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Paper Title: The Bottleneck in the Entrepreneurial Process: An Agent-Based Modeling and Simulation Approach

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The Bottleneck in the Entrepreneurial Process:
An Agent-Based Modelling and Simulation Approach

Abstract: The emergence of new economic activity is at the heart of entrepreneurship. Agent-based modelling and simulation (ABMS), unveils the process of emergence, has been recommended as a third research methodology in entrepreneurship for the purpose of supplementing quantitative and qualitative methodologies. However, application of ABMS in this field remains scarce due to the lack of researcher's awareness and modelling methods. This study suggests a new agent-based modelling method that uses bibliometric analysis, and applies this method to explain the business venturing process. As results, we find that ABMS is viable to entrepreneurship research, and the lack of investment is the bottleneck in the entrepreneurial process in some nations.

INTRODUCTION

The emergence of new economic activity by entrepreneur is at the heart of entrepreneurship (Wiklund et al., 2011). Complexity science that focuses on the process of emergence and individual is being promoted as a new platform for entrepreneurship research (McKelvey, 2004b; Garnsey & McGlade, 2006; Crawford, 2009). One of the major methodologies of complexity science, agent-based modelling and simulation (ABMS) has been recommended as a third research methodology for the purpose of supplementing quantitative and qualitative methodologies (Axelrod & Tesfatsion, 2006).

Agent-based model can express heterogeneous agents or individuals, and the heterogeneous attribute of these agents corresponds to the characteristics of entrepreneurs (McKelvey, 2004b). By virtue of the ABMS, the entrepreneurship researchers can capture the intricate cause-and-effect relationship in the entrepreneurial process, and the entrepreneurs can understand the present entrepreneurial environment and prepare for the future change. ABMS provide a number of benefits, including better communication, enhancing clarity and description of relevant actors and concepts in a system. This benefit is attained by explicit transparency of the modelling assumptions and conclusions, and allows for comparability of multiple models (Crawford, 2009).

In spite of several merits of ABMS, there are hardly cases where ABMS is applied to entrepreneurship research. Dean et al., (2007) investigated the data analysis trends of articles published in major journals in the field of entrepreneurship, such as *Entrepreneurship Theory and Practice* (ETP) and *Journal of Business Venturing* (JBV). As a result, it was found that statistical methods, such as simple regression (14%), multiple regression (16%) and logistic

regression (11%), were used at a high rate, but there was no article using simulations including ABMS. Many researchers insist that it is impossible to effectively model entrepreneurship or organizations with such a statistical technique (Andriani & Romano, 2001; McKelvey, 2004a; McKelvey & Andriani, 2005). Conventional regression analysis assumes linear relationships, normal distribution of results, and respondents' independency, but it doesn't accord with non-linear and interdependent complexity which is the foundation of most business relations (Crawford, 2009).

The reason that ABMS is not applied to entrepreneurship research is the lack of researcher's awareness and modelling methods that utilize the accumulated knowledge in this field. This study suggests a new agent-based modelling method that uses bibliometric approach, and as an example, applies this method for entrepreneurship research to explain the opportunity-driven entrepreneurial process.

LITERATURE REVIEW

For the entrepreneurship research, qualitative approach is conducted through face to face interview with entrepreneurs, but they may be reluctant to provide researchers with detailed information or glorify their entrepreneurial processes. Such a qualitative approach provides 'thick descriptions' about the reality of their entrepreneurial processes, but this kind of a description can be distorted by their social desires, and there are even limits to generalizing such research results (McKelvey, 2004b). On the other hand, a large-scaled survey about entrepreneurial processes, such as GEM (Global Entrepreneurship Monitor) and PSED (Panel Study of Entrepreneurial Dynamics), can enhance the possibility of generalizing research results, but it requires immense expense, and not only does it have such problems as either non-response or bias during the process of response, but just provides 'thin descriptions' about the entrepreneurial process (Podsakoff et al., 2003).

Simulations are virtual environments in which to model actual systems, processes and events. The simulations are computer programs for studying individual-level theories of behaviour. The simulations provide researchers with the ability to control all the variables of a model and perform repetitive tests (Anderson, 1999; Dooley & Van de Ven, 1999). Through a simulation about the entrepreneurial process, therefore, it is possible to deduce and explain a process how firms are formed and the similarity of their growth patterns suggested by thousands of entrepreneurial researches conducted from various different viewpoints (Shane, 2008). The results of simulation can be compared with results drew from quantitative analysis and qualitative analysis in order to increase the external validity. Data drew from the existing researches can be entered into a simulation model, through which it is possible to establish a simulation model corresponding to actual data (Crawford, 2009).

As an approach to simulation, agent-based model is designed to imitate actual responses of

humans, who have high-level complexity and cognitive information-processing abilities based on rules and intrinsic temperament, it is highly related to actual entrepreneurship research (North & Macal, 2007). In the agent-based modelling environment, agents have capabilities to study through experience and cognition patterns in order to understand their surroundings and even have abilities to use decision rules inside the environment in order to predict the consequences of such behaviours (Dooley, 2002). Agent-based model is a stochastic model that draws results different from the previous ones when it is repeatedly driven despite the same input values. Various agents are included in agent-based model, and responses to their behaviours and environments are determined by random or stochastic factors designed by researchers. Like a research on the real world, agents' behaviours are not determined by environmental factors. Therefore, they are expressed through a statistical means, such as average and variance (Harrison et al., 2007).

When agent-based model & simulation is repeatedly performed, each performance shows a single possibility of futures. As a result, even a single simulation is good enough to be seen as a complete experiment, and through this simulation, it is possible to find clues how an agent's behaviours contribute to the change of an entire system through its interactions with time and several other agents (McKelvey, 2004a). In various geographic spaces ranging from simple and limited two-dimensional space to complex and infinite space, agents behave complying with rules given, and they interact with other agents and environments and have capabilities to adapt to them (Dooley, 2002). As agents adapt, they can provide feedback to the system (Robertson & Caldart, 2008). When agents interact with each other over time, 'emergence' often appears in their simple rules and local behaviours.

A NEW AGENT-BASED MODELLING METHOD

This study suggests a new agent-based modelling method, and applies this method for entrepreneurship research. This modelling method consists of two parts – the first is to identify main concepts including agents by bibliometric analysis, the second is to build an agent-based model using the results of the analysis. The first part of this method conducted based on the following procedures: First, a domain corpus is established. Second, candidate domain terms are selected according to the frequencies, and the key concepts in the corpus are obtained by content analysis, which may represent agents. Third, the relationships among the key concepts are identified by co-word and content analysis. The Second part of this method conducted based on the following procedures: First, objects including agents are identified. Second, an agent-based conceptual model is built.

In this modelling method, co-word and content analysis is adopted. Co-word analysis is a kind of quantitative text analysis suggested in bibliometrics (Ding et al., 2001). To identify agents or properties and behaviours of the agents in a certain field, the key concepts of the field are selected, and the co-occurrence relationship among the key concepts are analysed. Content

analysis is applied to select the key concepts, and to identify the relationships among the concepts. The content analysis is a research technique for making replicable and valid inferences from texts to the contexts of their use (Krippendorff, 2004).

AN EXAMPLE OF AGENT-BASED MODELLING & SIMULATION

In this section, we will illustrate an example of the agent-based modelling method. This example models business venturing process.

Identifying Main Concepts

Establishment of Domain Corpus

In order to establish a domain corpus, we collect the titles and abstracts of 255 venture-related articles published in *Entrepreneurship Theory and Practice* (ETP) and *Journal of Business Venturing* (JBV). We confine the "related articles" in which the terms of 'venture(s)' or 'venturing' is included in titles or abstracts. Table 1 shows the number of venture-related articles published annually in major journals.

Table 1. The Number of Venture-Related Articles

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
ETP	7	8	5	3	10	19	24	11	16	13	116
JBV	12	14	12	12	15	17	13	11	16	17	139
Total	19	22	17	15	25	36	37	22	32	30	255

The corpus of venture study is prepared in the following procedure utilizing a text analysis program T-Lab 7.2.

- We collect the titles and abstracts of 255 papers, and save those collected texts onto an electronic file used for computational processing.
- Any multi-word nouns found in a dictionary or multi-word patterns observed in the corpus more than 20 times were expressed as one-word terms.
- Any stopwords such as articles (eg. 'a', 'the'), prepositions and exclamations were detected and excluded from a list of candidate keywords.
- To transform any plural form of nouns or verb changes into a basic form, stemming or lemmatization process was performed.
- The collected text was divided into an elementary context that is a sentence unit constrained in length (maximum of 400 characters). An elementary context functions as a criterion of co-word analysis.

Selection of Key Concepts

Nouns or noun phrases were selected as potential candidates for domain terms among those words that appear in the corpus more than 20 times. A noun or noun phrase that is frequently found in a corpus probably becomes a domain term, but all the nouns or noun phrases not necessarily become domain terms. Thus, we request each of two experts in entrepreneurship to individually determine whether each potential candidate word is a venture-related domain term or merely a general term. The selection process by experts corresponds to a coding process of quantitative content analysis that assigns a subject into a specific category. The reliability of quantitative content analysis is evaluated by the Cohen's kappa coefficient that explains the fitness among coders. As a result, 209 basic lemmas that appeared more than 20 times in the venture-study corpus are selected. Among the 209 basic lemmas, 136 candidate venture-domain terms (single nouns or noun phrases) are distinguished. Among the 136 candidate venture-domain terms, 66 venture-domain terms were determined by two experts in the field of entrepreneurship. The Cohen's kappa (κ) in the analysis by experts was 0.838, which showed that the level of fitness is satisfied. Table 2 shows the 66 domain terms of venture studies.

Table 2. Domain Terms in Venture Studies

agency	Experience	Knowledge	social capital
alliance	failure	learning	start-up
angel	family	management	strategy
capability	finance	manager	structure
capital	firm	market	success
characteristic	formation	network	survival
company	founder	opportunity	team
corporate venturing	fund	organization	technology
creation	governance	outcome	uncertainty
decision	growth	ownership	value
development	human capital	performance	venture capital
entrepreneur	industry	plan	venture capital firm
entrepreneurial firm	information	process	venture capitalists
entrepreneurship	innovation	resource	venture creation
environment	investment	return	venture performance
equity	investor	risk	wealth
exit	IPO		

Identification of Relationships among Key Concepts

This study undertakes co-word analysis and establishes pathfinder network (PFNet) to identify the relationship among the key concepts in venture field. In the existing studies that analyse the knowledge structure of academic field, multidimensional scaling (MDS) was frequently applied. Recently, however, the parallel nearest neighbour clustering (PNNC)

technique is used, which can replace MDS with PFNet and can simultaneously perform clustering in the process of establishing PFNet (Lee, 2006). The present study performs clustering for the venture-related domain terms in the process of establishing PFNet by applying PNNC technique. Figure 1 shows 66 domain terms of the venture field expressed with PFNet. As seen in the figure, **'entrepreneur', 'process', 'finance', 'venture capital',** and **'firm'** link the entire concepts as hub concepts.

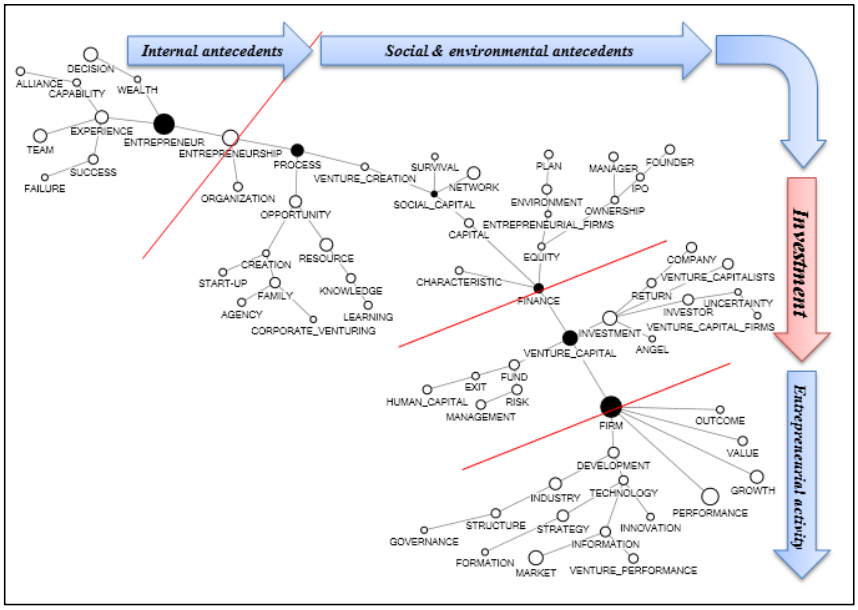

Figure 1. Pathfinder Network of Domain Terms in Venture Studies

Building Agent-Based Model

Identifying Objects

Through the contents analysis of the corpus, the concepts representing the objects (individuals) in domain terms can be identified. In general, the concepts representing object has the following features, and the agent can be defined as an object being the subject of action.

- Concepts encompassing the hierarchical relationship in the relevant domain (e.g. capital – venture capital)
- Major concepts that are the subject of action in the relevant domain (e.g. entrepreneur)
- Major concepts that are the target of action in the relevant domain (e.g. fund)

Of the 66 domain terms in venture field, the number of objects (individuals) that meet the

criteria above is 23. Of these 23 objects, the number of objects that can be agent in their meaning is 6, including **'angel', 'investor', 'venture capitalists', 'manager', 'founder'**, and **'entrepreneur.'** However, the concepts representing a group, such as **'firm'** or **'team'** can be also agent, if they are used as the concepts representing the subject of action in the corpus. Of the domain terms that are not object, it is a property or a method of the object.

Building Conceptual Model

It is possible to build an agent-based model with objects identified by previous analysis. However, in this example, we utilize identified objects to supplement the existing concept model of the opportunity-driven entrepreneurial process proposed by Global Entrepreneurship Monitor (GEM).

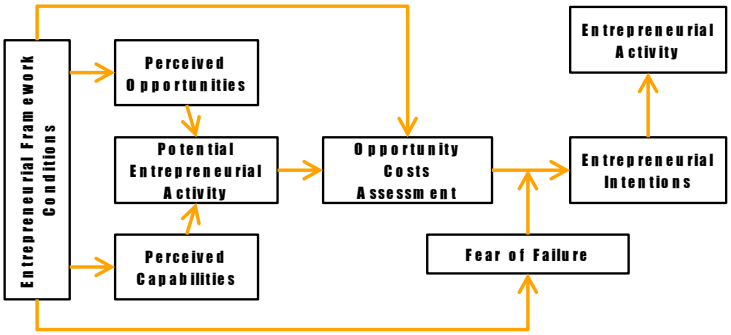

Figure 2. GEM Concept Model of Opportunity-Driven Entrepreneurial Process

Figure 2 shows the existing concept model that the entrepreneurial opportunity and the entrepreneurial capacity are related to the entrepreneurial intention and the entrepreneurial intention trigger entrepreneurial activity (Bosma et al., 2007).

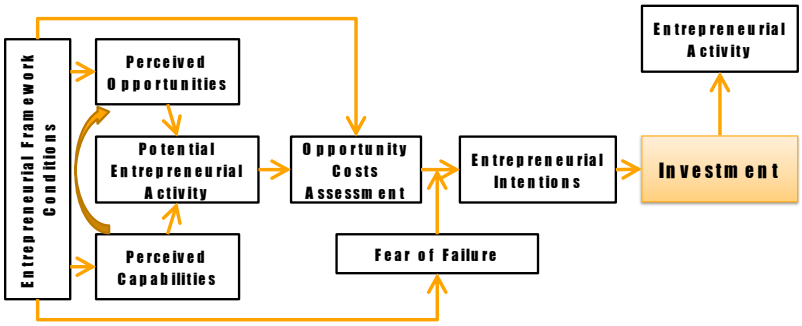

Figure 3. New Concept Model of Opportunity-Driven Entrepreneurial Process

Of the 66 domain terms in venture field, the concepts related to business venturing process

like **‘entrepreneur’, ‘opportunity’** are included in the GEM model. However, the concepts representing investment like **‘investor’, ‘angel’** are not included in the GEM model. We propose a new model that includes the investment considering the result of the new modelling method. Figure 3 shows the new concept model that includes the investment.

Running Model

Utilizing the revised concept model (Fig. 3) and the survey data of GEM, this study performs modelling and simulation to find out how the opportunity-driven entrepreneurial activities creates firms with the use of NetLogo 5.0.3. Two agents such as **'entrepreneur'** and **'investor'** are created and the behavioural rules are offered to the created agents. Table 3 shows the properties and methods of the ‘entrepreneur’ agent.

Table 3. Properties and Methods of the ‘Entrepreneur’ Agent

Category	Name	Descriptions
Properties	have-opportunity?	Whether the entrepreneur has opportunity?
	have-capability?	Whether the entrepreneur has capability?
	have-abandoned?	Whether the entrepreneur abandons the opportunity?
	have-money?	Whether the entrepreneur has invested?
	vision	The distance of the entrepreneur’s vision
	status	The status of the entrepreneur
Methods	search-opportunity	Each entrepreneur searches an opportunity in the area in his/her vision
	invest-and-startup	Each entrepreneur who found an opportunity searches an investor in the area in his/her vision *(NEW model only)*
	try-startup	Each entrepreneur with opportunity *(and investor)* creates a firm

Results of Example

Table 3 shows the input data used in the example. We use the Korean adult population survey data in GEM reports from 2008 to 2011, and Table 4 show the results of two simulations. GEM survey results of opportunity-driven new firs rates are 2.6~5.1%, the differences of NEW model simulation are less (0.2~0.6%) than the differences of GEM model simulation (3.3~7.4%p).

Table 3. Input Data of the Simulation

	Input Data			
Year	Opportunity Recognition	Capability Recognition	Fear of Failure	Investment Experience
2008	15%	30%	33%	5.4%
2009	13%	53%	23%	3.2%
2010	13%	29%	32%	2.7%
2011	11%	27%	45%	3.1%

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Comment [1]: 2010, first three columns, is the only data in this table I can find in the GEM reports. Where specifically is the other data from? How is it relevant to this ABMS?

Table 4. Results of Two Simulations

	Opportunity-Driven New Firms Rates			Differences	
Year	GEM Survey Results (R)	GEM Model Simulation (S1)	NEW Model Simulation (S2)	| R – S1 |	| R - S2 |
2008	5.1%	10.1%	5.3%	5.0%p	0.2%p
2009	2.6%	10.0%	3.2%	7.4%p	0.6%p
2010	3.2%	8.8%	2.7%	5.6%p	0.5%p
2011	2.8%	6.1%	3.0%	3.3%p	0.2%p

CONCLUSIONS

This study suggests a new agent-based modelling method that utilizes the accumulated knowledge in a field, and applies this method to find out how the entrepreneurial activities create firms. According to the result, ABMS is effectively performed with the new modelling method that uses bibliometric analysis. Moreover, the investment is the bottleneck for creating firms in the business venturing of Korea. It is concluded that ABMS is effectively applied to the entrepreneurship research with the conventional methodologies. From now on, various researches adopting ABMS is required to explain entrepreneurial phenomena effectively, and the attempts for the application of ABMS on entrepreneurial support activities including training and consulting is necessary.

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