that some key factors were identified before designing CIPM system. Although the other interviewees did not mention clearly, it's fundamental to identify key factors before CIPM system is designed.	×	×	✓	×	×	×	×
Individual participated organisations' responsibility and measurement should be clearly identified	Interviewees from CS1 and CS7 gave example that participated organisations' clear measurement and responsibility been clearly identified made everyone happier, and it's good for CIPM to implement.	✓	×	×	×	×	×	✓
Causal relationship between performance measures should be understood	Previous study suggested that causal relationship between performance measures should be understood, however, this case study does not find this point. There was no causal relationship to be mentioned by the interviewee.	×	×	×	×	×	×	×
CIPM should be maintained and reviewed	5 out of 7 interviewees did not mention that CIPM should be maintained and reviewed, however, according to previous research, it's important to have CIPM maintained and reviewed during the project time.	×	×	✓	×	×	×	✓

Table 16 Cross case analysis of characteristics of CIPM systems design process - case projects - Result of analysis (Confirmed - ✓; unconfirmed-✗; Confirmed and Extended-☑)

Characteristics of CIPM systems design process	**Key findings from cases**	**CS 1**	**CS 2**	**CS 3**	**CS 4**	**CS 5**	**CS 6**	**CS 7**
The purpose in each performance measure of CI is clearly defined	None of the interviewee confirmed that the purpose in each performance measure of CI was clearly defined during the project time, however, it was suggested by the previous researchers that it should be clearly defined.	✗	✗	✗	✗	✗	✗	✗
Data is available and accessible for constant review	4 out of 7 cases have the facility for data collection; however, sometimes it's quite a challenge to get them to do without actually sitting with them and going through. This affected the data collection for reviewing.	✓	✗	✗	✓	✓	✗	✓
Performance measures of CI are related to CI process and outcome	It has been approved by other researchers that it was necessary performance measures of CI are related to CI process and outcome, although none of the interviewee confirmed this.	✗	✗	✗	✗	✗	✗	✗
Performance measures of CI are easy to understand, use and maintain	Although there was only 1 interview confirm that performance of CI should be easy to understand, use and maintain, it's advised from the previous research that CIPM should be easy to understand, use and maintain. If it's not, it will be even harder to let the all the involved people to use the system and help to collect the useful data.	✓	✗	✗	✗	✗	✗	✗
Performance measures of CI are flexible which can be changed as circumstances change	5 out of 7 interviewees confirmed that performance of CI are flexible which can be changed as circumstances changes	✓	✗	✓	☑	✗	✓	✓
Performance measures of CI are applied at collaborative and individual level	Performance measures were used to measure participants' performance during the project time. Performances measures of CI are applied at collaborative levels were confirmed, but none of the interviewee confirmed that performance measures of CI were applied at individual level.	✓	✗	✓	✗	✗	✗	✗

Characteristics of CIPM systems design process	**Key findings from cases**	**CS 1**	**CS 2**	**CS 3**	**CS 4**	**CS 5**	**CS 6**	**CS 7**
Feedback regarding performance measures of CI is provided accurately and on time	3 out of 7 interviewees confirmed that feedback regarding performance measures of CI is provided accurately and on time. The interviewee from CS1 pointed that a full feedback system will be needed for any project to get the completed feedback information. Although the other 4 interviewees did not mention the feedback regarding performance measures of CI, it has been approved by other researchers in previous studies that it is very important.	✓	✓	×	✓	×	×	×
Objective performance criteria are preferable to subjective ones	It had only been confirmed by one of the interviewee this time, but it's because the questions had not been raised in the interview.	×	×	×	×	×	×	✓
Performance measures of CI are reported periodically	All the interviewees confirmed that performance measures of CI are reported periodically. The frequency of meetings was agreed at the beginning of the project.	✓	✓	✓	✓	✓	✓	✓
CIPM is cost-effective	2 interviewees out of 7 confirmed that CIPM should be cost-effective.	×	×	×	×	✓	×	✓
CIPM stimulate continuous improvement rather than only monitoring performance	4 out of 7 interviewees confirmed that CIPM not only monitoring performance, but also stimulate continuous improvement. Different projects have different ways to get useful data and use for stimulating continuous improvements.	✓	✓	×	✓	✓	×	×

7.2 Discussion

From the comprehensive analysis results shown in Table 15 and Table 16, it could be seen that the empirical evidence from the cross case analysis is consistent with the findings derived from the literature review. In total, 15 requirements and 11 characteristics of CIPM systems design process have been identified from the case studies. Not every requirement and characteristic is fully confirmed in all cases. However, the analysis presented in this chapter shows that there is no contradiction between the reference model and the empirical data.

Apart from existing points from the requirements of CIPM systems development process, characteristics of CIPM performance measures and CIPM performance measures in the proposed CIPM reference model, another three emerging points have been derived from the case analysis. The three points have been discovered respectively from requirements of CIPM systems development process, characteristics of CIPM performance measures and CIPM performance measures. Consequently, the CIPM reference model was updated with the three emerging points. In the following sections, discussion of confirmed and extended existing pointes will be presented, three emerging points will be discussed, and an updated reference model and construct will be presented.

7.2.1 Confirmed and extended existing points to the reference model

A number of points have been confirmed and extended through the case studies.

- Performance measures of CI should gain top management support from collaborative organisations – ***confirmed and extended*** *in requirements of CIPM systems development process*

In CS1, CS2, CS3, CS4 and CS5, it was found that top management support from collaborative organisations to performance measures of CI is crucial. Particularly in CS1, the managing director from one partner, who had a MBA degree, was very glad to be involved in the project, and he preferred to have the university to do the performance measures and give feedback. The director was very proud that his father, who founded the company, was quite forward thinking in collaborative innovation.

In the same project, a managing director of another partner had been working in the industry for over 40 years and was very knowledgeable about the industry. However, he was a bit more sceptical about working with university was hard to get him work with the university to implement performance measures. The company was owned by a small group of investors, and the company did not have long term planning.

This confirms the literature finding that performance measures of CI should gain top management support from collaborative organisations. In addition, this evidence also indicated that ***management style has impact on CIPM.***

- CIPM should gain support from participants – ***confirmed and extended in requirements of CIPM systems development process***

In CS1, CS2, CS4, CS5 and CS7, this point has been confirmed as one crucial point. In particular in CS5, people who worked in all the depots all participated the performance measure process and helped to collect the data on time. Without these staffs' supports, the data could not be collected properly.

According to the associate, sometimes it was hard to know if the results of performance measurement were correct or not. Because it could be the employees tried to perform better when they knew the measurement were ongoing. It is necessary to let the participated staff fully understand the PM process. Because it's possible that the staff

got a wrong figure, and still thought it's the right number, if people did not understand the thesis behind fully.

This shows that CIPM should gain supports from participants, however, it is important to make sure that people ***do not change their working way when they know there is ongoing measurement, and they go back to their normal working style***. It's necessary to ***let the staff have the full understanding of the performance measurement***.

- Performance measures of CI are flexible which can be changed as circumstances change

In CS1, CS3, CS4, CS6, and CS7, this point proves as an important point. Particularly in CS4, performance measures were used all the time in the company. The measurement was derived from the company's prioritised objective. For example, if the delivery on time to the retailer was the number one priority, then that would be the measure of performance, and performance of related areas in that area would be improved as well. Meanwhile, the company would have a look at what was affecting performance, and how the company could improve it. In six months, the top objective probably shifts to how accurate the delivery, then the performance measures would be changed accordingly.

During the project, it could end up with five measures of the same metric, and how the participants measured the metric could be variant. Take how people are thinking about how the unsold newspaper had been processed. For a publisher was probably more interested about making sure the unsold are collected and returned on time, so he could hit his sales figure. For a retailer, he did not really care how quickly the unsold ones were processed, as long as he got money at the end.

In CS4, the manager said that it was not always five or six metrics for all measures. Normally, the company tried to have a very simple metric, but when the company was

not achieving that metric, the company needed to go back to the process and analyse the process from start to the end. After analysing what causing that to fail, then the company needed to take it apart to rebuild it, or to repair it, or try and get better performance metrics. Sometimes, the company realised that the metric that they had got was not the metric they should have. In that case, the company needed to redefine the goals and metrics.

For the same metric, different people can have different point of views. The manager gave an example that they delivered 99.7% of the newspapers on time; the company was very impressive with this figure. However, from a customer's point of view, the 0.3% of the customers who did not get the delivery on time was the customers who got less volume.

The finding is consistent with the literature review that performance of CI should be flexible which can be changed as circumstances change. In addition, the evidence also ***shows that one measure could have a few metrics, and the metrics should be adjusted according to the target's needs.***

7.2.2 Emerging propositions

- ***Stakeholders should be prioritised.***

According to the literature review in Chapter 2 and 3, CI-related goals should be prioritised. This has not been confirmed firmly in the cases; however, the interviewees added other opinions that are related to collaborative innovation goals. The interviewee in CS5 claimed that when the partnership was created, the objectives needed to be set up according to what the company wanted, what areas they had to focus on, how they wanted to improve, and how much outcomes they wanted, etc. He mentioned that specified objectives definitely needed to be ticked off to maximise the stakeholder's benefits and expectations. There were different stakeholders involved in the projects,

and stakeholders' needs need to be prioritised as well. In CS5, the stakeholders included the company, the Technology Strategy Board, and the university. The company was the first priority in the collaborative project.

- According to the interviewee in CS4 it's better that the ***previous and current state was reviewed; a vision of future of state was created; some success criteria, goals, rules, and structure were defined clearly at the start of the project.***

Interviewee from CS4 said that during the project, when the metric was not achieved, in order to understand what the real problem was, the participants needed to analyse the process from the start to the end and found out what was causing that to fail. Sometimes, the participants needed to redefine the goals. Normally, a review of the success of the project would be done at the end of the process to judge that how realistic the project had been in terms of the cost etc. However, it could be too late to find out what the problems are. From the completed project, it would be easier for people to comply the interviewee found that if some success criteria, goals, rules, and structure been defined clearly before the project started. The interviewee mentioned that the previous and current state should be analysed, and a vision of the future state should be created, then the participants could know exactly they had reached success, when they achieved that metric.

- ***This evidence shows that in order to get a coherent and true feedback picture, a feedback system should be designed at the beginning of the project, apart from being provided accurately and on time.***

According to the literature review, feedback regarding performance measures of CI is provided accurately and on time. There are 3 interviewees confirmed this. During the interviews, there were more interviewees added more to this point. In CS1, the interviewee mentioned that the collaborative partners could come from different countries or different locations, and the performance measures could be distributed due to language problem. The performance measures could be implemented in different ways in different places by different people, and it was very difficult to get a coherent,

true, full feedback picture. So a business diagnostic of the collaborative participant was needed by using the same system for getting some more accurate feedback.

7.2.3 Updated reference model

Some of the points are not confirmed across all case companies, for example, “causal relationship between performance measures should be understood”. However, this does not mean that this is not an important requirement that should be excluded from further analysis. It has been studied and approved by other researchers in previous research that the causal relationship between performance measures should be understood. Though the interviewees in these case studies did not confirm this point firmly, there is no conflicting opinion regarding the causal relationship between performance measures. Thus, this factor, though not confirmed by the case companies, should still be considered to be one of the requirements of CIPM systems design process.

Moreover, the criteria of inclusion and exclusion in the case study in the research are dependent on the impact of the point in the case. In this qualitative research, all related points are designed to be investigated deeply in all cases, and some of them are confirmed to have strong influence on designing CIPM system in some cases. It cannot exclude such points even if they are confirmed in a few cases, because the cases selected are university-industry collaboration which have limited form of partnership, the unformed points can shift when the circumstances change or can make effect when the same organisation starts another collaboration. However, to investigate this limitation, quantitative perspective is promoted to be considered in the future research.

Table 17 presents the updated reference model consolidate the three additional points identified through the case studies.

Table 17 Updated CIPM Reference Model

Requirements of CIPM systems development process	**Characteristics of CIPM performance measures**	**CIPM performance measures**
• Performance measures of CI must be chosen from the organisational strategy and purpose • CI-related strategic objectives must be clearly and explicitly identified • CI Performance measures should gain top management support from collaborative organisations. ***The management style has impact on CIPM. (Confirmed and extended)*** • CI-related goals should be prioritised • Being responsible for communicating with participated organisations should be clearly defined • Existing PM systems related to CI should be reviewed and evaluated • Performance measures of CI should be designed and decided based on discussion with participants in the CI project • Data collection and methods related to calculating the level of CI performance should be defined clearly • CIPM should be able to measure non-financial aspects alongside financial aspects • CIPM should gain support from participants. ***Let staff have the full understanding of the performance measures, and it's important to make sure they do not change their working when they know there is ongoing measurement (Confirmed and extended).*** • Timescales for design and implementation of CIPM system should be set • Key factors of CIPM should be identified • Individual participated organisations' responsibility for measurement should be clearly identified • Causal relationship between performance measures should be understood • CIPM should be maintained and reviewed • ***Previous and current state was reviewed; a vision of future of state was created; some success criteria, goals, rules, and structure were defined clearly at the start of the project (Emerging point)*** • ***A feedback system should be designed at the beginning of the project (Emerging point).***	• The purpose in each performance measure of CI is clearly defined • Data is available and accessible for constant review • Performance measures of CI are related to CI process and outcome • Performance measures of CI are easy to understand, use and maintain • Performance measures of CI are flexible which can be changed as circumstances change. ***One measure could have a few metrics, and the metrics should be adjusted according to the target's needs (Confirmed and extended).*** • Performance measures of CI are applied at collaborative and individual level • Feedback regarding performance measures of CI is provided accurately and on time • Objective performance criteria are preferable to subjective ones • Performance measures of CI are reported periodically • CIPM is cost-effective • CIPM stimulate continuous improvement rather than only monitor performance • ***Stakeholders should be prioritised. (Emerging point)***	• Efficiency • Effectiveness • Finance • Quality • Speed • Stakeholder satisfaction • Innovation • ***Benefits***

7.2.4 Updated CIPM construct

It is important to verify if the construct had the characteristics highlighted in the updated CIPM reference model.

The contents assessment is shown in Table 21. It can be found that the construct includes most of the characteristics of an effective CIPM system design process. There are a few points have not been included obviously, although it has probably been considered when developing the construct. For example, the construct did not show *CI-related goals should be prioritised*; however, it has the action to *prioritise measures according to requirements.* The points that have been extended and added into the CIPM reference model after the case analyse. To reflect the change, the construct has been updated to include these points and the updated version is shown in Table 19. The updated points are shown in italic font.

Table 18 Evaluation of the contents in CIPM construct

Criteria for evaluation	**CIPM design construct**
The actions should be done during a CIPM system development process:	
Performance measures of CI must be chosen from the organisational strategy and purpose	√
CI-related strategic objectives must be clearly and explicitly identified	√
CI Performance measures should gain top management support from collaborative organisations. ***The management style has impact on CIPM.***	√
CI-related goals should be prioritised	**X**
Being responsible for communicating with participated organisations should be clearly defined	√
Existing PM systems related to CI should be reviewed and evaluated	√
Performance measures of CI should be designed and decided based on discussion with participants in the CI project	√
Data collection and methods related to calculating the level of CI performance should be defined clearly	√
CIPM should be able to measure non-financial aspects alongside financial aspects	√
CIPM should gain support from participants. ***Let staff have the full understand of the performance measures, and it's important to make sure they do not change their working when they know there is ongoing measurement.***	√
Timescales for design and implementation of CIPM system should be set	**X**
Key factors of CIPM should be identified	√
Individual participated organisations' responsibility for measurement should be clearly identified	**X**
Causal relationship between performance measures should be understood	√
CIPM should be maintained and reviewed	√
Previous and current state was reviewed; a vision of future state was created; some success criteria, goals, rules, and structure were defined clearly at the start of the project (A)	**X**
A feedback system should be designed at the beginning of the project	**X**
The requirements of measures in a CIPM system should achieve:	
The purpose in each performance measure of CI is clearly defined	√
Data is available and accessible for constant review	√
Performance measures of CI are related to CI process and outcome	√
Performance measures of CI are easy to understand, use and maintain	√
Performance measures of CI are flexible which can be changed as circumstances change. ***One measure could have a few metrics, and the metrics should be adjusted according to the target's needs.***	**X**
Performance measures of CI are applied at collaborative and individual level	√
Feedback regarding performance measures of CI is provided accurately and on time	√
Objective performance criteria are preferable to subjective ones	√
Performance measures of CI are reported periodically	√
CIPM is cost-effective	**X**
CIPM stimulate continuous improvement rather than only monitor performance	√
Stakeholders should be prioritised. (A)	√
A CIPM system should measure:	
Efficiency	√
Effectiveness	√
Finance	√
Quality	√
Speed	√
Stakeholder satisfaction	√
Innovation	√
Benefits	**X**

Table 19 Updated CIPM construct

Phase		**Purpose**	**Actions**	**Outputs**
Phase 1:	clarify CI organisations' strategies, purposes, objectives and requirements	to clarify clear and complete CI organisations' strategies, purposes, objectives and requirements	1a. identify CI organisations' strategies, purposes, objectives and requirements 1b. compare and analyse CI organisations' strategies, purposes, objectives and requirements	List of CI organisations' strategies, purposes, objectives and requirements
Phase 2:	identify existing performance measures in CI organisations	to obtain a clear and complete understanding of CI organisation existing performance measures and purposes	2. compare and analyse existing performance measures in CI organisations	Summary of existing performance measures in CI organisations
Phase 3:	refine and develop CI-related and strategies and goals	to refine and develop specific CI strategies and goals	3a. assess CI strategies and goals against CI organisations' requirements 3b. clarify the roles of partners in collaborative innovation 3c. develop CI objectives	Updated strategies and goals of CI project
Phase 4:	define measurement strategy for CI projects	to define measurement strategy and assign responsibility over individual measures	4a. define data sources, methods of data collection and calculation, and relevant time scale for each measure 4b. Agree how to collect data between/among CI partners	Summary of data collection core areas and methods for CI performance measures
Phase 5:	identify key factors of CI performance measures	to identify the key factors affecting the collaborative innovation objectives	5. define key CI performance factors and interrelationship among the factors	Summary of key factors and their interrelationship
Phase 6:	develop CIPM system(s)	to design CI performance measures and complete CIPM system (s)	6a. define financial and non-financial measures according to CI objectives 6b. identify causal relationships between CI performance measures 6c.design and check quality of each performance measure *6d. choose metrics for each measure according to the target's needs, and adjust them when it's necessary* 6e. prioritise measures according to requirements 6f. agree on designed performance measures	Formalisation of CIPM system(s)
Phase 7:	define CIPM system(s) review structure	to define an appropriate plan and structure for performance review and a system which can be used for reviewing CIPM system(s)	7a. agree on defined CI performance review plan 7b. agree on defined CI performance review structure 7c. agree on defined CI review procedure *7d. Review previous and current state, and create a vision of future state* *7e. define success criteria, goals and goals* 7f. design structure and format of phased progress reports *7g. design a feedback system*	Structure of CIPM system(s) review including records sheet with on-time feedback
Phase 8:	ongoing maintenance of CIPM system(s)	to update the CIPM system(s) accordingly	8. remove inappropriate ones 8b. introduce necessary new ones	Regularly updated CIPM system(s) to stimulate continuous improvement

7.3 Chapter conclusion

Empirical findings from all cases cross were analysed against the CIPM reference model derived from the systematic literature review. The fact is that the majority of the reference model indicates that the findings from empirical investigation corroborate existing studies.

The results from all the interviews were used to build a picture of the use of PM within collaborative innovation projects. It is interesting to note that none of these projects had used formal measures covering all the areas identified in the reference model. Financial measure was the common attribute that every partner used. Many of the measures that each company used were acknowledged to have significant shortcoming by all the interviewees. The measures are different from projects to projects, from companies to organisations. Some simple and essential measures (eg. financial measures) had been used during the whole projects, but some of the measures have been either ignored from the beginning or obsolete during the projects. Interestingly, nearly all the interviewees mentioned that they did not want to be involved in too many measures, because it will increase their work to produce too much complicated record, which would waste their time. Even the data was useable, if there were no effective communication / feedback system on time; the data was going to be wasted. When there were no supports from the employees for the performance measures, the collected data could be poor quality, and, in some circumstances, the blame for performance would develop in the organisations. This shows that gaining supports from top management and participants at the same time are very important for applying the performance measures to collaborative innovation projects. Although every collaborative innovation project had periodic review meetings, none of the project reported that a formal feedback system was applied.

Three additional findings were identified from the analysis, which were used to update the CIPM reference model and the construct.

Chapter 8. Discussion and conclusion

The research findings were presented and discussed in the previous chapter in terms of empirical evidences from the case studies. This chapter is going to discuss the conducted research in terms of the research methods, objectives, implications, limitations, the contribution to knowledge and future work.

8.1 Assessing the research methods

The research methods and techniques used for this research will be discussed in this section. The criteria that used to assess the research quality were presented in chapter 3. As discussed in chapter 3, there are several measures can be used to assess the research process quality and case studies. These include: construct validity, internal validity, external validity, and reliability (Easterby-Smity et al. 2012; Yin 2009; Healy & Perry 2000). The research conducted in this thesis meets all of the criteria for ensuring the reliability and validity of the research result. The following section will discuss the assessment in detail, and a summary will be provided in Table 20.

In the research presented in this thesis, several techniques that were identified in the previous literature (Healy & Perry 2000; Meredith 1998; Yin 2009) have been applied to make sure the research process meets the criteria of a rigorous study. Systematic literature reviews were carried out as part of this research with the following purposes:

- Identifying the research gap (Wacker 1998)
- Developing priori constructs for the deductive study of research questions (Eisenhardt & Graebner 2007; Meredith 1998; Eisenhardt 1989)
- Comparing the empirical evidence with the results of previous research iteratively (Eisenhardt 1989; Voss et al. 2002)

The literature review has been used at every stage of the research process, not just limited to the purposes that listed above.

Table 20 Evaluation of research quality criteria

Research quality criteria	**Case study techniques**	**How was this achieved in the research**	**Techniques occur in which phase of research**	**Where addressed in the thesis**
Construct validity	• Use multiple sources of evidence • Establish a chain of evidence • Have key interviewees' review draft case study reports	• Selection of multiple data collection techniques, reviewing literature, establish a chain of evidence, and structure reporting • Conceptual framework was developed from a selection of literature review • Using case study notes, combined with a research diary to complete analysis	• Data collection • Literature review • Data analysis	Chapter 2, 3, 5 Chapter 2 & 3 Chapter 6
Internal validity	• Patten matching was done Explanation building was done • Address rival explanations Logic models was used	• Pattern matching and explanation building were used to ensure the research internal validity • Conduct case analysis, followed by cross-case analysis to predict similar and different patterns.	• Data analysis • Data analysis	Chapter 6 Chapter 7
External validity	• Use theory in single-case studies • Use replication logic in multiple-case studies	• Multiple case-study research design was applied using replication logic in seven case studies	• Research design	Chapter 5
Reliability	• Use case study protocol • Develop case study database	• Case study protocol was used to ensure that the researcher collected all the necessary data • A case study database was developed, case study reports and cross case analysis were conducted to ensure that the research findings are reliable • The findings from each company were analysed against summarised literature review.	• Data collection • Data analysis • Data analysis	Chapter 5 Chapter 6 & 7 Chapter 6 & 7

8.2 Research objectives revisited

The aim of this research (mentioned in Section 1.1 Research aim and objectives) was to develop a reference model and construct to guide collaborative innovation organisations to design PM system in the context of CI. Two research questions were raised based on critical analysis of literature. The first question was, what are the factors influencing the effectiveness of collaborative innovation? The second was, how does performance measurement and management support collaborative innovation in the context of academia-industry collaboration?

To address Objective 1 and 2 and answer RQ1, the researcher conducted an exploratory and systematic review of literature about factors and effectiveness of collaborative innovation, characteristic of collaborative innovation. In order to address Objective 3 and 4 and answer RQ2, the researcher performed a focused literature review on how performance measurement and management support collaborative innovation, and conducted an empirical research which consisting of within case and cross case analysis of 7 cases.

The researcher progressed towards the objectives throughout the research by following the defined research methodology presented in Chapter 3 and research design shown in Chapter 5. Qualitative data were analysed through multiple cases in this research. The research findings were evaluated to be reliable by a peer-review process. The researcher is confident that the research presented in this thesis will be able to give contribution to both knowledge and practitioners, more details will be discussed in the following sections.

8.3 Implications of the CIPM reference model and construct

The findings of this research offer some practical guidance to those collaborative innovation projects. The developed CIPM reference model and proposed construct for collaborative innovation PM system design could be used as guidance to those designing performance measurement systems for collaborative innovation project.

The interviews provided relevant data to analyse the CIPM reference model and construct. There are three criteria will be used for evaluating the model and construct, which are usefulness, applicability, and novelty.

8.3.1 Usefulness of the CIPM reference model and construct

In general, the interviewees thought that both CIPM reference model and construct to be useful tools to design CIPM system. The interviewees felt that the reference mode and construct could be a valuable approach for encouraging a good collaborative culture. Apart from the opinions about the points in the reference model and construct, the interviewees also pointed out some valuable opinions, for example, have effective communication, build trust among partners, have good inter-relationship, etc. A lot of times, the participated organisations felt that the responsibilities was not clearly defined for the project, especially for companies felt that they did not have a good control in the project. The reference model and construct suggest defining strategies, objectives, communication responsibilities, and dimensions, which could increase the accountability of the participated organisations and the involved staff over the key areas of responsibility.

The CIPM reference model and construct can help to have continuous improvement for the collaborative innovation project according to collected feedback was highlighted by a few interviewees. Compare to other approaches, the CIPM reference model and construct provides an increased focus on the key objectives, goals, and stakeholders' benefits.

The findings focused on the initial impressions of the interviews. From those case studies, we can conclude that the following are the areas of major impact of CIPM reference mode in collaborative projects.

- *Save effort and time* – the CIPM reference model and construct could provide valuable guidance and supports to the collaborative participants, and save time and effort for designing CIPM system

- *Provide monitoring and continuous improvement* – the reference model and construct help to monitor the performance during the collaboration, and provide continuous improvement. Through providing appropriate mechanisms to assess the impact of the current strategy. Based on the assessment results, the participants can have some improvement actions.

- *Increase management commitment and support* – according to the reference model, performance measures of CI should be designed and decided based on discussion with partners in the CI project; should gain top management support from collaborative organisations. This encourages the top management from participated organisations increase commitment and support by involving the managers in the CIPM design process.

- *Identify individual participated organisations' responsibility for measurement* – clearly identify individual participant's responsibility for performance measurement, so that more accurate data could be collected for monitoring and improvements.

- *Increase the effectiveness of CIPM* – the use of a structured approach to CIPM reference model that has a stronger theoretical basis, and most of the aspects can be considered into the CIPM design to ensure the design of an effective CIPM system. For example, the strategy, the purpose, benefits and data collection methods etc. will be considered when designing the CIPM system.

8.3.2 Applicability of the CIPM reference model and construct

The CIPM reference model and construct can be used to different CI projects, different types of industry, different status of the project, and different organisational levels to carry out a variety of tasks. It could be very useful when a CI project plan was being developed. Although the reference mode and construct have a wide range of applicability, it is important to study the special needs in each project. The reference model suggests *"key factors of CIPM should be identified"* and *"causal relationship between performance measures should be understood"*, key drivers and causal relationship can be changed in different stages of the project, and so as the requirement listed in reference model "CIPM should be maintained and reviewed". Both CIPM reference mode and construct does not provide "off the shelf" solution to all types of collaborative projects for different stages.

In summary, the CIPM reference model and construct can be used in a wide range of collaborative projects in different types of industry; the participated organisations need to adjust them according to their special needs.

8.3.3 Novelty of the CIPM reference model and construct

Compare to other approaches, the CIPM reference mode and construct have the following novelty:

- They recognise the detailed requirements, characteristics, and dimensions of reference model, and steps of the construct.
- They emphasize the benefits of stakeholders as one of the dimension to ensure their initiatives.
- They provide a more comprehensive view of collaborative innovation performance.

8.4 Contribution to knowledge

Several outputs have been derived from the achievement of the research objectives, which resulted in contributions to knowledge. The main knowledge contributions are listed below:

- *A comprehensive list of the factors influencing the effectiveness of collaborative innovation has been identified.* The outcome of this research allows collaborative organisations to have a factor list to follow before designing collaborative innovation performance measurement system. (Table 3)

- *An understanding of performance measurement in collaborative innovation projects is provided.* It provides the base for proposing the reference model for collaborative innovation performance measurement. (Chapter 2 and Chapter 3)

- *A CIPM reference model has been proposed.* Requirements of CIPM systems design process, characteristics of CIPM systems design process, and dimensions of CI performance have been derived from the literature, and have been updated through the case studies. (Table 17)

- *A step-based construct for designing collaborative innovation performance measurement system* has been proposed, according to the CIPM reference model. (Table 19)

8.5 Research limitations

In this study, the researcher tried to apply established methods to, in order to ensure the validity and reliability of the research. Despite the above presented contribution, there are some drawbacks in the research that could be improved by the researcher.

Firstly, the research findings are based on seven case studies, and the interviewees were from different industry backgrounds, held different positions in their organisations. The researcher performed ten case studies, and only seven cases were used for analysis. The research is satisfied with the number of the valid cases involved; however, the research

results could be more comprehensive if all ten cases had been able to be included into the analysis. Therefore, more cases could be used to either test or update the CIPM reference model in future research. Although some points in the CIPM reference model have not been confirmed fully from the 7 case studies that might because the interviewee did not provide the answers clearly, the conclusions would not be altered.

Secondly, the researcher has strived to collect and analyse the data as much as possible, by meaning of triangulation and combining several data analysis techniques. However, due to the time constraint, the researcher did not re-visit the organisations when the project was finished. The research result could be further validated by re-visiting the organisations.

Thirdly, this research only investigated the UK based organisations. A further study could include partners from other countries. Due to different culture and background knowledge, the differences between countries might affect the interviewees' way of thinking, working approaches, and other factors that needed to be considered when designing performance measurement system for collaborative innovation projects.

At last, the research presented in this thesis is a qualitative research. Due to human being's subjectivity, the research more or less is subjective to the researcher's way of analysis. Therefore, the researcher needs to minimize the bias from the observations, interviews, and logical thinking to ensure the validity of the research in qualitative studies. The subjectivity could be minimised if data was analysed by multiple researchers.

8.6 Future work

The performance measurement of collaborative innovation is a very wide topic; there are still a lot of opportunities for empirical investigations. The construct that has been proposed in this research study can be used research to validate in practise in future. Based on the limitations discussed above, the following future work could be carried out:

- More case studies to be analysed to validate the model and construct.

- Revisit the organisations used in the case studies to validate the reference model and construct.
- More data from other countries to be collected and analysed, such as mainland Europe, America and Asia countries.
- Further research to be conducted by multiple researchers to minimise subjectivity.

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Appendix 1 – Invitation letter to organisation

Designing Performance Measurement and Management systems for Collaborative Innovation

– The PhD project at the Department of Design, Manufacture and Engineering Management at the University of Strathclyde in Glasgow

Peipei Wu

Dear Sir or Madam,

- **Brief Introduction**

In the global state-of-the-art economy, organisations tend to enter into collaborative partnerships to achieve innovation; however, many organisations can face the challenge of achieving effective performance in collaborative innovation (CI) projects. Having surveyed and analysed relevant literature in detail, the researcher has identified research need on designing collaborative innovation performance measurement and management (PMM) systems, which is specifically how to achieve effective collaborative innovation by applying performance measurement and management.

I understand that your organisation has successfully established collaborative relationships with other institutions or companies with innovation as an objective. Your contribution based on your experience and success would be invaluable for the results of my research.

I am looking for the access to valuable data to answer my research questions and to achieve my research objectives, which are: 1. to identify the factors which impact organisational performance measurement and management in collaborative innovation relationships or projects; 2. to provide guidance to collaborative partners to develop effective performance measurement and management systems for generating innovation.

- **Proposed Data Collection Scenarios**

During my visit, I would like to interview:

1. 1 Manager who has been in charge of the previous and/or current collaborative projects;

2. 1 Employee who have participated and/or are involving in collaborative projects.

Each interview will be conducted for approximately 1 hour.

- **Information proposed to be collected**

1. General information – brief history and overview of the organisation; interviewee's information.

2. Previous and current experience in working in collaborative innovation partnership – the requirements of achieving effective collaborative innovation.

3. Current state of designing and implementing performance measurement and management – the benefits and challenges of applying the PMM to achieve the goal of effective CI.

- **Confidentiality agreement**

Please be assured that obtained information about your organisation will be treated with strict confidentiality and will not be available to anyone outside the research team. Only aggregated data will be used in research reports, publications, conferences and presentations.

- **Benefits for you**

The findings of my Ph.D. research work would make a potential contribution to your organisation for improving further the quality of effective collaborative innovation performance. A case study report with potential suggestions about implementing performance measurement and management for collaborative innovation will be provided after the case study.

I would appreciate the opportunity to investigate (in direct contacts with you and members of your team) the ways you measure, monitor and manage collaborative innovation performance. I shall contact you in the next few days and I appreciate in advance your very valuable support and contribution to my research project.

Please do not hesitate to contact me for any further information about my Ph.D. research project.

Yours sincerely,

Peipei Wu

PhD researcher,

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Appendix 2 – Interview questions list

Semi-structured interview questions list –

Design Collaborative Innovation Performance Measurement and Management (CIPM) systems

Interviewer_____ **Date**_____

Interviewee_____

Interviewee Organisation_____

This question list is about a PhD project – Designing CIPM systems. The objectives of this PhD project are to:

- understand requirements of achieving effective collaborative innovation
- identify factors that impact the design, implementation and development of effective CIPM systems
- investigate the aspects of performance measurement and management in the process of designing CIPM systems
- provide guidance to assist partners to develop effective CIPM systems
- understand the influence of utilising CIPM construct

Structure of this interview question list

Part	Objective
1 – General overview of the organisations	Understand the organisation – its nature, history and characteristics

2 – Collaborative innovation projects	Identify the requirements achieving effective collaborative innovation
3 – Performance measurement and management	Investigate what aspects of performance measurement and management should be included in the CIPM construct
4 – CIPM construct and its influence	Understand the influence of utilising the CIPM construct

Part 1 – General overview of the organisations

- The information I have on your organisation may be incomplete. Would it be possible to complete the information on your organisation?
- How many employees are there in your organisation currently?
- As far as I know, your role and responsibility are xxx; would you like to tell me more about your duty or authority?
- Are you interested in participating in any academic research activities directly or indirectly related to the activities of your organisation?
- How would you define the production or service area of the collaborative innovation projects you have?
- What would you like to emphasise about the general overview of your organisation, which is in general or with reference to CI?

Part 2 – Collaborative innovation projects

- Have you had earlier experience of working on collaborative innovation (CI) projects with other companies or universities?
- Do the projects focus on producing jointly new products and services?
- Referring to collaborative innovation, what do you think about it?

- How can the collaborative projects best perform or succeed?
- Do you have managers working for CI projects or concentrating on CI projects?
- For a CI manager, what is the difference between the management of specifically CI, on one hand, and general management on the other?
- How do you select your CI partner/s?
- How would you coordinate and manage input by CI partners with different backgrounds and specialisation, such as engineering, pure research and others?
- How would you and your partners plan and achieve a CI project?
- How is a partner's individual contribution or the respective contribution of two or more partners to a CI project defined and implemented?
- What positive and negative factors have influenced the CI process as you have participated in?
- What areas should be particularly considered and checked when designing one or more CI projects?
- What is the most challenging aspect in the process of implementing a CI project? Do you feel still exposed to challenges even after completing detailed planning?
- During the implementation of a CI project, what would you do if you find another potential partner with more potential benefits, than the one is involving in the CI project?

Part 3 – Performance Measurement and Management

- Performance measurement is a hot topic. What does performance measurement mean to you? How does it differ from performance management?
- How do you evaluate performance measurement and management?
- How do you apply performance measurement to a CI project implementation?
- How do you manage performance measurement?
- Are you satisfied with the existing performance measurement system you apply? Is it good enough for the purpose of the CI projects or does it need improvements or adjustments?
- What types of performance measures do decision-makers need to see on a regular basis to manage and lead well?

- What are the specific requirements for a performance measurement system in your projects?
- What have you measured?
- Why have you measured them?
- How have you measured them?
- How would you explain and evaluate the difference between the realistic measurement outcome and estimated expectation?
- Do you have a system for evaluating your performance measurement?
- What are the major problems with the performance measurement systems and metrics that you have experienced?
- If you were to conduct the performance measurement again, what changes would you make in the process?
- What critical approaches have you applied when managing performance measurement?

Part 4 – CIPM construct and its influence

- How would you think of implementing performance measurement and management for supporting collaborative innovation?
- What is the best CIPM system for you in your organisation, and why? (Does it relate to numbers in financing a CI project or something independent of finance?)
- How would you deal with the application of a different performance measurement system by each project partner?
- Who of the CI partners should be in a dominant position in a collaborative relationship? Why?
- If the collaborative system were to break down temporarily, how would you keep the whole process moving in the development of a CI project? What parts would you consider in need of constructive review concerning reform, more investment and concentration, etc.?
- I have also concluded some factors influencing a CI process, which you have not mentioned (Additional Part as below). Would you please make comment on them?

- What is a CIPM system for you in your organisation? (Does it relate dominantly to numbers concerning finance or some other aspects in a CI project?)
- What measurement aspects do you think should be included in the applied construct for effectively designing CIPM systems?

Additional Part 1 – factors

Factors related to Input (Leading indicators)

- Environment: physical co-location and supportive socio-cultural environment
- Stable business climate
- Organisational structure with appropriate authority centralisation or decentralisation
- Technological tools which facilitate to improve effectiveness and efficiency in communication and collaboration
- Intangible and tangible resources, such as finance, time, physical space, materials, information, knowledge, know-how, expertise, skills and risks
- Appropriate organisational strategy
- Effective management style / Leadership
- Employee satisfaction and productivity
- Organisational culture
- Experience of collaborative innovation

Factors related to Process (Leading indicators)

- Trust between partners
- Social networks – formal and informal communication
- Knowledge management – effectively exchange and transfer knowledge
- Error management – monitor, identify and report errors for mutual benefit
- Setting up clear visions, objectives and goals
- Building effective teams
- Forming formal and informal learning opportunity between partners
- Coordination – partners make up plans, manage information and labour

- Participation of all members in the process of decision making
- Conflict resolution capabilities
- Open, transparent and honest communication
- Incentives – recognition and rewards of contribution; motivation
- Performance – maintain budgets, achieve targets, measure individual and collaborative progress and actions
- Balancing responsibility and contribution
- Level of process thinking
- Mutual understanding of clear goals and expectations
- delivery speed of innovative products
- reliability of innovative products
- percentage of on time deliveries of innovative products
- number of new products with relevant supportive service

Additional Part 2 – measurable objects

- Should the effectiveness of collaborative innovation be measured?
- Should the efficiency of collaborative innovation be measured?
- Should learning and growth of partners be measured?
- Should customer satisfaction (or partner satisfaction if interviewing university-industry collaboration) be measured?

Additional Part 3 – measurement standards

Factors related to Outcome (Lagging indicators)

The measurement should

- be relevant to collaborative innovation and easy to maintain
- be understood and utilised by participating collaborative partners
- be able to provide feedback quickly and accurately
- be reliable, valid and acceptable
- clearly define methods of data collection
- measure the level of performance