A Study on Decision Support for Managing Technology Incubator

(テクノロジーインキュベータ管理に対する意思決定支援に関する研究)

Raden Bagus Seno Wulung
D111012

Production Systems Engineering Laboratory
Department of System Cybernetics Graduate School of Engineering Hiroshima University

A dissertation submitted to the Graduate School of Engineering, Hiroshima University for the degree of Doctor of Engineering

HIROSHIMA UNIVERSITY

September 2014

Acknowledgement

This is to acknowledge that the dissertation entitled:

A Study on Decision Support for Managing Technology Incubator

テクノロジーインキュベータ管理に対する意思決定支援　に関する研究

Is a series of research works by **Raden Bagus Seno Wulung** during his doctoral study from October 4th 2011 to September 25th 2014 in Production System Engineering Laboratory, Department of System Cybernetics, Graduate School of Engineering, Hiroshima University, Japan. This dissertation has been accepted as a part of requirements in conferring in a **Doctor of Engineering** degree to him.

Dissertation committee

Katsuhiko Takahashi, Dr.Eng
Professor

Naoto Yorino, Dr. Eng
Professor

Ichiro Nishizaki, Dr.Eng
Professor

Abstract

Technology incubator is a facility that provides shared office space with affordable rent cost, training, equipment, business network, and access to technical and financial programs. Different with other incubator types, the technology business incubator focused on technology or knowledge transfer process as a main service for their incubatees. This dissertation focuses on providing decision support for the incubator manager to enhance the performance of technology business incubators. This dissertation provides the decision support for the incubator manager related with three important parts of technology incubator, incubatees selection, business support and mediation.

Firstly, in incubatees selection, this study proposes a multi-objective mathematical model to support the incubator manager select appropriate incubatee candidates. When developing a selection model, different orientations and preferences concerning finance and socially responsible or ethical investments of incubator managers are considered. A manager's financial orientation relates to financial performance, including investment returns, profitability and expected wealth. Socially responsible or ethical investments address environmental sustainability, unemployment, fair wages, human rights and other issues. The model utilizes three objective functions consist of profitability, survivability and worker absorption. Because different orientations of the incubator managers as decision makers (DMs) can influence the incubatee selection process, an interactive Tchebycheff method is used to provide a set of alternative solutions. Using a set of alternative solutions, this study provides a degree of freedom in the analysis to accommodate DM orientation.

Secondly, related to business support and mediation, previous researches indicate that incubatees face the difficulty in obtaining the financial support. The main obstacle in obtaining financial support is difficulty in providing high collateral requirement related to firm-risk. The investors are reluctant to provide incubatees financial support, because start-up SMEs have many uncertainties about their financial performance. In the case of a technology-based firm which positions incubatees inside the technology incubator, the difficulties could also include liabilities related to the novelty of the technology newness. Furthermore, the incubator manager also faces financial deficit and technology transfer and commercialization failure. To solve the problem simultaneously, a mathematical model outlining a profit sharing scheme to provide financial support for the incubatees is proposed. The model copes with the different objectives of the incubator manager who wants to maximize the profit of the incubatees and the income of the incubator and the investors who prefer to maximize their revenue. Furthermore, the proposed model investigates the technological progress of the incubatees, which influences the profit-sharing agreement between the incubator manager and the investors as decision makers.

In addition to the quantitative mathematical model, in this dissertation, the definition of technology incubator, the types, and kind of incubator support are provided. Furthermore, the technology incubator research stream and perspective are explored and the position of this study is defined. In the end of this dissertation, the conclusion and contribution of this study are proposed and the future research directions are derived.

Contents

List of Figures

List of Tables

Chapter 1
Introduction

1.1.Research Background

Technology incubator's facilities is well known for enhancing competitiveness of Small and Medium Enterprises (SMEs). Because of the popularity, technology incubators are established around the world. Technology incubator can be divided into three components of systems. Those components are task of selection, business support, and mediation (Bergek and Norman, 2008). The previous literature has exposed many problems facing the technology incubator program. The problems are the technology transfer failure during the incubation process, the difficulties to provide financial support for the incubatees, and financial deficit that faced the incubator manager. Those incubator problems are linked and cannot be separated each other. They are influenced by all of the system components of incubator. To date, however, no reports in the literature have proposed a model to solve the problems simultaneously and solve those problems by considering the contribution of the system components of technology incubator.

The selection process was viewed as an important component of technology incubator success. Hackett and Dilts (2004) indicated that the most concerning factor in the technology incubator model is relates to the issues of incubatee selection. That is the important task for incubator manager to identify the firm or potential start-up firm that are weak, but promising (Bergek and Norman, 2008). Aerts et al. (2007) survey incubator managers in Europe and find that European incubator managers do not screen their potential tenants on a wide and diversified set of criteria. Rather, the primary criteria used include financial ratios, the SME management team and market factors such as current size and growth rate. Their study also finds that incubator managers who use multi-criteria screening factors and conduct the screening process using a balanced set of factors realize a lower incubatee failure rate. Nevertheless, only 6% of European incubator managers use balanced multi-criteria screening factors. One reason for such a small value is the lack of a mathematical model that addresses multi-criteria selection.

After the incubator manager conducted the appropriate incubatee selection process, the others important components in technology incubator are business support and mediation process. The business support are the activities that relate to business development, including coaching and education. Especially in the technology incubator type, the support includes technology transfer process. Since technology incubators cannot provide all the need of their incubatees, the incubator has a role as intermediary or mediator between incubatees and relevant critical resources such as knowledge and technology, financial capital, marker related resources and human capital (Bergek and Norman 2008). However, some difficulties are faced by the incubator manager to conduct mediation with the other parties especially with the investors who provide financial support. The main obstacle in obtaining financial support is difficulty in providing high collateral requirement related to firm-risk (Columba et al., 2010; Hanedar et al., 2014). The incubator manager failed to convince investors to provide incubatees financial support, because start-up SMEs have many uncertainties about their financial performance (Everett and Watson, 1998; Macmillan et al., 1985). In the case of a technology-based firm which positions incubatees inside the technology incubator, the difficulties could also include liabilities related to the novelty of the technology newness (Löfsten, 2010). With regard to business support and mediation component, this study concern to provide decision support for incubator manager as intermediary to financial provider or investor.

1.2. Aims of Study

This study aims to solve the incubator problems and enhance technology incubator performance. Furthermore, in the modelling process, the important factors that influence the problems in all components of the incubator system,are explored. In the incubatees selection part, the study proposes an interactive multi-objective model in order to incorporate different orientation of incubator manager as decision maker. To support the incubator manager in getting financial support for the incubatees from the investors, the study proposes a profit sharing scheme and considers technological progress of incubatees as an important factor. By utilizing this study, the incubator manager will have a holistic approach in overcoming the problems, and enhancing the performance of technology incubator. The framework of the study is depicted in Figure 1.1.

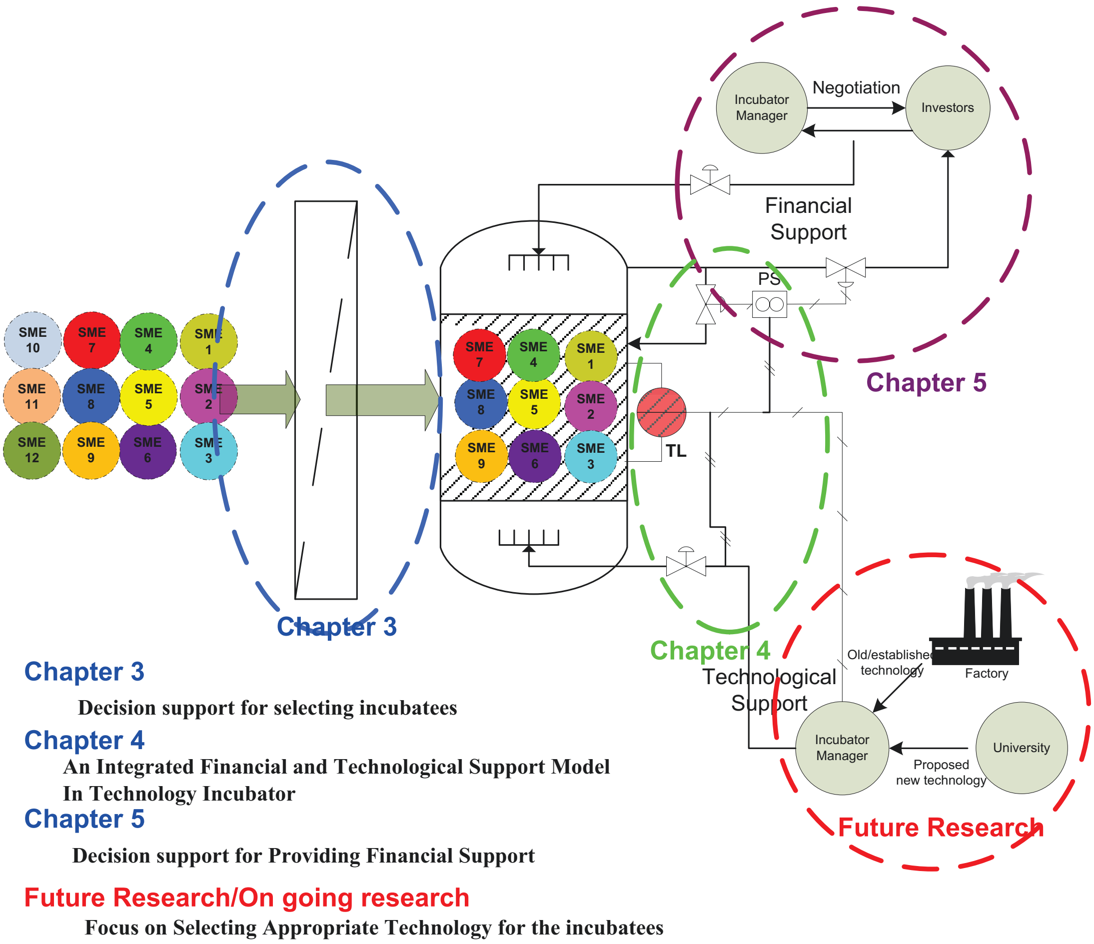

Figure 1.1. Framework of Study

1.3. Outline of the dissertation

The outline of the dissertations as follows:

Chapter 1 Introduction

Chapter 1 gives an explanation about research background, research position and problem definition. That is described the importance of the research and how the research can overcome the problems. The following outline of all chapters provides navigation to the dissertation content.

Chapter 2 Technology Incubator

TChapter 2 explores the types, roles of incubator, and indicates the performance measurement of technology incubator. The incubatees as the firm that are incubated inside technology incubator is defined and characterized. Since technology transfer process is an important feature in technology incubator, the mechanism and the importance is explained. Furthermore, this chapter explores the literature on technology incubator, defines research perspective, research stream and relationship with this study.

Chapter 3 Decision Support for Selecting Incubatees

Chapter 3 describes the new incubatees selection model in technology incubator. The selection is one of the important factors that influences technology incubator performance. The proposed selection model defines the performances consist of incubatees profitability, survivability and worker absorption. The model considers the orientation of incubator manager as decision maker. For incorporating the different orientation, the model utilizes an interactive Tchebycheff method to provide a set of alternative solutions. Using a set of alternative solutions, the model provides a degree of freedom in the analysis to accommodate DM orientation. Utilizing the proposed model, a decision maker can optimize incubator goals, thereby not only increasing profit but also ensuring the survivability of the incubatee and the success of the technology transfer process.

Chapter 4 An Integrated Financial and Technological Support Model In Technology Incubator

Chapter 4 considers that the supports for the incubatees including technological and financial are related and cannot separated each other. This chapter provides a conceptual model and influence diagram that show the relationship of the financial and technological support for the incubatees. Moreover, the chapter indicates some effect that might happen and should be anticipated by the stakeholder and recommendation for future research.

Chapter 5 Decision Support for Providing Financial Support

Based on the conceptual model is shown in Chapter 4, chapter 5 explaines the scheme to provide financial profit for the incubatees. In technology incubator programmes, several problems have been found. The problems are difficulties in obtaining the financial support that is faced by the incubatees, the failure of the technology transfer process, and incubator financial deficit. For overcoming the problems simultaneously, a profit-sharing scheme is proposed. In the model, the decision makers are incubator manager and the investors, who have different concerns and interests with each other. To cope with different interests of the decision makers, the negotiation process is used. Then, the behavior and benefit of negotiation process is analyzed. In the model, the technological progress of the incubatees during incubation is considered as an important factor. Those factors have certain value for the incubator manager and uncertain for the investor. Utilizing a mathematical model, the numerical experiments derive the managerial implications for the decision makers.

Chapter 6 Conclusion

Chapter 6 summarizes and discusses the recommendations for future research in relation to the current study.

Chapter 2
Technology Incubator

2.1. Technology Incubator Definition

The creation and start-up of an SME is its most significant challenge because many attempts to establish a business fail. Thus, the first success of a business is the birth of the business itself (Gelderen et al., 2006). Furthermore, start-up SMEs are weak in certain areas, such as marketing, capital generation, technology and finance (Gunasekaran et al., 2011). For this reason, technology incubators can provide a nurturing environment for business start-ups to enhance their competitiveness (Chan and Lau, 2005). Despite the maturity of technology business incubator as a practice and as a research field, a consensual definition is yet to be found (Bruneel at al, 2012). Business incubation is a business support process that accelerates the successful development of start-up and fledgling companies by providing entrepreneurs with an array of targeted resources and services (NBIA, 2007). European Commission (2002) also defined incubator as an organization that accelerates and systematizes the process of creating successful enterprises by providing comprehensive and integrated range of support. Several previous researches also defined a technology incubator as a facility that provides shared office space with affordable rent cost, training, equipment, business network, and access to technical and financial programs (Aerts et al., 2007; Chan and Lau, 2005; Mian, 1996). In the other research, Phan et al. (2005) defined that technology incubators are property-based organizations with identifiable administrative centers focused on the mission of business acceleration through knowledge or technology agglomeration and resources. More systematic definition is depicted by incubator-incubation concept proposed by Hacket and Dilts (2004) as shown in Figure 2.1.

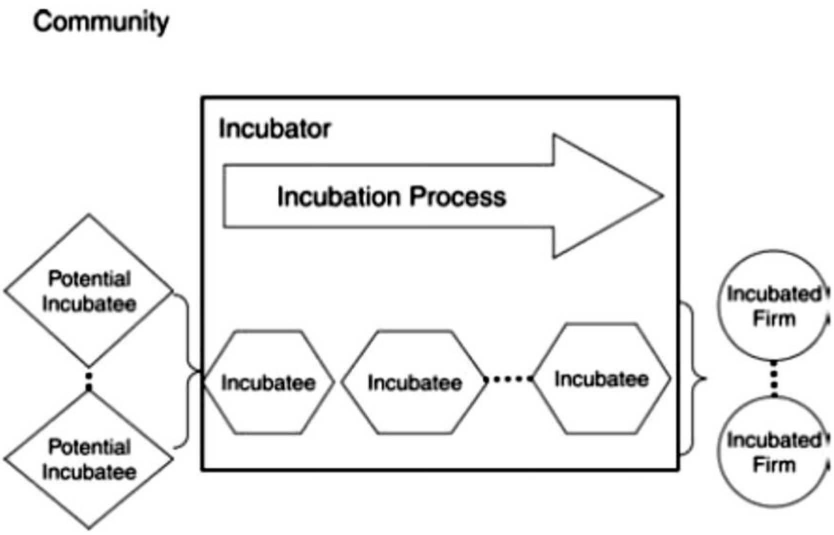

Figure 2.1. Incubator-Incubation concept map (Hacket and Dilts, 2004)

Based on Figure 2.1. incubation process can be divided into selection part and incubation. In the selection, the incubator manager selects the most appropriate potential incubatees to be incubatees. For the selected incubatees, the incubator manager organizes incubation process. After the incubatees have reach several performance criteria, then the incubatees is graduated and called incubated firm.

2.2. Type of Incubator

After explaining the incubator definition, the other important issue is to define clearly the type of incubator, its characteristic and the difference. Aernoudt (2004) stated that the number of incubator is growing rapidly, and more than 3000 incubators are established in the world. Based on the establishing philosophy, he classified the incubators to mixed incubators, economic development incubators, technology incubators, social incubators, and basic research incubators. The typology of incubators based on Aernoudt (2004) is shown in Table 2.1.

Table 2.1. Typology of Business Incubator (Aernoudt, 2004)

	Main philosophy	Main objective	Secondary	Sectors involved
Mixed Incubators	Business gap	Create start-ups	Employment creation	All sectors
Economic development incubators	Regional or local disparity gap	Regional development	Business Creation	All sectors
Technology incubators	Entrepreneurial gap	Create entrepreneurship	Stimulate innovation, technology start-ups and graduates	Focus on technology,
Social incubators	Social Gap	Integration of social categories	Employment creation	Nonprofit sectors
Basic research incubators	Discovery gap	Blue-sky research	Spin-off	High tech

Beside five type of business incubator described in Table 2.1, Aernoudt (2004) also indicated that there is existed the incubator that provides the assistance using online system. The Incubators is called virtual incubators. Aerts (2007) used the concept of European Commision in determining the incubator classification. By comparing the management support and technological level, the research defined the business incubator as depicted in Figure 2.2.

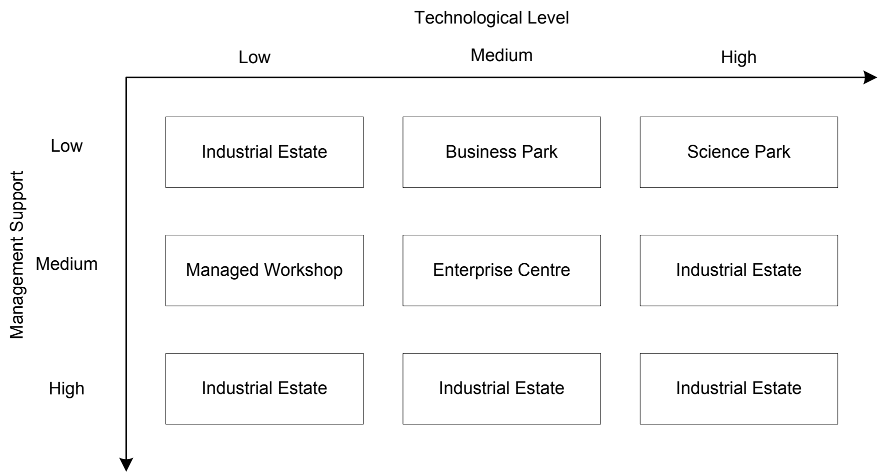

Figure 2.2. Position of the Business Incubator (European Commission, 2002)

2.3. Type of Incubator Support

As an organization for enhancing the performance of incubatees based on their purposes,technology incubator provides several supports. Vanderstraeten and Matthyssens (2012) divided the incubators support by four categories. The categories are administrative services, logistic services, business support services, and networking. Administrative services cope with the reception, telephone, postal delivery, and others. Logistic services are flexible office space, internet connection and photocopier. Business support services defined as in depth business support services focusing on operational business activities that depend on business type of the incubatees or incubator focus. Networking is defined as access to partners such as venture capitalist and lawyers. Furthermore, Vanderstraeten and Matthyssen (2012) also indicated the support services provided by the incubators is influences by type of incubator. They defined the incubators type as specialist incubators that focus on specific sectors and generalist incubators that have diversified sector focused. Specialist incubators offer more specific technology support and provide networking related to specific sector or field of technology as compared with generalist incubators. Similar classification have been made by Zedtwitz and Grimaldi (2006). The support categories are physical structure (e.g. office space, desk), office support (e.g. PC, email, security), access to capital (e,g. direct investment, venture capital, pseudo salaries), process support (e.g. training, coaching, mentoring, consulting), and networking (e.g, network to key employee, customer, supplier, collaborators). Bergek and Norman (2008)support the definition of type of incubator support by previous research, but they emphasized that the business support and networking are more important than only focus on facilities and administrative services. They argued that without the business support activities the institution is more like "hotel" than incubators. Moreover, they supported co-location and shared overhead resources in order to provide opportunities for knowledge transfer and experience sharing between the incubatees. In technology incubator type, the support mainly regards to technological support unlike other common support like providing office space and financial support. The technological supports are access to laboratory or workshop, laboratory/workshop equipment, technology transfer program, related R&D activity, employee education, and university image (Mian, 1994; Mian, 1997; Philips, 2002). Incubator also can be classified by the type of the incubatees. The types of incubatees that incubated in the incubator are start-up firm, new firm and mature firm.

Some researchers conducted research to assess the contribution and the importance of the incubator support for the incubatees. Chan and Lau (2005) found that incubator with existed university-technology start-ups relationship is more useful than that with science park-technology start-ups relationships with regard to the product development process. However, related to technical sharing facilities among firms, incubator is found not significant contribution as technology resources are varied from the incubatee to incubatee. The research also found that cost advantage caused by rental subsidies is most important and beneficial while no benefits are gained from networking support. Chan and Lau (2005) also indicates that the benefits from the technology incubators are spread during incubation period as depicted in Figure 2.3.

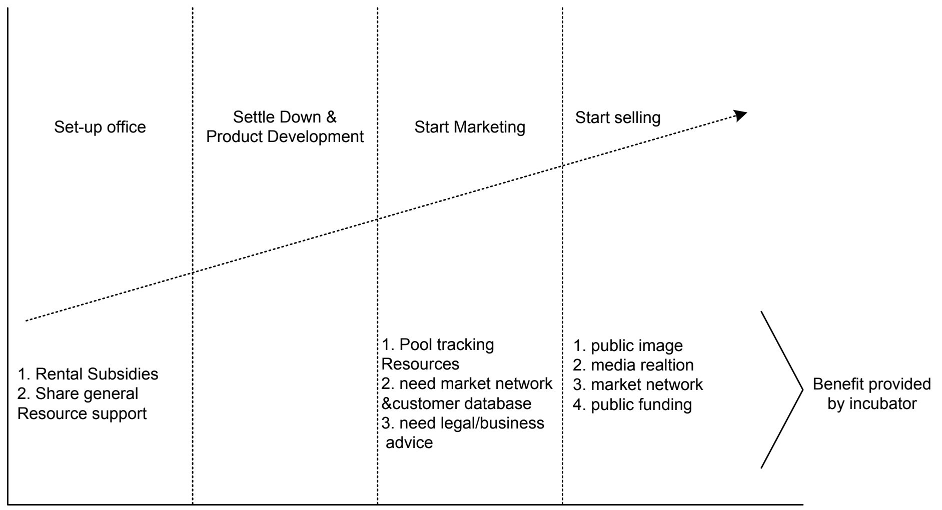

Figure 2.3. Development of technology start-up and benefits from incubators (Chan and Lau, 2005)

Philips (2002) conducted research to examine the technology incubator support focused on technology transfer and commercialization. The research indicated that the level of technology transfer support was lower than that would be expected. The research found that only half or less of the incubatees involved in the technology transfer activity. The finding is related to the function of the incubator in building networking with technology provider such as university or research centre. The main reason raised in the research about technology transfer failure is regard to the amount of royalties to be retailed by technology provider. It will make negotiation between incubator manager and the technology provider could stall and cancelled. Chen (2009) also found that the roles of technology incubator in supporting the incubatees through technology transfer and mediating technology commercialization with technology provider has negative effect and not significant relationship. Sohn et al. (2007) stated there are needed some better strategies for commercialization of research and technology transfer process related to low performance of technology improvement.

Those results indicated the networking support from the incubator is not sufficient and does not have significant benefits (Chan and Lau, 2005; Chen, 2009; Sohn et al. 2007). That is a intriguing finding because most incubators (88%) offer a network as an important support (Aerts et al. 2007). Furthermore, Aerts et al. (2007) also found that 96% of incubators provide meeting rooms or conference facilities, and 86% of them assist their incubatees in creating business plan.

2.4. Current achievement in technology incubator research.

Because of the popularity and importance of the technology-business incubation concept, numerous studies have been conducted. Hackett and Dilts (2004) conducted a review of business incubation research. They divided the technology incubation research stream to five research stream based on research period. The result of their study is shown in Table 2.2.

Table 2.2. Overview of incubator-incubation literature (Hacket and Dilts, 2004)

Research stream	Incubator development studies	Incubator configuration studies	Incubatee development studies	Incubator-incubation impact studies	Studies theorizing about incubators-incubation
Research Period	1984-1987	1987-1990	1987-1988	1990-1999	1996-2000
Main topics	● Definitions ● Taxonomies ● Policy prescriptions	● Conceptual framework ● Incubatee selection	● New venture development ● Impact of planning on the development	● Levels and unit of analysis ● Outcomes and measure of success	● Explicit and implicit use of formal theories (transaction cost economic, network theory, entrepreneurship, economic development through entrepreneurship)

In their review, Hackett and Dilts (2004) also defined the distribution of technology business incubator research perspective. By reviewing 38 journal papers, they found that the majority of the papers (18 papers) have research perspective in economic development, followed critical success factors perspective (5 papers). The distribution of research perspective based on Hackett and Dilts, (2004) is shown in Table 2.3.

Table 2.3. Distribution of research perspectives applied to incubator-incubation studies (Hackett and Dilts, 2004)

Research perspective	Frequency	Research perspective	Frequency
Economic Development	18	Technology development	1
Critical success factors	5	Economic rationality	1
New venture creation/development	3	Innovation theory	1
New technology based firms (NTBF)	3	Technology transfer	1
Public Policy	2	Middleman theory	1
Planning studies	2	Enclave theory	1
Entrepreneurship	2	Institutional perspective	1
New product development	2	Business incubation support	1
Organizational effectiveness	2	University technology commercialization	1
Small business studies	1	SME support	1
Life cycle model	1	Performance benchmarking	1
Value added	1	Impact assessment	1
Network Theory	1	Cost effectiveness	1

Table 2.3 shows that the research perspective in technology incubator-incubation studies is unbalanced and that the majority of papers have economic development perspective (18 of 38). The trend is not changed radically until now based on the review of the literature that published after the review paper by Hackett and Dilts (2004). Unfortunately no research in the literature has perspective to provide decision support to incubator manager as decision maker for managing the technology incubator.

Whilst Hackett and Dilts, (2004) explored the research stream and research perspective in incubators-incubation studies, Bruneel et al. (2012) conducted a research to explore the evolution of technology business incubators. They divided the technology business incubators into three different generation. The result is shown in Table 2.4.

Table 2.4. The evolution of Business Incubation's Value proposition (Bruneel at al., 2012)

	First generation	Second Generation	Third Generation
Offering	Office space and shared resources	Coaching and training support	Access to technological, professional, and financial networks
Theoretical rationale	Economies of Scale	Accelerating the learning curves	Access to external resources, knowledge, and legitimacy

2.5. Relationship with this study

2.5.1. Type of incubator

Incubator in this study is technology business incubator. The main service of the technology incubator is technological support beside other common support like providing office space and financial support. The supports related to technological support are access to laboratory or workshop, laboratory/workshop equipment, technology transfer program, related R&D activity, employee education, and university image (Mian, 1994; Mian, 1997; Philips, 2002).

The incubatees in this study are start-ups enterprises which weak but promising. Focusing on start-ups enterprises, the goal of incubator in this study not only profitability as financial performance or workers absorption as social oriented performance, but also survivability of the incubatees. As consequences of technology transfer process, technological progress as important factor should be considered.

2.5.2. Research perspective and research stream.

Regard to research perspective, this study hasperspective on decision support for incubator manager as decision maker in order to enhance incubator performance. This study also considered and elaborated several research perspectives based on Hackett and Dilts, (2002). The research perspective in this study is shows in Figure 2.4.

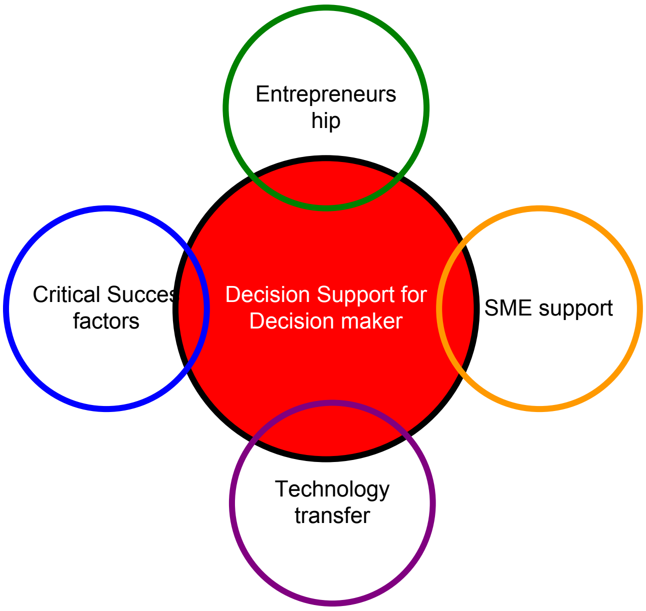

Figure 2.4. Research perspective

Based on Figure 2.4., this study accommodates several research streams which is indicated by Hackett and Dilts (2004) in order to provide holistic decision support for incubator manager.

This study is conducted in the field of operational research and management science, by utilizing mathematical model optimization. The research covers three components in technology incubator, incubatee selection process, business support and mediation (Bergek and Norman, 2008). The study is application of operational research into technology incubator-incubator research area. On the other hand, this study can be classified as the management of technology (Gaimon, 2008) or technology commercialization and entrepreneurship in operations management perspective (Shepperd and Patzelt, 2013; Krishan, 2013)

Chapter 3
Decision support for selecting incubatees

3.1.Introduction

Small- and medium-sized enterprises (SMEs) are widely accepted as making significant contributions to a region's economic development by reducing unemployment and increasing the gross domestic product (GDP) (Van Gils, 2005; Cull et al., 2006; Gunasekaran et al., 2011). The creation and start-up of an SME is its most significant challenge because many attempts to establish a business fail. Thus, the first success of a business is the birth of the business itself (Gelderen et al., 2006). Furthermore, start-up SMEs are weak in certain areas, such as marketing, capital generation, technology and finance (Gunasekaran et al., 2011). For this reason, technology incubators can provide a nurturing environment for business start-ups to enhance their competitiveness (Chan and Lau, 2005). A technology incubator is a facility that provides shared office space with affordable rent cost, training, equipment, business network, and access to technical and financial programs (Aerts et al., 2007; Chan and Lau, 2005; Mian, 1996). The incubator manager has several important tasks in the business incubation process. This study focuses on the decisions made by the manager in the role of decision maker (DM) for the selection of incubatees, i.e., the decisions about which enterprises to accept for entry and which ones to reject.

The fundamental difficulty in incubatee selection is the lack of reliable data as the candidate's business plan often includes exaggerated or highly optimistic values. In addition, the manager must evaluate the survivability of each candidate incubatee because the values for expected profit and employment performance are meaningful only if the enterprise does not fail. It is generally believed that the personality and characteristics of the entrepreneur who starts an enterprise influence the survivability of the enterprise. The empirical study conducted by Ciavarella et al. (2004) indicates that survivability is positively influenced by an entrepreneur's personal attributes of extroversion, emotional stability, agreeableness, conscientiousness, and openness to experiences. Hopefully, the weakness of the business plan can be compensated by evaluating the personality of the entrepreneur. Bergek and Norman (2008) support this viewpoint by noting that incubatee selection can be divided into idea-focused selection and entrepreneur-focused selection. In the idea-focused selection approach, the incubator manager evaluates candidate incubatees based on market and profit potential, while the entrepreneur-focused approach evaluates the characteristics of the entrepreneur, including his experiences and skills. Aerts et al. (2007) survey incubator managers in Europe and find that European incubator managers do not screen their potential tenants on a wide and diversified set of criteria. Rather, the primary criteria used include financial ratios, the SME management team and market factors such as current size and growth rate. Their study also finds that incubator managers who use multi-criteria screening factors and conduct the screening process using a balanced set of factors realize a lower incubatee failure rate. Nevertheless, only 6% of European incubator managers use balanced multi-criteria screening factors. One reason for such a small value is the lack of a mathematical model that addresses multi-criteria selection.

When developing a selection model, it is important to remember that incubator managers have different orientations and preferences concerning finance and socially responsible or ethical investments (Ballestero et al., 2012). A manager's financial orientation relates to financial performance, including investment returns, profitability and expected wealth. Socially responsible or ethical investments address environmental sustainability, unemployment, fair wages, human rights and other issues (Bauer et al., 2005; Hallerbach et al., 2004; Moon, 2002). Currently, interest in socially responsible investment is growing. Therefore, there are growing numbers of DMs who want to take social responsibility into account rather than consider future wealth or financial performance alone (Hallerbach et al., 2004). Furthermore, the orientation of the manager influences which incubatees are selected based on profitability and worker absorption optimization. To date, however, no reports in the literature have proposed an incubatee selection or screening model that incorporates different orientations of the incubator manager (Aerts et al., 2007). Thus, the challenge is to provide a mathematical model that incubator managers of both orientations can use to select appropriate incubatees.

This chapter proposes a multi-objective mathematical model that reflects the survey results of Aerts et al. (2007). An interactive weighted Tchebycheff method is used to provide a set of alternative solutions that provide a degree of freedom in the analysis to incorporate the DM’s orientation, i.e., towards finance or social responsibility. This interactive method was developed by Steuer and Choo (1983) with further development by Steuer et al. (1993), Reeves and Macleod (1999) and Soylu (2011). By providing several alternative solution sets, the model aid the DM in selecting the most preferable solution. The following two constraints are added to the model: minimum technology level and industry priority. The first constraint excludes candidate enterprises that are expected to have difficulty absorbing new technology or knowledge during the incubation process. The technology level of an enterprise is measured by a technometric model consisting of four factors: embodied technology in physical facilities or equipment (technoware), people (humanware), information or documentation (infoware) and institutions (orgaware) (UNESCAP, 1989). The industry priority constraint takes into account the various regional resources where the incubator will be established (Bergek and Norman, 2008). This constraint reflects the phenomenon found in previous research that incubators specializing in one or a limited number of sectors are more profitable (Chan and Lau, 2005). Despite the advantage of sector specialization, the drawback is increased incubator vulnerability (Aerts et al., 2007). Thus, there is a trade-off for the DM: whether to select incubatees in a narrow sector or to diversify.

The remainder of this chapter is organized as follows. Section 3.2 describes the proposed model compared to previous work. To improve understanding of the proposal, Section 3.3 illustrates the model development and our analytical models. Section 3.4 presents a numerical analysis and discussion. Section 3.5 summarizes, presents conclusions and provides recommendations for future work.

3.2.Literature Review

Because incubatee selection is an important component of incubator performance, many researchers have proposed incubatee selection processes. Mian (1994) performed a study of six technology incubators in the United States and compared the incubators' characteristics. The study suggested that there may be a trade-off between stringency in incubatee selection and value added. The technology level constraint used in our model increases selection stringency and may decrease profitability and worker absorption. However, using a technology level constraint can ensure successful technology transfer because the incubatees have the capability to absorb new technologies and knowledge. Merrifield (1987) proposed a selection method using qualitative business attractiveness factors, rating each factor on a scale of 0 to 10. Bergek and Norman (2008) divided incubatee selection into two overall approaches: selection focused primarily on the business idea and selection focused primarily on the entrepreneur or team. In our model, the two approaches by optimizing aggregate profitability (the idea-focused approach) and survivability based on the personal attributes of the entrepreneur (the entrepreneur-focused approach) are combined. A survey examining the performance of selection practices among incubators found that market characteristics (related to market growth) were the most important (Khalid et al., 2011) and that the relevant selection criteria were based on managerial, product, and financial characteristics (Aerts et al., 2007; Hacket and Dilts, 2008). In this work, multiple criteria in a multi-objective optimization to decide whether to accept candidates as incubatees is used. All of these studies explore incubatee selection methods for established incubators based on empirical or case studies. However, empirical and case studies are limited because incubator systems and purposes vary in each region, and their analyses cannot provide optimal solutions to satisfy DMs based on their missions. In our research, we propose a model to select incubatees and optimize incubator performance using a mathematical model.

Multi-objective decision making is widely used in a broad research area because DMs often have multiple purposes or agendas. Despite the fact that a multi-objective mathematical model does not exist for the incubatee selection problem, many other research areas have adopted this procedure for other purposes. Aretoulis et al. (2010) provided a model for evaluating suppliers before awarding contracts. Using a mathematical model, the research provides an early warning system before the project begins. Mendoza and Ventura (2013) developed a mixed integer nonlinear programming model to address actual transportation costs and order quantity allocation. Xidonas et al. (2009) also used multi-criteria decision making to provide a tool for portfolio managers, financial analysts, and traders to design their portfolios. In contrast to previous research models, this incubatee selection process had several difficulties because new and young SMEs have limited data, and uncertainty about profit and employment performance is high (Everett and Watson, 1998). The distinct characteristics are survivability based on personal attributes and the success of the technology transfer process. Furthermore, the advantages and disadvantages of sector specialization should be considered. This research shares the spirit of that of Aretoulis et al. (2010) in terms of reducing poor performance in incubation systems at an early stage by providing an appropriate incubatee selection process. In keeping with Xidonas et al. (2009), our proposed model provides flexibility for the DMs to choose the solution that is best for them.

Because increasing the rate of incubatee survival is an important goal for incubators, the incubatee selection model should incorporate survivability prediction. Several methods to predict business survival or failure have been proposed and discussed in previous studies. Discriminant analysis methods have been used most frequently in business failure studies, followed by logit analyses (Dimitras et al., 1996). Although discriminant analysis is more popular than logit analysis, the latter seems preferable because it does not require the independent variable to be a multi-variate normal (Dimitras et al., 1999). Logit models are more popular than probit models because probit analysis requires greater computational effort (Dimitras et al., 1996). The main significant drawback in logit model application is the interpretation of the model parameters, especially in the case of multi group classification problem. Dimitras et al. (1999) also suggested using rough set analysis to predict business failure because it has demonstrated more accurate predictions compared to discriminant analysis. Despite the advantages of rough set analysis over the other methods, the method needs a large amount of data. Furthermore, rough set analysis can sometimes be impractical to apply as it may lead to an empty set, and it is sensitive to changes in data (Kumar and Ravi, 2007). For prediction survivability some previous studies have used the financial ratio as a variable (Dimitras et al., 1996; Dimitras et al., 1999, Ahn et al., 2000). When using the financial ratio as a variable, the user need to assess the values of the ratios over several years based on the financial reports from the firm. This requirement leads to inappropriate use of financial ratios in new or young SMEs because their financial planning and accounting, including financial report or statements, are weak. Ciavarella et al. (2004) explored the impact of psychological characteristics on the survival of a new venture and found that the relationship between the entrepreneur's personality and venture survival was expressed by a logit model with a dichotomous dependent variable that used five significant personality attributes: extroversion, emotional stability, agreeableness, conscientiousness, and openness to experiences. The study indicated that an entrepreneur's personal attributes influence the survival of a new enterprise and that the strongest personality factor is conscientiousness.

The most important service of technology incubators is the enhancement of incubatee competitiveness through technology transfer. The important factors for effective technology transfer are agent transfer, medium transfer, object transfer, and recipient transfer (Bozeman, 2000). In an incubator, the absorptive capacity of the incubatee as a recipient is critical to technology transfer because this capacity can influence the technology gap between the transferor and the transferee (Jayaraman et al., 2004). The absorptive capacity is the degree to which an organization is able to devote the resources necessary to adopt a new technology (Cohen and Levintal, 1990). Absorptive capacity is related to the technology level of the enterprise such that a low recipient absorptive capacity hinders the transfer of technology and knowledge during the incubation process (Sung et al., 2003). The technology level of an SME can be assessed using a technometric model (UNESCAP, 1989), and a DM can use a minimum technology criterion for incubatee evaluation. In the proposed model, screening for a minimum technology level is conducted to ensure that the selected incubatee can absorb knowledge and technology during the incubation process.

Because an established technology incubator will have several different goals depending on the DM's orientation, an incubatee selection model must have the flexibility and interactivity to generate a set of alternative solutions for these problems. The Tchebycheff method has become popular for sampling a set of non-dominated solutions in an interactive search for the most preferred solution in multi-objective decision making (Steuer and Choo, 1983; Steuer et al., 1993). The Tchebycheff method has several advantages for multi-objective optimization compared with other methods. First, all efficient alternatives are considered when incorporating the DM's orientation; therefore, the DM can participate during the decision-making process (Reeves and MacLeod, 1999; Steuer and Choo, 1983; Steuer et al., 1993). Second, the method can also facilitate binary integer programming decision making (Steuer and Choo, 1983). Third, the DM can learn about his own preferences, which are often vague and imprecise in their initial form. An interactive Tchebycheff method with a dividing iteration path to provide a solution for each DM is used in this model. In previous research, Soylu (2011) indicated that the Tchebycheff method was appropriate for multi-criteria sorting and for incorporating DM preferences.

Based on the above review of the existing literature, the proposal to build an incubatee selection model that considers DM orientation using non-dominated multi-objective optimization is original. Moreover, the proposal will provide an incubatee selection model for technology incubators as well as opportunities for future study in the development of technology incubator systems.

3.3.Model Development

Because DMs have various objectives and use various performance measures, this model considers the multi-objective functions of profitability, survivability and worker absorption or employment growth (Löfsten and Lindelöf, 2002). Profitability is crucial for a financially oriented manager, while worker absorption is paramount to a socially oriented manager (Bauer et al., 2005; Hallerbach et al., 2004; Moon, 2002). As a practical matter, DM uses the incubatee candidate's business plan for the selection process (Thierstein and Wilhelm, 2001). The profitability and number of workers in an incubatee candidate's business plan may have a subjective effect on the selection process. Furthermore, data obtained from an incubatee candidate's business plan may not only be unreliable (Everett and Watson, 1998), but they do not reveal the characteristics of the entrepreneur (MacMillan et al., 1985). The difficulty in quantifying financial ratio data for new and young SMEs is because not all candidates can provide the data or the data provided is not valid. This situation is unfair and may lead to bias in the selection process. Based on the aforementioned reasons, using personal attributes to predict the survival ability of incubate candidates and excluding the financial ratio as a variable for survivability prediction is emphasized. Different with using financial ratios, personal attributes not based on financial report of candidates. Furthermore, personal attributes are embodied in the owners of SMEs and do not have different measurements in different countries and sectors. Accordingly, the probability of survival will be used as an objective function in the model. Assuming that the financial ratios can be assessed by DM, when the ability of an SME as an incubatee related to financial planning and accounting, including financial reports, increases through training in the incubation process. Furthermore, the other performances, such as profitability as a financial performance and employment as a social responsibility performance, as objective functions in multi-objective optimization are considered.

The conceptual framework of the developed model is shown in Figure 3.1, while the notation used is given in Table 3.1. In the model, incubator managers act as DMs and start-ups or young SMEs are incubatee candidates. We consider multi-objective functions consisting of profitability maximization (z_1), incubatee survivability (z_2), and worker absorption maximization (z_3) to reduce unemployment. Incubatee candidate properties, such as technology level (a_{ij}), profitability (P_{ij}), survivability (R_{ij}), worker absorption (L_{ij}) and total assets (A_{ij}) are the inputs, while incubator capacity (C), maximum total assets (A_r), minimum technology level (a_{min}) and industry priority proportion (I_j) are the constraint parameters. Applying the proposed model consists of several steps: First, candidates propose their business plans to the DM. Second, the DM assesses the technology level of the incubatees and the personal attributes of the entrepreneurs. Third, the applicants are screened for maximum total assets and minimum technology level to eliminate inappropriate candidates. Fourth, the available candidates are entered into the optimization process through three simultaneous objective functions to provide a set of alternatives that accommodate the different orientations of the DM. This approach allows the DM some degree of freedom to choose the single most preferable feasible alternatives.

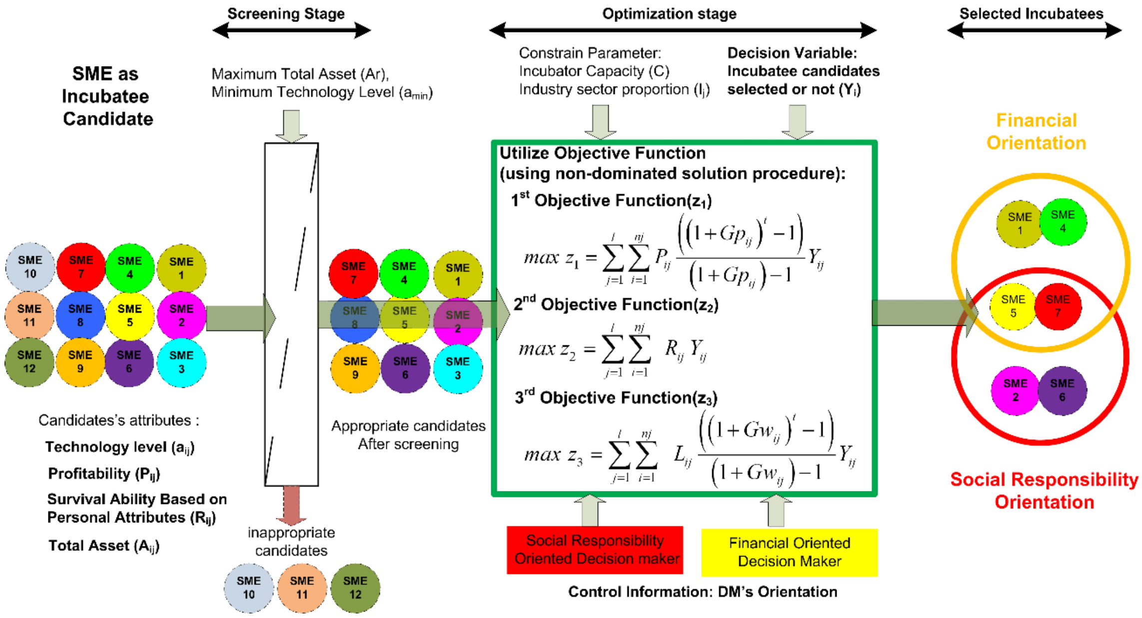

Figure 3.1 Conceptual framework

Table 3.1. Model Notation

Indices	
i j k	SME index ($i = 1, 2, .., n_j$) Industry sector index ($j = 1, 2, .., l$) Objective function index ($k = 1, 2, 3$)
Parameters	
a_{min} C n A_r	Minimum technology level Maximum number of acceptable incubatees Number of SME candidates in the selection process Total micro-enterprise assets according to government regulations
Variables	
a_{ij} L_{ij} P_{ij} I_j R_{ij} Gp_{ij} Gw_{ij} A_{ij}	Technology level of SME i from sector j Number of workers of SME i from sector j Profit of SME i from sector j Proportion of industry j Survival probability of SME i from sector j Expected profit growth of SME i from sector j Expected worker growth of SME i from sector j Total assets/investments of SME i from sector j
Decision variables	
Y_{ij}	Is 1 only if SME i from sector j is selected

3.3.1. Screening Process

Two screening criteria thet used in the model: total assets and minimum technology level.

3.3.1.1 Total Assets

This constraint strictly distinguishes SMEs from large enterprises. It is important to exclude the large enterprises as the focus of the incubator is to enhance the competitiveness of SMEs. The most common definitions used by government as regulators are based on the number of employees, sales, and total assets of the enterprise (Ardic et al., 2011). We use an enterprise scale constraint to fulfill the government regulation strictly based on the enterprise's total assets (A_{ij}). If $A_{ij} \leq A_r$, then SME i from industry j is an appropriate incubatee candidate, and vice versa. In contrast, using total asset as a smooth constraint in the objective function as a minimization function will lead the DM to include candidates that have high total assets, which will violate government rules.

3.3.1.2. Minimum Technology Level

This criterion ensures the technological capability of the recipient incubatee. If the technology level of the candidate (a_{ij}) is higher than the minimum technology level $(a_{\min})$, then SME i from industry j is an appropriate incubatee, and vice versa. Using the minimum technology level as a minimum requirement for technology capability of candidates, the DM ensures that the selected candidates can absorb the necessary technology and knowledge. The technology transfer process will be influenced by the technology distance of the technology level of incubator as a transferor and the technology level of the incubatee as a transferee. Very large technology distance will lead to failure in the technology transfer process (Jayaraman et al., 2004). To ensure the effectiveness of the technology transfer process, the candidates with technology levels lower than the minimum allowable technology level are eliminated (Philips, 2002). As a practical matter, the DM can use a technometric model to measure the technological capability of a candidate (UNESCAP, 1989).

3.3.2. Optimization Process

3.3.2.1. Objective functions

Accumulated profitability – the sum of the individual profits of the selected candidates over the incubation period assuming that a fixed value of expected growth is realized in each period:

$$max\ z_1 = \sum_{j=1}^{l}\sum_{i=1}^{nj} P_{ij} \frac{\left(\left(1+Gp_{ij}\right)^t - 1\right)}{\left(1+Gp_{ij}\right)-1} Y_{ij} \qquad (3.1)$$

where t is the incubation period, which ranges from 1 to 5 years.

Equation (3.1) uses a binary variable (Y_{ij}) that is equal to 1 if the candidate is selected, and 0 otherwise. The accumulated profit of the incubatees is then calculated by summing the individual profits (P_{ij}) of the selected incubatees. The DM selects a combination of incubatees that generates the maximum accumulated profit. To incorporate the future accumulated profit of the incubatees at the end of the incubation period, we consider profit growth (Gp_{ij}) based on time-series profitability changes. Forecasting typically uses time series and statistical or empirical data (Goodwin and Wright, 1994). However, because the candidates are new and new SMEs have a limited data record, the data may be insufficient for developing reliable statistical measures (Goodwin and Wright, 1994). Growth and changes in net operating assets provide information about future profitability (Fairfield and Yohn, 2001). Because the incubation period varies from 1 to 5 years, we use an incubation period parameter (t), to be decided by the DM, that influences the total accumulated profit (Aerts et al., 2007).

Survivability – the cumulative survivability of the selected candidates.

$$Max\, z_2 = \sum_{j=1}^{l}\sum_{i=1}^{nj} R_{ij}\, Y_{ij} \qquad (3.2)$$

Because the performance, including profitability and employee absorption, of new and young SMEs is uncertain, the DM must ensure that the incubatee will survive based on the personal attributes of the entrepreneur. For this purpose, the survivability of the incubatee (R_{ij}) is used in an objective function. In equation (3.2), the DM maximizes the cumulative survivability by selecting the combination of incubatees that attains the highest aggregate performance. Survivability can be calculated as a dependent variable, while the personal attributes act as independent variables (Ciavarella et al., 2004). A logit model is recommended for calculating the probability of survival, as shown in equation (3.3):

$$\ln\left(\frac{R_{ij}}{1-R_{ij}}\right)=e^{z_{ij}} \tag{3.3}$$

$$R_{ij}=\frac{1}{1+e^{-z_{ij}}} \tag{3.4}$$

Based on equation (3.4), R_{ij} represents the probability of incubatee survival.

$$z_{ij}=aW_{1(ij)}+bW_{2(ij)}+cW_{3(ij)}+dW_{4(ij)}+eW_{5(ij)} \tag{3.5}$$

where $W_1, W_2, W_3, W_4, and\ W_5$ are the entrepreneur's personal attributes - extroversion, emotional stability, agreeableness, conscientiousness, and openness to experiences (Barrick and Mount, 1993). *Worker absorption* – the total workers that will be absorbed by the selected candidates over the incubation period.

$$z_3=\sum_{j=1}^{l}\sum_{i=1}^{nj}L_{ij}\frac{\left(\left(1+Gw_{ij}\right)^t-1\right)}{\left(1+Gw_{ij}\right)-1}Y_{ij} \tag{3.6}$$

Equation (3.6) uses a binary variable (Y_{ij}) that is equal to 1 if the candidate is selected, and 0 otherwise. The incubatees' total workers are then calculated by summing the individual worker absorption numbers $\left(L_{ij}\right)$ for the selected incubatees. The DM selects a combination of incubatees that will generate the maximum total worker absorption. As with profit growth, we derive worker growth (Gw_{ij}) generated from the changes in the number of workers from a 5-year time series European statistical data set.

In this model, we utilize three objective functions. Profitability represents financial performance prospect of incubatee. Survivability represents the ability of the candidate to survive based on their personal attributes. The third objective represents the social responsibility performance to absorb workers and reduce unemployment. By using three different perspectives in incubatee selection, we can capture wide perspective of selection. Our proposed method has advantages over other alternatives that incorporate survivability in the evaluation of profit and workers absorption that leads to an expected profit and expected worker absorption. Our proposed multi-objective functions can avoid selecting high risk candidates that have high profit or worker absorption but low survivability. Our proposed multi-objectives functions also avoid selecting low performance candidates that have low profit or workers absorption but high survivability.

3.3.2.2. Constraints

Incubator capacity constraint – this constraint limits the number of incubatees in relation to the DM's budget.

$$\sum_{j=1}^{l}\sum_{i=1}^{nj} Y_{ij} \le C \tag{3.7}$$

This constraint is used to reflect incubators' capacity limitations because incubators have a limited area and limited resources.

Industry priority constraint –

$$\sum_{i=1}^{n} Y_{ij} \le I_j \; C \qquad \forall \; j \tag{3.8}$$

$$\sum_{j=1}^{l} I_j \le 1 \tag{3.9}$$

Equation (3.8) limits the number of selected incubatees (i) in each industry sector (j) based on the industry sector proportion (I_j). Using industry priority constraints, the DM can select incubatees based on priorities for industry development by considering competitiveness factors, such as resource availability, core competences, and supporting industries (Mian, 1996).

Our proposed model is a multi-objective problem that can be solved using several methods. One of the most popular procedures is goal programming, either by Archimedian or pre-emptive/lexicographic techniques. In Archimedian or weighted goal programming, the objective functions are substituted by weighted sum objectives. The substitutions may prevent this approach from getting close to a preferred solution. Furthermore, the specification of the weight may be difficult and have no direct meaning related to the DM's objectives. In pre-emptive or lexicographic goal programming, the DM must specify a lexicographic order for the goals. Unfortunately, pre-emptive goal programming often prohibits compromising with lower priority goals, and it also has no direct physical meaning (Miettinen, 2008). Moreover, given that the importance of the objectives will vary for each incubator, specifying the lexicographic order will be difficult and not appropriate to solve incubatee selection problem.

The model we have developed in this chapter is designed to incorporate both DM orientations, that is, financial and social. DM support is provided by offering a set of alternatives that allow DMs some freedom in selecting their most preferred feasible alternative. Finding alternative solutions means generating a non-dominated solution for the proposed model. To solve this problem, we use the Tchebycheff method and modify it by dividing the iteration process into two paths: a financial orientation path and a socially responsible orientation path. The method is appropriate for the incubatee selection problem as this problem does not have a huge number of constraints. The huge number of constraint will increase complexity and computational effort. This problem is considered the most important drawback of the method (Marler and Arora, 2004). Considering a multiple-objective program (Steuer and Choo, 1983)

$$\begin{aligned} &\max \ \{f_1(x) = z_1\} \\ &\ \ \vdots \\ &\max \ \{f_k(x) = z_k\} \\ &s.t.\ x \in S. \end{aligned}$$

Let $Z \subset R^k$ be the set of all feasible vectors in the criterion space. A given $\bar{z} \in Z$ is a non-dominated criterion vector if and only if no other $z \in Z$ exists such that $z_i \geq \bar{z}_i$, for all $i = 1,...,k$ with strict inequality holding for at least one component. Letting $N \subset Z$ be the set of all non-dominated criterion vectors, a point $\bar{x} \in S$ is efficient if and only if $\bar{x}$ is the inverse image of some $\bar{z} \in N$. This procedure is repeated until there is a non-dominated criterion vector $\bar{z} \in N$ that is sufficiently close to the ideal criterion vector z^{**}. The ideal criterion vector or utopia point z^{**} is calculated for all i = 1,…,k, where $z_i^{**} = \max\{f_i(x) | x \in S\}$. By obtaining the inverse image of $\bar{z}$, we obtain the final solution. To generate a set of non-dominated solutions, the model is formulated as an augmented weighted Tchebycheff (AWT) program. If z^{**} is the ideal criterion vector, then the AWT problem of obtaining a set of alternatives can be formulated using the modified model. The set of efficient alternatives is derived by obtaining an optimal criterion vector z^{**} and its associated weight vector λ^* from the model. As suggested by Steuer and Choo (1983), we rescale the model's original objective function in percentage terms to obtain identical units for measuring the deviation from the ideal point of the objective.

The modified model is shown here:

$$\min A + \rho\left\{\sum_{k=1}^{3}\left(z'_k - z_k^{**}\right)\right\} \tag{3.10}$$

s. t.

$$A \geq \lambda_k \left(z_k^{**} - z_k^{'} \right), k = 1,2,3 \tag{3.11}$$

where ρ is a small positive number called the Tchebycheff distance.

Constraint (3.7 to 3.11)

The rescaled objective functions are given in equations (3.12) to (3.14)

$$z_1' = \frac{\sum_{j=1}^{l} \sum_{i=1}^{nj} P_{ij} \cdot \frac{\left(\left(1 + Gp_{ij}\right)^t - 1 \right)}{\left(1 + Gp_{ij}\right) - 1} Y_{ij}}{\sum_{j=1}^{l} \sum_{i=1}^{nj} P_{ij}} \tag{3.12}$$

$$z_2' = \frac{\sum_{j=1}^{l} \sum_{i=1}^{nj} R_{ij} Y_{ij}}{\sum_{j=1}^{l} \sum_{i=1}^{nj} R_{ij}} \tag{3.13}$$

$$z_3' = \frac{\sum_{j=1}^{l} \sum_{i=1}^{nj} L_{ij} \frac{\left(\left(1 + Gw_{ij}\right)^t - 1 \right)}{\left(1 + Gw_{ij}\right) - 1} Y_{ij}}{\sum_{j=1}^{l} \sum_{i=1}^{nj} L_{ij}} \tag{3.14}$$

The decision process flow diagram of the proposed model is shown in Figure 3.2.

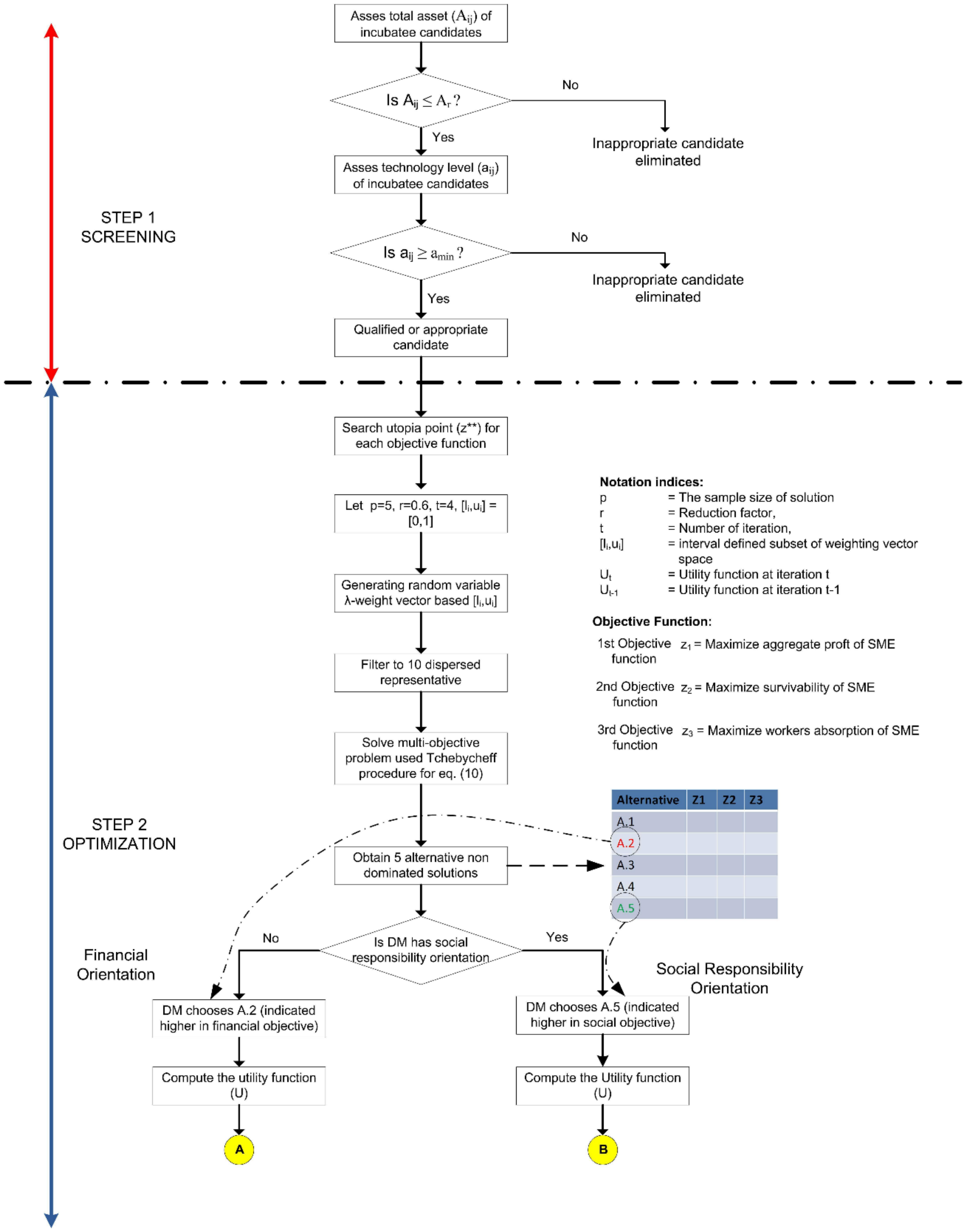

Figure 3.2. Decision Process Flow Diagram

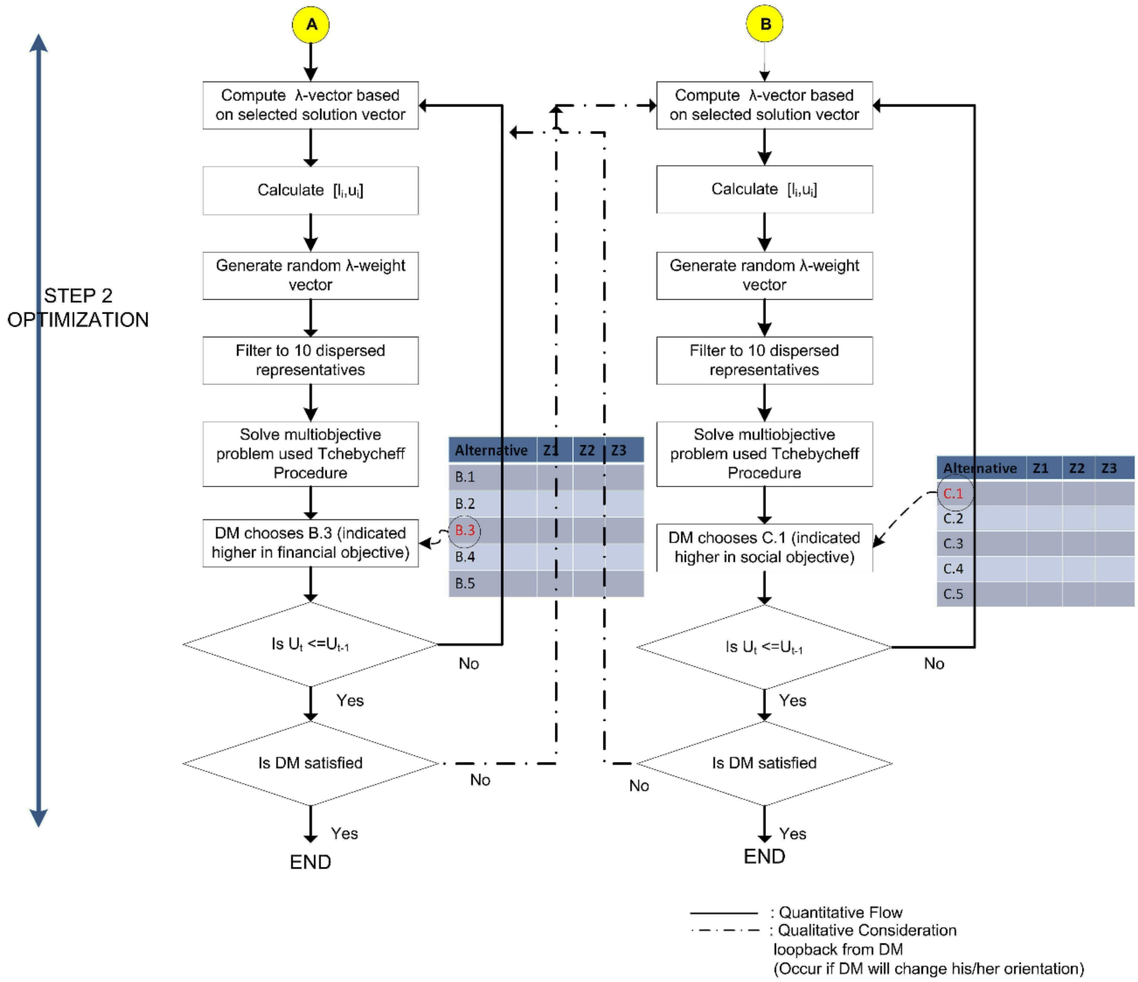

Fig 3.2. Decision Process Flow Diagram (Continued.)

3.4.Numerical Experiment

3.4.1. Incubator goal optimization considering the decision maker's orientation

To demonstrate the effectiveness of the model, numerical experiments are conducted. For optimization purposes, thirty data sets of SME samples from six different industry sectors are generated. The assumption that all sectors have the same number of candidates, meaning five candidates for each industry sector is used. Properties, such as technology level (a_{ij}), profitability (P_{ij}), survivability (R_{ij}), worker absorption (L_{ij}) and total assets (A_{ij}), were used as model inputs. Profitability (P_{ij}), worker absorption (L_{ij}) and total assets (A_{ij}) were generated using a probability distribution function (Tay and Wallis, 2000) based on European statistical data (Eurostat, 2009). Moreover, the distribution function of aggregate data are examined in ten countries using European statistical data (Eurostat, 2009). The probability distribution function (PDF) is plotted using the data, and then P_{ij}, L_{ij} and A_{ij} based on appropriate PDFs are generated (Tay and Wallis, 2000). In this research, profit growth (Gp_{ij}) is derived from the profitability changes in a 5-year time series European statistical data set. The derived growth uses an appropriate probability distribution function that covers data behavior from ten different countries. As with profit growth, worker growth (Gw_{ij}) from the number of worker changes in a 5-year time series using a European statistical data set is derived. In the numerical experiment, one value for profit and worker growth for SMEs in the same industry sector is used. The assumption based on the rationale that the growth is derived from aggregate data in Europe and the effect of external factors, such as governmental policy, will affect all SMEs in the industry sectors. These conditions cause SME growth in one sector to remain stable or closed. Using a probability distribution function based on real aggregate data from European statistics, the data can represent real SME behavior and situations because real data from new or start-up SMEs is unreliable and difficult to obtain (MacMillan et al., 1985; Everett and Watson, 1998). Based on previous research, the range of survivability is 0 to 1, where 1 means the SME will survive and 0 means it absolutely will not survive (Ciavarella et al., 2004). Then, the survivability (R_{ij}) within a range of 0.4 to 0.8 for the numerical experiment and the technology level (a_{ij}) within a range of 0.3 to 0.7 are determined, using a technometric model (UNESCAP, 1989). The data generated in this research are independent because the correlation among the data, such as between profit and technology level, is not well defined. The generated data are presented in Table 3.2.

Table 3.2. Data generated for the numerical example

Industry Sector Name	Industry Sector Index (j)	SME index (i)	Workers/ Year L	Total assets (million Euros) A	TCC a	Profit/ year (million Euros) P	Survival R	Gp_{ij}	Gw_{ij}	PDF
A	1	1	22	0.097	0.5135	0.1857	0.6814	5.10%	0.39%	**Beta (for L)**
		2	17	0.0295	0.4531	0.556	0.5459			α =0.722
		3	11	0.0244	0.494	0.6072	0.7855			β=0.968
		4	18	0.0662	0.6051	0.5691	0.4881			**LogNorm(for A and P)**
		5	3	0.0342	0.3355	0.6918	0.4800			Log-μ=0.0361
										LodStd=0.032
B	2	1	9	0.0189	0.3379	0.6094	0.6092	5.12%	1.69%	**Weibull(for L)**
		2	15	0.0592	0.6031	0.2005	0.492			α =6.99
		3	18	0.0358	0.3827	0.3702	0.7042			β=1.09
		4	15	0.0106	0.6793	0.2876	0.5678			**Normal(for A and P)**
		5	8	0.0116	0.5418	0.0935	0.701			μ=0.0343
										Std=0.0231
C	3	1	6	0.0107	0.3437	0.2837	0.5204	5.11%	1.70%	**Poisson(for L)**
		2	8	0.0179	0.5236	0.3773	0.7647			μ=7.5
		3	8	0.0767	0.6391	0.0581	0.4444			**Normal(for A and P)**
		4	10	0.0476	0.6438	0.1075	0.5945			μ=0.0469
		5	10	0.0019	0.5195	0.2067	0.7476			Std=0.0238
D	4	1	21	0.2126	0.3378	1.225	0.4622	5.08%	1.34%	**Beta(for L)**
		2	25	0.1352	0.5506	0.7278	0.4098			α =0.686
		3	24	0.1613	0.4573	0.4737	0.6599			β=0.83
		4	17	0.1723	0.6808	0.4254	0.4677			**Beta (for A and P)**
		5	12	0.2046	0.6934	0.2434	0.5739			α =1.89
										β=1.75
E	5	1	10	0.0846	0.3721	0.8786	0.7393	5.10%	1.55%	**Gamma(for L)**
		2	8	0.0668	0.6316	1.1405	0.6861			α =1.29
		3	12	0.201	0.3534	0.6302	0.4842			β=4.96
		4	9	0.1204	0.6538	0.2063	0.6546			**Exponential(for A and P)**
		5	8	0.0533	0.59	0.896	0.7735			μ=0.0496
F	6	1	9	0.0727	0.6501	0.5196	0.7648	5.10%	1.63%	**Triangular(for L)**
		2	13	0.0343	0.6674	0.6276	0.7402			Min=3.5
		3	9	0.0528	0.6698	0.519	0.6831			Mode=12
		4	13	0.0653	0.3286	0.3497	0.7904			Max=17.5
		5	13	0.078	0.4467	0.6739	0.7876			**Beta(for A and P)**
										α =1.45
										β=1.126

Unfortunately, it is difficult to avoid correlation as the small sample sizes raise several weak correlations. In the data, positive correlations of the data occur between L and A, with a correlation coefficient of 0.4727, and between A and R with a coefficient of -0.3991 are found. The other weak correlations occur between A and P (0.2508), L and R (-0.2696), and *a* and P (-0.2968), while any other correlations are considered to be very weak or uncorrelated. The impact of these correlations will be examined in the numerical experiment section.

The optimization process is conducted using non-dominated, multi-objective optimization with a binary decision variable Y_{ij} after screening for minimum technology levels a_{min} and maximum total assets A_r. We set the technology level a_{min} equal to 0.3, the maximum total asset A_r equal to 0.2, and the incubator capacity C equal to 10. We generated 50 random weight vectors from (l_i,u_i) interval and obtained 2 x p of the most differently weighted vectors, where p is the sample size of the solutions presented to the DM at each iteration, and 2 is an oversampling factor. We set p = 5, while the initial range of the random weight vectors (l_i, u_i) was (0, 1), and the reduction factor (r) was 0.6. These values were guided by previous literature reports (Steuer and Choo, 1983; Steuer et al., 1993; Reeves and MacLeod, 1999; Soylu, 2011).

Using the Tchebycheff method, the set of alternative solutions in the first iteration are as follows:

Solution ID	z_1 (million Euros)	z_2	z_3 (manpower)
1.1	31.1362	6.8543	413
1.2	22.6815	4.736	227
1.3	30.8630	6.6159	595
1.4	31.2355	6.8267	502
1.5	9.1332	1.6865	69

We assume that alternative 1.4, which has the highest profit (z_1), will be selected by the financially oriented DM. If the DM is socially oriented, alternative 1.3, which has the highest worker absorption (z_3), will be selected. Using the two selected alternatives, we divide the iteration into two paths, one for financially oriented and one for socially oriented DMs, and we then re-evaluate.

The second iteration yields 5 alternative solutions for financially and socially oriented DMs, given as follows:

Financial orientation				Social orientation			
Solution ID	z_1 (million Euros)	z_2	z_3 (manpower)	Solution ID	z_1 (million Euros)	z_2	z_3 (manpower)
2.1f	30.8630	6.6159	595	2.1s	30.8630	6.6159	595
2.2f	20.4414	4.0529	190	2.2s	31.0754	6.9791	466
2.3f	20.4319	4.2292	198	2.3s	15.5683	2.6789	117
2.4f	29.9726	6.8604	579	2.4s	25.5346	6.0211	283
2.5f	30.3446	7.0864	482	2.5s	11.7010	1.9054	85

The 1st and 2nd iterations indicate that alternative 1.4 is not included in the 2nd iteration even though alternative 1.4 has a higher profitability than all solutions generated in the 2nd iteration. The 2nd iteration process also produces the same solution for both iteration paths (3.1f in the financial orientation and 3.1s in the social orientation). These solutions occurred because, by using this method, we have a widely dispersed group of random λ-weighting vectors in the (l_i,u_i) interval. The interval (l_i,u_i) is reduced in each iteration based on the previous iteration result.

We then assume that alternative 2.1f will be selected by the financially oriented DM and that alternative 2.1s will be selected by the socially oriented DM. If the DM is still not satisfied with the solution after the second iteration, we conduct a third iteration.
The results of the third iteration are as follows:

Financial orientation				Social orientation			
Solution ID	z_1 (million Euros)	z_2	z_3 (manpower)	Solution ID	z_1 (million Euros)	z_2	z_3 (manpower)
3.1f	30.8630	6.6159	595	3.1s	30.1892	7.1566	393
3.2f	31.0754	6.9791	466	3.2s	30.8630	6.6159	595
3.3f	29.8396	7.0738	356	3.3s	30.8630	6.6159	595
3.4f	31.3525	6.7189	425	3.4s	15.5683	2.6789	117
3.5f	30.8630	6.6159	595	3.5s	29.4356	6.8295	348

In the third iteration, we assume that the DM will be satisfied with alternative 3.4f (which has the highest profitability) if the DM is financially oriented and that the DM will be satisfied with alternative 3.3s (which has the highest worker absorption) if the DM is socially oriented. If after conducting the 4th iteration a better solution cannot be found, assume that the DMs are satisfied with the 3rd iteration result as the final solution. In the interactive method, the stopping rule is the DM's satisfaction. Sometimes a DM was satisfied with the early steps of the learning process, which led to a stop of the iteration too early because they had almost achieved what they wanted (Miettinen, 2008). But, in the first iteration, the DMs generally still want to improve the performance because they want to know the next iteration result. By comparing the results of the two iteration paths, the financially oriented solution has a higher profitability, while the socially oriented alternative has a higher worker absorption.

The orientation of the DM impacts the selected incubatee configuration. This configuration is displayed in Figures. 3.3 and 3.4.

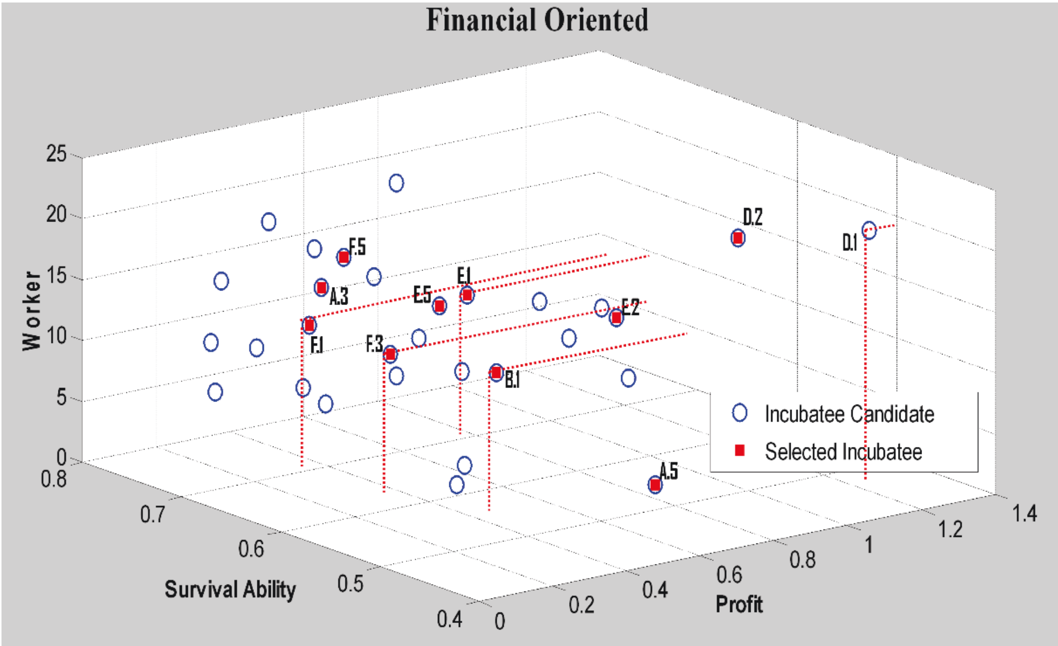

Figure. 3.3 Selected incubatees based on a financially oriented DM

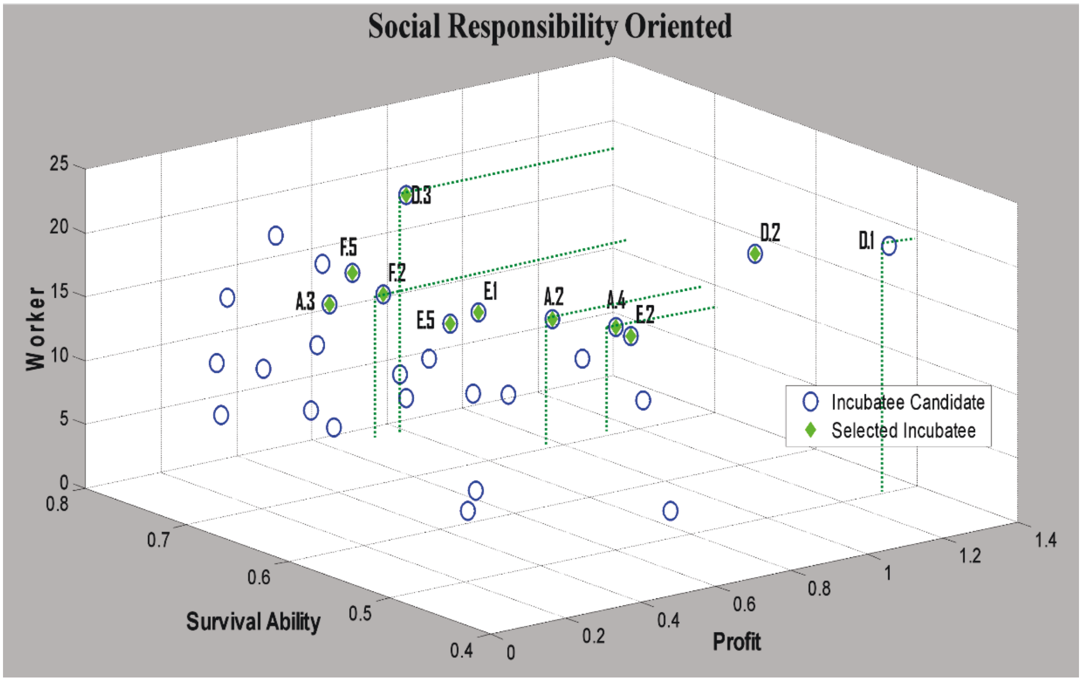

Figure. 3.4 Selected incubatees based on a socially oriented DM

As shown in Figures 3.3 and 3.4, the orientation of the DM affects the selected incubatee configuration. The financially and socially oriented DMs, using the same multi-objective functions, both selected the following six candidates: SMEs A.3, D.2, E.1, E.2, E.5, and F.5. These six candidates have the highest total objective value ($\sum_{k=1}^{3} Z_k$) compared to the other candidates. To fill the incubator's capacity to the set maximum of 10, each DM selected 4 different candidates to satisfy their preferences. SMEs A.5, B.1, F.1 and F.3 were included in the financially oriented DM. Conversely, the socially oriented DM selected SMEs A.2, A.4, D.3, and F.2 because of high worker absorption. Although SME D.1 has high profitability and worker absorption, neither DM chose SME D.1 as an incubatee because the candidate had higher total asset than the total asset limitation. In our experiment, based on generated data with correlation between survivability R and profitability P (0.0207), survivability R and workers L (-0.2696), the results show that the incubatees selected by financially oriented DM had a higher survivability than those selected by socially oriented DM.

3.4.2. Comparative analysis of several approaches to multi-objective optimization

In this section, we compare several approaches to analyze incubatee selection optimization. We compare our proposed approach with preemptive and weighted goal programming to show the advantages of our proposed model. The results of this comparison are given in Table 3.3.

Table 3.3. Results of comparative analysis

Method	Orientation	a_{min} = 0.3			a_{min} = 0.4			a_{min} = 0.5		
		(z_1)	(z_2)	(z_3)	(z_1)	(z_2)	(z_3)	(z_1)	(z_2)	(z_3)
Preemptive Goal Programming (z_1 as 1st priority)	None	32.036	6.5	478	29.502	6.665	530	26.287	6.346	526
Preemptive Goal Programming (z_3 as 1st priority)	None	19.294	5.804	745	20.405	5.84	725	16.651	5954	623
Weighted Goal Programming	None	30.865	6.616	595	27.874	6.558	640	25.457	6.263	583
Weighted Goal Programming without z_2	None	30.079	6.298	619	28.908	6.344	622	27.030	6.262	581
Proposed Multi-objective	Financial	31.353	6.719	425	29.316	6.641	587	26.286	6.346	526
	Social	30.865	6.616	595	27.874	6.558	640	25.457	6.263	583

From Table 3.3, it is clear that using a preemptive goal programming with profit as a first priority for financially oriented DMs and worker absorption as a first priority for socially oriented DMs resulted in the highest profit (z_1) or worker absorption (z_3), respectively. However, those approaches performed poorly for other goals. Considering multi-objective optimization, Table 3 also indicates that the solution when using the proposed method provides a higher profit compared to the weighted goal programming solution method. Thus, in our cases about incubatees selection using data sets in Table 3.2, the weighted goal programming approach can find most desired solution for the socially oriented DM but not for the financially oriented DM. A non-dominated multi-objective approach with random weighting was implemented in the incubatee selection model to incorporate DM interest because random weighting can provide a wide range of solution alternatives to satisfy both orientations of DMs. Usually, using weighted goal programming will result a mild result in the range of the result of using random weights. In special cases, the solution from weighted goal programming can reach the same solutions that have been chosen by the financially or socially oriented DM. That means, using the weighted goal programming cannot provide a set of alternative for the DM to choose the most preferable choice based on the DM's preference. That condition is not appropriate in this case because the incubator managers in different incubators have the same objectives but different people have different orientations. Based on the analysis and discussion, we contend that the proposed approach, which uses an interactive Tchebycheff method, has several advantages, including the incorporation of different orientations by providing non-dominated solutions in 3 or 4 iterations and appropriateness for integer or binary variables, in this case, selected or not selected. This proposed method also facilitates DM participation in the decision-making process. For each iteration stage, the DM is asked to select the preferred solution. The choice is used to generate the solution in the next iteration. Moreover, it is not necessary to specify positive weights or lexicographic order because the proposed model generates random weighting. These advantages are not provided by a weighted global criterion method or by goal programming (Miettinen, 2008). In the goal programming method, the DM will have difficulty specifying positive weights or lexicographic order of objective functions because the weight has no physical meaning. When considering survivability, we suggest that DMs use a logit model with personal attribute data as the independent variables. Using a logit model has several advantages, such as the ability to incorporate qualitative data as well as data periods that are smaller and shorter, and requires less computational effort (Ciavarella et al., 2004; Dimitras et al., 1996). In this model, we hope that using survivability as an objective function can reduce incubatees business failure, but in some cases, DMs will most likely face lower aggregate incubatee profitability, as shown in Table 3.3.

3.4.3. Effect of the minimum technology level requirement

In this model, we consider the effect of using a minimum technology level (a_{min}) as a screening factor to ensure a candidate's ability to absorb new technology. By using a minimum technology level, a DM can reduce the technology level gap between the incubator (as the technology source) and the incubatee (Jayaraman et al., 2004). We use a_{min} values of 0.3, 0.35, 0.4, 0.45, and 0.5 to show the effect of a_{min} on the selection process. We use a_{min} = 0.3 as the lowest level because all of the incubatee candidates have a technology level greater than 0.3. Thus, setting a_{min} equal to 0.3 is equivalent to not using a minimum technology level constraint. The results are shown in Figure 3.5.

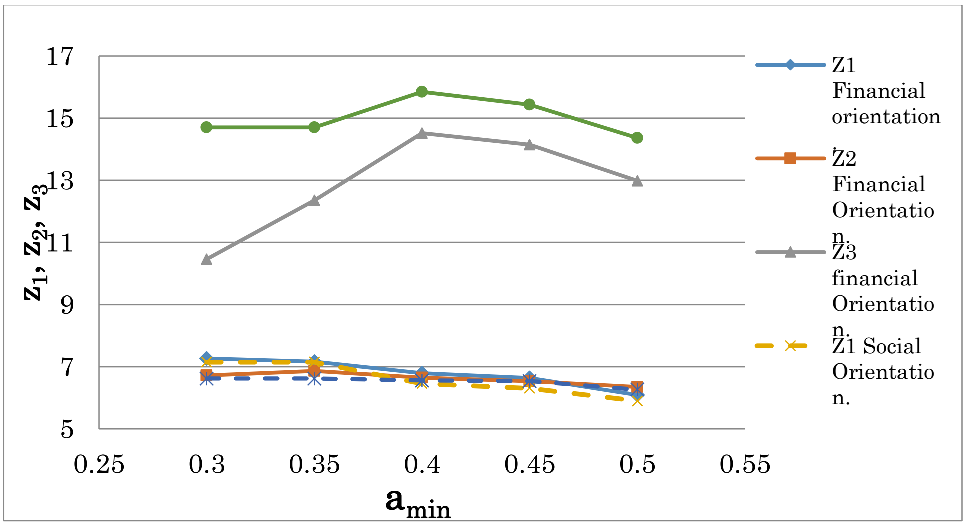

Figure 3.5 Effect of a_{min} on performance values

Figure 3.5 shows that the values for accumulated profit (z_1) and survivability (z_2) decrease as a_{min} increases. In Figure 3.5, we argue that highly profitable SMEs are evenly distributed and not dominated by high technology SMEs because as a DM increases the a_{min} technology constraint, the accumulated profit decreases; increasing a_{min} decreases the feasible area of selection. This result implies that when a DM increases the minimum technology level to ensure that incubatees can absorb knowledge, thus reducing the risk of technology transfer failure, the DM will likely face decreased accumulated profit if there are limited or inadequate candidates. That situation will occur when the technology level of candidates has not positive impact on their profitability. In our experiment, the technology level of candidates a and profitability P has weak negative correlation (-0.2968). This phenomenon occurs in practice because an SME's profit is uncertain and is influenced by several factors, such as age, price fluctuations and the economic environment (Ballantine et al., 1993). Worker absorption (z_3) increases with an increase in a_{min} in the range of 0.3 to 0.4, while from 0.4 to 0.5, worker absorption decreases. Because data correlation cannot be avoided, we examine the effect of the correlation to a result. This result is influenced by data correlations between worker absorption (L) and technology level (a). Although data correlations between L and a are very weak or uncorrelated (-0.0311), L and a do have a positive weak correlation (0.2632) in the range of a = 0.3-0.4 and a negative weak correlation (-0.3220). The other cause is that the feasible area of selection decreases when the DM increases the a_{min} requirement. In this case, the results indicate that the SME candidate's high worker absorption rates are in the range of a_{min} = 0.3 to 0.4. This result implies that a DM should carefully adjust a_{min} given the correlation between worker absorption and the technological ability of the SME. This model supports previous empirical research conducted by Aerts et al. (2008), which indicates that incubator performance is related to the incubatee selection method. We also analyze the effect of the a_{min} parameter for both orientations on the average survivability of the selected incubatees. The results are shown in Table 3.4.

Table 3.4. Average survivability of the selected incubatees

	a_{min}	0.3	0.35	0.4	0.45	0.5
Orientation	Financial	0.6719	0.6858	0.6641	0.6537	0.6346
	Social	0.6616	0.6616	0.6558	0.6535	0.6263

Table 3.4 indicates that, in our experiment, the financial orientation yields a higher average survivability of the selected incubatees for the minimum technology level parameter. This result indicates that based on the data represented in Table 3.2, financially oriented DMs have an advantage in attaining higher incubatee survival rates. The results in table 3.4 are influenced by the data correlation where there is a negative weak correlation between indicated worker (L) and survivability (R) (-0.2696), while the correlation between profit (P) and survivability (R) is extremely weak or even uncorrelated (0.0207). Although this result cannot be generalized and will differ when using other data sets, our proposed model shows that different orientations influence survivability. We suggest that incubator managers consider survivability when conducting an incubatee selection process based on their orientation. A higher probability of survival ensures profitability for the financially oriented DM and more worker absorption for the socially oriented

DM. Table 3.4 also indicates that when a DM increases the minimum technology level (to reduce the risk of technology transfer failure caused by the technology gap, as described by Jayaraman et al., 2004), they most likely face a decreased probability of survival. That condition has occurred because in our data sets, the technology level of incubatees a and survival rate R has weak or no correlation (-0.00546).

3.4.4. Considering industry sector priorities

To accommodate a DM's industry priorities in the region where the incubator will be established, an industry priority parameter is used in the proposed model because established incubators are affected by regional and state economic development (Mian, 1994; Löfsten and Lindelöf, 2002). For experimental purposes, we set the minimum proportion of selected incubatees for each industrial sector at 30% and 40% and, then, compare the results to those of a selection process that does not use sector priority. The results are shown in Tables 3.5 and 3.6.

Table 3.5. Industry priority for a financially oriented decision maker

Sector	**A**		**B**		**C**		**F**		No Priority
Proportion	30%	40%	30%	40%	30%	40%	30%	40%	
Profit	31.1362	29.8254	28.8102	27.0591	27.0224	25.0300	31.3525	29.9588	31.3525
Survival	6.8543	6.8155	6.898	6.7889	7.033	7.1394	6.7189	7.0933	6.7189
Workers	413	425	421	425	425	393	425	425	425
Sector A	3	4	2	1	2	1	2	3	2
Sector B	1	0	3	4	0	0	1	0	1
Sector C	0	1	0	0	3	4	0	0	0
Sector D	0	0	0	0	0	0	1	0	1
Sector E	3	3	3	3	3	3	3	3	3
Sector F	3	2	2	2	2	2	3	4	3

Table 3.6. Industry priority for a socially oriented decision maker

Sector	**A**		**B**		**C**		**F**		**No Priority**
Proportion	30%	40%	30%	40%	30%	40%	30%	40%	
Profit	30.8630	28.9557	28.8555	27.0120	26.3706	24.8863	29.9726	29.7589	30.8630
Survival	6.6159	6.5571	6.6776	6.4294	6.9032	6.6834	6.8604	7.1371	6.6159
Workers	595	631	579	587	522	494	579	542	595
Sector A	3	4	0	0	0	0	2	1	3
Sector B	0	0	3	4	0	0	0	0	0
Sector C	0	0	0	0	3	4	0	0	0
Sector D	2	2	2	2	2	3	2	2	2
Sector E	3	3	3	3	3	2	3	3	3
Sector F	2	1	2	1	2	1	3	4	2

Based on Table 3.5, when a financially oriented DM prioritizes sector F, that DM will have higher profitability than the DM who prioritizes another sector. When the DM is socially oriented, sector A will provide higher worker absorption, as shown in Table 3.6. Table 3.6 also shows that the DM will attain higher performance without an industry priority parameter. However, using an industry priority parameter does have advantages. First, one can ensure continuity in enterprise development by matching industry priority developments in specific areas related to the core competence and resource-based competitiveness of a specific region (Chan and Lau, 2005). Chan and Lau (2005) also found that other supporting parties (i.e., governments) can encourage this continuity by rewarding specialization. Second, one can limit risk by investing across multiple firms and industries (Everett and Watson, 1998).

3.4.5. Effect of Total Asset as a Screening Factor

In this model, we consider the effect of using total asset (A) as a screening factor to distinguish whether the candidate is an SME or a large company. We use the value for A as 0.1, 0.15, 0.2, and 0.25 to show the effect of the DM's decision to identify candidates as SMEs by using the total asset value (Ayyagari et al., 2003). The threshold of total asset is defined based on government rule where the incubator is established and may vary in every country. The results of sensitivity analysis are shown in Table 3.7.

Table 3.7. Effect of Total Asset as Screening Factor

	A=0.1		A=0.15		A=0.2		A=0.25	
	Financial	Social	Financial	Social	Financial	Social	Financial	Social
Profit	30.18924	28.07643	31.29161	30.41628	31.35247	30.86301	33.75059	32.72764
Survival	7.1566	6.9318	6.7841	6.6602	6.7189	6.6159	6.5322	6.4509
Workers	393	559	502	571	425	595	611	640
Selected Candidates by Sectors								
Sector A	2	4	2	3	2	3	2	1
Sector B	1	1	1	1	1	0	0	1
Sector C	0	0	0	0	0	0	0	0
Sector D	0	0	1	1	1	2	3	3
Sector E	3	3	3	3	3	3	3	3
Sector F	4	2	3	2	3	2	2	2

Based on Table 3.7, we conclude that when the DM uses lower total assets or conducts a strict screening process, the DM will realize lower profits and reduced survivability and worker absorption because some candidates with high performances will be eliminated. For example, D.1

(A= 0.2136) and E.3 (A=0.201) do not have a chance of being selected if the value of A = 0.2. When the DM increases the value of A, candidate D.1 and E.3 will be eligible for selection, and through the optimization procedure, D.1 will be selected, but E.3 will not be selected. Including D.1 as a selected incubatee will increase total profits, survivability and worker absorption. However, if the DM uses a higher value for total asset constraint, it is possible that a large company will be included in the selected incubatees. That situation is not appropriate for the incubator goal that focuses on SME enhancement. Table 3.7 shows that candidates from sector D will be not selected if the DM uses a low value for A, but will be included in selected incubatees if the DM increases the value of A. This fact indicates that the candidates in sector D are larger companies because having highest average of total asset, while sector C is lowest. The selected incubatee in table 3.7 is not influenced by data dispersion as the standard deviation of the data based on the distribution function for all sectors exhibits a closed value.

3.5. Conclusions

In this chapter we developed a model that supports the incubator manager as DMs in the incubatee selection process. Using this model, a DM has several advantages. First, the DM can select the best configuration of incubatees to optimize future profitability, survivability and worker absorption. Second, the DM can reduce the risk of business failure using survivability objectives based on the entrepreneur's personal attributes. Third, using minimum technology criteria, the DM can reduce the risk of technology transfer failure during the incubation process. These advantages are our first contribution.

This research used an interactive Tchebycheff procedure and modified the iteration procedure by dividing the iteration process into two paths: a financial orientation path and a social orientation path. This procedure generates a set of alternative solutions for each iteration path to accommodate a DM's orientation. DMs can be satisfied by being provided with a non-dominated solution and being allowed to contribute during the decision-making process. Even using the same mechanism, a financially oriented DM selects alternatives with higher profitability than a socially oriented DM. In contrast, the socially oriented DM selects an alternative with higher worker absorption than the financially oriented DM. The difference in orientation also influences the configuration of the sets of selected incubatees. Based on this fact, we are keen to state that the second contribution of this proposed model is an incubatee selection model that satisfies DMs whether they have a financial or a social orientation.

The results by using our data sets indicate that the profitability of the SMEs was evenly distributed and not dominated by SMEs with high levels of technology knowledge. We also indicate that the model can satisfy both financially oriented and socially oriented DMs by allowing them to select the most appropriate solution, either the one with the highest profitability for the financially oriented DM or the one with the highest worker absorption for the socially oriented DM. The research indicates that, by using data sets with recognized correlations, financial orientation results in a higher average survivability of the selected incubatees. However, the result depends on the incubatees data sets and their correlation attributes. The model also can incorporate industry priorities, as determined by a DM. The results show that various priorities impact the objective function of incubator performance. In future work, this model should be adapted to different data sets from broader industry sectors to determine the influence of industrial structures and the characteristics of each industry sector on DM orientation.

Chapter 4
An Integrated Technology and Financial Support Model in Technology Incubator

4.1. Introduction

Small and Medium Enterprises (SME) have an important role of economic development in many countries especially for creating value added and reducing unemployment (Cull et al, 2006; Gunasekaran et al., 2011; Tambunan, 2008). SMEs have several advantages over large company due to its size and flexibility in adapting to change (Gunasekaran et al, 2011). However, start-up or new SME face certain constraints including lack of capital and low technological capabilities (Gunasekaran et al., 2011; Tambunan, 2008). Popularity and importance of technology incubator to provide a nurturing environment for new business start-up are widely known (Chan and Lau, 2005). Hence, it is important to enhance new or young SME's competitiveness in the technology incubator. An incubatee is defined as an enterprise which is facilitated by the incubator to develop its competitiveness and ability to survive (Bergek and Norman, 2008). The technology business incubator is defined as micro environment with a small management team that provides physical work space, equipment, training, and access to financial services in one affordable package for incubatees (Aerts et al., 2007).

Because of a large amount of money invested in the incubators by governments, universities, research institution, and other interested parties, the question of what return society gets on these investments has been raised (Bergek and Norman, 2008). However, incubator's effectiveness to enhance incubatee's performance is not conclusive, improvement and new design are necessary (Bergek and Norman, 2008; Chan and Lau, 2005; Phan et al, 2005). In financial support service, an incubator act as mediator between incubatee and financial support provider (Bergek and Norman, 2008). Several previous researches provide models of financial support for SME such as micro finance institution (Sanfeliu et al, 2011), Grameen bank (Morduch, 1999; Schreiner, 2003), Islamic system bank (Al-Deehani et al., 1999; Haron and Ahmad, 2006). Unfortunately, the barrier for SME to get those supports is difficulty to provide a collateral for getting the commercial credits from those financial support providers (Sohn et al., 2007). In the technology transfer program, technology incubators failed to ensure technology transfer effectiveness (Philips, 2002). In incubatee perspective, the function and features in technology incubator was found not have significant contribution to new entrepreneur (Sung et al., 2003). In incubator manager perspective, the incubator budget deficit is the main problem beside technology transfer and technology commercialization (Philip, 2002). In investor perspective, providing financial support for start-up SME is high risk since the performances have many uncertainties (Everett and Watson, 1998). Most of related previous researches about technology incubator are primary descriptive, lacking conceptual or methodological grounding (Mian, 1994). Furthermore, none of previous research considers the model that incorporates problems that is faced by incubator's stakeholders, that is f incubator's manager, incubatee, and investor.

Many previous researches intended to provide technology transfer. In the previous research, a decision model has been proposed for technology transfer to maximize value added of each technology which will be transferred by considering resources which devoted for technology transfer (Lulu et al., 1996). Dynamic technology transfer by utilizing technology gap influence rate of transfer has been proposed in previous research (Jayaraman et al., 2004). Other previous research also proposed the rate of technology transfer as a function of labor that devoted to R&D activity (Jensen and Thursby, 1987) and production (Watanabe and Asgari, 2004). Unfortunately, none of previous research considers the characteristic of start-up or new SME as incubatee and incorporate financial support performance. So far, there has been little effort about how to formulate model that integrate technology transfer process and financial support scheme in incubation process.

Based on those research gaps as well as the finding and important issues of technology incubator, this study proposes an integrated technology and financial support model that incorporates financial performance related with technological rate progress of incubation process. The model also incorporates the satisfaction of incubator's stakeholders including incubator manager, financial provider institution or investor, and incubatee.

4.2. Literature Review

Technology Business Incubator is defined as facility in which a number of new and growing business operate under one roof with an affordable rent, sufficient sharing services, training, equipment, and equal access to wide range of professional, technical, and financial programs (Aerts et al., 2007; Mian, 1996). Because of popularity and importance of technology-business incubation concept, numerous studies have been conducted. Empirical assessment o to examine the effectiveness of technology incubator from the perspective of venture creation and development process was conducted (Chan and Lau, 2005). The research develops assessment criteria of technology incubator including costing, funding, and knowledge sharing. Based on the result, cost advantage in the form of rental subsidies and other expenses is found as the most important benefit.

A case study at six technology incubators in United States was performed and the incubator's characteristics was compared (Mian, 1994). The study found that all of surveyed incubators have benefited from state grants, and some of them heavily subsidized by their state. The finding has been supported by other research that indicated incubator's budget deficit is serious problem (Philips, 2002). The other research found that incubators in China are dependent on governmental resources and recommended that incubators need to operate more like market oriented business for the sustainability (Chandra et al., 2007). For solving the financial problem, some incubators charge competitive rents from their clients and are seen as less restrictive in entry policies (Mian, 1994). Unfortunately, that approaches do not appropriate since incubatees need affordable rent cost for enhancing their competitiveness (Aerts et al., 2007; Chan and Lau, 2005). Furthermore, reducing selection criteria tends to increase technology transfer failure because of low level of incubatee's absorptive capacity (Bozeman, 2000) and widen technology gap between technology transferor and transferee (Jayaraman et al., 2004). In this chapter, a model to overcome incubator's financial problem like budget deficit and technology transfer failure is proposed.

The importance of SME is very popular, and SME contribute to the economic development by virtue of their sheer number and increasing share in employment and gross domestic product (Ates and Bititci, 2011; Van Gils, 2005). But, despite their contributions, start-up or new SME are vulnerable to competition from likely structured company and large corporations. The important difficulty of SME is generating enough capital for business because SME can't provide collateral for getting commercial credits (Gunasekaran et al., 2011). For the reason, many previous researches propose financial support scheme. One of popular institution which supports SME financially is Microfinance. Microfinance institution provides small loans to new entrepreneurs who have promising and feasible investment ideas that can lead to profitable ventures. However, these special institutions faced financial matter like profitability, return, sustainability, and efficiency (Sanfeliu et al., 2011). The other proposed approach is using Grameen Bank scheme which uses group-lending contracts with joint liability, a mechanism that reduces problems of moral hazard and difficulties of providing collateral (Morduch, 1999). Despite the advantage like high repayment rates, Grameen Bank is in fact subsidized by government. Other ideas is utilizing profit sharing scheme between financial provider and SMEs. The financial support provider can be big company or bank. Big companies can be as investors which invest in SME by using profit sharing scheme in two-firm joint venture (Du, et al., 2006). Unfortunately, many investors reluctant to invest to SME since SME lack of reliable data and uncertain profit (Everett and Watson, 1998). On the other side, a bank which implements profit sharing scheme is Islamic Bank (Al-Deehani, et al., 1999). However, Islamic Bank still needs a guarantee and financial performance data which's difficult to be provided by SME. In our proposed model, we use profit sharing to incorporate the SMEs difficulties. In the model, we build investor-incubator-incubatee relationship model, in which incubator act as guarantee of incubatee performance including profitability, technology level and continuity.

Several previous researches proposed technology transfer model. The important effectiveness factors of technology transfer are characteristic of agent transfer, medium transfer, object transfer, and recipient transfer (Bozeman, 2000). The adsorptive capacity is the degree to which an organization is able to devote the resources needed to adopt a new technology (Cohen and Levintal, 1990). Absorptive capacity is related with technology level of enterprises. Low degree of technology and knowledge of incubatee as recipient will disturb technology and knowledge transfer during incubation process (Sung et al., 2003). In incubation system, the absorptive capacity of incubatee will be very important factor in technology transfer because influence the technology gap between transferor and transferee (Jayaraman et al., 2004). The technology gap will affect on technology transfer rate and technology assimilation process. On the other research, Lulu et al. (2006) proposed a decision model for technology transfer to maximize value added of each technology which will be transferred by considering resources which devoted for technology transfer. Unfortunately, none of previous research considers the characteristic of SME as incubatee and incorporates financial support performance. In this chapter, the technology assimilation and technology gap concept is used on the basis of the proposal in a previous research. (Jayaraman, et al., 2004). The concepts will be used as a part of investor-incubator-incubatee relationship model. The model in this chapter provides not only technology transfer mechanism but also financial support scheme.

Based on the literature review, the model that incorporates technology transfer mechanism and financial support scheme in incubation process is original. Moreover, the idea is beneficial to provide win-win solution for incubator, investor and incubatee. This chapter also promises more opportunity to future work for developing technology incubator system.

4.3. Conceptual Model

In this chapter, an integrated technology and financial support model that incorporates financial performance related with technological rate progress of incubation process is proposed. The model also incorporates incubator's stakeholder's satisfaction including incubator manager, financial provider institution or investor, and incubatee. The model development consists of several steps of modelling as follows:

1. Incubator - Incubatee relationship model
2. Investor – SME relationship model
3. Investor – Venture capital – SME relationship model
4. **Proposed Model** : Investor – Incubator – incubatee relationship model

4.3.1. Incubator – Incubatee Relationship

In incubator-incubatee relationship, incubator will support the incubatee with several supports, such as affordable facilities rent cost, technology enhancement through technology transfer, and also as facilitator for financial support (Aerts et al., 2007).

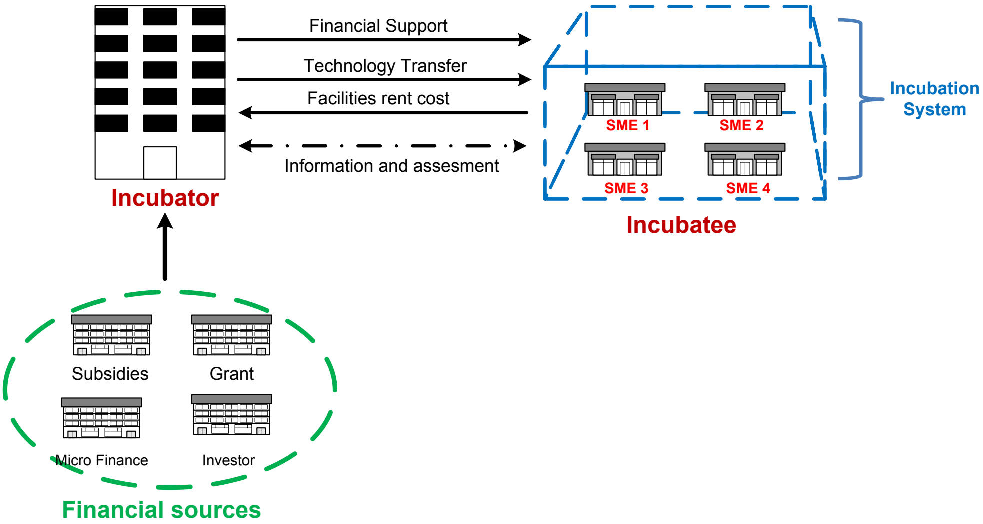

Figure 4.1. Incubator – incubate relationship Model.

The incubator-incubatee relationship model is shown in Figure 4.1. Incubator also acts as financial support mediator between microfinance institutions; bank, investor and government grant (Bergek and Norman, 2008). Selected incubatees in the incubator are weak and promising enterprise, especially start-up and young SMEs (Chan and Lau, 2005). Based on empirical research, the relationship model has several step mechanisms (Thierstein and Wilhelm, 2001). Firstly, incubator assesses information about incubatee's need. Secondly, the incubator will transfer technology and knowledge to incubatee for enhancing their production ability and reduce production cost. Thirdly, during incubation process, incubator also provides several facilities like office, showroom, laboratory, production space, and financial support (F). Fourthly, incubator receives rent cost from incubatee with discount rate. Incubator's operational costs derived from rent cost (C_{jt}), subsidies, government grant, and other investor.

The approachhas several drawbacks such as:

1. Investor reluctant to invest in incubator without clear mechanism since SMEs as incubatees have uncertain performance.
2. Incubator can't ensure that incubatees have capability to absorb the technology in technology transfer process.
3. Incubator will face financial problem, such budget deficit and government subsidies dependencies.

4.3.2. Investor – SME relationship

The second approach for SMEs enhancement is investor –SME model. The model is shown in Figure 4.2.

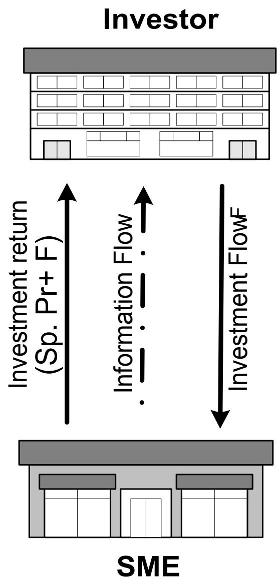

Figure 4.2. Investor – SME relationship model

The model shown in Figure 4.2 has several steps. Firstly, the investor assesses SME whether the SME is feasible and prospective or not based on several criteria (MacMillan et al, 1985). Secondly, if the investor feels that the SME is feasible and prospective, the investor will negotiate with SME about investment mechanism, include profit share (Sp) (Du et al., 2006). Thirdly, the investor will invest to SME. Fourthly, the investor getting the investment return and their profit ($(Sp.Pr + F)$). Several schemes are proposed to overcome the investment return. Some of investors like microfinance institution (Sanfeliu et al., 2011), Grameen Bank (Morduch, 1999; Schreiner, 2003), use low interest for their loan to SME. Micro finance institution and Grameen Bank have same purpose to support SME development with low interest rate. Hopefully, SME can create profit by using affordable interest in early stage of enterprise. In this relationship scheme, some difficulties will be faced investor, such as lack of reliable data and uncertain profit and employment performance (Everett and Watson, 1998). Furthermore, by using the model, SME also face difficulty in competitive improvement since the model does not provide technology enhancement.

4.3.3. Investor – Venture Capital – SME

The third approach is investor-venture capital-incubatee relationship model. The conceptual model is shown in Figure 4.3. In this model, the investor assumed has limitation to held SME's feasibility study for investment since difficulties to measure SME's performance. Then, venture capital act as an institution that helps the investor to manage the investment and assesses SME's prospect whether profitable and survive or not. The model mechanism consists of several steps. Firstly, the investors ask the venture capital about investment feasibility. Secondly, the venture capital proposes promising SMEs to the investors. Thirdly, the investors invest to SME through the venture capital. Fourthly, if SMEs can make profit, then the investor can get an investment return, and the venture capital get investment fees from investor. The drawback of this model is the investor cannot ensure performance of investee periodically, because the venture capital only conducts the feasibility study at the beginning of investment period and does not evaluate the performance of SME periodically. The drawback will lead to overestimate the SME's profitability and then it will disturb investors investment return. The previous empirical research found that venture capital-financed enterprises appear no more profitable than non-venture capital-financed enterprises, even though venture capital-financed enterprises have larger levels of sales (Puri and Zarutskie, 2012). It is means that the venture capital-financed enterprise value added does not increase. It can be guessed that the condition occurred because the enterprise cannot enhance their technology through technology transfer.

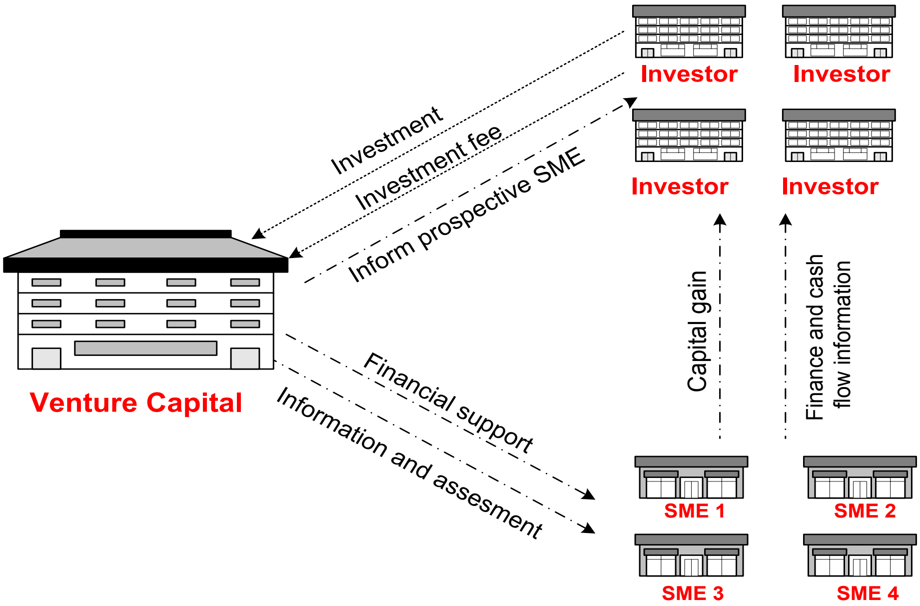

Figure 4.3. Investor – Venture Capital – Incubatee relationship model

4.3.4. Investor – incubator – incubatee relationship

This research will overcome the previous approach's drawback. The new proposed approach is shown in Figure 4.4. In this model the incubator has two different roles. Firstly, the incubator acts as technology transferor. As technology transferor, the incubator has technology sources (T_x) and will transfer the technology to the incubatee as transferee which has technology level (T_y). This model assumes that $T_x > T_y$. Secondly, the incubator acts as venture capital. As venture capital, the incubator manages investments from the investors, and then distribute them to incubatees.

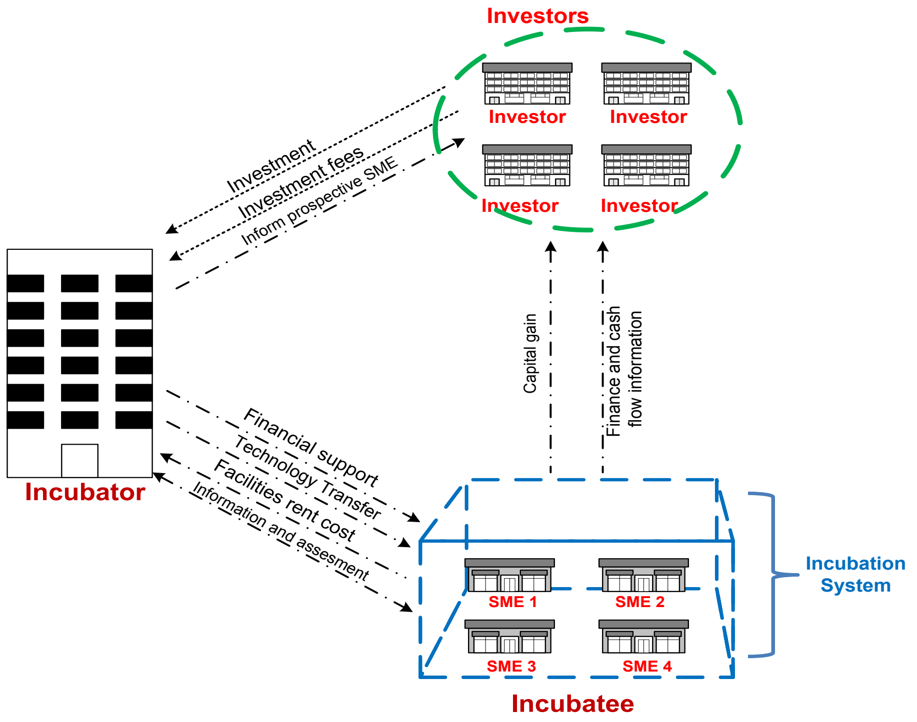

Figure 4.4. Incubator – Investor – Incubatee relationship model

The mechanism of the model is described as follows:

1. The investors searching for SMEs to invest their money
2. The incubator proposed their prospective incubatee
3. The investor (i) and incubator negotiate the amount of investment, investment fees and incubation time (t)
4. The investor (i) and incubator negotiate the amount of profit sharing from Incubatee (j)
5. The investor (i) invest through incubator
6. The incubator as venture capital manages and distributes the investment fund from the investor to incubatees based on performance assessment.
7. The incubator transfer the technology during incubation process
8. The incubatees run production by using new technology and fund from the investor
9. If the incubatees can create the profit during incubation period, the investor will get capital gain, and the incubator get investment fees from the investor.
10. The incubator also receives facilities rent cost from incubatees during incubation process.

For realized the model shown in Figure 4.4, the different interest of stakeholders consists of incubator manager and the investors should be incorporated. The incubator manager wants to maximize their incubatees financial and technological performnce while the investors tend to maximize their investment return. To increase the competitiveness of the incubatees and to enhance the value added of their products, the technology incubator provides technology support. The technology support is to overcome the finding of previous research that indicates that value added of the venture capital-financed enterprise not have improvement (see section 4.3.3.). Then, this chapter indicates that there are needed the scheme for satisfying the both decision makers. In this chapter, profit sharing scheme is utilized to satisfy the decision makers. Moreover, the technological progress of incubatees as a result from technology transfer activity should be considered. Then the model is to combine the technological support from the incubator and financial support provided by the investors.

4.4. Numerical Example and Discussion

The influence diagram of proposed model that incorporates technology transfer and financial support in incubation process is shown Figure 4.5.

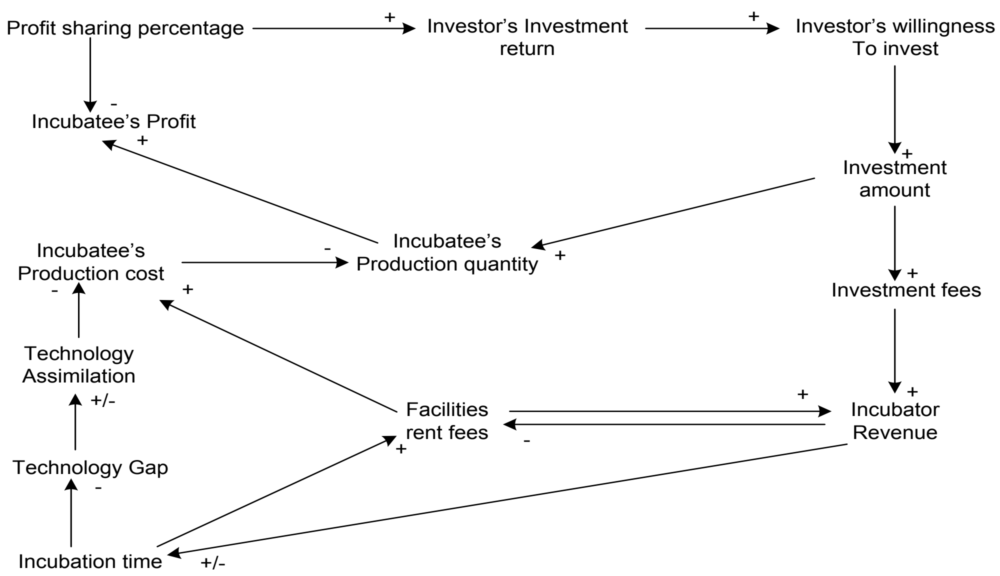

Figure 4.5. Influence Diagram of the Proposed Model

In Figure 4.5, the influence of each entities in the proposed model can be identified. The numerical example of the influence diagram is shown in Table 4.1.

Table 4.1. Result of Numerical Example

	Profit	Profit Incubatees						Technology assimilation rate incubatee					Technology level incubatee					Incubator	Investor
FDmin	Sharing	t = 1	t = 2	t = 3	t = 4	t = 5	Total	t = 1	t = 2	t = 3	t = 4	t = 5	t = 1	t = 2	t = 3	t = 4	t = 5	Revenue	share
0.3	0.241	-2.796	0.867	4.992	10.347	17.4	30.81	0.316	0.346	0.38	0.399	0.39	0.414	0.489	0.563	0.634	0.699	15.4	4.76
0.35	0.195	-2.248	1.658	6.034	12.007	19.968	37.418	0.368	0.402	0.438	0.457	0.447	0.414	0.489	0.563	0.634	0.699	15.4	4.07
0.4	0.169	-1.738	2.309	7.065	13.374	21.939	42.949	0.42	0.457	0.495	0.514	0.501	0.414	0.49	0.564	0.635	0.7	15.4	3.74
0.45	0.152	-1.293	2.847	7.786	14.405	23.477	47.221	0.472	0.512	0.551	0.569	0.554	0.414	0.49	0.564	0.635	0.7	15.4	3.47
0.5	0.14	-0.91	3.296	8.384	15.252	24.736	50.758	0.524	0.566	0.606	0.622	0.605	0.414	0.491	0.565	0.636	0.701	15.4	3.28
0.6	0.125	-0.29	4	9.32	16.566	26.686	56.282	0.627	0.673	0.712	0.723	0.702	0.414	0.492	0.566	0.637	0.702	15.4	3.01
0.7	0.115	0.183	4.525	10.02	17.542	28.135	60.405	0.73	0.777	0.813	0.819	0.794	0.414	0.492	0.566	0.637	0.702	15.4	2.83

The figure 4.5 and table 4.1 show that the profit sharing percentage will influence positively to the investors investment return and negatively impact on the incubatees profit. The investment return will increase the investor willingness to invest and will leads to an increasing the amount of investment. The amount of investment will have a positive influence on incubatees production and investment fees. Investment fees are related to the risk of investment management that faces incubator manager. Higher investment fees paid by the investors to incubator manager will increase incubator revenue. The assumption is since the incubator income from the investment fees increase, the incubator manager will reduce the facilities rent cost which should be paid by the incubatees. Then, the reduced cost will decrease production cost and increase the profit of the incubatees. This chapter also indicates that the incubation time as important factor in our model. Since the technology transfer is main support in technology incubator, the incubation time will influence technology assimilation rate by influencing the technology gap and technology distance between technology level of the incubatees and the incubator (Jayaraman et al. 2004). In the model, also suggest technology level of incubatees will influence incubatees production cost and their profit (Villafranca et al. 2009).

4.5. Conclusion

This chapter develops a technology-business incubation strategy for small and medium enterprises. In this proposed model, incubator, investor and incubatee concerns will be incorporated. Taking into consideration the importance of creating resilience SME for economic development, the proposed model focuses on critical factor for enhancing SME's competitiveness. Most critical factors are financial support, and technology transfer process. The proposed model considers important negotiated variables as follows:

a. Investment fees from the investor to the incubator
b. Profit share from the incubatee to the investor
c. Incubation time

Since decision makers have different objectives, the important variable should be negotiated between the decision makers. This chapter contributes to propose the model which can provide a win-win solution for the incubator, the investor, and the incubatees. By providing win-win solution for the decision makers, the proposed model has several benefits. For the incubator manager, the model can solve budget deficit problem and technology transfer failure. Furthermore, the model can solve financial problems for SME and reduce the investment risk for the investor.

In the negotiation process, both the incubator manager and the investor should decide variables that influence negotiation process. The variables are:

a. Facilities rent cost that decided by the incubator manager
b. Investment amount that decided by the investor

This research has several limitations. First, the research focuses on the manufacturing SMEs or SME which produce real product. Second, the effect of other environment factor like interest rate that influences the negotiation process is neglected. Third, the proportion of investment amount that devoted to incubator by investor to total investor's available fund is not considered. That factor may affect investor's risk and negotiation process.

4.6. Future Research

Future works are directed into extending numerical experiments based on investor-incubator-incubatees relationship model. The experiment can be extended by incorporating two type of investment scheme, one investor for one incubatee scheme and one investor for two or more incubatees. Then, for incorporating the investor reservation, the negotiation scenarios should be considered. The other possible extended work is considering incubatees's customer concern, since the technology level of incubatees will influence the quality and price of product. Finally, this model is expected can be applied in technology business incubator and satisfy the stakeholders.

Chapter 5
Decision support for Providing Financial Support

5.1. Introduction

Small and medium-sized enterprises (SMEs) are widely considered to make significant contributions to a region's economic development by reducing unemployment and increasing the gross domestic product (GDP) (Gunasekaran et al., 2011). With regard to the importance of SMEs in regional economic development, several attempts to establish new SMEs have been proposed. Unfortunately, start-up or young SMEs are weak in areas such as marketing, capital generation, technology, and finance (Gunasekaran et al., 2011). Therefore, facilitating new or start-up SMEs and locating them in a technology incubator that provides a nurturing environment for business start-ups are encouraged (Löfsten, 2010; Phan et al., 2005). Technology business incubators are established to foster new business development by providing technology transfer (Philips, 2002). By conducting technology transfer, technological-based incubation is designed to enhance the innovation capacity and technology development (Löfsten, 2010). The incubator also act as intermediary between incubatees and important resources such as technological and financial resources (Bergek and Norman, 2008).

However, the previous literature has exposed many problems facing the technology incubator program. The problem of obtaining financial backing is a main difficulty faced by incubatees for which the incubator manager should provide assistance (Aaboen et al., 2008; Löfsten, 2010). The main obstacles in obtaining financial support is difficulty in providing high collateral requirement related to firm-risk (Columba et al., 2010; Hanedar et al., 2014). From the investors' perspective, they are reluctant to provide incubatees financial support, because start-up SMEs have many uncertainties about their financial performance (Everett and Watson, 1998; Macmillan et al., 1985). In the case of a technology-based firm which positions incubatees inside the technology incubator, the difficulties could also include liabilities related to the novelty of the technology newness (Löfsten, 2010).

In technology incubator programmes, the problem is encountered not only by the incubatees, but also by the incubator manager. From the perspective of the incubator manager, an incubator financial deficit is the main problem (Philips, 2002). That situation is influenced by the evidence that technology incubators have dependency and receive a major part of their funding from the government (Löfsten, 2010). Moreover, technology transfer and commercialization failure is still found in technology incubators (Philips, 2002; Hess and Siegwart, 2013). Those incubator problems are linked and cannot be separated each other. To date, however, no reports in the literature have proposed a model to solve the problems simultaneously.

Profit sharing is known as the mechanism of reducing risk by sharing the risk and profit. Previously, a profit sharing scheme has been applied mainly in wage contract (Bughin, 1999), two firm joint venture in technology and product development (Chaudhuri, 1995; Du et al, 2006; Jiang, et al., 2010), and SME finance (El-Komi and Croson, 2013; Takalo and Tanayama, 2010). Moreover, no previous research considers a profit sharing system in technology incubators. Hence, an interesting question to be addressed is how to utilize a profit sharing scheme in a technology incubator in providing financial support for incubatees. Furthermore, since the technology incubator conducts a technology transfer process, technological progress of the incubatees should be considered. Then, focusing on the financial support of new or start-up SMEs as incubatees involved both the incubator manager and the investors, each of whom have different concern and interest regarding the incubation process, this research raises the issues:

1. Evaluating the decision making process for determining profit sharing percentage.
   In the profit sharing scheme, the incubator manager and investor try to reach an agreement about the profit sharing percentage and investment fees. Then, how to determine profit sharing percentage for the investor? Furthermore, is it beneficial to conduct a negotiation when determining the percentages and the fees?
2. Examining the influence of technological progress of incubatees.
   Because the technology incubator conducts a technology transfer process as main services, our proposed model investigates the technological progress of the incubatees during the incubation process and, then, how the technological progress of incubatees might influence their profitability and profit sharing percentage agreement?

To solve the problem and answer the research questions, we propose a mathematical model outlining a profit sharing scheme to provide financial support for the incubatees.

The model copes with the different objectives of the incubator manager who wants to maximize the profit of the incubatees and the income of the incubator and the investors who prefer to maximize their revenue. Furthermore, our proposed model investigates the technological progress of the incubatees, which influences the profit-sharing agreement between the incubator manager and the investors as decision makers. This chapter is extended from the model that described in chapter 4. The extension in this chapter is incorporating the investors reservation of profit sharing percentage by using negotiation process in profit sharing decision making. Moreover, in this chapter, two incubatee who has different technology level function is used in the model.

The remainder of this chapter is organized as follows. Section 5.2 describes the state of the art of our proposed idea compared to previous literature. Section 5.3 describes the model development and our analytical models. Section 5.4 presents a numerical analysis and its corresponding analysis and discussion. Section 5.5 summarizes and concludes the work and provides recommendations for future work.

5.2. Literature Review

To consider the important role of SMEs and the difficulty in obtaining financial support, some research has been conducted. Columba et al., (2010) proposed a mutual guarantee institution that may help SMEs achieve joint responsibility and improve their access to credit. El-Komi and Croson, (2013) indicate that a profit and loss sharing contract can be more efficient and profitable for lenders than an interest based contract. In the case of a technology based small firm, Sohn and Kim (2013) proposed a new technology behavioral credit scoring model that utilized not only technology attributes but also the financial ratio in annual changes. Takalo and Tanayama (2010) found that obtaining R&D subsidies can attract private funding because they provide additional information to investors about the quality of the project launched by technology based firms. The information is needed because the investors want to make rational decisions for maximizing their return (Shanmugasundaram and Balakrishnan, 2010).

The scheme in this chapter has same spirit in solving the difficulty that faced SMEs in obtaining financial support. The proposed scheme have the same idea as El-Komi and Croson (2013) in using a profit sharing contract rather than an interest based contract. In our model, the investors are offered a share of the revenue when the SMEs create a profit (Takalo and Tanayama, 2010). Whilst previous research indicates that obtaining R&D subsidies from government (Takalo and Tanayama, 2010), we use the capability of incubatees to absorb new technology during the incubation process and create profit as an important factor that informed the investors. Furthermore, we consider that factor in determining the profit sharing percentage for the investors.

Because of the importance of technology incubator programmes, numerous studies have been conducted. Löfsten (2010) conducted a study to analyse critical dimension for the incubatees performance in the incubators and indicate that obtaining financial backing is a major difficulty faced due to the liabilities of the project's newness. Philips (2002) found that technology transfer and commercialization has a low level of success. Furthermore, the study also found that technology incubator also faced budget deficit. Soltanifar et al. (2012) propose the bio-organising model to enhance the efficiency of technology business incubator. They argue that the model will cause the capital investor to be assured about his investment. McAdam and Marlow (2011) explore the role of the client advisor of the technology incubator, who collaborates with the entrepreneur to construct an investment ready proposal which, with success, can attain venture funding.

In this research, the problems like the difficulty to obtain financial support (Löfsten, 2010), budget deficit and a dependency on government funding (Philips, 2002; Löfsten, 2010), the failure of technology transfers process (Philips, 2002), are incorporated and solved the problems simultaneously using mathematical model. Furthermore, the proposed scheme have a similar idea as McAdam and Marlow, (2011) which is that in term incubatees need an intermediary to attain financial support. However, in our study, we describe the mediation process to reach an agreement using a profit sharing scheme between the incubator manager and investor in a mathematical model.

Because the technology incubator is involved in the technology transfer process, the technological progress of the incubatees cannot be neglected. In previous research, the technology level, which influences the production cost and profit, has been investigated (Villafranca et al., 2009). One of the critical factors that influence the success of the technology transfer process is the absorptive capacity of the incubatee (Bozeman, 2000; Cohen and Levinthal, 1990). Absorptive capacity is defined as the ability to recognize the value of new information, assimilate it, and apply it to commercial ends (Cohen and Levinthal, 1990). The absorptive capacity also was found as an important factor in cooperation agreements in research and development (Guisado-Gonzalez, et al. 2013). The other factors in the technology transfer process are influenced by the gap between the technology level of the transferor and that of the transferee (Jayaraman, 2004). To date, however, none of the previous research has considered the technology level and technology gap as an important factor that influences the financial support of technology incubators. Thus, the challenge is to incorporate the technology level and technology gap when set up a profit-sharing scheme for providing financial support for incubatees.

Discussions of joint-venture or profit-sharing problems with technology or new product development are not new in the literature. Du et al. (2006) propose a process between two firms to establish a joint venture using a profit-sharing scheme. The firms negotiate the value of the technology, of which firm 1 provides the technological know-how for a new product while firm 2 provides the capital for running the venture. Chaudhuri (1995) examined a two-stage duopoly model of a two-firm joint product development with technology asymmetry, in which the probability of success depends on the joint effort stream. The paper also examines the case of an uncertain technology level of the firm. Hinkkanen et al. (2012) found that the number of established cooperative R&D is influenced by an allocated fund for R&D activity in their own firm. Jiang et al. (2010) provide decision-making processes between the core firm and the partners in a technology innovation alliance. The core firm, which has more of a decision-making ability, acts as the leader and the partners act as followers in a Stackelberg 'Leader–Follower' model.

Our study utilizes the same idea as Du et al. (2006) in terms of a profit-sharing scheme that is related to technology valuation. However, in contrast to the approach of Du et al. (2006), our model considers the technology transfer process during incubation for enhancing both the technology level and the profitability of the incubatee, which influence the profit-sharing agreement. In our model, the incubator provides new technology that is utilized by incubatees for a production process while the investors provide the capital for running production. We also agree with Chaudhuri (1995) regarding the uncertain value of the technology level. Furthermore, in our research, the decision makers have different knowledge regarding the technology level and the assimilation rate of the incubatee, of which the incubator manager has a certain value, while the investors' knowledge of the level of technology value is uncertain. We use a profit-sharing scheme between the incubator manager and the investors, which is similar to the knowledge ratio of alliance described by Jiang et al. (2010). However, unlike the work of Jiang et al. (2010), in our proposed model, even though the incubator manager has more knowledge about the technology level and the assimilation rate of the incubatees, the incubator manager is not on the stronger side of the negotiation. That because the "need" to reach an agreement of the incubator manager is higher while the investors have several alternatives to which to allocate their money.

5.3. Model Development

In our model, the incubator manager assists their incubatees and attains venture funding by offering the profit sharing scheme to the investors. In the scheme, incubatees obtain investment without providing collateral; then, they use the investment for production by utilizing the new technology and facilities provided by the incubator. The incubatees' profit or loss will be shared between the incubatees and the investors as a consequence of the profit sharing scheme. That condition is to the advantage of the incubatees as SMEs inside the incubator compared to independent SMEs outside the incubator in term networking and accessing financial resources (Aaboen et al., 2008; Soltanifar et al., 2012). The incubator manager receives investment fees for managing the investment from the investors and facilities rental fees from its incubatees. The high technology level owned by incubatees will reduce the unit production cost and increase the incubatees' profit. However, the high level of technology among incubatees causes a reduction of the technology gap during the technology transfer process. Too small a technology gap will reduce the technology assimilation rate and, when the technology gap is equal to zero, the technology transfer will stop (Jayaraman et al., 2004). The allocated fund for technology development will foster the incubatees' technology level and technology assimilation rate. However, the fund allocated by the incubatees can increase their unit production cost and reduce their profit.

The proposed scheme in this chapter consider a situation in a technology incubator in which the incubator manager as decision maker 1 (DM-1) and a group of investors as decision maker 2 (DM-2) create a profit-sharing scheme to provide financial support to the incubatees. DM-1 provides technological support for the incubatees during the incubation period. Subsequently, DM-1 proposes to DM-2 an investment scheme for the prospective incubatees based on the attractiveness of their technological progress, including the technology level and technology assimilation rate, which influence both cost reduction and profit creation. DM-2 evaluates the offer from DM-1 to obtain a prospective return from the incubatees' profit share. In exchange, DM-1 will receive investment fees from DM-2 as well as the facilities' rental fees from the incubatees. In that condition, DM-1 has more knowledge about the incubatees' condition regarding the technology transfer progress than DM-2. Hence, the technological progress of the incubatees is certain from DM-1's perspective and uncertain from DM-2's perspective. DM-1 tends to overestimate and overstate its incubatees' technological progress while DM-2 tends to understate the uncertainty condition. The system under discussion in our model is described in Figure 5.1. In our system, we assume that there is one incubator manager serving as DM-1, two investors serving as DM-2, and two incubatees in the incubation system process. The incubator manager offers the investment opportunity to investor (i) involving incubatee (j) with initial profit sharing S_j^c and investment fees Cf_i^c. Investor (i) has several response choices: accept S_j^c and Cf_i^c, make a counter-offer proposal to S_j^v and Cf_i^v, or reject the proposal from the incubator manager and decide not to invest in the incubator. After the incubator manager and the investor have reached an agreement with profit-sharing rules S_j^a, investor (i) invests F_{ij} in the incubatee (j). Then, the incubator manager will conduct the incubation process for t years. During the incubation process, the incubatees use the investment amount F_{ij} and utilize technology from the incubator to run their production activity. The amount of investment influences the production quantity of incubatees Q_{jt}. If incubatee (j) can create profit Pr_{jt}, then the investor will receive the return $S_j^a Pr_{ij}$, and the incubator will receive an investment fee Cf_i^a from the investor as well as the facilities' rental cost Cr_{jt} from incubatee (j) during the incubation period.

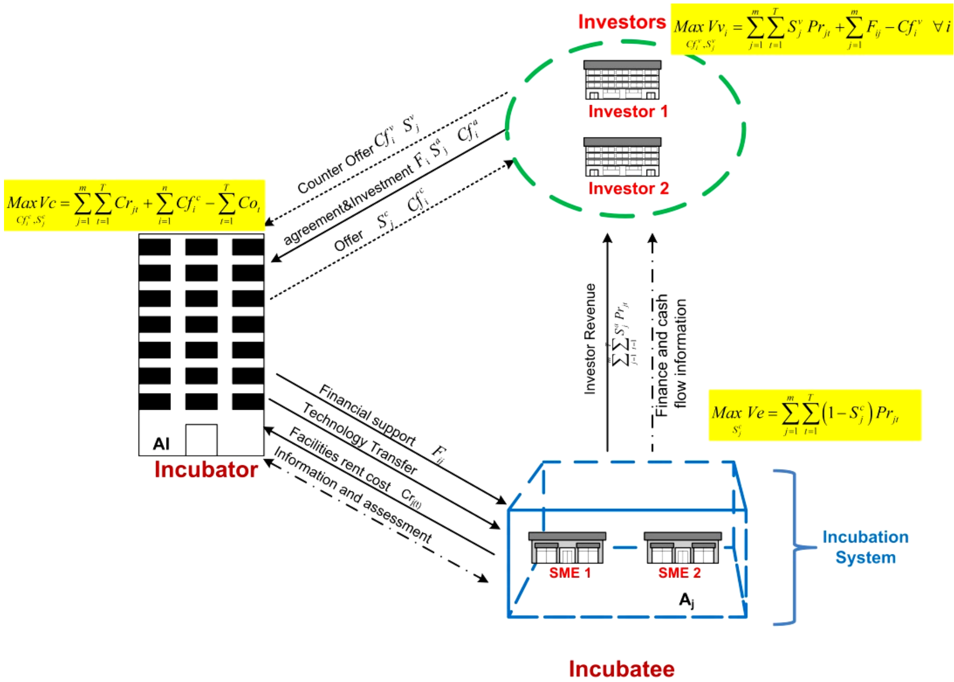

Figure 5.1. Incubator–investor–incubatee relationship model

5.3.1. Model components

In this chapter, based on the system discussed above, the proposed model use the decision variables S_j^c and Cf_i^c, which were determined by DM-1, S_j^v, and Cf_i^v, which were determined by DM-2. Then, if both sides reach an agreement, S_j^c or S_j^v and Cf_i^c or Cf_i^v will be changed to S_j^a and Cf_i^a as a result of the final decision of both DMs. A complete notation list is provided in Appendix A.

5.3.1.1. Technology level and technology assimilation rate

In the model, the technology transfer process is considered in deciding on a profit-sharing agreement. The technology level of the incubatee (j) is defined as a function of the incubation time (t) and satisfies the equation $A_j(t) = 1/\left(1 + a_j e^{-b_j t}\right)$ (Jayaraman et al., 2004). In the equation, define a_j as the initial state and b_j as the technology-level acceleration of the incubatee (j). Because DM-2 will find it difficult to define and believe the value of b_j, the equation is modified to to $A_j(t) = 1/(1 + a_j e^{-\sum_{p=1}^{z} b_j^p P(b_j^p) t})$, where $P(b_j)$

is the probability of b_j from the perspective of DM-2. This research assume that DM-2 tends to underestimate the progress of the technology of the incubatees. Hence, the upper level of b_j that is predicted by DM-2 is always below or equal to the value that is determined by DM-1. Based on the work of Jayaraman et al. (2004), during the technology transfer process, the rate of technology assimilation depends on the technology gap between the transferor and the transferee. The technology gap between the incubator as the transferor and the incubatees as the transferees at time t is given by $G_j(t) = AI - A_j(t)$, and the potential technological distance at time t is given by $D_j(t) = \left(AI - A_j(t)\right)/ A_j(t)$, where AI is the technology level owned by the incubator. Then, the level of technology assimilation of incubatee (i) at incubation time (t) is given as follows:

$$f_j\left(D,t\right) = \frac{F_{\max} e^{-D_j(t)}}{1 + \left(\dfrac{F_{\max} e^{-D(t)} - f_j\left(D,t_0\right)}{f_j\left(D,t_0\right)}\right) e^{-F_{\max} G_j(t) e^{-2D_j(t)} t}} \qquad (5.1)$$

where $f_j\left(D,t_0\right)$ is the initial assimilation level or the assimilation level at the beginning of the incubation period (t = 0). Similar to a_j, $f_j\left(D,t_0\right)$ is certain for DM-1 but probabilistic from the point of view of DM-2 because $f_j\left(D,t_0\right)$ depends on the candidate incubatee's selection procedure conducted by DM-1.

Unlike the method of Jayaraman et al. (2004), AI does not change as a function of time because the incubation period is 5 years or less. Using this scheme, $G_j(t)$ is decreasing as a function of incubation time (t), and, at the end of the incubation period, the value of A_j will be sufficiently close to AI.

5.3.1.2.Profit of the incubatees

In our proposed model, each incubatee produces products during the incubation period inside the incubator. The technology level of the incubatee affects the profit by reducing the production cost. The profit of each incubatee is defined as:

$$Pr_{jt} = \left(r_{jt} - Cp_{jt}\right) Q_{jt} \qquad (5.2)$$

An equation similar to that of Villafranca et al. (2009) is used to define the unit production cost, which considers the technology level and is defined as follows:

$$Cp_{jt} = \frac{\rho_{jt}}{A_{jt}\, k_{jt}} + Ct_{jt} + Cr_{jt} \tag{5.3}$$

The facility's rental cost Cr_{jt} that must be paid to the incubator by the incubatee (j) each year is changed based on production quantities (Q_{jt}). The incubatee (j) also allocates its resources to technology development (Ct_{jt}). The technology development cost Ct_{jt} will increase the technology level of the incubatee in the next year based on the technology assimilation rates as formulated in equation (5.4), as follows:

$$A_{jt} = A_{jt} + \left(A_{j(t-1)}\, f_{jt}(D,t) \left(\frac{\left(AI - A_{j(t-1)}\right)}{AI} \right) Ct_{j(t-1)} \right) \tag{5.4}$$

The first term (A_{jt}) is the technology level of the incubatee (j) at a time (t) defined as a function of time, as explained in section 2.1.1. The second term shows that the technology level of the incubatee will be accelerated as a function of Ct_{jt} and the technology assimilation rate $f_{jt}(D,t)$. The situation is indicated in which the absorptive capacity will influence the innovation and financial performance indirectly with a time lag (Kostopoulos et al., 2011). Equations (3) and (4) also show that the unit production cost can be reduced by innovation or the technology transfer process.

Then, the production quantity of each incubatee is defined in equation (5.5):

$$Q_{jt} = \frac{\sum_{i=1}^{n} F_{ij} + Pr_{j(t-1)} \left(1 - S_j^a\right)}{Cp_{jt}} \tag{5.5}$$

Based on equation (5), the model assume that the profit received by each of the incubatees, after providing the profit share given to the investor in the previous year, will be accumulated to define the production quantities (Q_{jt}). That situation should be considered by DM-2 when determining S_j^v; a value of S_j^v that is too high will imply a decreasing Pr_{jt} in the next year. The lower profit of the incubatee will cause a decline in DM-2's return from profit sharing. After an agreement is reached about profit sharing S_j^a, the incubatee (j) will share his/her profits with the investors and then the net profit of incubatee (j) becomes defined as:

$$Ve_j = \sum_{t=1}^{T} \left(1 - S_j^a\right) Pr_{jt} \tag{5.6}$$

5.3.1.3.Incubator income

The incubator provides facilities for incubatees during the incubation period. The incubator manager DM-1 intends to avoid an incubator budget deficit by optimizing the incubator income, which is defined as:

$$Vc = \sum_{j=1}^{m} \sum_{t=1}^{T} Cr_{jt} + \sum_{i=1}^{n} Cf_i - \sum_{t=1}^{T} Co_t \tag{5.7}$$

The first term describes the accumulated rental cost of the facilities received from the incubatees while the second term describes the investment fees received from DM-2. The incubator income is also reduced by the third term, which describes the facility's maintenance cost.

5.3.1.4.Investors' revenue

Investor DM-2 will evaluate the attractiveness of investing in the incubatees based on the profit-sharing scheme. The investor's revenue is defined as follows:

$$Vv_i = \sum_{j=1}^{m} \sum_{t=1}^{T} S_j^v Pr_{jt} - Cf_i^v \tag{5.8}$$

The first term describes the profit share S_j^v of the incubatee (j)'s profit at time (t) Pr_{jt}, while the second term is the investment fees paid by DM-2 to DM-1.

5.3.2. Objective function

Our proposed model has two DMs, each with different and conflicting objective functions. Each DM tries to optimize his or her objective function and obtain the optimum value of the decision variables, S_j^c and Cf_i^c for DM-1 and S_j^v and Cf_i^v for DM-2.

5.3.2.1.Incubator manager

The incubator manager DM-1 has a multi-objective optimization that consists of two objective functions. The first objective function involves the attempt to avoid a budget deficit and the second objective is to optimize the profit of the incubatees.

The objective functions of the incubator manager are shown in equation (5.9) and equation (5.10).

$$\underset{Cf_i^c, S_j^c}{Max\,Vc} = \sum_{j=1}^{m}\sum_{t=1}^{T} Cr_{jt} + \sum_{i=1}^{n} Cf_i^c - \sum_{t=1}^{T} Co_t \tag{5.9}$$

$$\begin{aligned} \underset{S_j^c}{Max\,Ve_j} &= \sum_{j=1}^{m} Ve_j \\ &= \sum_{j=1}^{m}\sum_{t=1}^{T}\left(1 - S_j^c\right) Pr_{jt} \end{aligned} \tag{5.10}$$

Based on the explanation in section 2.1.2, a correlation between Vc and Ve is established because Cr_{jt} is influenced by Q_{jt}; a high number of production quantity Q_{jt} will increase Cr_{jt}, where Q_{jt} is influenced by the profit of the previous year after the incubatee's profit is shared with DM-2.

5.3.2.2.Investor

Investor (i), a member of DM-2, has an objective function described in equation (5.11).

$$\underset{Cf_i^v, S_j^v}{Max\,Vv_i} = \sum_{j=1}^{m}\sum_{t=1}^{T} S_j^v Pr_{jt} - Cf_i^v \tag{5.11}$$

Equation (11) indicates that each investor (i) of DM-2 optimizes her/his profit-sharing revenue from the incubatees but should pay investment fees to DM-1.

Alongside this objective function, several assumptions are used and described as follows:

a. $A_{jt=0} \geq 0$, i.e., the technology level of the incubatees at the beginning of the incubation period (t =0) is higher than or equal to zero.

b. $A_{j(t=T)} \leq AI$, i.e., the technology level of the incubatee, as the technology recipient, at the end of the incubation period is lower than or equal to the technology level of the incubator as the transferor.

c. $\sum_{i=1}^{n}\sum_{j=1}^{m} F_{ij} \leq \sum_{i=1}^{n} F_i$, i.e., the total investment in the incubatee should be lower than or equal to the available funds of DM-2.

5.3.3. *The constraints*

The constraints for both decision makers are described as follows:

a. $0 \leq S_j^x \leq 1$; $x = \{c, v\}$, i.e., the profit share of DM-2 that is derived from the profit of the incubatee, should be greater than zero and lower than one.

b. $Cf_i^x \geq 0$; $x = \{c, v\}$, i.e., the investment fees paid by DM-2 to the incubator should be greater than zero.

c. $Cf_i^x \leq \sum_{i=1}^{n}\sum_{j=1}^{m} F_{ij}$; $x = \{c, v\}$, i.e., the investment fees paid by DM-2 to the incubator should be lower than the total amount of investment that is invested in the incubator.

d. $\sum_{j=1}^{m}\sum_{t=1}^{T} S_j^x Pr_{jt} \geq F_{ij} Ir$; $x = \{c, v\}$, where Ir is the commercial interest rate. The rationale is that DM-2 will invest his/her funds in the incubator if the profit-sharing revenue is higher than the interest revenue of their fund. Despite the constraints, both decision makers should satisfy the additional constraint-based decision-making scenarios.

5.3.4. *Decision-making scenario*

The decision-making scheme of the profit sharing and investment fees can be divided into two scenarios:

a. *Without using negotiation*: The profit share and investment fees are determined by DM-1 and proposed to DM-2 without negotiation. DM-2 only has binary choices: to either accept or reject the proposal of DM-1. In this case, DM-1 will optimize its objective function equation with respect to all the constraints. In this scenario, DM-1 guesses the expected DM-2 profit-share reservation as an additional constraint:

$$S_{ij}^{c}\sum_{t=1}^{T}Pr_{jt} \geq \gamma E\left(S_{j}^{v}\right)\sum_{t=1}^{T}Pr_{jt} \tag{5.12}$$

where $\gamma \in [0,1]$ is the DM-2 minimum reservation constant. Equation (12) shows that DM-1 should consider that the investors, DM-2, have a minimum share as their revenue, meaning that DM-1 should share its incubatees' profit $S_{ij}^{c}\sum_{t=1}^{T}Pr_{jt}$ with DM-2 that is higher than the minimum reservation of DM-2, or DM-2 will reject the offer and not invest in the incubatees. In this case, $\gamma = 0$ indicates that there is no restriction for DM-1 to make an initial offer and $\gamma = 1$ that DM-1 should satisfy the reservation of DM-2. In this scenario, DM-1 also defines the investment fees that should be paid by DM-2 based on the amount of DM-2's investment, as follows:

$$Cf_{i}^{c} = \mu\sum_{j=1}^{m}F_{ij} \quad \forall i \tag{5.13}$$

where $\mu \in [0,1]$ is the proportion of the amount of investment paid as investment fees by investor (i) to the incubator.

b. *Using negotiation*: A sequential process of establishing the value of the decision variables. The first round is performed by DM-1 to optimize its income and the profit of the incubatees. Then, DM-1 offers a proposal to DM-2 and DM-2 will optimize his/her objective function by considering the maximum profit-sharing reservation from DM-1 using the following constraint:

$$\left(1-S_{ij}^{v}\right)\sum_{t=1}^{T}Pr_{jt} \geq \lambda\left(1-S_{j}^{c}\right)\sum_{t=1}^{T}Pr_{jt} \tag{5.14}$$

where $\lambda \in [0,1]$ is the DM-1 minimum reservation constant. Equation (13) shows that DM-2 should consider a minimum reservation by DM-1 in its counter offer. Equation (14) means that if the counter offer of DM-2 is lower than this minimum, the negotiation with DM-2 is called off. The minimum reservation constant has also been proposed in previous research as the cooperation constant (Du et al., 2006), in which $\lambda = 0$ indicates that there is no restriction for investors to make a counter offer and $\lambda = 1$ that the investor should satisfy the reservation of the incubator manager. The counter offer should also consider the minimum reservation of DM-1 regarding investment fees as follows:

$$Cf_i^v \geq \pi \, Cf_i^c \qquad (5.15)$$

where $\pi \in [0,1]$ is DM-1's minimum reservation constant of investment fees.

5.4. Numerical Example

To evaluate the performance of the profit-sharing model, a numerical experiment is performed. The numerical experiment use $f_j(D, t_0)$ value within the range of 0.2 to 0.7, and $F_{\max}$ is 0.99. Let the commercial bank interest rate be in the range of 0.15 to 0.2. The investment from the investor to the incubatees is as follows: $F = \begin{pmatrix} 20 & 15 \\ 15 & 10 \end{pmatrix}$, F_{12} = investment from investor 1 to incubatee 2. In addition to the funds from the investor's investment, each of the incubatees has an initial investment, which is set to 5 each. We determine $r_{j(t=0)} = 0.4$. We also assume that each of the incubatees allocates 10% of the product prices to R&D activity; therefore, $Ct_{jt} = 0.1 r_{jt}$. The assumed technology level functions informed by the incubator manager are $A(t) = \dfrac{1}{1 + 1.8994 e^{(-0.2938t)}}$ for incubatee 1 and $A(t) = \dfrac{1}{1 + 1.4.61 e^{(-0.2562t)}}$ for incubatee 2. Those values are derived from Jayaraman et al. (2004). The technology level of the transferor (incubator) is set to 0.8.

By using the model developed in section 3, this research raise two hypotheses. *First*, the research hypothesize that the negotiation process is beneficial and needed for both decision makers to reach profit sharing agreement. That hypothesis derived in our research because both decision makers have different and conflicting objectives. *Second*, the research hypothesize that technology level and technology assimilation rates under uncertain condition in technology transfer process influence decision making process to reach profit sharing agreement. This is because technology level and technology assimilation rate might influence the capability of incubatees to absorb new technology and utilize it in profit creation.

5.4.1. Numerical Result

The incubatee profit as an incubator manager objective based on the negotiation without the negotiation process is shown in Figure 5.2 and Figure 5.3 for incubatee 1 and incubatee 2, respectively.

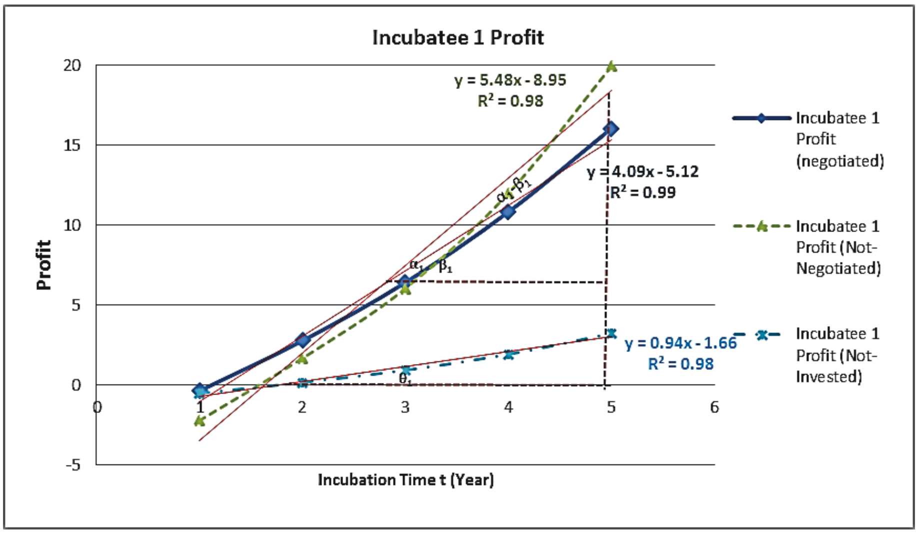

Figure 5.2. Incubatee 1 profit

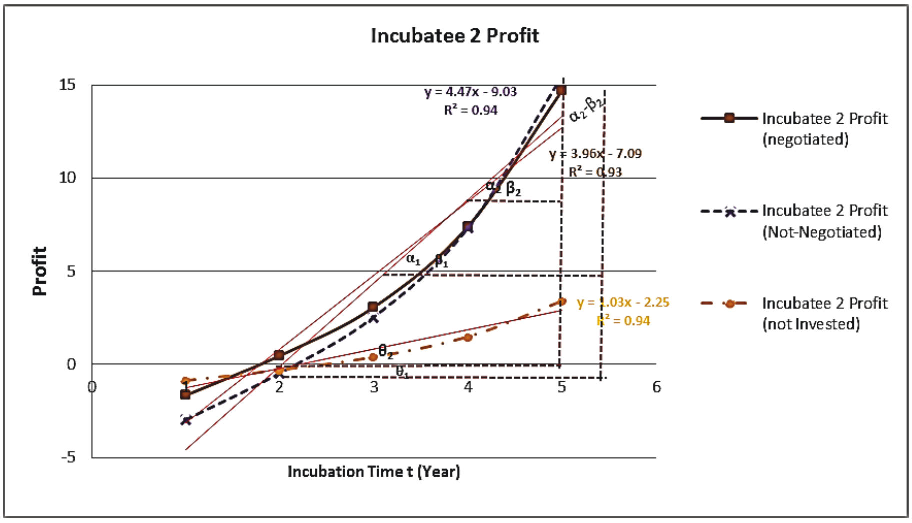

Figure 5.3. Incubatee 2 profit

Based on fig. 2 and fig. 3, without negotiation, the incubator manager can create a higher profit for the incubatees (incubatee 1 and incubatee 2), but that situation can make the investor reluctant to invest and the incubatee's profit can decrease drastically. Let $P_1(t)$ = the profit of the incubatee if the incubator manager does not conduct a negotiation process. $P_2(t)$ = the profit of the incubatee if the incubator manager conducts negotiation. $P_3(t)$ = the profit of the incubatee if the investor does not invest.

Then, we define:

$\alpha = \arctan \frac{P_1(T) - P_1(1)}{T-1}$, $\beta = \arctan \frac{P_2(T) - P_2(1)}{T-1}$, $\theta = \arctan \frac{P_3(T) - P_3(1)}{T-1}$ where T is the end of the incubation period, $P_x(1); x = \{1,2,3\}$ are the profits measured in the first years.

Then, we measure: R = $\alpha - \beta$ and L = $\alpha - \theta$.

The proposed analysis suggest that (R < L) indicates that the negotiation process is beneficial. That situation means that the sacrificed profit (R) of the incubatee when the incubator manager opens the opportunity for the investors to make a counter offer is less than the risk of profit loss (L) in the situation in which the investors do not invest. The sacrificed profit is measured as the gap between the profits using a non-negotiation scenario on the assumption that the investors accept the offer and invest (α) and the profits created from a negotiation scenario accommodate the investors' reservations (β). The profit loss is measured as the gap between (α) and the profits when the investors do not invest because they reject the offer from the incubator manager (θ). In this condition, the incubator manager should conduct a negotiation. Then, based on the analysis, the cases of incubatee 1 and incubatee 2 can be compared by using the data listed in Table 5.1.

Table 5.1. Profit sacrificing and profit loss

	Incubatee 1	Incubatee 2
α	79.65	77.39
β	76.26	75.83
θ	43.23	45.85
α-β	3.40	1.56
α-θ	36.43	31.54
R-L	33.03	29.98
L/R	9.32%	4.95%

Table 5.1 indicates that incubatee 1 has a higher α than incubatee 2, revealing that without negotiation and assuming that the investors agree to the scheme offered by the incubator manager, incubatee 1 will earn a higher profit than incubatee 2. However, incubatee 1 has an (R-L) a degree higher than that of incubatee 2, because incubatee 1 has a wider gap between the risk that the investors do not invest and the potential loss if the incubator manager conducts a negotiation to address the reservations of the investors. This situation has the implication that the incubator manager has a higher propensity to negotiate the profit share of incubatee 1. Based on table 1, L/R indicates the effectiveness of the model to reduce the potential risk of the incubatees' profit loss when the investors do not invest (L) by sacrificing some profit in a negotiation with the investors (R). The sacrificed profit of incubatee 1 is 9.32% to avoid risk, while that of incubatee 2 is 4.95%. In this case, incubatee 2 benefits more from the negotiation with the model indicating only 4.95% of the sacrificed profit of the total risk compared with 9.32% for incubatee 1. Those results support the first hypothesis, in which the negotiation process is beneficial for the incubator manager in maximizing the incubatees' profit (eq.10) if the sacrificed profit (R) is less than profit loss (L). However the benefit of the negotiation process is the difference for each incubatee and depends on R-L and L/R.

Analysis of the incubator's income and investors' revenue

In addition to maximizing the profit of the incubatees, the other objectives of our proposed model are to solve the incubator deficit, which has been described in previous research, and to reduce the investment risk for an investor to invest in an SME. The incubator income and investor revenue are based on three possible schemes, as shown in Figure 5.4.

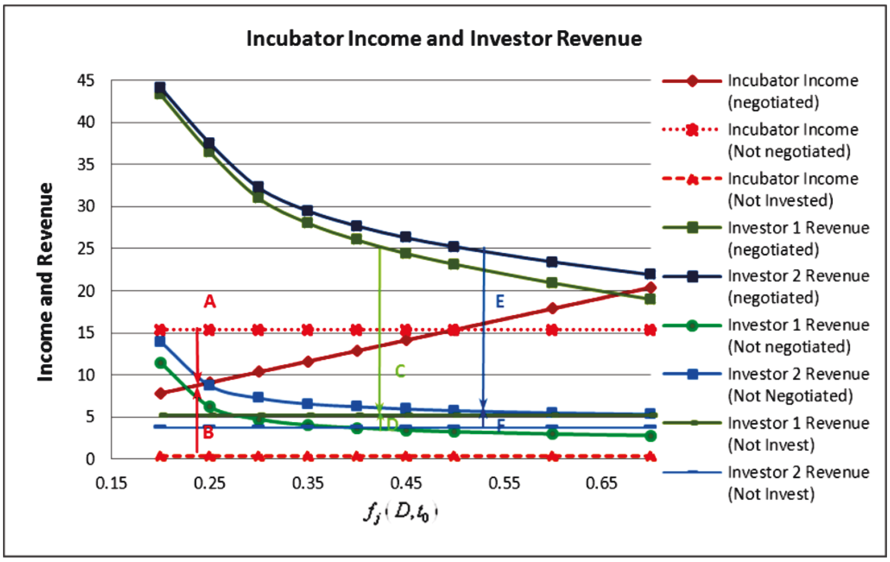

Figure 5.4. Incubator income and investor revenue

Based on Figure 5.4, define: A = the distance between the incubator income using negotiation and that without using negotiation; B = the distance between the incubator income using negotiation and that without investment from an investor; C = the distance between the revenue of investor 1 using negotiation and the case of not investing in the incubator; D = the distance between the revenue of investor 1 without negotiation and the case in which investor 1 decides not to invest in the incubator; E = the distance between the revenue of investor 2 using negotiation and the case in which investor 2 does not invest; F = the distance between therevenue of investor 2 without negotiation and the case in which investor 2 does not invest. Then, let $\varepsilon = \frac{A}{B}$, $\delta_1 = \frac{C}{D}$, $\delta_2 = \frac{E}{F}$.

In the calculations, we use the convention that a smaller ε denotes a higher tendency of the incubator manager to conduct the negotiation process because a smaller ε indicates a lower 'sacrificed profit' for avoiding high risk or a high risk of profit loss without conducting a negotiation. We also use the convention that a higher δ means that the investor will force the incubator manager to conduct a negotiation or else the investor will not invest. Then, we can use $\frac{1}{\delta}$ as the investor's propensity to invest. As a result, in the condition $\frac{1}{\delta} \approx \infty$ or $\delta \approx 0$, the investor will invest in the incubator based on the initial offer from the incubator manager. With regard to the first hypothesis, the result shows the tendency of the incubator manager to open the negotiation process and the propensity of the investors to invest in incubator programmes that are influenced by the initial assimilation rate of incubatees.

Analysis of the effect of the uncertainties b_j *and* $f_j\left(D,t_0\right)$

As described earlier in the model development section, in our proposed model, b_j and $f_j\left(D,t_0\right)$ are uncertain values for the investors. Furthermore, the investors attempt to predict those values in an uncertain value environment. Because the investors tend to underestimate those values, the upper level of the probabilistic value distribution is the same as or less than the value informed by the incubator manager. If b_j informed by the incubator manager is set to 0.3, and then the investor predicts the value in a uniform distribution $f\left(x;4\right)=\frac{1}{4}, x=0.2,0.25,0.28,0.3$, and the result of the agreement regarding profit sharing is shown in Figure 5.5.

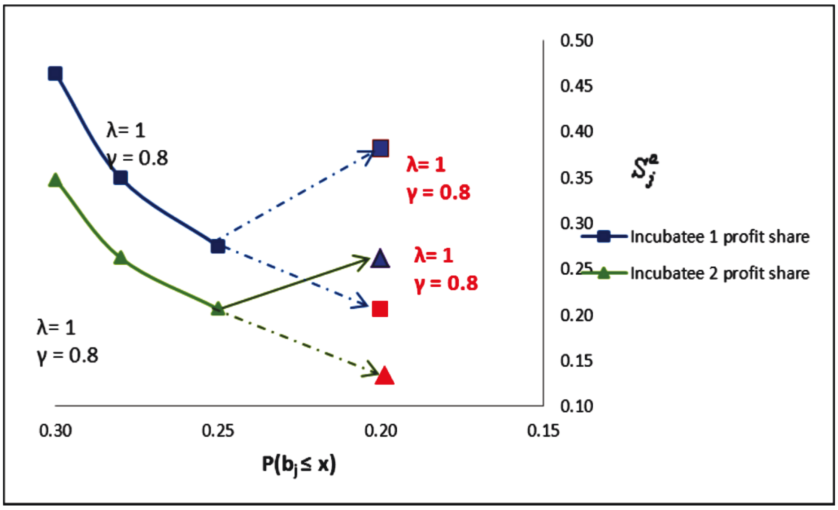

Figure 5.5. Profit-sharing agreement based on the b_j valuation by the investor

Based on Figure 5.5, when the investor is too pessimistic and only predicts that $b_j \leq 0.2$, an agreement will be achieved when the incubator manager reduces the reservation value (λ) = 0.8. We also examine the evolution of the profit-sharing agreement based on the uncertain condition of $f_j\left(D,t_0\right)$. Given that $f_j\left(D,t_0\right)$ by the incubator manager is 0.3, the investor attempts to predict the value in a uniform distribution function; the results of the profit-sharing agreement in this situation are shown in Figure 5.6.

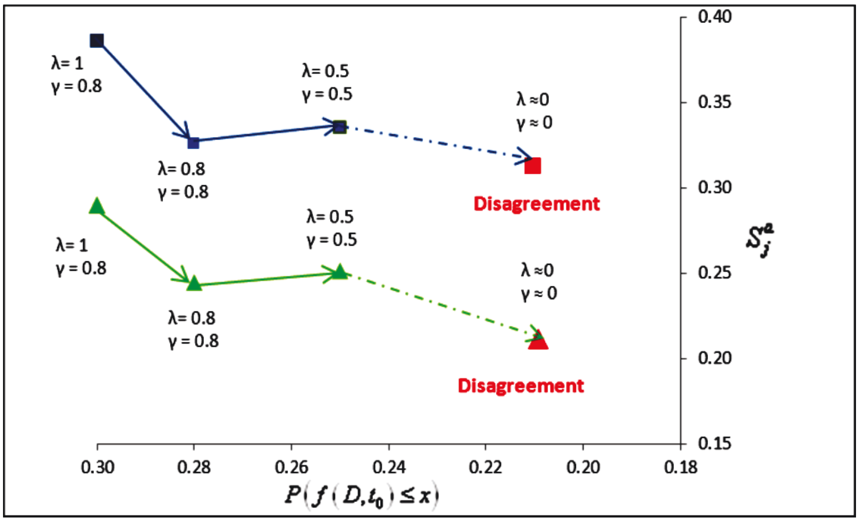

Figure 5.6. Profit-sharing agreement based on the $f_j(D,t_0)$ valuation by the investor

This is a similar analysis to b_j, but $f_j(D,t_0)$ tends to be more sensitive when the investors have different estimations. When the investors guess that $f_j(D,t_0)\leq 0.28$, agreement will be achieved if the incubator manager reduces the reservation λ and if the investors also reduce the reservation value γ. Although both sides reduce their respective reservation values to ≈ 0, they cannot reach an agreement on the profit sharing if the investors are too pessimistic and predict that the $f_j(D,t_0)$ value is no more than 0.2.

Based on an analysis of Figures 5.5 and 5.6, the results support the second hypothesis in which the technology level and technology assimilation rates under uncertain conditions influence the decision making process to reach an agreement. Furthermore, we can state that the uncertainty of $f_j(D,t_0)$ is more critical than that of b_j.

This research analyse the value of the technology level, the technology assimilation rate, and the incubatee profit as a function of the incubation time period (t). The technology level, assimilation rate, and profit progress of the incubatees are shown in Figure 5.7.

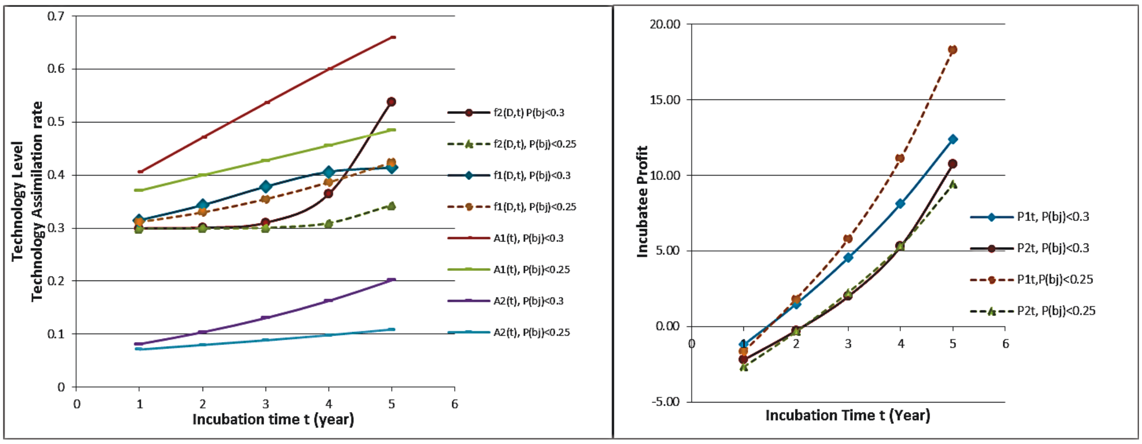

Figure 5.7. Technology assimilation rate, technology level, and incubatee profit during the incubation period

Based on Figure 5.7, the technology assimilation rate $f_j(D,t)$ of the incubatee increases as the technology level $A_j(t)$ increases; in addition, a higher technology level can result in a higher technology assimilation rate. This higher assimilation rate results from the reduced technology gap $G_j(t)$, which in turn results from a higher technology level. These outcomes will reduce the technology distances $D_j(t)$ between the transferor and the transferee. In the experimental results, because the technology level of incubatee 1, $A_1(t)$, is always higher than the technology level of incubatee 2, $A_2(t)$, the technology assimilation rate of incubatee 1, $f_1(D,t)$, is almost always higher than $f_2(D,t)$. A special case occurs between the fourth year and the fifth year of the incubation time period. During that period, under the condition $P(b_j) < 0.3$, $f_2(D,t)$ is higher than $f_1(D,t)$, even though $A_1(t) > A_2(t)$. This situation occurs because when the technology level is too high, $D_j(t)$ is closed; i.e., the absorptive capacity of the incubatee is powerful but the external resources of the incubator are reduced, thereby causing the assimilation rate $f_j(D,t)$ to decrease (Jayaraman et al., 2004); such a situation has an impact on the profit of the incubatees. Although the profit of incubatee 1 is still higher than that of incubatee 2, during the fourth and fifth-year period, the profit gain acceleration of incubatee 2 is higher than that of incubatee 1. Related to the second hypothesis, the influence of technology level and technology assimilation rate on the incubatees performance and decision making process is depending on incubation time. That situation because, the incubation time will influence technology distance $D_j(t)$.

Those results influence the incubator manager's decision on performing technology incubation. The technology gap between the transferor and the transferee is considered as an important factor. This result confirms the importance of the incubatee selection process because it is related to the technology level of the incubatee as a transferee. Furthermore, the incubator manager is suggested to select the technology that will be transferred to the incubatee, because the technology is related to the transferor's technology level. Technology with a high degree of sophistication will not be appropriate for incubatees who have a low absorptive capacity, which is represented by their technology level. On the other hand, low technology sophistication is not suitable for an incubatee with a high technology level.

5.5.Conclusion and Managerial Implication

This chapter proposed profit-sharing scheme in providing financial support for the incubatees. Because the technological and financial support in a technology incubator can be separate from each other, the technology assimilation rate to be an important factor should be considered. The concerns of both the incubator manager and the investors as decision makers will be incorporated into this proposed model.

This chapter analysed the benefits and issues of providing the profit scheme by comparing the results with a negotiation scenario and without a negotiation scenario. The negotiation is beneficial for the incubator manager when the sacrificed profit from using the negotiation process is less than the risk of profit loss without the negotiation scenario, in case the investors reject the offer and do not invest. Based on the result, we also analysed the propensity of investors to invest by comparing the revenue from the negotiation process, the process without negotiation, and when the investors do not invest in the technology incubator.

The scheme in this chapter considered that the technology level and assimilation rate have an impact on the decisions of both the incubator manager and the investors. Hence, we analysed the influence of the uncertainties of the technology level and the technology assimilation rate from the perspective of the investors and the effect on the profit-sharing agreement. We also indicated that for each condition of the agreement, the technology level and technology gap will affect the incubatees' profit. We recommended several factors to the incubator manager when setting up a technology incubator, such as the technological capabilities of the incubatees, the sophistication of new technology sources, and incubation time, which affect the technology gap and then influence technology assimilation rate of the incubatees.

The research can be extended by considering a university or research centre as the technology provider as a third player in the process in terms of the technology selection process. Finally, this model is expected to be applied in technology business incubators to satisfy the stakeholders.

5.5.1. Managerial Implication

The research derived several important implication for decision makers as follows:

1. Incubator managers should consider opening the negotiation process to the investor when sacrificed profit (R) is less than profit loss (L).
2. Incubator managers should consider the propensity to invest by the investors during conducting negotiation process.
3. Incubator managers should consider the technology level of the incubatees and technology gap by conducting the selection of incubatees, transferred technology, and incubation time.
4. Investors can reduce the risk of investment by considering the technological capability of incubatees to utilize their investment.

Appendix A

Notations

Indices	
i	Investor index ($i = 1,2 \ldots n$)
j	Incubatee index ($j = 1,2 \ldots m$)
t	Incubation time ($t = 1,2, \ldots T$)
Decision variables	
S_j^c	Profit share of incubatee (j) decided by the incubator manager and offered to the investors
S_j^v	Profit share of incubatee (j) decided by the investor as a counter offer to the incubator manager
S_j^a	Profit share of incubatee (j) as a final agreement
Cf_i^c	Investment fees from investor (i) in the incubator decided by the incubator manager and offered to the investors
Cf_i^v	Investment fees from investor (i) in the incubator decided by the investor as a counter offer
Cf_i^a	Investment fees from investor (i) in the incubator as a final agreement
Variables	
Pr_{jt}	Profit of incubatee (j) at time t
A_j	Technology level of incubatee (j)
G_j	Technology gap between incubatee (j) and the incubator
D_j	Technology distance between incubatee (j) and the incubator
$f_j(D,t)$	Technology assimilation level of incubatee (j) (functions D and t)
Cp_{jt}	Production unit cost of incubatee (j) at time t
Cr_{jt}	Facilities rent cost of incubatee (j) at time t (paid to the incubator)
Ct_{jt}	Technology development cost of incubatee (j) at time t
Q_{jt}	Production quantity of incubatee (j)
F_i	Investor (i)'s total investment in the incubator
F_{ij}	Investment amount from investor (i) in incubatee (j)
Ve_j	Net profit of incubatee (j)
Vc	Incubator income
Vv_i	Investor (i) revenue
r_{jt}	Unit product price of incubatee (j) at time t
ρ_{jt}	Incubatee (j)'s production cost/unit capital
k_{jt}	Total capital of incubatee (j)

Notations (continued)

Parameters	
a_j	Technology level of incubatee (j) constant (we interpret it as an initial state constant)
b_j	Technology level of incubatee (j) constant (we interpret it as an acceleration constant)
Al	Incubator technology level
$F_{\max}$	Maximum technology assimilation rate
Ir	Interest rate
γ	Minimum profit-share reservation constant of the investors
λ	Minimum profit-share reservation constant of the incubator manager

Chapter 6
Conclusion

6.1. Conclusion

This dissertation concerns on providing decision support for incubator manager in order to enhance the technology incubator performance. The decision supports relate to incubatees selection component of incubator, and business support and mediation component by utilizing a mathematical model.

Firstly, for supporting the incubator manager in the incubatees selection process, the model is developed in chapter 3. Using this model, a DM has several advantages. First, the DM can select the best configuration of incubatees to optimize future profitability, survivability and worker absorption. Second, the DM can reduce the risk of business failure using survivability objectives based on the entrepreneur's personal attributes. Third, using minimum technology criteria, the DM can reduce the risk of technology transfer failure during the incubation process.

The developed model in chapter 3 used an interactive Tchebycheff procedure and modified the iteration procedure by dividing the iteration process into two paths: a financial orientation path and a social orientation path. This procedure generates a set of alternative solutions for each iteration path to accommodate a DM's orientation. DMs can be satisfied by being provided with a non-dominated solution and being allowed to contribute during the decision-making process. Even using the same mechanism, a financially oriented DM selects an alternatives with higher profitability than a socially oriented DM. In contrast, the socially oriented DM selects an alternative with higher worker absorption than the financially oriented DM. The difference in orientation also influences the configuration of the sets of selected incubatees. This second contribution of this paper is an incubatee selection model that satisfies DMs whether they have a financial or a social orientation.

In the incubatees selection model, the results of numerical experiments indicates that the profitability of the SMEs was evenly distributed and not dominated by SMEs with high levels of technology knowledge. The model can satisfy both financially oriented and socially oriented DMs by allowing them to select the most appropriate solution, either the one with the highest profitability for the financially oriented DM or the one with the highest worker absorption for the socially oriented DM. The research indicates that, by using data sets with recognized correlations, financial orientation results in a higher average survivability of the selected incubatees. However, the result depends on the incubatees data sets and their correlation attributes. The model also can incorporate industry priorities, as determined by a DM. The results show that various priorities impact the objective function of incubator performance.

Secondly, the mechanism to provide a financial support for the incubatees is formulated. In Chapter 4, the conceptual model in supporting the incubator manager to attract the investor in assisting the incubatees financially is proposed. Since the technology transfer is the main support in technology incubator programmes, the financial support should be integrated with technological support provided by the incubator. This chapter also depict an influence diagram that shows the relationship of variables.

Thirdly, continuing the conceptual model proposal in Chapter 4, a profit-sharing scheme in providing the financial support for the incubatees is proposed. The proposal is explained in Chapter 5. Because the technological and financial support in a technology incubator can be separated from each other, the technology assimilation rate is considered to be an important factor. The concerns of both the incubator manager and the investors as decision makers will be incorporated into this proposed model. In this chapter, the benefits and issues of providing the profit scheme by comparing the results with a negotiation scenario and without a negotiation scenario is analyzed. The negotiation is beneficial for the incubator manager when the sacrificed profit from using the negotiation process is less than the risk of profit loss without the negotiation scenario, in case the investors reject the offer and do not invest. Based on the result, the propensity of investors to invest can be identified by comparing the revenue from the negotiation process, the process without negotiation, and when the investors do not invest in the technology.

In the proposal by utilizing a profit sharing scheme, the technology level and assimilation rate are considered have an impact on the decisions of both the incubator manager and the investors. Hence, the influence of the uncertainties of the technology level and the technology assimilation rate from the perspective of the investors and the effect on the profit-sharing agreement are analyzed. This scheme in chapter 5 also indicated that for each condition of the agreement, the technology level and technology gap will affect the incubatees' profit. Based on the scheme and the result of the numerical experiment, several factors to the incubator manager when setting up a technology incubator, such as the technological capabilities of the incubatees, the sophistication of new technology sources, and incubation time, which affect the technology gap and then influence technology assimilation rate of the incubatees are recommended. The proposed profit sharing scheme derived several important implications for decision makers as follows:

1. The incubator managers should consider opening the negotiation process to the investor when sacrificed profit (R) is less than profit loss (L).
2. The incubator managers should consider the propensity to invest by the investors during conducting negotiation process.
3. The incubator managers should consider the technology level of the incubatees and technology gap by conducting the selection of incubatees, transferred technology, and incubation time.
4. The investors can reduce the risk of investment by considering the technological capability of incubatees to utilize their investment.

6.2. Contribution

6.2.1. Incubatees selection model

In the incubatees selection model that provides in chapter 3, the contribution of this dissertation is twofold: First, the model proposes an incubatee selection model based on a mathematical model that uses a multi-criteria selection process to address the existing gap. The model uses the personal attributes of the entrepreneur to predict survivability. Additionally, the technology level is utilized to ensure the success of the technology transfer process and industry sector constraints to incorporate the advantages of sector specialization and diversification. Second, the model uses non-dominated multi-objective decision making to provide a set of alternative solutions that can satisfy the DM regardless of whether the DM has a financial or a social orientation. To generate the non-dominated solutions, an interactive weighted Tchebycheff procedure is used and the iteration procedure is adjusted and modified by dividing the iteration process into two paths: a financial path and a social responsibility path. The two-path iteration process is to facilitate the two orientations of the DMs.

6.2.2. A profit-scheme in providing the financial support model

In the model for supporting the incubator manager in the business support and mediation part, the dissertation has two contributions; First, the model proposes a profit-sharing scheme to provide the financial support for incubatees in a technology incubator that incorporates the different objectives of the incubator manager and the investors. Second, the model investigates the technology transfer process and considers both the technology level and the technology assimilation rate of the incubatees as important factors. From the proposed model, the profit scheme agreement behavior between the incubator manager and the investors, which is influenced by the technology transfer is identified.

6.3. Future Research

The dissertation identified several potential future researches as follows:

1. In the incubatees selection, the model should be adapted to different data sets from broader industry sectors to determine the influence of industrial structures and the characteristics of each industry sector on DM orientation.
2. In the business support and mediation part, the research can be extended by considering a university or research centre as the technology provider as a third player in the process in terms of the technology selection process. Finally, this model is expected to be applied in technology business incubators to satisfy the stakeholders.
3. Other interesting research direction is how to deliver the selected technology to the incubatees.

References

Aaboen,L., Lindelöf, P. Löfsten, H. (2008) Incubator performance: an efficiency frontier analysis. International Journal of Business Innovation and Research, 2: 354-380.

Aernoudt, R. (2004). Incubators: tool for entrepreneurship? Small Business Economics 23:127-135

Aerts K, Matthyssens P, Vandenbempt K (2007) Critical role and screening practices of European business incubators, Technovation 27:254-267.

Ahn BS, Cho SS, Kim CY (2000) The integrated methodology of rough set theory and artificial neural network for business failure prediction. Expert System Application18:65-74.

Amstrong, C.P., Sambamurthy, V (1999) Information technology assimilation in firms: The influence of senior leadership and IT infrastructures. Information System Research 10:304-327.

Ates, A., Bititci, U (2011) Change process: A key Enabler for building resilient SMEs. International Journal of Production Research 49:5601-5618.

Aretoulis GN, Kalfakaku, GP, Striagka FZ (2010) Construction material supplier selection under multiple criteria. Operational Research: An International Journal 10:.209-230.

Ardic OP, Mylenko N, Saltane V (2011) Small and medium enterprise: A cross-country analysis with new data set. Policy Research Working Paper, the World Bank.

Ayyagari, M, Beck T, Kunt AD (2003) Small and medium enterprise across the globe: A new database. Policy Research Working paper, the World Bank.

Ballantine JW, Cleveland FW, Koeller TC (1993) Profitability, uncertainty, and firm Size. Small Business Economics 5: 87-100.

Ballestero E, Bravo B, Perez-Gladish B., Parra MA, and Pla-Santamaria D (2012) Socially responsible investment: A multicriteria approach to portfolio selection combining ethical and financial objectives. European Journal of Operational Research 216:487-494.

Barrick MR, Mount, MK (1993) Autonomy as moderator of the relationship between the big five personality dimensions and job performance. Journal of Applied Psychology 78:111-118.

Bauer R, Koedijk K,Otten R (2005) International evidence on ethical mutual fund performance and investment style. Journal of Bank Finance 29:1751-1767.

Bergek A, Norrman C (2008) Incubator best practice: A framework. Technovation 28:20-28.

Bozeman B. (2000) Technology transfer and public policy: A review of research and theory. Research Policy 29:627 – 655.

Bruneel, J, Ratinho, T, Clarysse, B, Groen, A. (2012). The evolution of business incubators: comparing demand and supply of business incubation services across different incubator generations. Technovation 32:110-121

Chaudhuri, P.R. (1995) Technological asymmetry and joint product development. International Journal of Industrial Organisation 13: 23–39.

Chan KF, Lau T (2005) Assessing technology incubator program in the science park, Technovation 25:1215 – 1228.

Chandra, A., He, W., Fealey, T (2007) Business incubator in China: A financial services perspective. Asia Pacific Business Review 13:79-94

Ciavarella MA, Buckholtz AK, Riordan CM, Gatewood RD, Stokes GS (2004) The big five and venture survival: Is there a linkage? Journal of Business Venturing. 19: 465-483.

Columba, F., Gambacorta,L. Mistrulli, P.E. (2010) Mutual guarantee institution and small business finance. Journal of Financial Stability 6:45-54.

Cull R, Davis L E, Lamoreaux N R., Rosenthal JL (2006) Historical financing of small and medium size enterprise Journal of Bank Finance 30:3017-3042.

Dimitras AI, Zanakis SH and Zopounidis C (1996) Theory and methodology: A survey of business failures with an emphasis on prediction methods and industrial application. European Journal of Operational Research 90: 487-513.

Dimitras AI, Slowinski R, Susmaga R and Zopounidis C (1999) Business failure prediction using rough set. European Journal of Operational Research 119:263-280.

Du, L., Hu, Q. Liu, L. (2006) A profit sharing scheme for a two-firm joint venture. European Journal of Operational Research 170:277–292.

El-Komi, M. Croson, R. (2013) Experiments in Islamic microfinance. Journal of Economic Behavior and Organization 95:252-269.

Everett J, Watson J (1998) Small business failure and external risk factor. Small Business Economic 11: 371-390.

European Commission. (2002), Bencmarking of business incubators, final report. Brussel

European Commission Eurostat, (2009), http://www.epp.eurostat.ec.europa.eu/.

Fairfield PM, Yohn TL (2001) Using asset turnover and profit margin to forecast changes in profitability. Review of Account Studies 6:371-385.

Gelderen M, Thurik R, Bosma, N (2006) Success and risk factors in pre-startup phase. Small Business Economic 26: 319-335

Goodwin P,Wright G (1994) Heuristic, biases and improvement strategies in judgmental time series forecasting. Omega 22: 553-568.

Guisado-Gonzalez, M, Guisado-Tato, M. Ferro-Soto, C. (2013) Business strategy and enterprises cooperation agreements in research and development. International Journal of Business Innovation and Research 7:1-22.

Gunasekaran A, Rai BK, Griffin M (2011) Resilience and competitiveness of small and medium size enterprises: an empirical research. International Journal of Production Research 49: 5489-5509.

Hackett SM, Dilts DM. (2004) A systematics review of business incubation research. Journal of Technology Transfer 29:55-82

Hackett SM, Dilts DM (2008) Inside the black box of business incubation: Study B – scale assessment, model refinement, and incubation outcomes. Journal of Technology Transfer 33: 439-471.

Hallerbach W, Ning H, Soppe A, Spronk J (2004) A framework for managing a portfolio of socially responsible investments. European Journal of Operational Research 153:517-529.

Hanedar, E.Y, Broccardo,E. Bazzana, F. (2014) Colleteral requirements of SMEs: The evidence from less-developed countries. Journal of Banking and Finance, 38:106-121.

Haron, S., Ahmad, N., (2006). The effect of conventional interest rates and rate of profit on funds deposited with islamic banking system in Malaysia. International Journal of Islamic Financial Service 1: 1-20

Hess, S. Siegwart, R.Y. (2013) University Technology Incubator: Technology transfer of early stage technologies in cross-border collaboration with industry. Business and Management Research 2:22-36.

Hinkkanen, J.J., Jääskeläinen, M. Väätänen, J. (2012) Cooperation for R&D in Russian enterprises: motives, drivers and outcomes. International Journal of Business Innovation and Research 6: 636-652.

Jayaraman V, Bhatti MI, Saber H (2004) Towards optimal testing of a hypothesis based on dynamic technology transfer model. Applied Mathematics Computation 147: 115-129.

Jensen, R., Thursby, M., (1987). A decision theoretic model of innovation, technology transfer, and trade. Review Economic Studies 4:631-647.

Jiang, Z.S, Hu, L.Y, Chen, K.K. (2010) Decisions of knowledge transfer in technology innovation alliance: a Stackelberg leader-followers model. Operational Research: An International Journal 10:231-242.

Khalid FA, Gilbert D Huq A (2011) ICT Incubation in Malaysia: Selection performance practice. Proceedings of the 8th AGSE International Research Exchange: 653-667.

Kostopoulos, K, Papalexandris, A, Papachroni, M, Ioannou, G. (2011) Absorptive capacity, innovation, and financial performance. Journal of Business Research 64:1335–1343.

Krishnan, V. (2013). Operations management opportunities in technology commercialization and entrepreneurship. Production and Operations Management 22:1439-1445

Löfsten H, Lindelöf P (2002) Growth, management and financing of new technology-based firms—assessing value-added contributions of firms located on and off Science Park. Omega 30: 859-876.

Löfsten, H. (2010) Critical incubator dimensions for small firm performance – a study of new technology-based firms localised in 16 incubators. International Journal of Business Innovation and Research 4:256–279.

Marler, RT, Arora, JS (2004) Survey of multi-objective optimization methods for engineering. Struct Multidisc Optim 26: 369–395.

Mendoza A, Ventura JA (2013) Modeling actual transportation costs in supplier selection and order quantity allocation decisions. Operational Research: An International Journal 13:5-25.

Merrifield DB (1987) Executive forum: New business incubator. Journal of Business Venturing 2:277-284.

MacMillan IC, Siegel R, Narasimha PNS (1985) Criteria used by venture capitalist to evaluate new venture proposals. Journal of Business Venturing 1:119-128.

McAdam, M. Marlow, S. (2011) Sense and sensibility: The role of business incubator client advisors in assisting high-technology entrepreneurs to make sense of investment readiness status. Entrepreneurship and Regional Development 1:449-468.

Mian S (1994) US University-sponsored technology incubators: an overview of management, policies and performance. Technovation.14:515-528.

Mian, S. (1996) Assessing value added contribution university technology business incubator to tenant firm. Research Policy 25:.325-335.

Miettinen K, Ruiz F, Wierzbicki AP (2008) Introduction to multi objective optimization: interactive approach. Multi objective Optimization, Lecture notes in computer science, 5252, pp.27-57, Berlin.

Moon J (2002) The social responsibility of business and new governance. Government Opposition 37: 385-408.

Morduch, J. (1999) The role of subsidies in microfinance: Evidence from the grameen bank. Journal of Development Economics 60:229-248.

NBIA (2007). Business Incubation. www.nbia.org.

Phan, P.H., Siegel D.S, Wright, M. (2005) Science parks and incubators: observations, synthesis, and future research. Journal of Business Venturing 20: 165–182.

Philips, R.G. (2002) Technology business incubator: how effective as technology transfer mechanism? Technology in Society 24:299–316.

Puri, M., Zarutskie, R., (2012). On the Life cycle dynamics of venture-capital-and non-venture-capital-Financed firms. The Journal of Finance 57:2247-2293.

Reeves GR MacLeod KR (1999) Some experiment in Tchebycheff-based approach for interactive multiple objective decision making. Computers and Operations Research 26:1311-1321.

Sanfeliu, C.B., Royo, R.C., Clemente, I.M (2013) Measuring performance of social and non-profit microfinance institution (MFIs): An application of multicriterion methodology. Mathematical and Computer Modelling 57:1671-1678

Schreiner, M., (2003). A cost-effectiveness analysis of the grameen bank of Bangladesh. Development Policy Review 21: 357-382

Shanmugasundaram, V, Balakrishnan, V. (2010) Investment decision-making – a behavioral approach. International Journal of Business Innovation and Research 4:584-597.

Shepperd, D, Patzelt, H. (2013). Operational entrepreneurship: how operations management research can advance entrepreneurship. Production and Operations Management 22:1416-1422

Sohn, S.Y, Kim, Y.S. (2013) Behavioural credit scoring model for technology based firms that considers uncertain financial ratios obtained from relationship banking. Small Business Economics 41:931-943.

Soltanifar E, Keramati A, Moshki, R. (2012) An innovative model of business management in knowledge-based organisations; the case of the business incubators. International Journal of Business Innovation and Research 6: 573-596.

Soylu B. (2011) A multi criteria sorting procedure with Tchebycheff utility function. Computers and Operations 38: 1091-1102

Sung TY, Gibson VG, Kang BS (2003) Characteristic of technology transfer in business venture: the case of Daejon Korea. Technological Forecasting and Social Change 70: 449-466.

Steuer RE Choo EU (1983) An interactive weighted Tchebycheff procedure for multiple objective programming. Mathematical Programming 26:326-344.

Steuer RE, Silverman J Whisman AW (1993) A combined Tchebycheff / aspiration criterion vector interactive multi-objective programming procedure. Management Science 39:1255-1260.

Takalo, T, Tanayama, T. (2010) Adverse selection and financing of innovation: is there a need for R&D subsidies? Journal of Technology Transfer 35:16-41.

Tay AS Wallis KF (2000) Density forecasting: A survey. Journal of Forecasting.19: 235-254.

Thierstein A, Wilhelm B (2001) Incubator, technology, and innovation centers in Switzerland: features and policy implication. Entrep Reg Dev 13: 315-331.

United Nations-Economic and Social Commission for Asia and the Pacific (UNESCAP)

(1989) Technology Atlas Project: A Framework for Technology Based Development. Bungalore, India.

Van Gils A (2005) Management and governance in Dutch SMEs. Eur Manag J 23:583-589.

Vanderstraeten, J, Matthyssens, P. (2012). Service-based differentiation strstegies for business incubators: exploring external and internal alignment. Technovation 32:656-670

Villafranca, F.F., Jarne, G, Choliz, J.S. (2009) Industrial leadership in science-based industries: a co-evolution model. Journal of Behavior Organization 72: 390–407.

VonZedtwitz, M, Grimaldi, R. (2006). Are service profiles incubator-specific? Result from an empirical investigation in Italy. Journal of Technology Transfer 31:459-468

Watanabe, C., Asgari, B. (2004). Impact of functionality development on dynamism between learning and diffusion of technology. Technovation 24:651-664.

Xidonas P, Askounis D, Psarras, J (2009) Common stock portfolio selection: a multiple criteria decision making methodology and an application to the Athens Stock Exchange. Operational Research: An International Journal 9:55-79

Publications

A. **International Journal**

A.1. Wulung, R.B.S.*, Takahashi, K. and Morikawa, K. (2014) 'An interactive multi-objective incubatee selection model incorporating incubator manager orientation', Operational Research, *online first*. pp. 1-30, DOI 10.1007/s12351-014-0148-7.

A.2. Wulung, R.B.S.*, Takahashi, K. and Morikawa, K. (2014) 'A profit-sharing scheme to provide financial support for incubatees considering the technology transfer process', International Journal of Business Innovation and Research, *article in press.*

B. **International Conference**

B.1. Wulung, R.B.S.*, Takahashi, K., Morikawa, K., Hamada, K., Cakravastia, A., and Diawati, L. 'A multicriteria incubatees selection model considering investor orientation', Proceeding of 11th International Conference on Industrial Management. (29-31 August 2012), Tokyo, Japan. pp. 437-444

B.2. Wulung, R.B.S.*, Takahashi, K. and Morikawa, K. 'An integrated financial and technological support model in technology incubator', Proceeding of 19th ICE and IEEE-TMC conference (24-26 June 2013), The Hague, Netherland. pp 1-12 (In USB)

B.3. Wulung, R.B.S.*, Takahashi, K. and Morikawa, K. 'E-learning management system implimentation in technology business incubator by considering absorptive capacity of incubatees and incubation time schedule', Proceeding of 12th International Conference on Industrial Management. (2-4 September 2014), Chengdu, China

C. **National Conference**

C.1. Wulung, R.B.S.*, Takahashi, K., Morikawa, K. 'Multicriteria incubatees selection model for optimizing incubator output performance', 日本経営工学会中国四国支部研究論文発表会論文集 Vol.18, Hiroshima, Japan, pp.13-18, 20 October 2011.