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Performance Analysis on Different Research and Development (R&D) Types: Proactive Support Program for International Environmental Regulation

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Abstract

This study analyzed and compared the performance of companies involved in R&D and R&D Infrastructure activities. This study used Proactive Infrastructure Program for International Environmental Regulation as a case study because it is a program that supports both R&D and R&D Infrastructure in Korea. It also evaluated the R&D performance by combining and isolating R&D and R&D Infrastructure.

The analysis result shows only a handful of companies are actively involved in both R&D and R&D Infrastructure in the program. Differences in technical, economic, and social performance showed no statistically significant. For Economic performance, companies participated in R&D alone showed higher numbers; while for technical performance, companies involved in both activities had higher numbers. From the results of the analysis, it is difficult to state that combining R&D with R&D Infrastructure will create higher performance than R&D alone; however, the study noted an important point in that it R&D activities and its performance measurement need to be analyzed by types.

Keywords: Research and Development (R&D) Activities, Korea, Performance Analysis, Logic Model, Support Program Evaluation

1. Introduction

The interest in the latest research and development (R&D) activities for nations, enterprises, and all economic entities are on the rise. With the accelerated technological developments and higher uncertainties in competitions, innovation through R&D has become a vital source for the growth of nations and enterprises. For continuous innovation, it is important to focus on science-based strategies and on constant R&D; the effects of innovation are different depending on the situation and the strategies the nations and enterprises implement.

The purpose of this study is to analyze and breakdown the R&D driven technological innovation. According to OECD (2002), R&D is defined as acquiring new knowledge of all matters, including humans, cultures, and societies, or using already acquired knowledge in a systematic way to devise new applications. R&D activities, on the basis of the definition of R&D above, can be defined as 1) accumulating knowledge of science and technology, 2) acquiring new knowledge on objects, functions, and trends such as searching for new

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applications in an organized and creative way by taking advantage of knowledge accumulated, 3) taking advantage of existing knowledge to find out new ways for creative efforts and 4) supporting different R&D activities, such as financial affairs and R&D department operations.

Based on these comprehensive definitions, R&D activities can fall into three categories: R&D, R&D education and training, and R&D services (OECD, 2002). R&D, as defined above, refers to obtaining new knowledge through systematic and creative activities. R&D education and training refers to educational programs for human resources, and R&D service, which does not directly relate to R&D, refers to service programs that support science and technology activities.

Based on these definitions, R&D activities can be further classified as either R&D or R&D Infrastructure. R&D includes basic research[1], applied research[2], and development research activities[3]. R&D Infrastructure includes R&D education, human resources, R&D support services, facilities and equipment. While many studies have emphasized the importance of R&D, R&D Infrastructure has highlighted the importance of science and technology sector, but it has not been much discussed.

From the literature reviews, an increased attention to non-technological factors like R&D infrastructure related activities was observable; however, most of these studies focused on generalizing R&D activities and have used a unified performance measurement indicator. In reality, R&D activities can be classified by types, and each type needs a different performance measurement indicators and targets. Therefore, this study analyzed the different performance measurement results of R&D and R&D Infrastructure by using a case study of "Proactive Support Program for International Environmental Regulations." The study checked for comprehensive range of R&D activities, and evaluated the possibility of performance evaluation of R&D activities through practical engagement and disengagement of R&D and R&D Infrastructure.

2. Literature Review

2.1. Past Literatures on R&D Effectiveness and R&D Performance Measurement

It is undeniable that the interest of R&D performance measurement is on the rise. This topic had been under intense debate as there was no clear-cut definition of R&D performance measurement techniques. According to Brown (2005), measuring R&D performance was difficult because 1) the outcomes of R&D activities cannot be quantified and 2) outcomes of R&D activities lag the output of activities by several decades (ORAU, 2005). However, R&D performance measurement continued to be an important area of research as it raised interest to practitioners and R&D managers.

Earlier R&D performance researches were at the firm level. Chiesa, Frattini, Lazzarotti, Maznini & Troja (2008) looked at how to design a performance measurement system (PMS) that fitted the characteristics of R&D activities. There were lack of literatures in capturing the R&D performance measurement phenomenon and what performance measurement system was made up of (objectives, dimensions, and control objects). The paper used 48 Italian companies to provide logical steps a firm should follow through in designing a performance measurement system.

1 An experimental or theoretical study carried out to obtain new scientific knowledge based on natural phenomenon, and without targeting specific application

2 An original study carried out to acquire new scientific knowledge for practical purposes under specific goals

3 A systematic activity to improve materials, products, systems or services by utilizing knowledge obtained by studies

Continuing on their research, Chiesa et al (2009) looked at companies' objectives when measuring R&D activities' performance and what approaches of R&D performance measurement were to be used in different objectives. Through a case study of 15 Italian technology-intensive firms, the paper found that companies measured R&D performances with different purposes, such as to motivate researchers and engineers, to evaluate profitability of R&D projects, and stimulate organizational learning.

Similarly, there were many literatures on R&D performance measurement in the business-level. Many of the literatures have been using the relationship between R&D expenditures and investment with GDP or even patent number variables to see the effectiveness of R&D activities at the company level (Ojanen & Vuola, 2003). However, not many studies have conducted research and analysis R&D performance at the national level.

2.2. Importance of Linking R&D and R&D Infrastructure

Szakonyi (1994a, 1994b) developed an approach to compare performance of R&D departments and have identified ten R&D activities: Selecting R&D; Planning and managing projects; Generating new product ideas; Maintaining the quality of R&D process and methods; Motivating technical people; Establishing cross-disciplinary teams; Coordinating R&D and marketing; Transferring technology to manufacturing; Fostering collaboration between R&D and finance; Linking R&D to business planning.

R&D activities such as establishing cross-disciplinary teams, motivating technical people, and coordinating R&D and marketing, are examples of "non-technological factors" of R&D and innovation. According to Mothe & Nguyen Thi (2010), technological innovation refers to product and process innovation. It includes significant improvement to technical specifications and usages, components, materials, software and even user friendliness. Non-technological innovation, on the other hand, is related to organizational innovation, which is defined as "the implementation of a new organizational method in the firm's business practices", and marketing innovation, such as product strategy, price strategy, and promotion strategy (Mothe & Nguyen Thi, 2010).

There have been increases in the number of studies that have stressed the importance of non-technological innovations like R&D Infrastructure. Schmidt and Rammer (2007) mentioned that there were aspects of business, such as cooperate reorganization and marketing that cannot be demonstrated by innovative activities. Therefore, Schmidt and Rammer claimed that by combining non-technological innovations, such as marketing, organizational innovation, human resources development, and R&D Infrastructure, with product and process innovation will bring an improvement in sales.

With the recent proliferation of open innovation paradigm, innovation have encompassed both the term R&D and Infrastructure. OECD published Oslo Manual in 2005 that included organization, marketing and Infrastructure innovation along with product and process innovation. Schmidt and Rammer (2007) analyzed the effects and determinants of technological innovation and non-technological innovation by using Germany's CIS 4 (Community Innovation Survey) data.

Frenz and Lambert (2009) evaluated OECD innovation microdata projects in a firm-level in 20 countries to seek information on innovation. It used factor analysis on innovation survey data to see the different modes of innovation practices and acknowledge the importance of non-technological factors such as organizational and marketing innovation. Technological and non-technological innovations were activities that

complement each other, not substitutes. Frenz and Lambert analyzed that there were no consistent patterns in the effects of innovation practices and the productivity. It was evident that similar policy instruments can lead to different responses in countries. Frenz and Lambert also suggested that other non-technological factors like value added or financial performance research should be pursued in the future.

OECD (2011) conducted a study on the different firms' sizes of the types of innovation (technological innovation only, non-technological innovation only, or a mix of the two). It was clear that the mix of technological and non-technological firms is growing as the number of firms with mix of innovation types is far more than the firms focusing on one type. It is important to consider the different impact of the two types of innovation when formulating innovation policies or setting up government support programs. Policies tend to favor the technological innovation more, but evidences showed that success often depends on the non-technological innovation (OECD, 2011).

A recent flow of studies shows that instead of focusing on just product or process innovation activities, non-technological innovation, such as administrative changes, organization structure, infrastructure and human resources, should be considered in order to generate more innovation. Therefore, rather than approaching innovation as a concept of R&D, it is necessary to understand R&D activity as an integrated perspective of Infrastructure and non-technological innovation.

Seeing it more logically, there needs to be properly supported R&D activities that not only support R&D programs, but also R&D Infrastructure programs along with effective policies to evaluate and analyze the influence of these programs.

2.3. R&D Programs for Different Types of R&D Activities in Korea

R&D performance measurement researches can be categorized and divided by functions and stages. Research evaluation techniques should vary by different types of R&D (Ojanen & Vuola, 2003). According to Pappas & Remer (as cited by Ojanen & Vuola, 2003), research functions vary from basic research, exploratory research, applied research, development research and product improvement research, while evaluation techniques need to vary from qualitative[4], semi-quantitative[5], and quantitative methods[6].

Depending on the type of R&D, it can be classified as either R&D or R&D Infrastructure program. According to the Ministry of Science, ICT, and Future planning (2013), R&D programs covers basic research, short and long-term industrial technology development, public technology development, defense technology development, and regional R&D. Infrastructure programs covers human resources, facilities & equipment, diffusion, and international cooperation. Table 1 shows the different R&D program taxonomy defined by the Korean government.

For R&D, it can be defined as application research and development programs for new technologies for a short-term (within 3 years) commercialization. For Infrastructure programs, it is a performance based program, such as technical achievement, management/diffusion, and policy support. Similarly, recent national R&D programs in Korea are a mix of both R&D and R&D infrastructure support.

4 Algorithm or predefined ratio to generate numbers that can be compared with other projects and past experiences (Ojanen & Vuola, 2003)

5 Qualitative judgments that are converted to numbers (Ojanen & Vuola, 2003)

6 Intuitive judgements (Ojanen & Vuola, 2003)

Table 1. R&D programs taxonomy

Characteristics	Type	Concepts and Classification
R&D	1. Basic Research	➢ Create and acquire new knowledge through analyzing and researching new natural phenomena. (Pure Basic Type) ➢ Problem solving knowledge and creative fundamentals based research for a wide-range of applications for now and the future.
	2. Short-Term Industrial Technology Development	➢ Short-term (within 3 years) programs to commercialize new technologies and applications for developing new products and R&D.
	3. Long-term Industrial Technology Development	➢ Long-term (more than 3 years) programs to commercialize, promote R&D
	4. Public Technology Development	➢ Applied, Development and R&D programs that contribute to the quality of public life such as public health and disaster preventions
	5. Regional R&D	➢ Regional Infrastructure programs development such as university-industry cooperation, local clusters development
	6. Defense Technology Development	➢ Applied, Development and R&D programs that aims to strengthen the national defense and defense industry development
R&D Infrastructure & HR	7. Human Resources	➢ Supporting universities, colleges, professional training industry personnel and offering science and technology classes for primary and secondary education.
	8. Facilities & Equipment	➢ Construction of large research facilities and equipment ➢ It excludes purchasing simple equipment under the facility expansion with programs budget
	9. Diffusion	➢ Program purposes like technology commercialization, standardization, certification, outcome management/diffusion and policy support.
	10. International Cooperation	➢ Attracting overseas institutions, multilateral and bilateral cooperation agencies.

Source: Ministry of Science, ICT, and Future Planning (2013). National R&D Programs Standard Performance Indicators (Performance Goals & Indicators Guideline)

2.4. Past R&D Logic Model Researches

R&D performance research can also be separated by process phases. Numerous studies have also suggested that innovation and R&D should be managed as a process. According to Brown & Svenson (as cited by Ojanen & Vuola, 2003), R&D productivity should be evaluated as a processing system, which contains inputs, outputs, and outcomes. Cordero (1990) developed a model to measure innovation performance by looking at resources for technical, commercial, technical output, and marketable output units. Lee, Son & Lee (1996)

used fifteen important criteria from input, throughput, output and outcomes to measure R&D effectiveness for twenty eight firms in Korea.

Instead of measuring the R&D performance by process phase, a logic model, one of the tools used to identify R&D program plans, is commonly used to analyze the logic flow of the programs by finding disconnections in the flow. Despite logic models' unpopularity among government R&D program planning process in Korea, number of researchers has focused on logic models. Kang (2013) improved a R&D program logic model and conducted a feasibility study on logic models. Park (2015) examined the relationship between R&D performance creation processes with R&D logic model for innovative R&D programs. Park created a logic model and identified ten variables; three input variables (R&D budget, R&D period and R&D workforce); five performance variables (SCI Publications, Patent Registration, Technology Transfer, Sales, and New Employment); and two external influence variables (Institution Type and R&D Collaboration Type). Park used a logistic regression on 929 R&D project data. The study found that 1) input variables were positively correlated; 2) R&D budget was positively correlated with all 5 performance variables; and 3) performance variables were statistically significant.

To the best of our knowledge, there were no prior studies that have applied a logic model to a government support program in Korea as a case study to evaluate and measure the R&D performance.

3. An Outline of the Case Study: Proactive Support Program for International Environmental Regulation

This study compared two R&D types by carrying out a case study in Proactive Support Program for International Environmental Regulation. It compared the performance of R&D and R&D Infrastructure companies with companies that focused only on R&D. Finally, this study analyzed the developing mechanisms by linking R&D with R&D Infrastructure.

According to Korea Institute of Industrial Technology (KITECH) (2014), the main objectives for Proactive Support Program for International Environmental Regulation are to 1) to be proactive, 2) to build an eco-industrial programs that can enhance competitiveness, and 3) to support "low-cost timely response" by providing international environmental regulation information, consulting, human resource support and certification support. It also needs to constantly monitor international regulation trends to provide "proactive response" reliably and build/operate automotive/chemistry /electronic industry-related international environmental regulatory tracking systems.

There are five points to highlight about an infrastructure program. First, it is to provide up-to-date international environmental regulation information analysis and consulting support to companies. Second, it is to operate and manage chemical information in products and delivery system. Third, it is to diagnose domestic enterprises' environmental regulation cognitive level and to examine the impact of enactment/amendment of environmental regulations on industries. Fourth, it is to train experts in the field of international environmental regulations in the field of absorptive capacity of companies. Lastly, it is to support international environmental response R&D projects from 2006 to 2013. R&D was supported by type of technologies, such as product technologies, core industrial-environmental technologies, product services, and sustainable technologies.

Table 2 shows the different R&D performance of the program from 2006 to 2013. In a performance research conducted by yearly frequency analysis, the chart below shows that 2008 had the highest at 60, and decreased to 13 in 2013. This program

Table 2. R&D performance outcomes

	Frequency	Percent	Valid Percent
2006	11	5.0	5.2
2007	47	21.4	22.2
2008	60	27.3	28.3
2009	52	23.6	24.5
2010	9	4.1	4.2
2011	15	6.8	7.1
2012	5	2.3	2.4
2013	13	5.9	6.1
Total	212	96.4	100.0

is divided into infrastructure (which includes information, consulting, certification, and human resources) and R&D. 2014 Infrastructure project outcomes include a total of 897 cases of consulting and support services (177 cases of international environmental regulation counseling support, 683 cases of call center services, and 37 cases of on-site consulting). There were other outcomes, which include a total of 237 participants in the international environmental regulation proactive conference, 5 reports, enterprise database of 8,725 cases and personal database of 21,056 cases and more.

4. Research Methodology

4.1. Logic Model and its Usage for Program Evaluation

As described by Brown & Svenson (as cited by Ojanen & Vuola, 2003), innovation and R&D should be measured as a processing system, and therefore, this paper aims to measure the R&D performance of a Korean government support program through a logic model.

Logic model is a good tool to be used in managing, evaluating and measuring program performance. Logic model allows an in-depth, multi-perspective evaluation and dissemination of programs. According to Conrad, Randolph, Kirby & Bebout (2008), a logic model is a visual model that describes the essential components of a program, and shows the logical relationship between these components and their expected outcomes. There is no one way of representing a logic model, but it has four properties: 1) context; 2) theory and assumption of program's intervention; 3) the intervention; and 4) the outcomes. Logic model is a useful method for evaluating and measuring the R&D performance because not only the outcomes are visible, but also the probable relationship among components.

Through the course of program analysis, appropriate R&D performance measurement logic model is selected. Program logic model assists to better understand the work of stakeholders, performs program analysis to take advantages of performance targets and indicators, and analyzes the expected results of commitment of resources, program processes, and product specific time intervals (short, mid, and long-term). It also enhances the mutual understanding of different stakeholders like administrators, and evaluators by mapping out the program operations. Program associates can facilitate by linking performance targets and indicators through program analysis.

The performance measurement logic model is an instrument that observes the characteristics of a program utilizing components, such as ambient conditions and surroundings. Figure 1 displays a simple form of a logic model. There are a total of five components, which are inputs, activities, outputs, outcomes, and influences, such as important environmental features of the program such as social, cultural and political aspects. There are two sides to logic models: the R&D program/policy and the results chain. The R&D program/policy looks at the program or policy delivered by evaluating the inputs, activities and outputs. The results chain looks at the results from the program by separating the

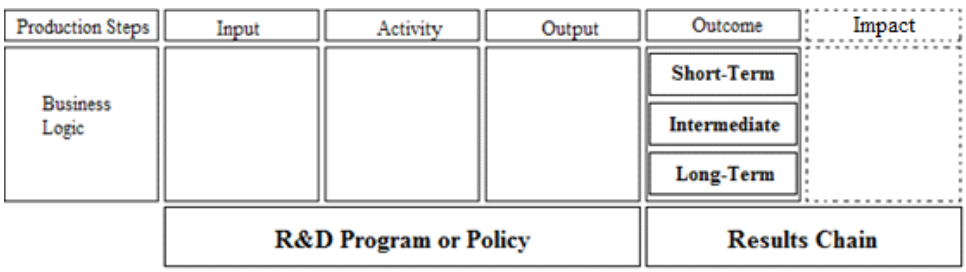
outcomes by time-periods (short-term, intermediate, and longer-term). It is expected that for short-term programs, the outcomes will occur within 3 years, 3 to 5 years for medium, and more than 6 years for long-term programs; however, it may vary depending on the program.

In detail, the "Input", also known as resources, for the logic model is related to funding, accumulated technical knowledge, facilities, equipment and other input required to support programs such as developing and promoting technologies. For "Activity", it is to induce a series of actions or outputs and results taken to achieve the technical development. "Outputs" is related to direct and immediate results in goods, services or products that can be reflected in numbers. The "Outcome" is presented as a program performance in the short-term (changes and benefits that are caused by program's outputs), intermediate (results from short-term outcomes), and long-term (impacts followed by intermediate outcomes). It is expected that short-term outcomes will occur within 3 years of the program's initial phase, 3 to 5 years for intermediate outcomes, and more than 6 years for long-term outcomes; however, it may vary according to the program. Since there are many arenas of R&D and innovations, there are different kinds of intermediate and ultimate outcomes such as economic, social and mission benefits (Jordan, 2008). "Influence" is not a result of the program, but is a critical feature of the performance. Influences, which can be either positive or negative, are the intended or unintended changes in the society or in the economy due to the implementation of programs.

The logic model process requires five steps (Samsuri, 2011): first, collecting information, second, defining the problem and context of the program, third, defining elements for the logic model, fourth, constructing the logic model, and fifth is to verify the logic model. Many governments' agencies have used logic models to monitor and evaluate programs. For example, the US Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) have used the logic model to increase energy supplies and modernize the energy infrastructure (Jordan, 2008).

A logic model has several objectives for program evaluation (Conrad et al, 2008). First, it provides clarification of program goals. Most programs have more than one goal; a logic model helps to identify the more important goals for evaluation. Second, it identifies underlining theory. Logic model is a "valuable tool for elucidating the theory behind a program because it defines the assumptions and the line of reasoning among the assumptions, activities and outcomes" (Conrad et al, 2008). Third, logic model provides a framework in which a program can be evaluated from. A logic model describes a model in details and can assist what data should be collected during the evaluation process. Fourth, logic model is a good tool that can help program managers to prevent from deviating from the ideal situation, and stay consistent throughout the program period.

Figure 1. Basic form of logic model



There are numerous benefits of using a logic model. First, it is a model that highlights "plausible pathways through which resources translate into outcomes" and sense how programs will function under set conditions (Samsuri, 2011). The logic models help to examine various aspects of the program, such as the type of R&D, managements, evaluation, planning and structure of the program to understand and set appropriate performance goals and indicators. The logic model can be created any time during the program life cycle, and can be revised as more information and data are collected.

4.2. Setting Performance Indicators for a Logic Model

Performance indicators are set according to the type of R&D when the logic model is established. R&D performance indicators can be examined using five performances (scientific, technical, economic, social and infrastructure). The Ministry of Science, ICT, and Future Planning (2013) recommends setting the performance indicators as presented in Figure 2 below for each type of R&D programs.

The program's length are determined by considering each program's characteristic, but in general as stated above, short-term programs last within 3 years, 3 to 5 years for mid, and more than 6 years for long-term programs. Performance targets and indicators must be configured by firm-type and by key performance achievements. For program types, other than basic research, program associates should avoid putting high weight on papers and journal articles, and should identify at least two performance indicators.

Scientific performance indicators are not associated with pure science, application or development. It refers to basic research, and applies to elementary principles of all areas, and represented by national R&D achievements like publications, and life resources.

Technical performance indicators are direct and indirect results of technological development aiming at industrial applications, contents, software, and services. It is difficult to distinct the initial and the applied phase, since it is closely related to the industrial nature. The results of technical development can be tangible such as IP (intellectual property), products, but also intangibles like services.

Economic performance indicators can be divided into either direct or indirect results. Direct results refer to economic values that were generated through market transaction. Indirect results refer to contents created by companies supported by R&D organizations. Examples of economic performance indicator are sales rise and market value of a company receiving support.

Social performance indicators refer to training, job creation and other human resources related areas, and are divided by sectors. It also represents promoting international cooperation, and creating a culture for technology and science. Some typical examples are employment related numbers (number of college graduates in the field, employment rate, etc.), and marketing performance.

Business Type/Period	Output	Short-Term Outcome	Long-Term Outcome
1. Basic Research	Scientific Performance Technical Performance	Scientific Performance Technical Performance	Scientific Performance Technical Performance Economic Performance Social Performance
2. Short-Term Industrial Technology Development	Technical Performance Financial Performance	Technical Performance Financial Performance	Technical Performance Financial Performance
3. Long-term Industrial Technology Development	Scientific Performance Technical Performance	Scientific Performance Technical Performance Economic Performance	Economic Performance
4. Public Technology Development	Scientific Performance Technical Performance	Scientific Performance Technical Performance Economic Performance	Economic Performance Social Performance
5. Regional R&D	Scientific Performance Technical Performance Economic Performance	Technical Performance Economic Performance Social Performance	Economic Performance Social Performance
6. Defense Technology Development	Technical Performance Economic Performance Infrastructure Performance	Technical Performance Economic Performance Infrastructure Performance	Technical Performance Economic Performance Infrastructure Performance
7. Human Resources	Scientific Performance Technical Performance	Scientific Performance Technical Performance	Economic Performance Social Performance
8. Facilities & Equipment	Infrastructure Performance	Infrastructure Performance	Economic Performance Social Performance Infrastructure Performance
9. Diffusion	Technical Performance Economic Performance Infrastructure Performance	Technical Performance Economic Performance Infrastructure Performance	Technical Performance Economic Performance Infrastructure Performance
10. International Cooperation	Scientific Performance Technical Performance	Scientific Performance Technical Performance	Economic Performance Social Performance

Figure 2. Programs' key performance by type (example)

Infrastructure performance indicators refer to research facilities, equipment, IT systems and military purpose technologies (weapon systems). Some typical examples are research facility equipment, information systems, and weapon systems.

5. Using the Logic Model in the Case Study Evaluation

For measuring the performance of the program, the study conducted a review of the performance measurement logic model and set the overall framework. In order to set the program evaluation logic model, it is necessary to look at the nature of the program systematically. In the case of this program, it is a key to distinguish the type of R&D (R&D or the R&D and R&D Infrastructure) and understand that logic models may vary accordingly. Proactive Support Program for International Environmental Regulation is a long-term industrial-technology development program; therefore, according to previous studies and Figure 2, the indicators would be the technical, economic and social performances.

Table 3. Examples of logic models for Proactive Support Program for international environmental regulation

Logic Models		Input	Activity	Output	Outcomes		
					Short-Term	Intermediate-Term	Longer-Term
Business Logic		Support International environmental regulation information analysis and consultation	Operate delivery system, manage chemical information, and measure impact factors	International environmental regulation policy satisfaction Utilizing international environmental regulation trend analysis	Additional investments in environment response industry Cutting down production costs Improving technical performance such as technology transfer success and patents	Increase sales Growth in exports Job creations Environmental compliance Creating university-industry partnership	Establishing international environmental regulation platform
Branch table by Business Types	R&D			Business performance satisfaction	Number of cases of creating IP Number of cases of technology transfer Total reduction of production costs Additional R&D proactive investments	Sales/Exports increase Total employment headcount Enhancing cooperative relations	Establishing international environmental regulation platform
	Infrastructure			Business performance satisfaction	Revenue generating contribution Creating new businesses Whether to invest in additional companies Resolving technical difficulties	Number of new technologies Promote university-industry cooperation Employ field personnel	Degree of vitalization of international environment regulation response

Table 3 shows the selected performance measurement logic model for the Proactive Support Program for International Environment Regulation. R&D part of the program can be divided into short-term industrial development and diffusion sector; it is difficult to output results for scientific and infrastructure achievements due to lack of support. The Ministry of Science, ICT, and Future Planning (2013) has created a set of performance indicators for different activities. The study selected the most appropriate indicators for Input, Process, Output, Outcomes (Short, Intermediate and Long-terms) of the performance measurement logic model.

In order to design and measure the performance measurement logic models, surveys and quantitative assessment were conducted. In order to analyze the logic models, the type of participation was separated into three groups: R&D only companies, R&D and Infrastructure companies, and Infrastructure only companies. Due to the different ways of supporting (logic models and the character of business), it is not easy to compare the performance of R&D only and Infrastructure only companies. Therefore, this study focused on comparing companies participating in R&D only with companies involved in R&D and Infrastructure.

Table 4. Forms of participation for Proactive Support Program for International Environmental Regulation (multiple responses)

Headings		Number of Cases	%
Companies involved in R&D		202	17.8
Companies involved in Infrastructure Program	Support in accordance to consultation		16.3
	Involved in environmental regulation proactive training		81.3
	Participation in international environmental regulation related events		40.1
	Obtain governmental proactive information on international environmental regulations		51.0

Table 5. International Environment-Government Support Program by company types

	Company Type	Frequency (Number)	Percent (%)
Participating in R&D	Conglomerates	1	6.7
	SMEs	8	53.3
	Venture Company	2	13.3
	Others	4	26.7
	Total	15	100.0
Participating in Both the R&D and Infrastructure	Conglomerates	8	38.1
	SMEs	6	28.6
	Venture Company	1	4.8
	Others	6	28.6
	Total	21	100.0
Participating in Infrastructure	Conglomerates	55	33.1
	SMEs	86	51.8
	Venture Company	5	3.0
	Others	20	12.0
	Total	166	100.0

5.1. Analysis and Common Achievements for Proactive Support Program for International Environmental Regulation

5.1.1. Subject of Analysis

This study conducted an analysis on 202 companies participating in the international environmental government support programs. Table 4 shows the different R&D types of firms that participated in the program. Research shows that only 18% companies, involved in the governmental support program, participate in R&D. Meanwhile, portion of environmental regulations training companies has increased to 81%. The range of companies involved in activities such as education and acquisition of information has increased.

Table 5 shows the companies participating in the program by types. The number of companies involved in only R&D was 15; whereas the number of companies involved in only Infrastructure was 166. In addition, 21 companies were associated with both the R&D and the Infrastructure. SMEs accounted for 53.3% and 51.8% of the R&D only and Infrastructure only companies, while a relatively large 38.1% of companies participating in both the R&D and Infrastructure were conglomerates.

Table 6 shows the satisfaction level and the opinion of the 202 companies that participated in the international environment government support program. The overall satisfaction level of this program is 3.31; partnership had the highest rating of 3.39, and followed by project system (3.29), and research outcomes (3.24).

Table 6. Satisfaction of the Proactive Support Program for International Environmental Regulation

Headings	Cases	Average Rating
Program Execution Systems	202	3.29
Partnerships		3.39
Research Outcomes		3.24
Subtotal		3.31

5-point scale (Very Unsatisfied: 1, Unsatisfied: 2, Average: 3, Satisfied: 4, Very Satisfied: 5)

Table 7. Satisfaction of the Proactive Support Program for International Environmental Regulation by company participation types

Headings	Type of Participation	Average Rating
Program Execution System	Participating in R&D	3.60
	Participating in both the R&D and Infrastructure	3.48
	Participating in Infrastructure & HR	3.24
Partnerships	Participating in R&D	3.87
	Participating in both the R&D and Infrastructure	4.00
	Participating in Infrastructure	3.27
Research Outcomes	Participating in R&D	3.73
	Participating in both the R&D and Infrastructure	3.67
	Participating in Infrastructure	3.14

Table 7 shows the overall satisfaction of the international environment government support programs by participating form. For project execution systems and research outcomes for companies involved in R&D showed a satisfactory level of 3.60 and 3.73, respectively. The satisfaction level with partners for companies involved in both the R&D and R&D infrastructure has been identified as high as 4.00. The satisfaction based on partnership for companies involved in R&D infrastructure is considered to be relatively low.

Table 8 indicates the different levels of satisfaction for the International Environment Government Support Programs' outcomes. Two highest ratings were policy settings (3.59) and support/information exchange (3.58). Satisfaction level for technical achievements like technology commercialization and new technology development was relatively low.

Table 8. Satisfaction for research outcomes of the Proactive Support Program for International Environmental Regulation

Headings	Number of Cases	Average Rating
International Environmental Policy Settings Satisfaction	202	3.59
Enhancement of R&D capabilities of the Company		3.24
New Technology/Product Development		3.16
Increased revenue through technology commercialization		3.05
International environmental response support and information exchange		3.58
Subtotal		3.32

Table 9. Satisfaction for research outcome of the Proactive Support Program for International Environmental Regulation by company participation types

Headings	Type of Participation	Average Rating
International Environmental Policy Settings Satisfaction	Participating in R&D	3.67
	Participating in both the R&D and Infrastructure	3.86
	Participating in Infrastructure	3.55
Enhancement of R&D capabilities of the Company	Participating in R&D	3.67
	Participating in both the R&D and Infrastructure	3.43
	Participating in Infrastructure	3.18
New Technology/Product Development	Participating in R&D	3.60
	Participating in both the R&D and Infrastructure	3.19
	Participating in Infrastructure	3.11
Increased revenue through technology commercialization	Participating in R&D	3.47
	Participating in both the R&D and Infrastructure	3.14
	Participating in Infrastructure	3.00
International environmental response support and information exchange	Participating in R&D	3.53
	Participating in both the R&D and Infrastructure	3.95
	Participating in Infrastructure	3.54

Table 9 shows the satisfaction for research outcomes of the international environment government support program by business participation types. For "international environmental policy settings satisfaction" and "international environmental response support and information exchange", companies participating in both the R&D and R&D infrastructure show relatively high satisfaction level of 3.86 and 3.95 respectively. For companies involved in R&D, satisfactions in "enhancement of R&D capabilities of the company", "new technology/product development" and "increase revenue through technology commercialization" are identified as 3.67, 3.60 and 3.47 respectively. Meanwhile, companies involved in R&D infrastructure show relatively low satisfaction level in research outcomes.

6. Performance Comparison of companies by R&D Types

In order to compare the performance by companies participating in both R&D and Infrastructure with companies involved in only R&D, the study analyzed the results in three perspectives: economic, social and technical performance.

6.1. Economic Performance

When analyzing the economic performance using the sales and production cost reduction, companies involved in R&D showed relatively higher than companies participating in both the R&D and the Infrastructure. This difference, however, is insignificant. Table 10 shows the statistics results of the economic performance of the program.

6.2. Social Performance

This study investigated the changes in sales and in cost reduction. For social performance, full-time employment workforce for both types of companies showed a similar number of an average of 2.5 workers. In addition, temporary job creation was slightly higher in companies involved in both R&D and Infrastructure than companies in R&D alone; however the difference is not statistically significant. Table 11 shows the statistics results of the social performance of the program.

6.3. Technical Performance

Comparing the technical performance before and after technological independence, companies participating in both R&D and R&D infrastructure were somewhat higher than companies involved in R&D. In addition, companies involved in both R&D and R&D infrastructure had a higher number of patent applications/registration and papers published. Companies involved in R&D only showed a higher number of technology transfers and in imports; the mean difference between the two types was considered to be statistically significant under 0.1%. Table 12 shows the statistics results of the technical performance of the program.

Table 10. Economic Performance for program participating companies by research types

	Cumulative Research Performance (times)	
	Sales	Production Cost Reduction
R&D	3.53	2.26
R&D and Infrastructure	3.25	1.70
t-test	0.845	0.416

Table 11. Social Performance for program participating companies by research types

	Full-time Employment (Headcount)	Part-Time Employment (Headcount)
R&D	2.56	1.11
R&D and Infrastructure	2.55	1.45
t-test	0.995	0.758

Table 12. Technical performance for program participating companies by research types

	Technology Independence		Technology Transfer (Number)	Technology Transfer Import (1 mil won)	Patents		Papers
	Before	After			Applied	Registered	
R&D	58.0	98.0	1.67	248.6	2.8	1.2	1.2
R&D and Infrastructure	62.5	107.5	0.85	138.5	6.0	1.3	4.5
t-test	0.833	0.774	0.069	0.453	0.430	0.975	0.125

* Figures for Patents and Papers are sum of both domestic and international

7. Conclusion

This study analyzed and compared the performance of companies involved in R&D and R&D Infrastructure activities utilizing the Proactive Support Program for International Environmental Regulation as a case study. It also evaluated the R&D performance by combining and isolating R&D and R&D infrastructure. In addition, Proactive Support program for International Environmental Regulation was a suitable case for this study because it is a program that supports both R&D and Infrastructure.

The analysis result shows only a handful of companies are actively involved in both R&D and R&D infrastructure in the program. Differences in technical, economic, and social performance showed no statistically significant. For economic performance, companies participated in R&D alone showed higher numbers, while for technical performance, companies involved in both R&D and R&D infrastructure had higher numbers. The consequence does not align with the previous studies' outcomes of combining technological and non-technological factors will improve innovation performance. Despite receiving additional government support through R&D and R&D infrastructure co-participation, existing companies rely on the government for support on investment areas that have to be self-financed. From the results of the analysis, it is difficult to state that combining R&D with R&D infrastructure will create higher performance than R&D alone; however, the study noted an important point in that it R&D activities, and its performance measurement need to be analyzed by types.

This study contains the following limitations. First, this government support program targeted a small number of companies in a limited area. This result cannot be predicted with limited analysis; therefore, a review of companies and more diverse programs are needed. Second limitation is measuring performance using government support program alone. Due to the high possibility of improving a company's performance through self-investment and support, reviewing company's innovation performance through indirect effect like government support shows limitation. Third limitation is in the logic model used in the research methodology. This research was conducted on the basis of the national R&D evaluation guidelines; therefore, the paper acknowledges that there is a limit in selecting a fragmentary policy methodology. However, this study was significant in applying an actual policy model and fixing the government's biased tendency to focus on R&D-oriented performance and exploring/comparing/reviewing the combined performance of R&D and R&D infrastructure.

Since the two R&D types of participation did not show statistically significant difference, it would be important to draw upon the policy implications. In the future research, a more diverse analysis and

comparison of science and technology policy programs of R&D types would be needed. In addition, showed in the analysis section of this study, it is important to distinguish R&D only and R&D for Infrastructure types. Looking at the current study analysis, since there was not a big difference in the performance between the two types, this subject of non-technological factor with technological factors will increase innovation performance need to be taken into account in depth.

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References

Chiesa, V., Frattini, F., Lazzarotti, V., Manzini, R., and Troja, I. (2008). An Exploratory Study on R&D Performance Measurement Practices: A Survey of Italian R&D Intensive Firms. Serie Tecnologia 14.

Chiesa, V., Frattini, F., Lazzarotti, V., and Manzini, R. (2009). Performance measurement in R&D: exploring the interplay between measurement objectives, dimensions of performance and contextual factors. R&D Management 39, 5.

Conrad, K., Randolph, F., Kirby Jr., M. & Bebout, R. (1999) Creating and Using Logic Models, Alcoholism Treatment Quarterly, 17:1-2, 17-31, DOI: 10.1300/J020v17n01_02

Cordero, R. (1990). The Measurement of Innovation Performance in the Firm: An Overview. Research Policy, 19, 2, 185-192.

Lee, M., Son, B. and Lee, H. (1996). Measuring R&D Effectiveness in Korean Companies. Research Technology Management, 39, 6, 28-31.

Jordan, G. (2008). Logic Models and Their Applications to Research, Technology, Development, and Deployment Policies and Programs [Mext Seminar Series].

Kang, H. (2013). Development of Logic Model for R&D Program Plan Analysis in Preliminary Feasibility Study. International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering,7(9).

Ministry of Science, ICT, and Future Planning (2013), National R&D program Standard Performance Indicators (Guideline for setting Performance Goal Indicators)

Mothe, C., & Nguyen Thi, T. (2010). The impact of non-technological innovation on technological innovation: Do services differ from manufacturing? An empirical analysis of Luxembourg firms. CEPS Instead.

Oak Ridge Associated Universities (ORAU). (2005). Performance Measurement of Research and Development (R&D) Activities.

OECD (2002). Frascati Manual: The Proposed Standard Practice for Surveys of Research and Experimental Development

OECD (2011), "Mixed modes of innovation", in OECD Science, Technology and Industry Scoreboard 2011, OECD Publishing.

Ojanen, V. and Vuola, O. (2003). Categorizing the Measures and Evaluation Methods of R&D Performance – A State-of-the-art Review on R&D Performance Analysis. Telecom Business Research Center Lappeenranta.

Park, S. (2015). The R&D logic model: Does it really work? An empirical verification using successive binary logistic regression models. Scientometrics, 105.

Samsuri, M. (2011). "Design R&D Program Evaluation Based on the Logic Model Approach: An Example from a Productivity Program in Indonesia." Asian Research Policy 2 127-38. Web. 23 Sept. 2015.

Schmidt, T., Rammer, C. (2007), "Non- technological and Technological Innovation: Strange bedfellows?", ZEW Discussion Papers 07-052, ZEW – Zentrum fur Europaische Wirtschaftsforschung GmbH/Center for European Economic Research

Szakonyi, R. (1994a). Measuring R&D Effectiveness-I. Research Technology Management, March-April, 37, 2, 27-32.

Szakonyi, R. (1994b). Measuring R&D Effectiveness-II. Research Technology Management, May-June, 37, 3, 44-55.

Tipping, J.W., Zeffren, E. and Fusfeld, A.R. (1995). Assessing the Value of Your Technology. Research Technology Management, 38, 5, 22-39.

Does Exposure to University Research Matter?—Evidence from Europe

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Abstract

This paper addresses the behavior and performance of young companies established by entrepreneurs who have been previously exposed to academic research for a considerable amount of time. We use data from a large survey of young companies established in ten European countries and eighteen high-tech, low-tech and knowledge-intensive service sectors. While a fair amount of similarity exists in terms of business motivation and client focus, our findings reveal the group of firms founded by Ph.D. holders to exhibit extensive dependence on university graduates and post graduates as employees, higher reliance on venture capital funding, higher dependence on internal R&D and external scientific and research networks as sources of knowledge, better innovative performance especially in terms of new-to- the world products, increased awareness of intellectual property protection and, last but not least, better performance both in terms of both employment/sales growth and international sales. These we find as important—even though exploratory—indication of support for our basic premise that exposure of company founders to university research affects entrepreneurial incentives and behavior in ways that reflect higher levels of creation and use of scientific and technological knowledge and market niche specialization.

Keywords: university entrepreneurship, academic research, knowledge-based entrepreneurship, SMEs, young firms

1. Introduction

Academic entrepreneurship has been a long discussed topic among scholars. Since the end of World War II, the outstanding success achieved by the application of scientific knowledge to the development of military technologies led to an exponential increase of government funding for academic research, especially in the US (Franzoni and Lissoni 2009). A parallel process has been the transfer of university produced knowledge to the private sector especially during the last three decades along with a remarkable increase in new forms of entrepreneurship associated with new innovations (Franklin et al., 2001) usually taking the form of 'university spin offs'. The idea that knowledge stemming from research conducted on university campuses can be used to commercial applications, led Etzkowitz (1998) to coin the term entrepreneurial university describing the role that universities have been assuming in modern economic development activities. In this vein, research universities are

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becoming increasingly engaged in entrepreneurial activities that allow them to capitalize and commercialize academic knowledge, while at the same time they also embrace entrepreneurial culture in the main academic areas of education and research (D'Este et al., 2010).

This paper examines young companies established by entrepreneurs holding advanced post-graduate degrees (Ph.D.). It explores the formation of entrepreneurial ventures created by individuals who have been previously exposed to academic research for a considerable amount of time, at a bare minimum of three years, during the preparation of their Ph.D. thesis. This is a form of academic-related entrepreneurship—defined rather broadly—implemented by graduates with advanced education background. Recent research suggests that entrepreneurship in new independent firms represents a possible 'missing link' between publicly available knowledge and economic growth through the exploitation of this knowledge (Acs et al., 2008). By examining the attributes of firms founded by Ph.D. holders we seek to shed more light on whether university research outputs and acquired skills can be converted into 'dynamic entrepreneurship' which in turn may affect positively economic growth and social well-being.

To the best of our knowledge, existing empirical studies do not take into account entrepreneurial activities that have been initiated by university graduates after they have left the university. These people are only loosely connected to the university and are very difficult to identify in empirical studies. In addition, most universities do not keep records of the companies founded by graduates from their undergraduate, master or Ph.D. programmes (Wright et al., 2007). Taking into consideration that a) there is a significant increase in the number of Ph.D. holders worldwide during the last three decades (OECD, 2013) and b) that the additional supply of highly qualified human capital cannot be fully absorbed in existing businesses, the need for new entrepreneurial activity becomes more significant. Our study, using a rich European dataset, attempt to address this gap in the literature by providing empirical evidence on the structure and behavior of young companies established by entrepreneurs holding advanced (doctoral) degrees.

A founding team's characteristics be can be critical to a young firm's success and subsequent growth. Founders with a broader general knowledge base are presumed to have a better ability to effectively search their environment and identify new opportunities (e.g. Ucbasaran et al., 2008; Shepherd and DeTienne, 2005). At the same time, entrepreneurs with a high degree of human capital are capable to fruitfully exploit new opportunities. In particular, the cognitive base and the educational background of the founders is an important variable for the study of knowledge-intensive entrepreneurship in general and academic entrepreneurship in particular. In this study we adopt a broader definition of academic entrepreneurship and investigate whether new ventures founded by Ph.D. holders exhibit different characteristics and/or different behavior patterns compared to the rest of the firms established in the same period in Europe. More specifically, the paper explores the extent to which this form of academic-related entrepreneurship possesses different properties in terms of employees' human capital, formation factors and funding, knowledge sources, success factors and strategy as well as innovation and firm performance.

The rest of the paper proceeds as follows: Section 2 provides a brief synthesis of the literature in search of a broader definition of academic entrepreneurship. Section 3 describes the dataset and section 4 presents the results of the empirical analysis and offers a discussion of the main findings. The paper ends with a section on conclusions.

2. In Search of a Broader Definition of Academic Entrepreneurship

A straightforward conceptualization of academic entrepreneur would suggest that he/she is "a university scientist, most often a professor, sometimes a PhD student or a post-doc researcher, who sets up a business company in order to commercialize the results of her research" (Franzoni and Lissoni, 2009). However, the abovementioned definition, although easily conceptualized, fails to take into full account the complexity of economic incentives that influence the behavior of academic scientists. In that vein, Franzoni and Lissoni acknowledge academic entrepreneurship as a multifaceted phenomenon that results from a much more complex set of strategies and incentives. They also suggest that academic research, in general, should rather be conceived as a 'scientific enterprise', in which career-motivated scientists act as research-oriented entrepreneurs, whose approach to commercial activities depends upon a broader career strategy (Franzoni and Lissoni, 2009).

When the term academic entrepreneurship was first introduced, it simply referred to an extension of business entrepreneurship to academia. However, its popularity increased through time and studies focused on this research can be integrated into three main categories representing the extensiveness of the definitions used: a) commercial approaches, b) knowledge transfer approaches, and c) value creation perspectives. The prevailing definitions of academic entrepreneurship originate from commercial approaches and center on the idea of for-profit business creation highlighting university spin-offs (Shane, 2004; Wright et al., 2009). A major drawback of commercial approaches is that they refer only to pure entrepreneurial intentions. In this way, they either exclude other means of profit making e.g. through knowledge transfer that the academia has at its disposal, or they disregard the fact that monetary value is just one type of value that can be generated through entrepreneurial action (Cantaragiu, 2012). However, the other two approaches of academic entrepreneurship broaden their scope and take these issues into consideration.

In particular, those scholars who choose to conceptualize academic entrepreneurship as a means of transferring knowledge from university to the market extend the definition of academic entrepreneurship so that it includes all types of contacts that academics may develop with business entities on the basis of monetary value creation both in the context of hard and soft academic entrepreneurial activities (Philpott et al., 2011). Hard activities produce more tangible entrepreneurial results and include patenting, licensing and spin-off formation, while softer activities may refer to knowledge transfer activities such as academic publishing, grant seeking and contract research which do not count as academic entrepreneurial examples under the strict commercial definition. In addition, value creation conceptualizations perceive entrepreneurship as a means of creating societal value without putting much emphasis on economic value (Botes, 2005; Kingma, 2011). In light of the above discussion, the main ideas which spun across the different abovementioned definitions can be integrated in order to arrive at a more complete and less vague conceptualization of academic entrepreneurship where individual or collective action is undertaken by academia members with the intention to transfer knowledge between the university and the external environment so as to generate economic and/or societal value (Cantaragiu, 2012).

Several scholars have attempted to broaden the concept of academic entrepreneurship. For example, Wright et al. (2007) in their study on academic entrepreneurship in Europe, focus not only on university spin-offs that build upon formal, codified knowledge embodied in patents but also include start-ups by faculty based in university which may

draw on their own IP or knowledge. They argue that they have broadened their perspective because in some institutional contexts intellectual property is not necessarily owned by the university and in this way they would miss a substantial part of reality. In a similar line of reasoning, Goel and Grimpe (2012) in their study of the differential forces driving academic entrepreneurship distinguish between research-driven academic entrepreneurship in which firm creation is a pure result of the scientist's drive to commercialize his research results created in the university, and general academic entrepreneurship in which firm creation is driven by factors (maybe chance, family connections, non-academic opportunity, due to someone else's research, etc.) other than the commercialization of the entrepreneur's own research results. However, as far as the role of individual academic entrepreneurs is concerned, while early work included a broad conceptualization of the academic entrepreneur (e.g. Doutriaux, 1998), more recent and influential scholarship put emphasis almost exclusively on the role of individual university faculty (Hayter et al., 2016) disregarding the fact that graduate students can have a catalytic impact on academic entrepreneurship (Boh et al., 2016; Lubynsky, 2012).

A common feature of the abovementioned studies is that although they stress the role of the academic entrepreneur as initiator of knowledge transfer from the university towards the creation of a new venture they do not take into account those companies created on the basis of university knowledge but not by members of the academia. Thus, firms created by university graduates after they have left the university are excluded. These people are only loosely linked to the university and are very difficult to identify in empirical studies. Most universities do keep track of the companies founded by graduates from their undergraduate, master or Ph.D. programmes (Wright et al., 2007). However, even in the case that they do it is usually not clear whether the company's set up is based on knowledge developed and transferred in the university setting or whether it is based on knowledge accumulated by the graduate outside the university. Nevertheless, the number of firms created by graduates should not be underestimated as empirical evidence show that they might even outnumber spin-offs (Wright et al., 2007).

In the present study a wider perspective of academic entrepreneurship is adopted suggesting that agents who have been exposed to academic research for significant lengths of time can create high-potential entrepreneurial ventures. Moreover, it is assumed that these new endeavors do not essentially encapsulate scientific or research knowledge directly created and consequently transferred from university into the business setting. In this vein, these ventures can be founded by people with a strong scientific background and a prior formal relationship with the academia who do not necessarily exploit knowledge generated during their academic career. In particular, we hypothesize that Ph.D. holders can be involved in 'high-potential' entrepreneurial action or knowledge intensive entrepreneurship setting up firms which focus on the dynamic application of new knowledge.

It is widely accepted that the founder(s) characteristics serve as important resources to competitive advantage in the creation of new entrepreneurial ventures. In particular, the cognitive base and the educational background of the founders is considered as an important factor for innovation (Arvanitis and Stucki, 2012). Through formal education, people acquire skills helping to identify opportunities in the external environment (Shane, 2000). In addition, a higher education level may enhance the ability of founders to absorb new ideas and thus the ability to conceive innovative opportunities.

There has been a significant increase in the number of Ph.D. holders as a percentage of the population across all countries between 2000 and 2011 (OECD,

2013). Taking into consideration that the educational attainment and previous research exposure of founders may be strongly related to innovative entrepreneurship, these individuals constitute a pool of high-potential would-be entrepreneurs. In this paper we investigate whether new ventures founded by Ph.D. holders exhibit different characteristics and/or different behavioral patterns compared to the rest of the firms established in the same period in Europe. More specifically, we try to link prior academic research exposure to knowledge-intensive entrepreneurship (KIE).

Knowledge-intensive entrepreneurship can be considered a type of high-potential entrepreneurship. It indicates ventures the initiation or expansion of which is based on the dynamic application of new knowledge. Knowledge-intensive firms can play important roles in sectoral, local and national innovation systems by operating as problem-solvers, knowledge brokers, knowledge-intensive service providers, or specialized suppliers. Following Malerba and McKelvey (2016), we rely on a formal definition of knowledge-intensive entrepreneurship developed in the context of AEGIS[1], a large-scale, integrated, EU-funded research project. Here, KIE is associated with four basic characteristics: (a) new firms (ventures); b) new ventures that are innovative; c) new ventures engaging in activities that are knowledge-intensive; and d) new ventures that are not to be found solely in high-tech industries, but may well be active in lower technology industries.

3. Data

The data used in the quantitative analysis originate in the AEGIS survey. The survey purported to identify the motives, characteristics and patterns in the creation and growth of knowledge-intensive young firms in high-tech manufacturing, low-tech manufacturing and knowledge intensive business services (KIBS). For the purpose of this study we delineated young firms as those founded between 2001 and 2007 i.e. firms that had been established for 10 years or less at the time of the survey and also had managed to exceed the critical three-year survival threshold. At the time of the survey, then, the sample firms were between 3 and 10 years old (average firm age 6.81 years) and were established in ten European countries: Croatia, Czech Republic, Denmark, France, Germany, Greece, Italy, Portugal, Sweden, and UK. The countries were selected strategically in order to include the largest four economies and some of the medium and small economies in Europe belonging into different socioeconomic configurations (e.g. Nordic countries, southern European countries, eastern European countries).

The survey targeted 18 sectors spanning the categories high tech, medium high tech, medium low tech, low tech, and knowledge-intensive services (see Annex 1).

The initial population of companies was drawn from the Amadeus database, which contains comprehensive information on over 18 million companies across Europe. This was supplemented with companies from additional data sources, namely Kompass and Dun & Bradstreet, in order to reach the pre-selected targets of sample stratification per country and sector combination.

The population extracted from all available data sources included 202,286 newly established firms, with reported primary activity in the pre-selected sectors.

To ensure the criterion of firm newness the questionnaire screened out:

- Firms that were just new legal entities, i.e. companies that have resulted from some kind of legal transformation of already extant firms

1 EU funded research project "Advancing Knowledge-Intensive Entrepreneurship and Innovation for Economic Growth and Social Well-Being in Europe" (AEGIS), 7th Framework Programme for Research and Technological Development, European Commission

· Subsidiaries of existing firms and firms that had resulted from a merger, an acquisition or a joint venture

The average response rate to the questionnaire was 31.2%, however it varied from country to country ranging from 19.5% in the UK to 39.9% in Croatia.

Data were collected through telephone interviews with one of the firm's founders carried out by a professional company using a structured questionnaire. The survey was launched in September 2010 and was completed in March 2011. During this period a pilot test of the questionnaire was run for approximately a month and 80 pilot interviews were conducted in all ten countries. This trial phase assisted considerably in checking whether the questionnaire was understandable to the respondents in different countries, testing its length and in improving its clarity. A total of 4,004 complete questionnaires were obtained, with data on almost 300 variables. Table 1 summarizes the obtained completed questionnaires per country across three categories of sectors: high tech (high and medium-high-tech), low tech (medium-low- tech and low-tech), and KIBS[2].

Table 1. Firm distribution across country and sector group

Country	Sector groups			Total
	High-tech	Low-tech	KIBS	
Croatia	29	114	57	200
CzechRepublic	26	78	96	200
Denmark	35	69	226	330
France	59	189	322	570
Germany	67	161	329	557
Greece	22	177	132	331
Italy	63	287	230	580
Portugal	29	154	148	331
Sweden	37	90	207	334
United Kingdom	56	160	355	571
Total	423	1479	2102	4004

In this paper we isolate the subsample of these new entrepreneurial firms that count among their founders at least one doctorate (Ph.D.) degree holder. These are 323 companies spread across all ten European countries. Their distribution across major sector groupings is shown in Table 2, in comparison to the sectoral distribution of non-Ph.D. founder firms. Knowledge-intensive business services account for a disproportionately large share: more than two-thirds of the Ph.D.-founder firms compared to almost half of the rest.

Table 2. Subsample characteristics

Sector group	Ph.D. Founder		Non-Ph.D. Founder	
	count	%	count	%
High-tech	50	15.5%	373	10,1%
Low-tech	45	13.9%	1434	39,0%
KIBS	228	70.6%	1874	50.9%
Total	323	100%	3681	100%

The majority of firms in both subsamples are micro firms with up to 10 people. Micro firms account for 64% of the firms in the Ph.D.-founder subsample for 60% of the firms in the non-Ph.D. founder subsample.

4. Findings

Our basic premise is that exposure of company founders to university research affects entrepreneurial incentives and behavior in ways that reflect higher levels of creation and use of scientific and technological knowledge and market niche specialization. We look at the educational levels of employees, factors affecting firm formation, funding sources, factors to create and sustain competitive advantage, overall strategic direction, sources of knowledge, and innovativeness by two groups of new companies: those founded by at least one person holding a Ph.D. degree and the rest.

2 See Annex 1 for an analytical list of sectors in the three sector groups.

4.1. Educational Level of Employees

A very first indication that firms founded by entrepreneurs exposed to university research are more knowledge intensive comes from the finding that in our sample across ten European countries and across eighteen sectors the vast majority of such firms (91%) employ university graduates with a mean number of 8 per firm compared to 63% of all other firms and a mean number of 5 such employees (university graduates)[3]. Breaking these numbers down per aggregate sector of activity, we observe sustained behavior across sectors with differences intensifying in low-tech sectors and KIBS (Table 3). Interestingly, differences increase when we look at employees with Ph.D. degrees (Table 4) where only a tiny 6% of non-Ph.D. founder firms employ a person with such a degree compared to more than three-fifths of the Ph.D. founder firms. These differences are consistent across all sector groups (Table 5).

Table 3. Firms employing people holding a university degree per sector group

Sector Group	Ph.D. Founders			Non-Ph.D. Founders		
	N	%	Mean number of university graduates per firm	N	%	Mean number of university graduates per firm
High-tech	44	88.0%	6.59	222	59.5%	5.85
Low-tech	39	86.7%	4.56	740	51.6%	3.35
KIBS	211	92.5%	9.16	1343	71.7%	6.15

Table 4. Firms employing people holding a Ph.D degree per subsample

Firm Type	Count of firms employing Ph.D. holders	% of firms employing Ph.D. holders	Mean number of Ph.D holders per firm
Ph.D Founders	226	70%	2.17
Non-Ph.D Founders	212	6%	1.84

Table 5. Firms employing people holding a Ph.D. degree per sector group

Sector Group	Ph.D.			Non-Ph.D.		
	N	%	Mean number of Ph.D. holders per firm	N	%	Mean number of Ph.D. holders per firm
High-tech	35	70.0%	2.23	25	6.7%	2.24
Low-tech	30	66.7%	1.73	57	4.0%	1.77
KIBS	161	70,6%	2,24	130	6,9%	1,79

4.2. Factors Affecting Firm Formation and Availability of Finance

The observed differences above in terms of university graduates' employment do not carry over to the factors affecting firm formation (Table 6). Similar factors lead to company formation across the two subsamples. Irrespective of the education achievement of their founders, firms are established in fields where founders have had significant prior experience and adequate market knowledge. Technical knowledge in this field, knowledge of the specific market, and networks established in prior career are

3 We would expect the differences to be even larger if the comparison population was firms founded strictly by non-university graduates.

quite important factors in setting up a company. T-tests across the two groups indicate that firms with Ph.D. founders exploit more effectively their technical and engineering knowledge in the field, while at the same time they appear to evaluate the identification and exploitation of opportunities related to changes in technologies or markets as more important factors for firm set up compared to their counterparts.

Such observations hint to a positive link between prior significant exposure to academic research and to fields of business activity that require it and a tendency to continue in the same trajectory in their newly established business. That is, a focus on more knowledge intensive market niches.

Table 6. Factors affecting firm formation

Factors	Ph.D. Founders (N=320)	Non-Ph.D. Founders (N=3658)	t-test (observed differences)
	Average rating	Average rating	
Work experience in the current activity field	4.34	4.31	0.317n.s.
Technical/engineering knowledge in the field	4.07	3.81	3.408***
Design knowledge	3.03	3.04	-0.198n.s
Knowledge of the market	3.98	4.06	-1.364n.s
Networks built during previous career	3.85	3.73	1.669n.s
Availability of finance	3.37	3.33	0.634n.s
Opportunities in a public procurement initiative	1.97	2.10	-1.779ns
Existence of a large enough customer	3.04	3.27	-2.804***
Opportunity deriving from technological change	3.23	2.95	3.349***
Opportunity deriving from a new market need	3.42	3.25	2.096**
Opportunity deriving from new regulations or institutional requirements	2.44	2.50	-0.636n.s.

*** denote statistical significance at p<1%, n.s: no significant differences observed

Table 7. Funding sources

Funding sources	Ph.D. Founders		Non-Ph.D. Founders	
	Count of firms using a specific source (N=315)	% of firms	Count of firms using a specific source (N=3605)	% of firms
Own financial resources	287	91%	3303	92%
Family member	29	9%	337	9%
Previous employer	14	4%	78	2%
Venture capital	35	11%	142	4%
Bank	60	19%	1018	28%
National government or local authorities	31	10%	250	7%
EU funds	9	3%	103	3%
Other sources	27	9%	150	4%

Table 8. Average percentage of funding

Funding sources	Ph.D. Founders	Non-Ph.D. Founders
	Average % funding	Average % of funding
Own financial resources	76.99	79.49
Family member	34.10	43.27
Previous employer	45.36	43.94
Venture capital	61.11	40.73
Bank	45.13	51.98
National government or local authorities	32.48	34.36
EU funds	27.78	34.51
Other sources	62.11	57.08

Similar observations could be made for funding sources. The two subsamples seem to behave quite similarly with the exception of greater support of new firms with Ph.D. founders by venture capital (Table 7). The difference between the two subsamples was basically compensated by a relatively larger support of firms with no Ph.D. founders by banks (implying lower risk). For those firms receiving it, venture capital funding accounted for a very significant share of funding (Table 8).

4.3. Success factors and strategy

The ranking of critical factors for creating and sustaining competitive advantage indicates that in both cases market focus and offering novel products or services dominate. For companies with non-Ph.D. holders in their founding team it appears that the capability to offer products at low cost is a more significant success factor. For companies with Ph.D. founders R&D activities, networking activities and relationships with other firms or universities take

Table 9. Factors for creating and sustaining competitive advantage

Success factors	Ph.D. Founders	Non-Ph.D. Founders	t-test
	Average rating (N=323)	Average rating (N=3521)	
Capability to offer novel products/services	3.76	3.68	1.287n.s.
Capacity to adapt the products/services to the specific needs of different customers/market niches	4.23	4.22	0.087n.s.
Capability to offer expected products/services at low cost	3.00	3.29	-4.201***
R&D activities	3.59	2.88	8.593***
Establishment of alliances/partnerships with other firms	3.26	2.92	4.407***
Capability to offer high quality product/services at premium price	3.89	3.72	2.597**
Networking with scientific research organizations	3.00	2.18	10.325***
Marketing and promotion activities	3.22	3.23	-0.035n.s

***, ** denote statistical significance at p<1%, and p<5% respectively, n.s: no significant differences observed

Table 10. Main strategy

	Ph.D. Founders (N=323)		Non-Ph.D. Founders (N=3681)	
	Count of firms	% of firms	Count of firms	% of firms
Offer standardized products and services at low cost	31	9.6%	608	16.5%
Offer unique products and services	199	61.6%	2148	58.4%
Exploit opportunities in new market niches	93	28.8%	925	25.1%

up higher importance (Table 9). Marketing and promotion activities seem to be equally important for both groups.

Main company strategy is to offer unique products and services followed by the exploitation of new market niches at some distance. Offering standardized products at low cost appears to be the least popular option for both groups. However, the percentage of firms with non-Ph.D. founders implementing the latter strategy is significantly higher compared to that of firms with Ph.D holders.

4.4. Sources of Knowledge

Clients are clearly the most important source of knowledge for indentifying business opportunities in both business groups. However, companies with Ph.D. founders assign relatively lesser role to suppliers and higher importance to internal sources of knowledge including R&D and know-how. Other external sources of knowledge such as universities and research laboratories are reported of moderate importance in both cases. However, they appear to be ranked higher by firms with Ph.D. founders. Participation in nationally or EU-funded research projects appears to be limited across the two groups. Nevertheless, these knowledge sources appear more significant for companies with Ph.D. holders in their founding team.

These findings suggest that although both groups rely mainly on external knowledge sources related to industry (clients and competitors) to explore new technological and market opportunities, firms with Ph.D. founders appear to rely more on in-house R&D activities and external knowledge sources related to science and research activities for this purpose. This may be argued to indicate a more prominent capability both in generating new knowledge and in absorbing scientific knowledge through participation in collaborative activities. Most interestingly, suppliers appear to be more important knowledge source for companies with non-Ph.D. founders suggesting that these firms try to balance their lack of internally generated knowledge with knowledge seeking activities related to industry actors.

Table 11. Sources of knowledge

Sources	Ph.D. Founders	Non-Ph.D.Founders	t-test
	Average rating	Average rating	
Clients or customers	4.40	4.41	-0.223n.s.
Suppliers	2.82	3.41	-7.639***
Competitors	3.22	3.28	-0.858n.s.
Public research institutes	2.45	2.07	5.000***
Universities	2.67	2.07	7.546***
External commercial labs/R&D firms/technical institutes	2.22	2.02	2.868***
In-house (know-how, R&D laboratories in your firm)	3.84	3.22	7.925***
Trade fairs, conferences and exhibitions	3.08	2.94	1.895n.s.
Scientific journals and other trade or technical publications	3.21	2.84	4.896***
Participation in nationally funded research programmes	2.27	1.86	5.140***
Participation in EU funded research programmes	2.11	1.85	3.293***

*** denote statistical significance at p<1%, n.s: no significant differences observed

4.5. Innovation

Three quarters of the firms with Ph.D. founders reported to have introduced new or significantly improved goods or services in the last three years compared to two-thirds of the remaining (Table 12). This was consistent across sector group, with firms in high-tech sectors leading firms in low-tech sectors followed closely by KIBS. It is important to note that innovating firms with Ph.D. founders outperform their counterparts in terms of introducing new-to-the market and especially new-to-the world innovations indicating capability to introduce more radical product innovations.

Table 12. Introduction of innovations

		Firm type			
		Ph.D. founders		Non-Ph.D. founders	
		# of firms	% of firms	# of firms	% of firms
Radicalness of Innovation	No Innovation	82	25%	1374	37%
	New-to-firm	49	15%	825	22%
	New-to-market	102	32%	1002	27%
	New-to-world	90	28%	480	13%
Total		323	100%	3681	100%

The firms in our sample generally use more informal (secrecy) or semi-informal (confidentiality agreements, trademarks) than formal (patents and trademarks) methods of intellectual property protection. Informal protection methods are often much simpler and faster to introduce than formal protection methods, and can be maintained with limited resources, which is very important especially for newly established firms. Formal protection methods require major financial and human resources if they are to be exploited thoroughly in business. Nonetheless, firms with Ph.D. founders use all methods of intellectual property protection more extensively than the rest (Table 13).

Table 13. Intellectual property protection

Methods	Firm type	
	Ph.D. founders	Non-Ph.D. founders
	% of firms	% of firms
Patents	31.5%	15.0%
Trademarks	49.8%	40.2%
Copyrights	34.9%	26.7%
Confidentiality agreements	79.7%	52.2%
Secrecy	58.5%	38.5%
Lead-time advantages on competitors	59.8%	53.1%
Complexity of design	57.7%	44.5%

It is also worth noting that companies founded by Ph.D. holders also reported higher innovative inputs in terms of R&D expenses compared to the second group. Results suggest that there is a statistically significant difference in terms of the percentage of turnover spent on R&D activities during the last three years.

4.6. Firm performance

Growth in firm size provides one measure of performance over time. Firm growth can be measured in terms of inputs (e.g. employees), value (e.g. assets) or outputs (e.g. sales revenues) (Delmar, 1997; Weinzinmer et al. 1998; (Colombo et al., 2010). We measure growth in terms of employees and sales. In addition we measured firm performance as the percentage of sales obtained in international markets during the last three years. Internationalization exposes young firms to multiple and diverse exogenous (e.g., competitive conditions) and endogenous stimuli (e.g., resource demand) (Sapienza et al., 2006). It reflects the degree of young firms' success in pursuing opportunities beyond domestic markets. Table 14 suggests that firms with Ph.D. founders outperform firms with non-Ph.D. founders in all performance measures used.

Table 14. Firm performance

Firm performance	Firm type	N	Mean	t-test (observed differences)
% Sales in International market	Ph.D. founders	323	26.04	6.466***
	Non-Ph.D. founders	3681	13.43	
Avrg. Growth Sales (quartile)	Ph.D. founders	301	5.77	2.966***
	Non-Ph.D. founders	3361	5.25	
Avrg. Growth Employment (quartile)	Ph.D. founders	306	2.29	2.589**
	Non-Ph.D. founders	3391	2.08	

***, ** denote statistical significance at p<1%, and p<5% respectively

5. Concluding Remarks

As the world economy is experiencing an unusual stage of stagnation and uncertainties, entrepreneurship and innovation are increasingly regarded as critical drivers of sustainable development. In addition, in an ever changing global environment where acculturation is fast, more attention to changing mindsets and open entrepreneurial spirit might be a prerequisite for successful individual careers, innovative performance of firms and sustainable development of nations (Vuong and Napier, 2015).

This explorative paper used a rich European dataset to take an initial look at the structure and behavior of young companies established by entrepreneurs holding advanced (doctoral) degrees. In this respect, the paper explores the formation and relative performance of new entrepreneurial ventures created by persons who have been previously exposed to academic research for a considerable amount of time. We suggest that this can be considered as a form of broadly defined academic-related entrepreneurship. We hypothesized that Ph.D. holders can be involved in "high-potential" entrepreneurial activity setting up firms focusing on the dynamic application of new knowledge. Our interest in this form of "high-potential entrepreneurship" stems from the fact that in the knowledge intensive economy this type of entrepreneurial activity matters more than ever before for economic development (Autio and Acs,

2007; Henrekson and Johansson, 2010) as it provides a link between the production of new technological knowledge and its consequent commercialization (Delmar and Wennberg, 2010). Moreover, to the best of our knowledge, empirical evidence on entrepreneurial ventures founded by Ph.D. degree holders is practically non-existent.

The paper uses data from a large-scale survey undertaken in ten European countries which reached over 4000 young, small firms established during 2001-2007 in a set of manufacturing sectors and knowledge-intensive services. About one-tenth of this population has been established by entrepreneurs holding doctoral degrees.

Our findings suggest that young European companies whose founders have been exposed to academic research indicate, on the aggregate, a fair degree of similarity in behavior to those whose founders have not had the same exposure. Important similarities between the two groups of companies include: 1) Market focus and offering novel products or services are the critical factors for creating and sustaining competitive advantage; 2) Main company strategy is to offer unique products and services followed at some distance by exploiting new market niches; 3) Clients are the most important source of knowledge.

In addition, however, our results reveal that the former group of firms (Ph.D. founders) exhibits extensive dependence on university graduates and post graduates as employees, higher reliance on venture capital funding, higher dependence on internal R&D and external scientific and research networks as sources of knowledge, better innovative performance especially in terms of new-to- the world products, increased awareness of intellectual property protection and, last but not least, better performance both in terms of both employment/sales growth and international sales.

These results are suggestive rather than conclusive as they are obtained through simple tabulations and t-tests rather than extensive econometric analysis. Nonetheless, we believe that they are indicative of important differences in behavior and performance of companies founded by people with significant prior exposure to academic research.

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References

Autio, E., Acs, Z.J., (2007), "Individual and country level determinants of growth aspirations in new ventures", Paper presented at the Third Global Entrepreneurship Research Conference, October 2007, Washington.

Acs, Z.J., Parsons, W., and Tracy S., (2008), "High-impact firms: gazelles revisited". Small Business Administration Advocacy Office, under contract SBAHQ-06-Q-0014, Washington, DC.

Arvanitis S., Stucki T., (2012), "What determines the innovation capability of firm founders?," Industrial and Corporate Change, 21(4), pp. 1049-1084.

Boh, W. F., De-Haan, U., and Strom, R. (2015), "University technology transfer through entrepreneurship: Faculty and students in spinoffs", The Journal of Technology Transfer.

Botes L., (2005), "Beyond the IvoryTower –From Traditional University to EngagedUniversity", in: Proceedings of United Nations Conference on Engaging Communities,Brisbane Convention Centre, Australia, 14-17 August.

Cantaragiu R., (2012), "Towards a conceptual delimitation of academic entrepreneurship", Management & Marketing, 7(4), pp. 683-700.

D'Este P., Mahdi, S., Neely, A., (2010), "Academic Entrepreneurship: What are the Factors Shaping the Capacity of Academic Researchers to Identify and Exploit Entrepreneurial Opportunities?", Danish Research Unit for Industrial Dynamics, Working Paper No. 10-05.

Delmar F., (1997), "Measuring growth: methodological considerations and empirical results". In Entrepreneurship and SME Research: On its Way to the Next Millennium, Donckels R, Miettinen A. (eds). Aldershot: Ashgate; 199–216.

Delmar, F., Wennberg, K., (2010), Knowledge Intensive Entrepreneurship: The birth, growth and demise of entrepreneurial firms, Edward Elgar, Cheltenham, U.K

Doutriaux, J. (1987), Growth pattern of academic entrepreneurial firms. Journal of Business Venturing, 2(4), 285–297

Etzkowitz, H. 1998, "The norms of entrepreneurial science: cognitive effects of the new university–industry linkage", Research Policy, 27(8), pp.823-833.

Franklin S. J., Wright, M., Lockett, A., 2001, "Academic and Surrogate Entrepreneurs in University Spin-out Companies", The Journal of Technology Transfer, 26(1-2), pp. 127-141.

Franzoni C., Lissoni F., (2009), "Academic Entrepreneurs: Critical Issues and Lessons for Europe", in Varga, A. (ed.) Universities, Knowledge Transfer and Regional Development: Geography, Entrepreneurship and Policy, Edward Elgar, Cheltenham, UK.

Goel R. K., Grimpe C., (2012), "Are all academic entrepreneurs created alike? Evidence from Germany", Economics of Innovation and New Technology, 21(3), pp. 247-266.

Hayter, C., Lubynsky, R. and Maroulis, S. (2016), "Who is the academic entrepreneur? The role of graduate students in the development of university spinoffs", The Journal of Technology Transfer, pp.1-18.

Henrekson, M., Johansson, D., (2011), "Firm Growth, Institutions and Structural Transformation", In Fritsch M. (ed.) Handbook of Entrepreneurship and Regional Development. Edward Elgar, Cheltenham, UK.

Kingma B., (2011), "Preface" in Kingma, B. (ed.), Academic Entrepreneurship and community engagement: Scholarship in action and the Syracuse Miracle, Edward Elgar Publishing, Massachusetts.

Lubynsky, R. (2012), "Critical challenges to nascent academic entrepreneurs: From lab bench to innovation", University of Maryland, unpublished dissertation.

Malerba, F., McKelvey, M. (2016), "Conceptualizing knowledge-intensive entrepreneurship: definition and model", in Malerba, F., Caloghirou, Y. McKelvey M. and S. Radocevic (eds) Dynamics of Knowledge-Intensive Entrepreneurship: Business Strategy and Public Policy, Routledge, Oxon, UK.

Mangematin V., (2000), "PhD job market: professional trajectories and incentives during the PhD", Research Policy, 29(6), pp. 741-756.

Organization for Economic Cooperation and Development (2013), Science, Technology and Industry Scoreboard, Paris: OECD.

Philpott K., Dooley L., O'Reilly C., Lupton, G., (2011), "The entrepreneurial university: Examining the underlying academic tensions", Technovation, 31(4), pp. 161–170.

Sapienza, H. J., Autio, E., George, G., & Zahra, S. A. (2006), "A capability perspective on the effects of early internationalization on firm survival and growth", Academy of Management Review, 31: 914–933.

Shane S., (2004), "Encouraging university entrepreneurship: the effect of the Bayh-Dole act on university patenting in the United States", Journal of Business Venturing, 19(1), pp. 127-151.

Shepherd, D. and DeTienne, D. (2005),"Prior Knowledge, Potential Financial Reward, and Opportunity Identification", Entrepreneurship Theory and Practice, 29(1), pp.91-112.

Ucbasaran, D., Westhead, P., and Wright, M. (2008), "Opportunity identification and pursuit: does an entrepreneur's human capital matter?" Small Business Economics, 30(2), pp.153-173.

WeinzimmerL.G, Nystrom P.C., Freeman S.J., (1998), 'Measuring organizational growth: issues, consequences and guidelines', Journal of Management, 24(2): 235-262.

Wright M.,Clarysse B., Mustar P., Lockett A., (2007), Academic Entrepreneurship in Europe, Edward Elgar Publishing, Cheltenham, UK.

Wright M., Piva, E., Mosey, S., Lockett, A., (2009), "Academic entrepreneurship and business schools", The Journal of Technology Transfer, 34(6), pp. 560-587.

Vuong, Q. and Napier, N. (2015), "Acculturation and global mindsponge: An emerging market perspective", International Journal of Intercultural Relations, 49, pp.354-367.

Annex 1

Table I. Industry coverage in the AEGIS survey

Selected Sectors	NACE rev. 1.1 code
High-technology manufacturing sectors	
Aerospace	35.3
Computers and office machinery	30
Radio-television and communication equipment	32
Manufacture of medical, precision & optical instruments (scientific instruments)	33
Pharmaceuticals	24.4
Medium to high technology manufacturing sectors	
Manufacture of electrical machinery & apparatus	31
Manufacture of machinery and equipment	29
Chemical industry (excl pharma)	24 (excl. 24.4)
Low-technology manufacturing sectors	
Paper and printing	21, 22
Textile and clothing	17, 18, 19
Food, beverages and tobacco	15+16
Medium to low manufacturing sectors	
Basic metals	27
Fabricated metal products	28
KIBS sectors	
Telecommunications	64.2
Computer and related activities	72
Research and experimental development	73
Other business services activities	74.1, 74.2, 74.3, 74.4, 74.5, 74.8*

How Do Chinese Firms Manage Innovation? A Perspective of Dynamic Capabilities

Wei Zhao

Abstract

Combining the literature on technological catch-up, innovation management and dynamic capabilities, this paper identifies the major problem when firms from developing economies manage the process of innovation when they are approaching the technological frontier. Illuminated by an array of empirical cases of Chinese firms from multiple industries, we find that their common weakness of managing innovation is often the lack of integrating and articulating simultaneously technological change, market change and organizational change in a dynamic way, i.e., a kind of "dynamic capabilities" of management at strategic level. For years Chinese industrial firms have accumulated technological capabilities through different modes (technology transfer, indigenous R&D, and foreign technology acquisition, etc.) and different relationship with customers in the market, now they have to improve the quality of innovation management if they seek to produce significant innovation outcome and compete with the innovative firms from the advanced economies. The findings contribute to research and management practice on how catch-up firms in developing countries can transform themselves from imitators or followers to innovators.

Keywords: innovation management, dynamic capabilities, strategic integration, technological change, Chinese firms

1. Introduction

The recent Chinese industrialization has been a rapid integration of SMEs in global networks of contractors, for example in electronics and clothing, and the development of an important domestic light industry which provides parts and sometimes equipment to foreign companies. Now, the challenge to the Chinese firms is to find ways to "move up the global value chain", that is to say, to produce more sophisticated products and be less dependent on international outsourcers (Bironneau, R., R. Arvanitis, F. Bafoil and B. Kahane, 2012). In reality, there are many Chinese firms beginning to move from being simply assemblers or providers to having access to final market of consumption. They want to choose their markets rather than being chosen by their foreign clients. Beyond strong production experience and technology accumulated in business, these Chinese firms try to combine new technologies from different sources in order to adapt to market conditions. Overall, it appears that China is struggling to build a real innovation capacity of industry (Zhao, W. and R. Arvanitis, 2010).

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China's massive industrialization has been actively promoted by its government (Zhao, W., R. Arvanitis and F. La Pira, 2011). Since its first National Development Plan of Innovation in 2000 (Bironneau, R., 2012), the government invested heavily in building innovation capabilities, especially in terms of inputs. China's total R&D investment has risen from $30 billion in 2005 to $200 billion in 2014 (2% of GDP), making it the No. 2 R&D spender in the world in absolute terms since 2006. Chinese universities confer 28700 PhDs in science and engineering per year and Chinese researchers published more than 420000 scientific papers in 2013 (Zhao, W., 2015).

With government support, there were signs of development of innovation capacity through firm R&D as well as creation of R&D centers by multinationals in China. Some iconic companies made seriously investment in R&D, such as Huawei (9% of sales, or 5.9 billion Yuan per year) and Lenovo (2.8 billion Yuan per year). The result was in an increase in both labor productivity (value added per head) and total factor productivity in the manufacturing sector since 1990s. This exceptional growth regime has attracted some argument that Chinese firms have developed a new model of disruptive innovation, called "cost innovation", i.e., making innovations by exploiting low cost labor and materials (Zeng, M. and P. J. Williamson, 2007). A recent McKinsey report also concludes that China has the potential to meet its "innovation imperative" and to emerge as a driving force in innovation globally. Chinese industry is more innovative than is generally acknowledged. Chinese firms have established strong positions in two types of innovation—developing new products and services that address consumer needs, and process innovations that make manufacturing more efficient. But China needs to make more efforts on raising innovation performance in engineering and science for industries (McKinsey & Company, 2015). For Hout and Michael (2014), the speed with which Chinese firms develop new products from existing technologies and ramp up large-scale production is quite impressive. They learned how to produce swiftly to meet buyers' demand for quick turnaround; to adapt designs to use different materials when the original materials were too expensive or unavailable; to modify equipment so that they could make different products; and, above all, to keep costs down. Though Chinese firms don't involve the upstream creation of technology, original designs, selection of materials, and design of equipment, or customer knowledge and marketing savvy, their strong points are mainly downstream industrial competencies. The practices of Chinese firms in managing innovation are characterized by the following ways (Hout, T. and D. Michael, 2014):

- Chinese firms generally keep engineering and manufacturing close, often co-locating them.
- Chinese firms tend to acquire new technologies either through formal licensing deals or by reverse-engineering them, but they keep the physical work of experimentation and production in-house.
- Chinese firms hire more midlevel engineering and manufacturing people, even though they're getting expensive. The added engineering and manufacturing bandwidth gives the Chinese firms possibility of solving difficult problems in product industrialization. As many people know, when Apple had to redesign the screen of its first iPhone at the last minute, its Shenzhen supplier roused its engineers out of bed, developed a better screen, and overhauled the production line—in just four days' time.

However, despite Chinese firms' strong growth in R & D and rapid catch-up in technological capabilities, few of them have built up sustainable technological dynamics on indigenous R & D. In

other word, the innovation capacity of Chinese industry is still "potential" than real (Zhao, W., 2006; 2013). In fact, innovation capacity of firms depends largely on relationships with suppliers and customers, with organizations and institutions that can supply technologies, and with the immediate environment that allows firms to consolidate R & D and engineering activities. This systemic nature of innovation requires not only learning and using of advanced technologies, but also more sophisticated approaches and competencies of management. Firms never come out with new products or improved processes in isolation. For innovation, they have to manage simultaneously the changes in technologies, organizations and markets, and integrate them timely (Tidd, J., J. Bessant and K. Pavitt, 1997). By the time of the 2008 crisis, Chinese firms had already very well taken use of the double trends of globalization of industrial production and standardization of complex technologies. But it was also during this period of time that the weakness of Chinese innovation capacity became evident: Most of Chinese firms begun to touch an "invisible ceiling" of forging ahead to innovate in global competition. They know much better how to use the "common" process and engineering know-how supplied by Western firms to power the global value chains than how to manage the whole company to transform from imitators or followers to true innovators.

How Chinese firms manage innovation? What are exactly the weak points in their management? How can they improve it? Using some Chinese industrial firms as examples, this paper aims to explore certain problems of innovation management that catch-up firms from developing economies have to consider when they are approaching the innovation frontier, either in technology or business model. For these catch-up firms, there is no simple and automatic progression from the early stage of accumulation of technological capabilities to high-level stage of building up of management capabilities of integrating skillfully the complex change processes of innovation. Thus, the paper particularly analyses the characteristics of the catch-up firms' innovation management and summarizes their practice weakness at strategic level as a lack of "dynamic capabilities" of top managers.

This paper is organized in 6 sections. After this introduction, Section 2, based on some existing theoretical literature, will construct a framework to clarify the nature of innovation management for catch-up firms. Section 3 presents data collection process and methodology. In Section 4 and 5, we carry out qualitative analysis on some Chinese firm cases from multiple industries to illuminate precisely their core problems of innovation management. Section 6 concludes.

2. Management of Innovation in Catch-up Firms: From Changing Processes to Dynamic Capabilities

In literature, firms in developing economies are often called "latecomers" because they are dislocated from international sources of technology, science and R&D, or even dislocated from demanding users, international markets, advanced user-producer links, clusters, networks, industrial districts etc. (M. Hobday, 1995). When they learn over time to accumulate technological capabilities and progressively carry out some innovative activities, they become "catch-up" firms because they begin to compete with firms at the international frontier in advanced industrial countries (Mathews, J.A. 2006). However, many catch-up firms have experienced substantial difficulty during this process of transformation from imitators or followers to real innovators. The traditional literature of catch-up firms emphasizes on their technological learning process and knowledge acquisition practice while inadequate attention has been paid to their strategic management aspects. On the other side, there is a

large amount of literature on management of innovation and the role of dynamic capabilities in Western innovative firms, which can be a heuristic to explore the managerial aspects of catch-up firms.

2.1. Challenge of Developing Innovation Capacity in Catch-up Firms

The existing theory cleaves into two different arguments about how catch-up firms in developing countries can advance from imitation to innovation. On one side, the "sustaining perspective" is represented by the works of A. Amsden and M. Hobday. Amsden (Amsden, A. 1989; Amsden, A. H. and W-w. Chu 2003) identifies that technological learning at shop-floor of firms is the original driving force of upgrading to innovation. She detailed the three aspects of technological learning as: 1) speed of learning (how rapidly foreign technology is borrowed, which depends on investment rate of firm, investing in foreign design, and arrangement of technology acquisition or transfer), 2) scale of learning (whether foreign technology is utilized at the appropriate scale, which depends on how fast the market is growing and whether firm is producing at an appropriate scale), and 3) efficiency of learning (how efficiently foreign technology is employed, which depends on firm's experience related to cumulative production and the effects of learning-by-doing on firm). Very much in line with Amsden, Hobday (1994; 1995) shows how electronics companies in the four dragons of East Asia link their technological learning to export markets; specifically, subcontracting and original equipment manufacturing (OEM) mechanisms acted as a training school for latecomers, enabling them to overcome entry barriers and to assimilate manufacturing and design technology. In contrast with R&D and design-led strategies, catch-up firms often began with incremental improvements to manufacturing processes which led on to minor product innovations. Since the development of technological capabilities during catch-up is a learning process, firms' internal development and design capabilities grow as they move between successive stages from OEM to ODM (original design manufacturing) and OBM (original brand manufacturing), but there is no role for research. Based on East Asian experience, the sustaining perspective asserts that successful catch-up firms may go through a kind of 'reverse product cycle.' They begin with simple assembly processes but gradually and systematically accumulate the capability to modify, design and build their own new product and process technologies progressively. Customers play a major part in this cycle, which proceeds through successively higher value-added forms of production.

China's technological learning at the firm level brings nothing new to this existing model of catch-up in East Asian economies. The Chinese firms followed a mixed pattern of interactive learning, maintaining a variety of sources of technology, keeping a large portfolio of clients and products, accepting to be at the same time manufacturing subcontractors, OEM providers for some products, and autonomous brand makers for others, depending on the market. They introduced new models as long as their foreign clients provided them new blueprints. Even firms advancing more rapidly toward an innovation frontier are in this pragmatic, down-to-earth catching-up model, upgrading cumulatively productive and control knowledge. These catch-up firms, who entered in a transitional stage in upgrading from a basic production to more sophisticated technology development, maintained the same diversified types of contacts with their clients, simply aggregating more sources of knowledge and trying to keep a multiplicity of external sources (Arvanitis, R., Zhao, W., Qiu, H. and Xu, J.-n., 2006).

The other argument about imitation to innovation can be termed as "disruptive perspective". Through the case of a Mexican company Vitro, the largest

glass company in the world after Owen-Illinois, Gabriela Dutrénit (2000; 2004) argues that there is no simple linear progression from the early stage of accumulation of the minimum levels of innovative capability to the management of knowledge as a strategic asset and the deployment of core capabilities. The transition process is complex and while catch-up firms make the breakthrough in innovation, they have to build deeper and broader specialized knowledge and develop new ways of strategic integration. The innovation capability can be reached only through a specific kind of "spontaneous" actions rather than a succession of different stages of formation of technological capabilities. Similarly, based on South Korea's experience from imitation to innovation, Linsu Kim (1997; 1998) argues that cumulative learning of firms takes place through learning-by-doing, but discontinuous learning takes place only in crisis. Effective learning firms (such as Hyundai) construct a crisis by setting ambitious targets intentionally to develop organizational systems and manage their processes to make the crises truly creative. Although creative imitation (producing knockoffs and clones) through reverse-engineering is still important, it is the continuous increase in in-house R&D investment that plays the key role in leap from coping imitation to indigenous innovation. He suggests that catch-up firms shall intensify dramatically their formal R&D activities to engage in independent product innovation and participate actively in global alliances. The continuing debate over whether the technological learning, or the production mode, or the market linkages, or the knowledge management, or the R&D management is the key for catch-up firms to move onto innovation stage calls for more attention to basic theories on management of innovation in Western advanced firms. Indeed, innovators can inspire the followers on which way to take.

2.2. Managing the Process of Innovation

At general level, innovation can be regarded as a series of industrial activities translating new technologies and knowledge into products and services in the market. These activities of firms are technical, commercial and economic by nature and consist essentially of interactive learning between individuals and organizations related to implementing new technologies. In a broader sense, innovation involves institutional, organizational and psychological changes in doing business. In management practice, it is more pertinent to take "innovation" as a complex process or processes than just as results of process. As shown by the linked-chain model (Klein, S., 1985), the key activities include "research and knowledge creation", "market exploration and discovering," "invention and analytical design", "details design and test ", "re-design and manufacturing", and " distribution and marketing", etc. They are linked with each other and constitute different feedback loops with different types of innovation. According to Dosi (Dosi, G., 1988), innovation as a process is an adventure of searching and problem-solving. It needs to mobilize and combine public and private (individual-specific and firm-specific) knowledge, general scientific principles, and unique experience. It also needs appropriate procedures of communication among knowledge and implicit capabilities.

Pavitt (Pavitt, K., 2003) identified three overlapping processes of innovation: the production of knowledge; the translation of knowledge into products, systems, processes and services; and the continuous matching of the product of innovation to market demand. The difficulty of managing innovation process lies in the fact that with the increasing specialization of knowledge production and the sophistication of products and contained knowledge, it is more and more difficult to integrate technological opportunities, market demand, and

organizational arrangements just rightly to produce the expected new outcome. To innovate, firms have to coordinate and integrate various specialized knowledge, and carry out learning under conditions of uncertainty. The formal management approach proposed by Tidd, J., J. Bessant and K. Pavitt (1997) emphasizes on supporting the innovation development project through coordinating four strategic aspects: elaborating an innovation strategy, building an organization for innovation, setting up implementation mechanisms of project, and exploiting external links with market and alliance. Similarly, Trott (Trott, P., 2005) defined innovation management as the practice of integrating activities of strategic planning, technology research and development, marketing, and organizing, all based on firm's accumulated knowledge. Thus, the nature of innovation management is not managing the processes of technological change, market change and organizational change separately, but coordinating and integrating all these changes.

In practice, the management of technological change emphasizes on new technology forecasting and evaluation (Christensen, C. M., 1997), new product development (Henderson, R. M. and K. B. Clark, 1990), R&D investment (Cohen, W. and D. A. Levinthal, 1990), and innovative design (Le Masson, P., B. Weil and A. Hatchuel, 2010). These activities reach beyond efforts to improve the efficiency of production or research and development, to include the effectiveness of technological development, which is the translation of technology into successful products and services. Based on the classic model of "innovation diffusion" (Rogers, E. M., 1983), the management of market change had a shift from depending on crude market segmentation and analysis of consumer behavior, to relationship and networked marketing that demands fine targeting of product development and closer linkages with lead customers (Hippel, E. v. 1989 ; Moore, G. A., 2014). The management of organizational change has shifted from an emphasis on change management of structure and culture, to the design and improvement of new mechanism for project implementation and internal work processes, such as knowledge management (Nonaka, I. and H. Teukeuchi, 1995), corporate venturing (Burgelman, K. A. and L. R. Sayles, 1986), and external linkages and networks to profit from innovation (Teece, D., 1986).

However, the knotty part of innovation management is still at firm's strategic level. Since the processes of technological, market and organizational change interact with each other, the management of innovation is inherently interdisciplinary and multifunctional. It compasses the management of R&D, production and operations management, marketing management, product development or organizational development. Strategic managers should match organizational structures and processes which support innovation, and opportunities for, and constraints on, innovation in specific technological and market environments. The key task of managing innovation is how to integrate simultaneously these changes of market, technology, and organization (Tidd, J., J. Bessant and K. Pavitt, 1997). Schumpeter's economics definition of innovation is long overdue for the realization of new combinations of factors of production. But the strategic management focus is more on combination of various change processes. Taking the project management of a radical innovation as example, the first step should be selecting the right disruptive technology. There are two criteria for a disruptive technology: it never exceeds the existing technical performance but exceeds the performance requirements of the market; and it is improving rapidly its own technical performance. Once managers decide to pick up technology for its disruptive nature, the next step is to position the initial market for the technology. Because the technological change implies an

emergence of new market, managers can only detect the new segment relying on weak signals generated from interacting directly with experts, scholars, venture capitalists and potential distributors, and other unconventional channels. Managers can get market information such as who the customers are, which product features they want, and what price they would pay, by fast experimental marketing or market tests through a related or unrelated start-up organization. At the same time, the created start-up organization shall undertake the business development with disruptive technology. Even when the emerging market becomes bigger and stable, this organization's independence in design, production, sales and distribution shall be maintained, instead of being assimilated back into its parent company (Bower, J. L. and C. M. Christensen, 1995).

2.3. Dynamic Capabilities: Strategic Integration for Innovation

The strategic dimensions of managing innovation by top managers can be characterized as a main part of the "dynamic capabilities", which enable firms to create, deploy, and protect the intangible assets that support superior long-run business performance (Teece, D., 2007). Originally, the concept refers to firms' ability to adapt to and exploit changes in their business environment and even to provoke change. According to perceptions of stability or dynamism in the environment, some authors decompose dynamic capabilities into three levels: incremental, renewing, and regenerating capabilities of firm (Ambrosini, V., C. Bowman, and N. Collier, 2009). More precisely, all along the activities of enhancing, combining, protecting, and, when necessary, reconfiguring the firms' intangible and tangible assets, dynamic capabilities can be disaggregated into three specific capacities: (1) to sense and shape opportunities and threats, (2) to seize attractive market possibilities, and (3) to transform the organization to maintain good fit with the business environment (Teece, D., 2007). Sensing means firms actively predict the future, study, search, scan and explore all the development possibilities. Seizing means firms make choice among opportunities, invest to exploit the potentials, and allocate resources to realize development. Transforming means firms fix resources in assets, institutionalize the activities, create new structures and change routines to keep the development trend. Dynamic capabilities are the fruits of entrepreneurial management of managers. Entrepreneurship is about sensing and understanding opportunities, getting things started, and finding new and better ways of putting things together. It is about creatively coordinating the assembly of disparate and usually specialized elements, getting 'approvals' for non-routine activities, and sensing business opportunities. Entrepreneurial management has little to do with analyzing and optimizing. It is more about sensing and seizing—figuring out the next big opportunity and how to address it (Teece, D., 2012).

The very entrepreneurial and forward-looking nature of dynamic capabilities is exactly what management needs for innovation. Though dynamic capabilities are firm-specific and different firms may need expertise in different areas, they are generally manifested by firm's competency of integrating activities of different natures: the exploration of strategic options and certain opportunities, the exploitation of technological endowment and unique intellectual property, as well as its customer base and upstream relations with suppliers, and the organizational "routines" or common aspects of practice in the firm that allow it to adjust to a user needs to get a customer, and to establish a price for products / services without too much regard for competition. This strategic management competence to overview and combine different change processes is a unique asset to firms in innovation-based competition. In large multi-technology multi-market

corporations, headquarters management staff has to develop such dynamic capabilities because they are able to mobilize and allocate resources to innovation project. In capital market and financial institutions, some venture capitalists and investment bankers also build up their visions over innovative projects and use financial tools (portfolio management, option-pricing method, etc.) and corporate governance restructuring power (alliance, merger and acquisition, spin-off, etc.) to combine various processes of changes (Teece, D. and G. Pisano, 1994; Teece, D., G. Pisano and A. Shuen, 1997).

The decomposition of dynamic capabilities into concrete actions of sensing, seizing and transforming has significant implication to innovation management. In fact, strategic integration of technological change, market change, and organizational change requires all these concrete actions in each change process. Therefore, developing and coordinating the dynamic capabilities in every change process constitute the key roadmap of innovation management. As demonstrated by literature, managing firms with some accumulated technological capabilities from developing economies to forge ahead to compete with world-class enterprises at innovation frontier is not an easy job. The combination of detailed breakdowns of dynamic capabilities and innovation process provides a fresh framework to assess and manage the innovation practice of catch-up firms.

3. Data and Methodology

The following section will use some cases and examples of Chinese industrial firms to illuminate how they seek to establish innovation capacity in terms of strategic management. The firm cases in textile and electronic industries are all based on primary information collected through visits and in-depth interviews. The main fieldwork in China was carried out between March of 2007 and April of 2009 through the research program "Innovation Potential of Chinese Industries", financed by the Hong Kong –based French Research Center on China (CEFC) in cooperation with the Research Institute of Guangdong Development (Sun Yat-sen University in China). Thanks to the official nature of the research program, most of our firm visits were recommended, arranged and accompanied by local government officials. At each firm visit, in-depth interviews lasting 1-2 hours with senior managers or company owners were undertaken, followed by factory or site visit.[1] The example of Bluestar Company in France was also based on our field visit in 2013.

Firm cases and examples of automobile industry and famous Chinese corporations are from documentary sources, mainly Chinese management magazines and newspaper reports, e.g., New Entrepreneurs (Xin Qi Ye Jia), China Business Week (Zhongguo Shang Ye Zhou Kan), and Caijing (Finance & Economy). The advantage of famous companies is they are always reported by several professional journalists. So we were able to cross-check the information about facts, even they were all news reports.

The sampling of firms for field interviews was principally done by local governments, with their preferences and standards to select "well-established,

1 A list of visited firms during these two years contains mainly: Fenghua High-Tech Corporation (Zhaoqing), TCL Joint-stock Corporation (Huizhou), Huaiji Auto Accessories Company (Huaiji), Zhaoqing Auto Parts & Accessories Company (Huaiji), Dachangjiang Motorcycle Group (Jiangmen), Shuopu Motorcycle Technology Company (Jiangmen), Hedy Group (Guangzhou), Delica Plumbing Equipment Company (Shuikou), Shuikou Technological Innovation Center (Shuikou), Yishion Group (Humen), Humen Textile Innovation Center (Humen), Fumin Fashion City Company (Humen), Xiaiqo Textile Innovation Center (Xiqiao), Dachong Furniture Technology Center (Dachong), Zhengda Pharmaceutical Company (Wuhan), Balance Pharmaceutical Company (Wuhan), Mike Bio-Pharmaceutical Company (Xiamen), North-East Pharmaceutical Company (Changchun), Geely Group (Ningbo), Beijing Oriental Electronics Group (Beijing), Delphi Shanghai Ltd. (Shanghai), Desano Bio-Pharmaceutical Company (Shanghai), and Shanghai-Volkswagen Company (Shanghai).

large sized, relatively well performed and technologically sophisticated local firms and entrepreneurial activities". Many of case firms were located in Guangdong Province, which is often called the "world factory" due to its lion share of China's foreign trade value (25.1% in 2011). These firms, with even the most famous Chinese corporations today like Lenovo or Huawei, all experienced the early development stage of OEM or subcontract manufacturing. So they were all typical Chinese catch-up firms, with better or worse performance.

The firm cases in this paper were studied till 2008/2009, a period of time when most of these quantitatively large enough but qualitatively less innovative firms begun to reach the limits of their long catching up process and meet difficulty in upgrading to innovation level. The 2008 world economic crisis imposed in fact a "window of threat" or "moment of truth" on Chinese industrial firms and exposed them intensively to main problems of innovation management. At that moment, and to some degree till today, it was a big question whether Chinese firms were able to "make the crisis truly creative" and take it as an opportunity to innovate, just like South Korean firms (Kim, L., 1998). With the analysis framework drawn from literature review, we assess each firm's dynamic management (sensing, seizing and transforming) of each innovation process (technological change, market change and organizational change). Based on these detailed assessments of cases, we can identify the key areas of problems in their innovation management, such as integration, coordination, dynamism, and forward-looking, etc.

4. Findings on Cases of Chinese Industrial Firms

The Chinese firms studied in this section vary in terms of ownership, size and fame. The textile industry is mainly represented by private small and medium sized local firms who are export-oriented, but at the same time supply domestic market. In electronic industry, larger State-owned firms with higher technological level can be found. Similarly, the automobile firms in this research are large State-owned firms. The limited numbers of the most internationalized Chinese firms are all large joint-stock companies. Nevertheless, all these firms have a more or less similar history of technological capability development starting from OEM (Original Equipment Manufacturing) or subcontracting production for foreign companies as their "clients" or "customers". In terms of developing innovation capacity, these Chinese industrial firms eventually confront the similar or even same problematic of catching up and forging ahead, once they have already accumulated certain amount of technological capability.

4.1. Cases in Textile Industry

As OEM producers, textile firms in south China have become specialized in manufacturing products according to the specifications given by the foreign clients. For local firms in Dachong, a textile cluster in the Western part of Pearl River Delta region of Guangdong, the possibility of innovating in product or process depends very much on their relations with foreign clients. Since 1993, Dachong cluster has become one of the biggest Chinese producers specialized in jeans for export under foreign brands. In terms of technological change, the firms are on a typical path of incremental technological accumulation. They learnt mature process technologies from foreign clients by using imported equipment and doing production jobs on the shop-floor. The product designs were given by foreign firms to exploit the economies of scale in these firms who adopt industrialization-age factory structures. To them, the "market" is the foreign firms who place orders, with which they have very little contact. These local firms have no knowledge in

fact on the final customers of their products, since access to final foreign markets is extremely difficult to them. Foreign orders were decreased enormously during the 2008 economic crisis and the owners of the biggest factories in the cluster collectively attempted to sell directly abroad, with the support from local authority. But they found that the distribution channels to final customers were all controlled by their foreign clients, without them they were unable to interact with the real market. The strength of firms in Dachong includes cheap labor, large scale, and low costs in production. Their weakness is their dependence on foreign clients and the eventual distance from end-market. This weakness in market linkage can be fatal because even with good manufacturing expertise and facilities, the firms are far from the true sources of technology – the users. The factories made improvement in efficiency of using standardized technologies, but the purchasing prices given by clients were so low that their production capacity was very vulnerable to fluctuations in world markets and they had no additional resources to invest in R&D or market detection. As private firms, it was impossible for them to get loans for investing in any new business development activities from banks, who only lend to large State firms.

Yet the low margin in textiles is not unavoidable. On the Eastern side of Pearl River Delta, the clothing firms in Humen district are more successful. In this specialized industrial district, local government established a public technical center, whose duties ranged from fashion designing to copy Western models and marketing to export. This technical center created its own market - a building accommodating hundreds of small business who opened their stands of clothes exhibition. Each year the district holds a competition of young Chinese designers and sends the winners to follow training in an English school of design. The result is that it is easier for firms in Humen to develop and promote their own brands and business networks. Later, the technical center was acquired by a local private garment group Yishion, which had a business of 3 billion Yuan yearly. The technical center thus became a profit center and opened to foreign design companies. Yishion was founded in 1997 as an OEM manufacturer of garments. Later it entered in wholesale business and became an apparel trader specialized in import/export of clothes, which brought it a lot of contacts with retailers in and outside China. Then Yishion discovered a very buoyant market in China - the children's clothing- and created its own brand "Yishion". In 2000, it sold its wholesale business and established its own brand stores by developing a franchise network in China. Until 2008, it had a network of 2,000 stores all across the country and became the 9th biggest apparel group in China. Yishion was no longer a manufacturer under other companies' brands because its franchise stores only sold its own brand products. It even expanded its marketing network in neighboring countries of Southeast Asia.

The big shift from exports to domestic or regional markets of Yishion happened in the beginning of 2007 when it restructured the whole organization in group form and kept its headquarters in Dongguan to focus on developing new activities: new products, fashion design of clothes but also franchise concept stores, and improvement of quality management system. Other than its product line for children, Yishion re-segmented the clothes market and launch four new product lines: leisure clothes series, sport clothes series, fashion clothes series, and business clothes series. After transforming the acquired public technical center to its own platform of design, Yishion recruited new designers and collaborated with overseas design firms to develop new series of products. Every year, Yishion launched 10 thousand new clothes models in the market. At its site of headquarters, initiated by Mr. GUO Donglin, the CEO and his management team, Yishion constructed

a giant "show center" composed of all kinds of concept boutiques and stores designed specially to sell its own brand clothes. Franchisees were solicited to visit the boutiques and select the collections of clothes. Yishion changed its business model from selling clothes to retailers to selling design services, boutique systems and clothes to the franchisees. In upstream activities, Yishion integrated all suppliers in its new IT system and the terminals in the boutiques of its Show Center were also connected with suppliers. In 2002, Yishion already invested to establish a Quality Examination & Test Center (QETC). In 2005, it invested 40 million Yuan to build up a Specialized Quality Examination & Test Laboratory (SQETL) which was the biggest test lab in clothes chemical elements in China. Till 2007, Yishion finally built up a complete QETC with a total investment of 120 million Yuan and more than 1000 employees working on clothes quality. The QETC was able to monitor and test all textile elements from its material inputs to finished clothes. A hot-line service center was also created to receive and treat the complaints and requirements of clients and franchise stores.

Certainly, the firms like Yishion are still far from being innovatively competitive in Western markets. But the key element of Yishion's bigger innovation potential than firms in Dachong lies not merely on its stronger dynamics of technology development through privatization of a public technical center, but also on its investment in market research, sales system, and brand building in Chinese market. The participation in domestic consumption growth generates more comfortable margins to Yishion so that it can continue to invest in design and technical progress. The relative success of Yishion in managing innovation is due to its technological sourcing from Western clients, at the same time its learning actively and directly from final customers and new market segments. This management strategy of parallel learning from both technological providers and final customers in market in fact should suit most of the small and medium sized firms in local clusters of Dachong and Humen. It is also the main lesson which can be drawn from the experience of some State-owned firms in "strategic" industries. These State-owned firms often have the most advanced machines, good work organization, better paid employees, and bigger power over suppliers. Contrary to private firms, they have R&D activities supported by public programs of technology development and easier access to universities and technical centers for cooperation. Moreover, several of these firms are themselves originated from public research centers that are "commoditized" (Bironneau, 2013). They also have arranged partnerships with banks to ensure their investment. But in terms of managing market change, they may not be as good as their private counterparts.

4.2. Cases in Electronic Industry

Fenghua Hi-Tech Corporation, located in the Northern part of Pearl River Delta, is a State-owned company benefiting from innovation policy of national and local governments. Founded in 1984, Fenghua was ever the number one producer of electronic components in China and ranked number 8th in the world. Fenghua produced various electronic components, including resistors, capacitors and transistors, with its 16 production lines. It diversified in artificial silica for components used in printed circuit boards and motherboards. From 1999, its business experienced a spectacular growth: in the late of 2000s, Fenghua occupied in the domestic market a quarter of China's production of components and exported to the world (USA, Japan, France, Germany, and Poland). About 70% of their production was for very large customers (Motorola, Thomson, etc.).

Fenghua's production of electronic materials (binders and powders) was also one of the biggest in China. In 1985, it imported a line of production

of silica layers whose technology was "multi layers ceramic capacitor" (MLCC technology) from the United States. At that time, sixteen lines of the same technology were imported into China but only the line of Fenghua was installed and kept. From 1991, Fenghua increased its production capacity and gradually extended its production sites to Shenzhen, Suzhou and Jilin Province. In 1993, it reached to have another capacity of 100 million units of aluminum capacitors. In 1995, it reached to produce 5 billion units of resistors. In 1997, it reached the production of 360 million units of transistors. In 2001, Fenghua set up a production line of MLCC which became its main product, and a production line of magnetic cores with a capacity of 4000 tons a year. In 2002, it had reached the capacity of 80 billion units of electronic components. With the increase of productive capability, the staff number grew from more than 100 to 10,000 employees: 500 employees in the production of powder materials, 9000 in components, and 500 in equipment manufacturing. Indeed, from early enough Fenghua extended its production from components to artificial silica, an essential raw material for all electronic components, and attempted to become technological leader in this field in China. Fenghua decided to focus on materials because it found that that the key process technology could only be identified in material: It also took long time to integrate process technology into the component production. Fenghua, as other component producers, would not leave this key issue in MLCC production controlled by other firms.

The organizational change of Fenghua was rather exogenous. Arranged by Central Government, the company jointly developed local-produced ceramic materials of MLCC with Qinghua University in 1995. In 1996, Fenghua was publicly traded, with 20% of the capital owned by the city government of Zhaoqing, 20% by the State, and the rest floating in the market. With government as major shareholder, Fenghua's development projects of electronic powders and binders were integrated in the National Torch Program and enjoyed financing from Ministry of Science and Technology. In 2000, Fenghua was approved by Central government to increase it's A-share stocks and collected 1.1 billion Yuan to invest in its project of "National Base of Large-scale Components" approved also by the government. To support the technology development of Fenghua, the government established 3 technology centers at national level and one research institute inside the firm. Government allocated to it more than 1000 experts in electronic technology. Fenghua was selected as one of the 36 pilot stations of post-doctoral research in firms at national level. To assure the sales of its products, the government designated Fenghua as the key national supplier of localized components for mobile telecommunication products.

With such huge financial support, technological aid, and market access from State, Fenghua built up technological competences in material technology, equipment technology, transformation technology, painting technology, and some design and test technology. However, during 2001-2004, the whole electronic components market fell down. During 2001 to 2003, high frequency PCs had rigid exigencies of the components and that required technological breakthroughs of component producers. At the same time, small scale products such as mobile phones needed also new components. Therefore the old products were in end of their life cycle, and the market demands of traditional components were in decrease. In Chinese and international markets, there were increasing demands for new products, smaller but with higher quality. Fenghua, with 5% of sales allocated to R&D, responded by investing additional 30 million Yuan for R & D to modify its product lines. Its Research Institute successfully developed new resistor in MLCC (capacitor) in replacing silver and BAI metal by NIE metal. During 2000 to 2006, Fenghua

developed 140 new technologies: 20% of them were inventions and others were practical new designs. In 2006, Fenghua recovered its sales with 1.2 billion Yuan revenues.

During this period of time, Fenghua's R&D was directed to high added value materials (binders and powders), mainly for MLCC. Before 2001, 60-80% of MLCC cost was of materials; but after 2001, only 30-40% of MLCC cost was of materials, and high-valued components only had 20% cost of materials. Besides, conventional products had 40-50% of cost for manufacturing, but high valued products contained 80% of cost for manufacturing process, mainly for equipment investment. Therefore, Fenghua turned its R&D focus from materials to specific equipment. As a first step, Fenghua developed test equipment, such as Auto Optical Inspection Equipment. With own-produced equipment, Fenghua could economize 200-300 million Yuan in capital budgeting. Yet most of its equipment was still imported. Fenghua emerged as a main player in high and middle voltage products. With lots of investment in equipment, it reached the economy of scale very easily. But for products of same capacity, it had gaps with Japanese companies and competitors in the world market.

From 2005 to 2006, Fenghua found that there was a big change on the demand side from its clients. Before, the clients purchased electronic components one by one. So Fenghua sold its components by piece and had to negotiate every year with its downstream clients on prices of every component. But suddenly, clients turned to competitors to purchase the integrated-set of components to save money. It brought a big reduction of prices in the market. Fenghua did not predict the market change, but had to plan producing integrated-sets to serve its clients. Once again, Fenghua found itself in a very disadvantageous position in face of upstream IC designers. Once the IC design finished, Fenghua could only accept and produce according to the architectural design of IC. Fenghua would like to have designers integrate their components in IC design in early phase. So it negotiated with some IC designers, and even created a joint research laboratory with a Taiwanese IC firm of mobile phones who had strong ties to a US institute and foreign companies. Nevertheless, for Fenghua, becoming a system integrator in mobile telecommunications represented another technological path beyond Fenghua's competency, and the dominant position of IC designers in the value chain seemed very difficult to be broken down.

It was also during this critical period of time that Fenghua lost its key clients, in face of fierce competition in electronic components from foreign and Taiwanese companies such as Chuntian, Guoju, TDK, and Taiuyotai, etc. One key client lost was INTEL, the leading company of micro-processor in the world. The multinational had identified Fenghua as a qualified supplier and even created joint R & D programs with it. However, Intel had nearly 150 Chinese suppliers. In the beginning of 2008, INTEL made an internal decision to break the contract with Fenghua. This loss of relationship with a key customer was fatal for the firm, because the pulling force of its particular MLCC technology, whose technical performance ranked far behind the Japanese and Korean competitors, suddenly disappeared. The break-up with INTEL imposed a dead-end on Fenghua's MLCC technology. In fact, to attain a global level and approach the technological frontier as Samsung, Fenghua should have invested much more in R & D, and continuously improved the method of manufacturing. Its relationship with INTEL was particular, because INTEL was Fenghua's key client and key technology source at the same time. Staying in an ecosystem is vital if a firm wants to maintain and improve the high-level technological capabilities. Fenghua, despite of its significant internal technology efforts, ongoing State support, and good financial and credit conditions,

was eventually not able to insert itself into such a small and closed circle composed of global producers of multilayer components. The loss of key market relations left Fenghua perplexed in overall development direction. It hesitated between the ideas of integrating in a system integrator and finding a comfortable place in the new industrial chain, or localizing the production to strengthen its industrial structure of transistor, capacitor and resistor production, or implementing own-brand strategy through investing more in indigenous R&D. In 2007, Fenghua started searching for strategic investors since the financial support from the State was almost exhausted. The government's plan was also selling Fenghua to foreign groups. In 2008, it decided to stop production abruptly.

The rise of Fenghua was due to its enormous inputs in R&D with the government's supportive corporatization reform of organization. The technologies developed through R&D were innovative for Fenghua, but in the electronic components industry they were mostly catching up to the technology frontier. Fenghua could sense the technological opportunities and invest in developing them. But it had difficulty in transforming and exploiting the developed technologies to attain and maintain competitive advantage in the market. Every time it worked out a new technology closer to the frontier, the technology became obsolete quickly. This difficulty of building up market competitiveness seems to be due to the weakness in technological capabilities - Fenghua was always one step lagged behind the most advanced technology. But the real cause is the absence of dynamic capabilities to manage the market change. Fenghua was not able to project market trends and sense threat from market. Its over-dependence on a limited number of clients seriously reduced their power to negotiate technology change process with its clients in the market (who were its key technology sources). In terms of market linkages, Fenghua was in the same situation as the Chinese private OEM producers of jeans or garments, whose relationship with foreign customers was essential because these customers were also technology providers. This situation was very different from those of Taiwanese companies or Japanese and Korean companies some twenty to thirty years ago. These East Asian companies strategically leveraged their technologies and production capacities to diversify customers and markets. They actively searched for new market opportunities, invested in market development, and maintained strong customer relations. In turn, they negotiated better commercial and technological cooperation conditions with their foreign clients (Ernst, D. and Kim, L., 2002). Their good mastering of market change supported the technological change process with strength. With no capability on market change, Fenghua was not able to articulate between technological progress and market development, despite its significant investment in technology and production. And the reason why Fenghua was lack of "feeling and sense" of market change may be due to the heavy intervention of government: on one hand, Fenghua's market was almost "guaranteed" by the government; on the other, Fenghua's management team had only limited control over the organizational change process. The corporate governance, project financing structure, and even personnel allocation were all arranged by the government: the dynamic capabilities of making organizational change were weak in Fenghua. Without strong supports from active market management and effective organizational change, its technological adventure eventually fell to a dead end.

The problem of integrating effectively changes of market and customer needs to lead choice of technological paths can be found in other electronic firms. For example, the television producer TCL launched its overseas expansion after strong growth in the domestic market. In 2002, TCL bought the

television division of Schneider, but stopped the production in 2004. TCL also bought the mobile phone business unit of Alcatel and the colors TVs division of Thomson. At that time, TCL was already the world leader of cathode television, occupying 11% of the global market. It planned to reduce the selling price of TVs by controlling Thomson's manufacturing technologies and supply chains through acquiring the weak Western brand. However, there was a sharp decline of demands in market, especially in Europe. TCL underestimated the speed of market changes and the fastness of technological change. When TCL Thomson launched its new LCD product in 2005, TCL found itself fall behind its competitors in the European market, in terms of knowledge of LCD technology. Its organization and collective expertise exclusively in cathode technologies were of little help to meet the new demand of flat screens TVs. Though TCL finally didn't miss the technological transition to LCD[2], its way of managing innovation was problematic. TCL's aggressive international acquisition represented a dynamic organizational development triggered by the needs of exploiting existing technologies, but its relative inactive market change management made TCL difficult sense and seize the technologies a step ahead of market. It followed passively emerging technologies in the market. Like many other reputed Chinese firms (Lenovo, Galanz, Medea, etc.), TCL became eventually important market player, thanks more to its productive capacity of large scale, than to the dynamic capabilities of orchestrating technologies, markets and organizations to make innovation.

If the problem of dynamic capabilities in Fenghua and TCL is on managing of market change in relation to technological change, the problem of most Chinese firms' efforts to upgrade to innovation is still more related to absence of appropriate management of imported technology itself. Beijing Oriental Electronic Company (BOE), a factory of CRT (CRT) in Beijing, is such an example. In the eighties, BOE established a joint venture with Matsushita to produce electronic tubes for color TVs, but the technology was still managed and controlled by Japanese companies. BOE wanted to change from the cathode technology (CRT) to liquid crystal display (LCD) monitors. So BOE chose to acquire technology through organizational acquisition of foreign companies. It bought the STN-LCD divisions of Hyundai Group (Hynix) and the business unit producing TFT-LCD. Then BOE bought the distribution company of Hynix liquid crystals and invested in constructing production lines of the fifth-generation TFT-LCD in its own factories in China. To get the key technology, BOE singed turn-key contract with Hyundai Group for constructing three complete production lines of TFT-LCD, including the patents of the TFT-LCD of second and third generation, buildings, workshops, fixed assets, and the entire global distribution network. In short, BOE's acquisition covered all the operations necessary for the acquisition of hardware technologies, access to information sources and methods of commercial distribution: it bought everything that was tangible and believed in this way it mastered the complete technology and, more important, could become the market leader. However, after the accomplishment of turn-key contract, when BOE began producing liquid crystals displays (LCD), managers discovered that the manufacturing process needed a lot of tacit knowledge and know-how. For example, the production of screens actually depended on the temperature and humidity. But this tacit knowledge, only based on the experience of workers on the production line, was not included in the purchase contract and obviously not transferred to BOE.

2 In 2009, it was the third biggest brand of LCD TV in China and the 7th biggest worldwide. It was a bigger LCD TV exporter than any of its Chinese rivals.

BOE had to invest more for acquiring the tacit knowledge on LCD technology, such as training and exchanges with workers in Korean and Japanese firms. When it finally mastered the whole process, the imported technology had already become obsolete in the market. Moreover, operating costs were too high compared to competitors because of the additional investment required for technology transfer. To catch up with technological change, BOE decided to import the fifth-generation TFT-LCD. However, after losing a lot of money in the acquisition of Korean production chains, it had not enough resources to ensure the new technological leap forward. BOE eventually lost control of upstream suppliers, as well as its downstream distributors, due to the increased costs of production.

4.3. Cases in Automobile Industry

Similar to BOE, many Chinese State-owned automobile firms also tried to move closer to innovation frontier through transferring and absorbing foreign technologies, supported by the national policy which encouraged large Chinese corporations to invest directly in foreign companies. A typical case was the acquisition of the car company MG Rover by two Chinese groups: SAIC (Shanghai Automotive Industrial Corporation), China's largest auto company, and Nanjing Automobile Corporation (NAC). The process of acquisition of MG Rover Group was complicated and two very different Chinese companies were put together without a successful dialogue. The technologies of MG Rover were split into two packages: SAIC spent 67 million British pounds to purchase the technologies of two patented car models (Rover 25 and 75) and two patented engine models (KV4 and KV6). SAIC acquired no assembly line or physical production assets, neither the brand of Rover. NAC, on its side, spent 53 million British pounds to buy MG and Austin brands, the technologies of four patented car models (MGZR, MGZS, MGZT, MGTF) and three engine models, as well as all assembly lines for manufacturing those car models and motors. When the deals were completed, the two Chinese firms started to compete with each other in the Chinese market, instead of cooperating.

In late 2005, SAIC created an imitated Chinese brand "Roewe" in domestic market by using the technologies it had acquired from MG Rover. It was virtually a legal copy of the Rover 75. Three years later, SAIC sold totally 5,300 cars under the brand "Roewe 750". With no equipment and no production line, SAIC encountered difficulty in reproducing exactly the Rover car model. For example, the engine manufacturing required advanced equipment. SAIC produced some engines by itself, most of engines were still bought from its traditional Chinese suppliers. SAIC sensed the coming opportunities in Chinese automobile market and would like to catch it as soon as possible. But it would not wait for a high quality Roewe car to launch. NAC has the same attitude of rush into the domestic market, except that the initial situation was a little different: NAC bought the MG brand, so it has all the legality of using this brand. Owning the properties of the brand, technology, production equipment and assembly lines, NAC also decided to launch as quickly as possible the car production and marketing it on the domestic market. NAC dismantled all the engine production lines and the most important car production lines of Rover, and transported them from UK to China. As a result, NAC spent more than four months to re-install all the lines on their production site in China. The dislocated lines, mainly for manufacturing more than 40 key engine components, were composed of more than 600 equipment. In July 2007, without R & D activities on the imported lines, NAC launched its car model MG ZT, the Chinese version of MG7. Later, NAC used these lines to reproduce other MG car models for the Chinese market.

The above three State-owned firms, BOE, SAIC

and NAC, like many other Chinese State firms, identified the emerging Chinese market opportunity and intended to catch it by imported foreign technologies. After overseas M&A deals, they all dismantled the tangible assets, relocated them to China, and sell products to domestic market, instead of continuing the operations abroad or re-export to foreign markets. They couldn't fully absorb, assimilate, and transform the bought technologies because there was no dynamics to create new internal and external organizational arrangements to carry on further technological change, such as JV or alliance which could facilitate transfer of tacit knowledge. The purchase of high technology and advanced equipment cannot assure upgrading to innovation of firms. As a result, these firms counted on their old tactics of large production scale, low sales pricing, and short lead time to market, to survive the competition in domestic Chinese market.

4.4. More Examples: Chinese Emerging Transnational Corporations

Nevertheless, better innovation management practice with stronger dynamic capabilities now can be found in Chinese automobile industry. The acquisition of Volvo by Geely, a private car maker only entering the automobile industry in 1997, is an example. Geely kept almost all the organizational structures of Volvo outside China and triggered further development of Chinese market for Volvo cars. Two new Volvo factories were constructed in Chengdu and Daqing to produce new models for Chinese market. Geely established a joint R&D platform with Volvo to develop CMA models, but the program was dominated by Volvo R&D team. Geely integrated the procurement systems of the two companies and reduced enormously the production cost of Volvo for both Chinese and international markets.

A similar example is Chinese Bluestar Company, a subsidiary of largest Chinese national chemical group ChemChina. In 2007, after acquiring the French Rhoda Silicon, Bluestar kept the French R&D center with 130 researchers in Lyon almost intact. Over years, Bluestar continued to invest in the R&D projects in France, but also created internal training and personnel exchange programs with manufacturing factories in China. Bluestar later bought upstream activities through acquiring Elkem, a Norway chemical company, and downstream activities through acquiring Adisséo, a French animal nutrition and sulfur producer, whose business were linked to former Rhodia Silicon. By these organizational and managerial arrangements, Bluestar progressively assimilated the core technologies as well as the know-hows of Rhodia Silicon and diffused them across the whole group.

Generally, those few Chinese firms that succeed in internationalization development are those that deviate from strategy of large quantity and lower prices. The management characteristics of their more successful innovative activities appear again and again: firstly, by learning and absorbing foreign technology, they establish close interactions with customers in domestic market, as well as the branded foreign clients; they become more and more sensitive to market demands; then, through creation of new organizational frameworks such as overseas R & D centers, alliances, or mergers & acquisitions, they approach further foreign sources of knowledge; normally they will restructure the internal and external organizations, and leverage the Chinese production capacity with newly acquired technological capabilities for global markets (Zahra, S. A., R. D. Ireland and M.A Hitt, 2000). Huawei may be the most typical case of such dynamic management. It tested its production capacity and management of wireless networks in China's Xinjiang region first before seeking to export to developing markets such as Zimbabwe, Kenya and Thailand. It then established R&D centers in Europe (Stockholm), Texas and Silicon Valley, and recently

in India and Russia to detect the most advanced technologies. Note that Huawei created its first R & D centers abroad very early, well before its production line of server network was fully finished and when it was under legal attack of CISCO who accused Huawei of plagiarizing its server technology. Of course, overseas R&D Centers of Huawei were not for adapting its research already conducted in China, but for learning, acquiring and repatriating foreign technologies, to both overseas market and later Chinese market. As for the appliance manufacturer Haier, when it established operations in the U.S., it smartly targeted the specific market segments in North America, such as dormitory refrigerators, wine refrigerators, and TV sets in children's room, etc., things they were able to produce easily in mass with their standard technologies. Based on market feedbacks, Haier launched more sophisticated R&D projects to further develop the North American market.

But not all Chinese emerging multinational firms manage well the innovation dynamics all the time. Lenovo, which has made a series of international acquisitions, might be an example of problematic dynamic capabilities. The acquisition of PC business from IBM reinforced Lenovo's technological progress in laptop computers, but Lenovo did not reconfigure and transform the emerging market of mobile phones, even though it already sensed it early and try to seize it by investing in production in 2002. Lenovo bought out Motorola Mobile in 2014, but this seizing action was too late. Lenovo neither seized the opportunity of internet business, even it was fully aware of the transformation of IBM. After acquisition of IBM, Lenovo spent huge energies and resources to transform the internal organization to focus on embedding IBM's market sales system and PC technologies in the group, while neglecting to large extent the market dynamics. Now it has world-class production scale, cost control and supply chain system, but its R&D budget was below 1.9% during 2006-2014. The firm seems to stop sensing.

5. Discussion and Implication

The firm cases in this paper show that Chinese firms have been technology learners. In terms of linking market needs with commoditized technologies, most of Chinese firms have huge potential of growth and improvement, which is still under-utilized and can be exploited through more investments in in-house R & D and partnering with external research institutions. In terms of dynamic capabilities, we synthesize the analysis of each firm's innovation management practice in the Table 1.

Table 1. Assessments of innovation management of case firms

	Sensing, seizing and transforming of technological change	Sensing, seizing and transforming of market change	Sensing, seizing and transforming of organizational change	"Orchestration" skills of strategic integration
Firms in Dachong (private SMEs)	Weak in sensing (technologies were brought in by foreign clients) Strong in seizing and transforming (mass production capacity)	Very weak (no access to final market)	Very weak (keeping the simple factory structure)	Weak (Owners not able to leverage technological capabilities to change market positioning and business models.) Weak technology sensing due to absence of market access
Yishion (large private firm)	Strong (buying the public center and pursuing fashion designs)	Very strong (recognizing children's clothes and segments; local brand building; franchising)	Very strong (creating the franchising system; upgrading IT system; improving QC system, etc.)	Very strong (integrating design, suppliers, franchise stores, etc. in its Show Center system)

Fenghua (large State-owned firm)	Weak in sensing the most advanced technologies Strong in seizing (investing in technology development) Medium in transforming (technology became obsolete before fully exploited)	Very weak (depending on a few foreign clients; government endorsement)	Weak (most of organizational change was arranged and directed by government)	Very weak (Since there was no market prediction, there was always technological "surprise" to the firm. No market input in technological change.) No organizational motivation to trigger market development
TCL (large joint-stock company)	Weak in sensing the most advanced technologies Strong in seizing and investing Strong in transforming and exploiting acquired technologies through manufacturing system	Strong in Chinese market but weak in European market	Strong in sensing and seizing (overseas mergers and acquisitions of Thomson) Medium in transforming (difficulty in cultural integration)	Problematic (did not take maximum use of foreign acquisition to trigger market change process in Europe and then the technological change process)
BOE (large State-owned firm)	Medium in sensing the most advanced technologies in the world Strong in seizing, investing in and exploiting acquired technologies	Strong in Chinese market but very weak in foreign market	Very weak (problems of managing personnel and employees)	Very weak (only concentrating on managing technologies as tangible commodities)
SAIC & NAV (large State-owned firms)	Strong in sensing foreign advanced technologies Medium in seizing and transforming (buying the equipment and technologies without further development and investment)	Strong in sensing and seizing the Chinese market Very weak in foreign market	Very weak (no organizational change since only the acquired assets were moved to China)	Medium (somehow combing the Chinese market opportunities with imported technologies through overseas assets take-over)
Geely, Bluestar, Haier, Huawei (emerging Chinese MNCs)	Strong or every strong in detecting foreign technologies Very strong in investing in overseas R&D Very strong in exploiting the developed technologies	Strong in exploring and developing foreign markets Medium in transforming and reconfiguring foreign markets	Very strong in sensing and seizing organizational change through aggressive M&A Strong in transforming overseas organizations and structure (relative successful cultural integration)	Strong (managing the market, technology and organization changes simultaneously to create positive feedbacks among them; leveraging Chinese production capacities with foreign technologies in both foreign and domestic markets)
Lenovo (emerging Chinese MNC)	Weak in sensing (mobile and internet technologies) Medium in seizing (investment in mobile was light and then late) Strong in transforming and reconfiguring (for matured PC technologies)	Strong in sensing (having a strong tradition of selling and customer service) Medium in seizing the new market trends Strong in transforming (setting and managing distribution system; branding)	Strong in sensing and seizing (buying IBM PC business; moving head-office to US, etc.) Weak in transforming (not creative in organizational change; difficulty in cultural integration)	Problematic (strong in sustaining the existing business but weak in orchestrating in creating new business; typical incumbent syndrome.)

The table illustrates some main problems of innovation management in Chinese firms. At the most basic level, many Chinese firms still confuse "innovation" with "invention" and replace innovation by technological breakthrough, patent registration, or R&D investment. Innovation management is thus heavily biased to technology management and is regarded as technical matters to be handled by product designers, engineers, and technicians. Even in terms of managing technological change itself, Chinese firms, especially large State-owned firms, still give more importance to hardware and information of technology than to knowledge and human skills in technology acquisition, as the cases of BOE, SAIC and NAC demonstrated. Some others just focused on technical advancement rather than changing market and competition situation, as the case of TCL.

For those who built up large productive capacity through strong technological learning and accumulation with customers, including foreigners as their technology providers, either they are kept too distant from the final consumers (as the firms in Dachong Cluster), or they become too much dependent on key foreign client in technology (as Fenghua). Sensing, seizing and transforming the market is absent in their innovation management. The counter-example is Yshion, which began to forge ahead in innovation thanks to its development in domestic market and avoided too much technological path dependency on foreign clients.

Merely managing R&D or marketing is not enough for innovation. The dynamics of technological, market and organizational changes are inter-linked and reinforced each other. Theories on innovation management, particularly the approach of dynamic capabilities, emphasize the importance of integrating strategically the technological, market and organizational changes to successful innovation. As shown by the cases, the integration, articulation, or "orchestration" skills are often the weak points for managing innovation in Chinese firms. Firms like Geely, Huawei, Haier and Blustar have been skillful in integrating and articulating simultaneously and appropriately the different dimensions of change in innovation, but the firms having this type of dynamic capabilities are still rare to find in China.

In this respect, China differs dramatically from the competitive challenge to Western companies that Japan presented 30 years ago. Japan's secret sauce was management; but that is China's weakness (Lieberthal, K. and G. Lieberthal, 2003). Maybe it will take decades for them to overcome the ingrained management weaknesses that prevent them from mastering the dynamics of innovation. Knowing the importance of management to innovation, Chinese managers can start by asking some basic questions when facing a potential innovation project:

How do we choose the technology? Do we have a clear technology strategy and a suitable roadmap for technological capability development? Is technological innovation the core part of project?

Do we have a corresponding market strategy for the technological innovation? What relations and interactions with customers or clients should we have to support the coming technological change? How will we change the market with the innovation?

Should we change correspondingly our internal and external organizations of people and business to meet the technological innovation? What way of organizing people and activities is suitable to achieve the innovation goal of project?

Most importantly, how can we coordinate and integrate the above changes in three domains? Can we articulate and leverage these three processes to create sustainable dynamics of innovation of the firm? Do we have such dynamic capabilities in management?

By nature, the rampant problem of weak dynamic capabilities in managing innovation in China is the shortage of high-level human resources of managers. China will need a whole new generation of managers

to upgrade. In fact, innovation management as a specialized major can only be found in several top business schools in China. Entrepreneurial and forward looking managers are difficult to find in existing corporations, since the strategic development divisions of large firms or strategy consultants are mainly oriented to financial strategies or IT operations. Some innovation managers may be employed in financial sectors (policy-leading funds, industrial investment funds, venture capital firms, specialized technology banks, and business angels, etc.). Chinese government shall understand the importance of these intangible assets and capabilities and reform its education and training system to form a new generation of managers. On the other side, they shall free the firms to find their own strategies and cultivate their endogenous capabilities of managing innovation.

6. Concluding Remarks

When Chinese firms, like catch-up firms in other developing countries, try to innovate closer to the frontier, specific management skills can be vital, among others factors. Through some empirical cases, this paper highlights how Chinese firms manage the technological, market and organizational changes for innovation activities in terms of sensing, seizing and transforming them. If the Chinese firms are more or less strong in managing technologies, markets or organizational changes separately, the most innovative firms are also strong in a kind of dynamic capabilities: management skills of strategically orchestrating and integrating the change processes in different fields. In this sense, the weak capability of strategic integration is the main problem of innovation management in China. This conclusion supplements the literature on catch-up firms and has implications for practice and policy.

One of the limitations of this research is the case "stories" are old, though their timing can reflect more intensively the problematic of innovation management. Further research shall be done to follow the recent situations of the case firms or other emerging E-commerce companies in China, in order to observe whether Chinese firms have evolved in their way of managing innovation. Besides, quantitative data and econometric method can help clarify the complicated cause-effect relations among innovation process, dynamic capabilities, innovation outcomes, and business performance of firms.

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References

Ambrosini, V., C. Bowman, and N. Collier (2009), Dynamic capabilities: An exploration of how firms renew their resource base, British Journal of Management, vol. 20, no. S1, pp. 9-24.

Amsden, Alice H. (1989), Asia's Next Giant. South Korea and the Late Industrialization, Oxford: Oxford University Press.

Amsden, Alice H. and W-w. Chu (2003), Beyond late development: Taiwan's upgrading policies, The MIT Press, Cambridge, Massachusetts, 224 pages.

Arvanitis, R., Zhao, W., Qiu, H. and Xu, J.-n. (2006), Technological Learning in Six Firms in South China: Success and Limits of an Industrialization Model, International Journal of Technology Management, 36 (1/2/3), 108-125.

Bironneau, R. (2012), Le système d'innovation chinois, in Bironneau, R., R. Arvanitis, F. Bafoil et B. Kahane (Eds.), China Innovation Inc. Des politiques industrielles aux entreprises innovantes, Paris: Presses de Sciences Po.

Bironneau, R., R. Arvanitis, F. Bafoil et B. Kahane (Eds.) (2012), China Innovation Inc. Des politiques industrielles aux entreprises innovantes, Paris: Presses de Sciences Po.

Bower, J. L. and C. M. Christensen (1995), Disruptive Technologies: Catching the Wave, Harvard Business Review, January-February 1995, pp. 43-53.

Burgelman, K. A. and L. R. Sayles (1986), Inside Corporate Innovation, London: Macmillan.

Christensen, C. M. (1997), The innovator's dilemma: when new technologies cause great firms to fail, Boston, Massachusetts, USA: Harvard Business School Press.

Cohen, W. and D. A. Levinthal (1990), Absorptive capacity: a new perspective on learning and innovation, Administrative Science Quarterly, vol. 35, no 1, pp. 128-152.

Dosi, G. (1988), The Nature of the Innovative Process, in G. Dosi, C. Freeman, R. Nelson, G. Silverberg et L. Soete (′ed.), Technical Change and Economic Theory, Pinter Publishers.

Dutrénit, G. (2000), Learning and knowledge management in The Firm, From Knowledge Accumulation to Strategic Capabilities, Cheltenham, UK: Edward Elgar.

Dutrénit, G. (2004), Building Technological Capabilities in Latecomer Firms: A Review Essay, Science, Technology & Society, 9 (2), pp. 209-241.

Ernst, D. et Kim, L. (2002), Global production networks, knowledge diffusion, and local capability formation. Research Policy, 31 (8-9), pp. 1417-1429.

Hobday, M. (1994), Export-led Technology Development in the Four Dragons: The Case of Electronics, Development and Change Vol. 25 (1994), 333-361.

Hobday M. (1995). Innovation in East Asia: the Challenge to Japan , Aldershot, England: EdwardHobday, M. (1995), Innovation in East Asia: the Challenge to Japan, Aldershot, England: Edward Elgar.

Henderson, R. M. and Clark, K. B. (1990), Architectural Innovation: The Reconfiguration Of Existing Product Technologies and the Failure of Established Firms, Administrative Science Quarterly, Mar 1990; 35, No. 1., pp. 9-30.

Hippel, Eric von (1989), The Sources of Innovation, Oxford University Press.

Hout, T. and D. Michael (2014), A Chinese Approach to Management, Harvard Business Review, September 2014 Issue.

Kim, L. (1997), Imitation to Innovation. Cambridge, Mass.: Harvard Business School Press, 1997, 303 pages.

Kim, L. (1998), Crisis construction and organizational learning: Capability building in catching-up at Hyundai Motor, Organization Science, 9(4), 506-521.

Kline, S. (1985), Innovation is not a Linear Process, Research Management, 28 (July-Aug.), pp. 36-45.

Le Masson, P., B. Weil, and A. Hatchuel (2010), Strategic Management of Innovation and Design, Cambridge University Press.

Lieberthal, K. and G. Lieberthal (2003), The Great Transition, Harvard Business Review, October 2003 Issue.

Mathews, J.A. (2006), Catch-up strategies and the latecomer effect in industrial development, New Political Economy, 11 (3): 313-335.

McKinsey & Company (2015), The China Effect on Global Innovation, McKinsey Global Institute, October 2015, 136 pages.

Moore, G. A. (2014), Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customers (3rd ed.), Harper Collins Publishers.

Nonaka, I. and H. Teukeuchi (1995), The Knowledge-creating Company: How Japanese Companies Create the Dynamics of Innovation, Oxford University Press.

Pavitt, K. (2003), The Process of Innovation, in Fagerberg, J, D. Mowery and R. Nelson (Eds.) Handbook on Innovation, Oxford University Press.

Rogers, E. M. (1983), Diffusion of Innovations (3rd ed.), New York: Free Press of Glencoe.

Teece, D. (1986), Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy, Research Policy, Vol. 15, No. 6, December 1986.

Teece D. (2007), Explicating Dynamic Capabilities: the Nature and Micro-foundations of (Sustainable) Enterprise Performance, Strategic Management Journal, vol. 28, no. 13, 1319-1350.

Teece, D. (2012), Dynamic Capabilities: Routines versus Entrepreneurial Action, Journal of Management Studies, 49:8 December 2012, 1395-1401.

Teece, D. and G. Pisano (1994), The dynamic capabilities of firms: an introduction, Industrial and Corporate Change, Vol. 3, pp. 537-556.

Teece, D., G. Pisano, and A. Shuen (1997), Dynamic Capabilities and Strategic Management, Strategic Management Journal, 18, pp. 509-533.

Tidd, J., J. Bessant and K. Pavitt (1997), Managing Innovation: Integrating Technological, Market and Organizational Change, Chichester: Wiley.

Trott, P. (2005), Innovation Management and New Product Development, Prentice Hall.

Zahra, S. A., R. D. Ireland and M. A. Hitt (2000), International expansion by new venture firms: International diversity, mode of market entry, technological learning, and performance, Academy of Management Journal, 43 (5), pp. 925-950.

Zeng, M. and P. J. Williamson (2007), Dragons at your door, How Chinese cost innovation is disrupting global competition, Boston, Mass.: Harvard Business School Press.

Zhao, W. (2015), Is R&D Upgrading China from Imitation to Innovation? An Institutional Analysis of Absorptive Capacity, Journal Transition Studies Review, Vol.22, No. 2 (2015), pp. 81-110.

Zhao, W. (2013), La capacité d'innovation chinoise : Apprentissage technologique dans les industries automobiles et électroniques, Paris: Presses Académiques Francophones.

Zhao, W. (2006), Economie de l'innovation et développement des capacités technologiques en Chine: l'apprentissage technologique dans les industries automobile et électronique en Chine, thèse doctorale de l'Université Paris 3, Paris.

Zhao, W. and R. Arvanitis (2010), The Innovation and Learning Capabilities of Chinese Firms, Technological Development in the Automobile and Electronics Industries, Chinese Sociology and Anthropology, 42 (3), pp. 6-27.

Zhao, W., R. Arvanitis and F. La Pira (2011), Innovation Policy and Local Cluster of Entrepreneurs in South China, International Journal of Management & Enterprise Development, 2-3 (2-3), pp. 109-126.

Science and Technology Trends
Fostering Startup Ecosystems

An Evaluation of the Startup Ecology in Korea

Dong-Won Sohn

1. Introduction

The Korean economy is considered, insofar as its existing large firm-oriented growth model, as no longer viable for making leaps forward. At the same time, the expectation that startups serve as the driver of new growth has been constantly increasing, particularly since examples of business growth have come to the fore, including Google, Facebook, Tesla, and Alibaba, which began as small startups and have developed as successful players that lead new businesses. It is expected that the role of startups will expand, especially in the area of the so-called fourth industrial revolution, which includes novel industries such as biotechnology, artificial intelligence, virtual reality, and electric vehicles. Therefore, in the Korean economy, it could be said that the ability to nurture startups is more necessary than ever before.

At this point, an evaluation of the startup ecology in Korea, as well as the planning of future roadmaps based on the results of such an evaluation, will provide a meaningful insight. Considering the widespread use of the term "startup," work to evaluate the startup ecology has been very limited. This concept is partially mentioned in some policy documents and research literature (Lim, 2015; Small and Medium Business Administration, annually); however, in-depth and systematic research results have not yet been established. This can be explained by the fact that the current level of startup ecology is not sufficiently mature. Moreover, an evaluation of the startup ecology has been deferred because it is a rapidly changing field.

Notwithstanding these limitations, this study aims to establish a preliminary framework for the evaluation of the startup ecology in Korea. Although few previous studies have been conducted, and there are dynamic ups and downs in startup industries, it is believed that evaluation cannot be avoided when discussing startups in Korea. In this study, the theoretical fundamentals of startup ecology will be discussed, and major field tests evaluated. However, it is expected that the depth of this research will be limited to a basic experimental level.

Why do we need to look at the startup ecology? If a startup company were a tree, then the startup ecology would be the forest. To develop an in-depth perspective, we need to look beyond a single tree, and focus on the founding principles of the forest, which in turn will give us an insight into the life cycle of each individual tree. The concept of a

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business ecosystem was first established by scholar John Moore as “An economic community supported by a foundation of interacting organizations and individuals”; it was emphasized that members of the ecosystem are influencing each other's roles by helping one another. Here, it is important to take note of the co-evolution that occurs in response to interactions between members, not unlike the ‘co-evolution’ that occurs in biological ecosystems. Biologist Gregory Bateson defined co-evolution as a ‘reciprocal evolutionary change in interacting species’ (Bateson, 1979), which means that two different organisms evolve by influencing each other. The case in which a change in one species (A) is a catalyst for changes in another species (B), or vice versa, is the basic characteristic of co-evolution. Based on the view that the development of an individual startup is aligned with the conditions of the entire ecology system, this study aims to provide an analysis of the evaluation results of the current status of the startup ecology.

The startup ecology is fundamentally classified into one of two areas. One area is the entrepreneurial ecosystem, while the other is an investment reflux ecosystem (Sohn, 2013). First, an entrepreneurial ecosystem includes the conditions required for startups, incentive systems, and infrastructures. Also, the number of startup companies and the various competition conditions are included. Second, an investment reflux ecosystem includes investment drivers for startups, investment returns from startup growth, a series of processes and sentiments related to investment activities, and infrastructures. The major players include angel investors, accelerators, and venture capital (VC). Also, exit channels such as M&A and the KOSDAQ (KONEX) market are elements of this investment reflux ecosystem.

This study evaluated these two areas separately. It was noted that in both areas globalization is progressing. The role of global players is not crucial yet, but it is worthwhile to mention that their influence could be massive in the future. It is expected that if global players come into domestic markets, the number of domestic players will increase and competitiveness levels will rise. From this perspective, the participation of global players in domestic inbound areas will have positive effects on the composition of the ecosystem.

This study takes note of the following two characteristics of the startup ecology: the first is that the ecosystem will find its equilibrium on its own, while the second is that a virtuous cycle will be implemented through the interaction between each of the participants. To this end, a virtuous cycle will be realized and fully sustainable when the ecosystem reaches a positive equilibrium, and a vicious cycle will be created when it reaches a negative equilibrium. However, the current equilibrium does not necessarily mean it will yield optimal results. Once the ecosystem reaches its equilibrium, enterprises are provided with a sense of security. This sense of security will allow enterprises to fall into “the success trap,” which refers to the belief that an enterprise's former strategy has enabled a state of security in the enterprise ecosystem. However, this belief is generally erroneous. From this perspective, this study will first expand upon the current equilibrium, and it will then focus on and discuss what future ecology should look like in order to reach a healthier equilibrium.

2. An Evaluation of the Startup Ecology in Korea

In this study, the evaluation of the startup ecology in Korea will include a review of the current conditions of the existing ecosystem; at the same time, it will also focus on how it will be reproduced in the future. The conditions of a startup ecology will also be evaluated by classifying it into either an ‘entrepreneurial ecosystem’ or an ‘investment reflux ecosystem.’ The evaluation results will be

interpreted by considering their implications on future reproduction. Here, 'reproduction' refers to the concept that a population of the same species grows and prospers in the ecosystem. The terminology is borrowed from biology, which is the original field for the study of ecosystems. For an economic phenomenon to increase and prosper, its economic suitability is most important. The principle that economically valuable entities will survive and thrive is applicable in this ecosystem space. When we consider the economic suitability of the startup ecology, the success of these startups and the infrastructures that are in place to support them should be reviewed. Next, whether ecology conditions have the mechanisms to distinguish between superior entities and inferior entities should also be investigated. The reason is that the distinction between the two are clear in the healthiest form of evolution, which gradually works to eliminate inferior entities and support superior entities.

2.1. An Evaluation of the Entrepreneurial Ecosystem

A startup trend has been sweeping the globe. In the US, China, and the UK, the number of newly established companies has been constantly increasing over the last three years. In particular, China has recently been actively implementing startup policies. Throughout 2015, the number of newly established companies in China was about 4.4 million, which is an increase of 21.6% when compared with the previous year (2014). It is believed that the startup atmosphere is inspired by the emerging companies that are leading the global market, such as Alibaba and Xiaomi; these companies have a history that spans less than 20 years. In addition to the huge number of startups, the creation of the infrastructure that produced global startups such as Alibaba, Baidu, and Tencent has more important implications (Su, Ali, & Sohn, 2011).

In Korea, according to Statistics Korea and the Small and Medium Business Administration, the number of newly established companies during the first quarter of 2015 increased by 9.1% when compared with the same period in the previous year; there were a total of 22,652 new companies, a quarter record. Also, the investment for domestic startups in 2014 was KRW 780.2 billion, and the size and number of investments have been increasing steadily ever since. The motivation of prospective startups has been stimulated by some mobile game companies, which are listed as startups, and which have executed successful IPOs in KOSDAQ. Also propelling this trend are buzz-generating companies like Woowa Brothers, which developed the Baedal Minjok application.

One of the main reasons that these results have been brought to light is that the South Korean government selected the nurturing of startups as the most important strategy in the Creative Economy. Supported by the governmental policy, more angel investors and venture capitalists are investing in new startups and accelerator programs (a new type of startup-supporting program); these funders select entrepreneurs and offer them intense support for a short period of time.

With respect to the various areas of the startup ecology, quantitative expansion—especially by young entrepreneurs—is most important; moreover, basic assessment of the forms and effects of government support are also important.

2.1.1. Quantitative Expansion of Startups

Based on the trends over the last eight years, it was found that the number of newly established companies has been constantly increasing each year. Given that the data include both opportunity-driven enterprises (in which most startup companies are included) and necessity-driven enterprises, it is not possible to estimate the number of startups alone. However, overall, the trends indicate that startups have been actively developing over time.

Table 1. Trends of newly established companies

Founder Age	2008	2009	2010	2011	2012	2013	2014	2015
Young (39 years old and younger)	15,778	17,410	18,518	18,665	21,048	21,311	22,806	25,404
Middle Age (40 years old and older)	35,077	39,420	41,794	46,445	53,114	54,263	61,891	68,364
Total	50,855	56,830	60,312	65,110	74,162	75,574	84,697	93,768

(Source: Statistics Korea)

Based on the trends over the last eight years, it was found that the number of newly established companies has been constantly increasing each year. Given that the data include both opportunity-driven enterprises (in which most startup companies are included) and necessity-driven enterprises, it is not possible to estimate the number of startups alone. However, overall, the trends indicate that startups have been actively developing over time.

When evaluating startup ecology, noting the number of startups is important, but it is critical to remember that this figure only captures a segment of the big picture. Qualitative analysis needs to be included, and the two types of enterprises (opportunity-driven and necessity-driven) need to be distinguished.

Supported by the youth entrepreneurship policy, various supportive polices such as entrepreneurship education, commercialization support, and angel investor matching have been implemented, which make it easier for young entrepreneurs to start their businesses. As a result, the number of new companies established by young entrepreneurs has been increasing markedly. For instance, the number of student startup companies rose dramatically from 377 in 2012 to 637 in 2014, and the rate of increase of youth startup companies was nearly 30% in 2015.

However, despite this quantitative growth, it should be noted that there are voices warning against the high dependency on policy support. There have been criticism that government funding has been excessively expanded under the claim, “Youth entrepreneurs will boost the Korean economy”. Despite a great deal of support, there still are vulnerability factors among youth startups. Specifically, the rate of business closure among young entrepreneurs is 25.5%, which is higher than the average rate of 12.9% (Employment Information of Statistics Korea, 2014). This shows that youth startups are generally not sustainable; the startup idea cannot move forward, and the entrepreneurial spirit is not strong enough. Second, although the number of youth startups has increased, the portion of necessity-driven enterprises remains higher than that of opportunity-driven enterprises. The Creative Economy paradigm spotlighted youth entrepreneurship due to the importance of opportunity-driven entrepreneurship; however, it has been shown that opportunity-driven enterprises have yet to represent the majority in the market. As is well known, necessity-driven enterprises are an alternative to job-seeking competition, and opportunity-driven enterprises are attempts to take on future growth engines. The latter type have the potential to grow into drivers of the national economy; examples include Google, Facebook, and Tesla. Therefore, the effects of the two types of enterprises are significantly different.

Table 2. Number of university student startups

Year	2012	2013	2014	2016
Number of Startups	377	500	637	770

(Source: Korea Institute of Startup & Entrepreneurship Development)

The number of university student startups has also dramatically increased since 2014. It is believed that this is directly affected by the Creative Economy policy. It is encouraging that university student startups are active in the areas of idea-based and technology-based startups. However, these enterprises also pose risks insofar as the chance of failure is high given the lack of experience and knowledge. The change in the number of university student startups can be estimated based on the level of governmental policies geared toward encouraging youth entrepreneurship.

The number of university startup clubs has dramatically increased, supported by the governmental entrepreneurship encouragement policy. This policy reflects strong interest in youth startups.

Table 3. Number of university startup clubs

Year	2013	2014	2015
Number of Startup Clubs	1,833	2,949	4.070

(Source: 2015 Investigation on the Actual Infrastructure Conditions for University Startups, Korea Institute of Startup & Entrepreneurship Development)

Table 4. Number of startups created by university faculty members

Year		2013	2014	2015
Number of Startups	College	9	6	15
	University	69	43	118

(Source: Higher Education in Korea)

The number of startups founded by faculty at universities has been on the rise in 2016. It seems that the government's policy focus in the last few years on raising high-quality technology startups is beginning to take effect. The startups founded by science and technology professors and graduates at various universities can be viewed as representing these high-quality startups. Albeit over a short observational period, the increasing number of these types of startups can be regarded as an encouraging phenomenon when evaluating the startup ecology.

2.1.2. Expansion of Governmental Support

Over the last five years, the amount of governmental support for startups has been consistently on the rise. In particular, the support for startup preparation has dramatically increased. One can interpret this as an influence of the Creative Economy, which focuses on the startups' early stages. Overall it appears that the government has maintained continuous effort to create a startup ecology. Although there have been changes to the policy's motto in accordance with the current governmental slogan, the amount of support provided has not changed significantly.

2.2. Evaluation of an Investment Reflux Ecosystem

The conditions for an investment reflux ecosystem include the presence of angel investors, accelerators, and crowdfunding. Furthermore, exit channels such as M&A and IPO are also included.

Table 5. Government support by startup phase (Unit: one hundred million KRW, %)

	2011 Budget	2012 Budget	2013 Budget	2014 Budget	2015 Budget Proposal
Startup Preparation	677.4	613.4	833.2	1,144.3	1,416
Startup Implementation & Commercialization	14,735.9	14,943.3	16,429.7	14,666.3	11,599.6
Early Growth Stage	954.2	2,350.7	3,078.3	3,513	4,006.8
Rechallenge Support	1,687.9	1,866.1	2,160	2,337.9	2,093.1
Total	18,055.4	19,773.5	22,501.2	21,661.5	19,115.5

(Source: National Assembly Budget Office)

2.2.1. Angel Investors

It is uncommon for large-scale venture capital investments to reach out first to a startup company. Raising venture capital funds increase the chance for a successful IPO (Sohn, Kim, & Hur, 2012), but in reality, this chance is rare. Therefore, angel investors are important to startup companies (Kim & Park, 2013).

Angel investments are currently facing a revival after a long period of depression that lasted the past 15 years. The first renaissance was the venture boom period of the late 1990s; following that, a slump continued for more than 15 years. When attracting investments for startups, the closest investors are angel investors. In this vein, the revitalization of angel investment is regarded as an important condition for the development of a startup ecology.

Table 6. Angel investment in Korea

Year	2011	2012	2013	2014	2015	(March) 2016
Number of Angel Investors	369	2,610	4,868	7,060	9,468	10,377

(Source: Korea Business Angels Association)

2.2.2. Crowdfunding

Crowdfunding, a funding practice whereby monetary contributions are raised from a large number of people, is in its beginning stages. There is much room for improvement and development with respect to Kickstater, which is a US crowdfunding platform. It is believed, however, that when startups are nurtured, the crowdfunding market will naturally expand. Economic principles cannot go against the current; it is predicted that during the initial years, crowdfunding will be firmly rooted through supporting policies.

Table 7. Organization of private investment funds and investment (cumulative)

Category	2009	2010	2011	2012	2013	2014
Number of Funds	71	71	71	78	85	108
Amount (unit: one hundred million KRW)	407	411	411	432.3	664.9	731.5

(Source: Korea Business Angels Association)

Table 8. Investment crowdfunding in Korea

Industry	Offering Amount (KRW)	Issuing Amount (KRW)	Offering	Issuing	Funding Success Rate	Issuing Company
Manufacturing	3,996,023,012	2,109,680,500	24	13	54.2%	13
Publication, video, broadcast communications, and information services	2,630,153,200	1,323,776,000	21	13	61.9%	13
Professional, scientific, and technical services	2,515,940,808	865,454,036	14	7	50%	7
Wholesale and retail	2,300,025,899	1,585,214,649	12	9	75%	7
Finance and insurance	800,000,000	800,000,000	2	2	100%	2
Arts, sports, and leisure-related services	520,000,000	0	3	0	0%	0
Associations and organizations, repairs, and other personal services	300,800,000	0	1	0	0%	0
Education services	200,000,000	0	1	0	0%	0
Real estate and leasing services	150,000,000	148,800,000	2	2	100%	2
Agriculture, forestry, and fisheries	50,000,000	0	1	0	0%	0
Total	13,462,942,919	6,832,925,185	81	46	56.80%	44

(Source: CrowdNet)

2.2.3. Accelerators

The key elements of an accelerator program include a small equity investment for early startups and an intensive training (mentoring) period for a certain amount of time. Generally, an accelerator program selects a few promising startup companies (as little as two and as many as dozens) and invests tens of millions of KRW for each company, securing about 5 percent of equity (Kim & Hong, 2013). These programs then move companies to a business incubator center, which provides three to six months of Spartan training and mentoring. These programs help entrepreneurs fast track the development of their products or services. Startup founders who have success experiences share their know-how on product development and marketing. By the time of the completion of the program, additional opportunities for supplemental funding are offered via Demo Day when the successful founders invite many investors through their networks.

The accelerator program is a new model that focuses on funding and incubating startup companies, as exemplified by Y-Combinator in Silicon Valley in 2005 (Kim, S.W., 2015). Y-Combinator has developed Dropbox and Airbnb into global companies. Following its success, TechStars was established in 2006, Seedcamp in 2007, and Startupbootcamp in 2010. In Korea, Primer is the first accelerator, which was established in 2010. Currently, more than 20 accelerators have been established and are in operation. As a point of reference, one of the most representative accelerators in Korea, SparkLabs, has operated six batches thus far and nurtured 50 teams (as of December 2015). It is estimated that private accelerators in Korea have nurtured about 700 teams.

An accelerator is a business model that earns its profits by nurturing startups, and it has become a growing trend worldwide since the model was successfully established in the US (Kim, S.W., 2015). Currently, accelerator programs are actively in operation in Korea; these programs are continuously trying to identify promising startups, while establishing their own business models by nurturing these startups. However, there are not enough empirical studies on the causes of success or failure of accelerator programs, or on how they provide assistance to the startup companies. The reason for this lack of data is that the history of accelerator programs and their operations is short. The existence and efforts of accelerator programs are important for the development of a startup ecology; however, it seems that more time is required to evaluate how these programs can internally achieve their respective goals.

Table 9. Number of startups selected by accelerators in Korea

Global Startup Network	NEOPLY	TheVentures	VENTURE SQUARE	VENTURE PORT
45 Companies	22 Companies	17 Companies	28 Companies	15 Companies
ORANGE FARM	SparkLabs	CNT TECH	Coolidge Corner	Fashion Technology
62 Companies	48 Companies	25 Companies	25 Companies	8 Companies
FAST TRACK ASIA	FuturePlay	Primer	Mashup Angels	Kstartup AppCenter
23 Companies	30 Companies	72 Companies	41 Companies	20 Companies
SK Planet 101	sopoong	D3 Jubilee	ActnerLab	KOISRA Seed Partners
35 Companies	17 Companies	19 Companies	12 Companies	14 Companies
Total: 578 Companies				

(Source: Each company's website)

2.2.4. M&A

For startups, one of the important exit opportunities is the M&A (Lim, J.W., 2015). This is evidenced by success stories of many US startup companies that have been acquired by other firms. For instance, Instagram initially had only about 10 employees and was barely two years old, when it was acquired by the emerging large company, Facebook, for the tremendous amount of 1 billion USD (about 1.2 trillion KRW). This is an exemplary success story for startups.

The one area Korea needs most at present involves mergers and acquisitions (M&A). M&A is an essential factor that is urgently needed and should be further developed to ensure growth. Multilateral efforts to expand M&A have been undertaken, but it is not an easy problem to solve due to a number of cultural constraints. Therefore, it is believed that more effort and patience is needed.

Table 10. Startup M&A in Korea

Year	2014	2015
Number of Companies	9	72

(Source: Startup Investment Trends, Platum)

2.2.5. IPO (Initial Public Offering)

Besides M&A, another exit opportunity available for startups is the initial public offering (IPO). NASDAQ - where US high-tech companies including Google and Facebook are listed - is a representative IPO market. Similarly, in Korea, KOSDAQ is the main IPO channel.

The number of companies listed on the KOSDAQ is currently 1,168, as of the end of June 2016. The market capital amounts to about 206 trillion KRW. However, the opportunity to list a company on the KOSDAQ does not come easily. Considering that the number of startups and the number of certified business ventures exceed 30,000, this shows how challenging it is to go public through an IPO on KOSDAQ. In the US, the proportion of IPO firms on the NASDAQ is less than 30%, and the proportion of exit through M&A is more than 70%. This is the reason why we hear startup Cinderella stories following acquisitions by large cap companies. In Korea, attaining high absolute scale of IPO is difficult for startups, which is why expectations are high for a more active M&A market.

The KOSDAQ market has been maturing over the course of the 20 years since it first opened in 1996. The KOSDAQ was shaped in a developed market, and it came in third place of all IPOs in globally emerging markets. However, it is clear that an IPO is not an easy exit channel for startups.

3. Conclusion and Discussion

It cannot be denied that the role of startups is important for propelling the Korean economy. It is also reasonable to suggest that venture-based startup growth is more suitable than larger company-focused growth, especially in new industrial areas such as biotechnology, fintech, artificial intelligence, virtual reality, and smart farming.

From this perspective, ‘An Evaluation of the Startup Ecology in Korea,’ as proposed by this study, is only at the experimental level; however, it is meaningful insofar as it evaluates the maturity level of an ecosystem that serves as an absolute condition

Table 11. The number of IPO firms on KOSDAQ by year (Unit: Number of firms)

Category	’03	’04	’05	’06	’07	’08	’09	’10	’11	’12	’13	’14	’15
General	71	52	70	56	67	38	55	58	61	26	38	43	77
SPAC	-	-	-	-	-	-	-	18	1	-	2	26	45
Total	71	52	70	56	67	38	55	76	62	26	40	69	122

for the nurturing of startups. Also, it is meaningful to note that the measures used to develop a healthy ecosystem were reviewed based on the evaluation discussed herein.

The primary results of the evaluation, which featured the classification of two key elements of the 'entrepreneurial ecosystem' and the 'investment reflux ecosystem,' are as follows. First, the startup ecology is growing relatively actively, and it is estimated that in recent times, the number of startups that have been founded has increased at a rapid pace due to the government's promotion of the Creative Economy paradigm. However, an increasing number of startups is not always a positive phenomenon. The increase of startups must be accompanied by more high-quality startups. Given that the number of startups founded by university professors or graduate students (who can develop innovative or novel technologies) has neither increased nor decreased, it can be evaluated that qualitative growth is lagging. It is time that the role of technological startups is ascribed greater importance than that of necessity-based startups, and it is believed that a startup policy reflecting this point is required.

The recent startup boom reminds us of the failures associated with the first venture boom from 1998 to 2000. At that time, the excitement over business ventures was high, but only gave rise to young entrepreneurs who were unprepared. The same mistakes should not be repeated again; young entrepreneurs should be nurtured so that they can lead the Korean economy (Sohn & Kenney, 2007). Korea has grown to become the world's 11th-largest economy; however, even its key industries are facing a critical situation due to the changes in areas of specialization in Northeast Asia. Moreover, the technology pursuits of China further highlight how important it is to focus on progress without making costly mistakes. We already experienced the chaos that followed the end of the first venture boom (1998-2000), when the startup ecosystem floundered in the absence of true entrepreneurship (Sohn, 2004). The government needs to prepare policies that prevent these problems from emerging in the Creative Economy, while also helping young startups to truly succeed.

Whether they become game changers, entrepreneurs that control networks, or prominent business operators, there is a need for young entrepreneurs to establish themselves in the market. In particular, as startup policies are currently focused on supportive measures (especially by providing proactive support), young entrepreneurs may become vulnerable to moral hazards (Sohn, Kim & Lee, 2009). One could argue that these policies have given rise to the following two problems. First, young people who are not truly determined to establish a business may stay in the young startup group, possibly becoming 'prize hunters,' who seek prizes in various startup competitions. Second, this shows the limitations of hindering identification of true innovation. In various venture activities, 'differentiation'—which can differentiate superior entities from inferior entities—is a core function. Thus, it is depressing to note that such differentiation is not occurring in the early stages of startup development.

As the number of startups increase, the differentiation mechanism should be activated to distinguish between superior entities and inferior entities. However, it appears that the preparation for this mechanism is insufficient. Since the supply of startups has increased, especially due to policy support, such preparation has become critical. Before the market distinguishes between superior startups and others, a general supportive policy is the major lifeline for a startup ecology. When support polices are applied equally to all startups, moral hazard will result, and even lead to reverse selection against quality startups. The healthiest startup ecology is an ecosystem in which truly superior startups are

selected and are increased in competitiveness (Sohn, 2007). The future roadmap for startups in Korea should be established to lay the foundation for these conditions to emerge in an entrepreneurial ecology.

Second, unlike the growth of an entrepreneurial ecosystem, it was evident that an investment reflux ecosystem is still in its early development phase. An investment reflux ecosystem includes investment incentives, startup growth, and investment returns, and the major players are accelerators, angel investors, and crowdfunding. Overall, it has been shown that in its current state, the investment reflux ecosystem cannot be evaluated given that the picture of the currently existing infrastructure and the status of various players in this model are generally in their infancy. However, as the supply of startups and the proportion of blue-chip startups will increase to meet the growth of new industries, it is certain that the conditions for an investment reflux ecosystem will continue to develop. This is represented by the aggressive attraction of accelerators, the active participation of global players, and the reform of crowdfunding policies. One must remember that those seeds that sprout early need to take root in difficult environments, and once cultivated with care, they will subsequently act to nurture new startups. Evaluation of this investment reflux ecosystem will be left for future research.

Examining the future of the startup ecology in Korea, several facts that should be taken note of and must be attended to are apparent. An ecosystem will inevitably reach its equilibrium; however, this balance is not at all related to an ecosystem's overall performance (Sohn, 2013). In other words, equilibrium is not always a desirable point, and it also is not always the state in which optimal results are obtained. An ecosystem does not evolve in a specific direction with a particular purpose in mind, but simply continues to follow the current. In this vein, one can clearly understand why Charles Darwin referred to an ecosystem's evolution as a 'blind watchmaker.'

The same is true for the startup ecology in Korea. If we do not make an effort to promote the healthy evolution of an entrepreneurial ecosystem, it is difficult to predict the direction of its development in the future. The case in point is the fact that over the past 15 years ventures in Korea have reached its equilibrium by the convenience of several stakeholders rather than striking an optimal balance. I have named this concept an 'evolution failure' (Sohn, 2013), which means that the Korean economy did not reach its optimal point for startups; rather, an equilibrium was reached where it conformed to a "comfortable" condition for existing startups. With respect to the argument that startups should play leading roles in the Korean economy to help propel it forward, it is essential that the startup ecosystem's conditions be healthy and sophisticated enough to direct its evolution.

The role played by the government is not always negative, and it is also encouraging that some sophisticated programs are already being implemented. A good example of this is the "TIPS Program," which selects promising startup teams through angel investors and provides government R&D services linked to the angel investment. This policy encourages high-quality manpower to pursue technology startups; this can yield positive effects such as promoting angel investments, developing M&A markets, and activating supplemental venture capital investment markets. It provides opportunities for technology startup teams with limited investment funds, which in turn will prompt private angel investors to enhance their capacity to identify and incubate these startups. For the selected startup teams, angel investments of 100 million KRW for a maximum of up to three years, plus up to 500 million KRW (about 90%) + α of government R&D, is provided for initial establishment, R&D, and commercialization. This may be regarded as good practice, where the government has come forward to foster the creation of the market in an environment

where the investment market for a startup ecology is underdeveloped. As such, policy intervention is inevitable for market creation.

One of the notable trends in the startup ecology in Korea is globalization. Globalization has been prominent in two areas. The first is that global players have been entering into the Korean startup ecology; the second is that there is demand for Korean startup companies to expand into global markets, including in China. The level of domestic players is rising, and their level of competitiveness is also being amplified, particularly since global players have emerged in the Korean startup ecology. In this regard, it is estimated that the domestic participation of global players will serve as a signal that big shifts are unfolding in the startup ecology in Korea. As this will bring about revolutionary changes that will propel the development of the investment reflux ecosystem, which is currently in its early stages, it is believed that this change will be a turning point that will create lasting changes in the ecosystem. In addition to comprehensive incubators like Google Campus, accelerators in the US and China are also showing interest in numerous startups in Korea. The diversity they introduce to the ecosystem will ultimately help enhance the level of competitiveness among participants in Korea's startup ecosystem.

References

Kim, S.W. 2015. "The Role of Accelerator in Startup Ecology and Issues" Science and Technology Policy, 25(6), 20-25.

Kim, J.S., Hong, D.H. 2013. "Domestic and International Status of Accelerator and Analysis on Operation Cases" Information and Telecommunications Trends, 164-173.

Kim, J.H., Park, S.H. 2013. "A Study on the Performance after IPO of Firms financed by Venture Capital" Korean Journal of Accounting Research, 18(1), 83-103.

Sohn, D.W. 2004. <The Laws of Venture Evolution>, SERI Press

Sohn, D.W. 2007. <The Secret of the Life Cycle of Firms>, SERI Press

Sohn, D.W. 2013. <Rebirth of Venture Boom in Korea>, Nemo Books

Lim, J.W. 2015. "An overview of Korean startup eco-system and its challenges" Korea Information Science Society, 33(1), 19-25.

Small and Medium Business Administration, Annual Reports.

Bateson, G. 1979 Mind and Nature, NY: Dutton Press.

Moore, J.F. 1995. The Death of Competition. HBR Press.

Sohn, D.W. & Kenney, M. 2007. "Universities, Clusters, and Innovation Systems: The Case of Seoul, Korea" World Development, Vol 35, No 6, pp 991-1004.

Sohn, D.W., Kim, H. & Lee, J.H. 2009. "Policy-driven University-industry Linkages and Regional Innovation Networks in Korea" Environment and Planning C: Government and Policy, Vol 27, No 4, pp 647-664.

Sohn, D.W., Kim, H. & Hur, W. 2012. "Effect of Venture Capital and Government Support on the Performance of Venture Firms in Korea" Asian Journal of Technology Innovation, Vol 20, No 2, pp 309-322.

Su, D.J., Ali, M., & Sohn, D.W. 2011. "A Model to Create High-Tech Startups from the Academic Environment: The Case of Peking University (PKU) and Tsinghua University (THU)" African Journal of Business Management, Vol 5, No 26, pp 10821-10833. October, 2011.

Science and Technology Trends
Fostering Startup Ecosystems

Japan's Startup Ecosystem: From Brave New World to Part of Syncretic "New Japan"

Kenji Kushida

1. Introduction

This paper asks the following: what does Japan's startup ecosystem look like now, how did it develop, and where is it headed? These are critical questions because high-growth startup firms are now recognized as potential drivers of growth, innovation, and productivity gains for advanced industrialized countries (Gornall and Strebulaev, 2015; Wiens and Jackson, 2015).

Japan's historical postwar economic "catch-up" model revolved around a focus on large firms, which successfully delivered rapid economic growth and relatively high levels of social equity from the late 1950s through 1990 (Okimoto and Rohlen, 1988). However, since 1990, Japan's economic growth stalled and the country experienced multiple recessions. Many of the factors that had been considered beneficial to Japan's economic success such as long-term employment and stable corporate groups, were subsequently blamed for its slow growth. This was accentuated when new digital technologies brought new logics of competition and new global market dynamics with the rise of other Asian countries. The need to create a vibrant high growth startup ecosystem in Japan, contrasting that of the postwar large-firm centered model, therefore became one of the key foci of Japan's policy and social goals since the mid-1990s.

In the mid-1990s, when Silicon Valley was the focus of entrepreneurial dynamism worldwide, Japan's startup ecosystem faced numerous barriers on almost all fronts. With the political economy optimized for favoring large firms, the Japanese regulatory structures and social norms hindered activities in the fundamental areas underlying a Silicon Valley-style ecosystem, including financing, labor market, industry-university ties, industrial organization, and other ecosystem players.

From the late 1990s onwards, the Japanese government enacted a series of legal changes that improved the regulatory environment, lowering many of the barriers to creating a vibrant startup ecosystem in areas of financing, employment, M&A, and industry-university ties. At the same time, Japan's gradual economic structural shift and performance crises at many large firms began feeding the startup ecosystem by lowering the relative

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attractiveness of large firms. As the Information Technology (IT) sector grew, it also embraced high labor mobility, as did the growing presence of foreign firms. Social norms began to shift, making it startups a more attractive career choice.

Currently, Japan's startup ecosystem is more vibrant, with a greater potential to have a larger impact on Japan's economy as well as industries worldwide, than the past few decades. In terms of size, the amount of venture capital investment has followed US upturn and downturn cycles, and is still miniscule compared to Silicon Valley, but sizable compared to Germany, France or the UK. Initial Public Offerings (IPOs) are far smaller than those in US, but this also means that startups that do IPO get stable funding sooner, at the cost of potential breakneck growth that a pre-IPO firm may be capable of. Pre-IPO valuations are lower than in Silicon Valley, which makes M&A cheaper, and although M&A activity is still limited, it has grown considerably. More importantly, new patterns have emerged, such as Japanese robotics firms purchased by large Silicon Valley firms such as Google. The sectoral variety of Japanese high-growth startups is broad, with notable highly valued startups hailing from sectors including biotech to gaming, media, logistics, "Fintech", artificial intelligence, and others, focused both on consumer and business target areas. Tokyo remains the largest focal point of startups in Japan in a variety of sectors, but within Tokyo, the startup ecosystem does not have a single central geographic center. Finally, there is a new breed of entrepreneurs who grew up during Japan's slow-growth era who never experienced Japan's high growth era that ended in 1990, at least as part of the professional workforce. Many of the high-flying Japanese startups were founded by elite university graduates that would have, in previous eras, entered civil service or large firms.

Global technological opportunities such as the advent of global-scale Cloud computing that provides low-cost, scalable computing resources on demand, and the advent of smartphone platforms that have global reach, have accelerated startup ecosystems worldwide, including Japan (Kushida et al., 2015). The disruption of Japan's domestic limited mobile Internet platforms actually helped link its domestic startup ecosystem, which had been previously trapped in the domestic market, to access global markets.[1] Japan's startup ecosystem is also more international than ever before, with a new wave of Japanese startups that are forging strong ties to Silicon Valley, with some receiving Silicon Valley financing and others establishing branches in Silicon Valley.

The overall context of Japan's economic remodeling since the 1990s, within which the current trajectory of Japan's startup ecosystem is embedded, is best characterized by that of "syncretism." Syncretism refers to the simultaneous coexistence of distinct traditional, hybrid, and new economic characteristics and organizations (Kushida et al., 2014). While some areas remained traditional, such as regional banks and small-medium industries, new areas emerged, including the massive entry of foreign firms into previously protected areas of the economy, and a new high growth startup ecosystem. Other areas hybridized, combining traditional and new features, such as holding companies enabling financial institutions to enter various sectors, legal changes that allow for more diverse corporate governance structures, and increased variation in employment structures. The point of the concept syncretism, however, is that not everything hybridized; instead the distinct traditional, new, and hybrid areas remain. Japan's evolving startup ecosystem, the topic of this paper, is part of the "new" areas of development.

1 This phenomena of Japan's mobile content ecosystem and advanced platform services being trapped in the domestic market has been referred to as "Galapagos" or "leading without followers" (Kushida, 2011).

2. Silicon Valley and Startup Ecosystems: Intellectual and Institutional Foundations

Silicon Valley's startup ecosystem has provided the intellectual and economic driving force behind a focus on high-growth startup firms and the institutions that support an environment to foster such an ecosystem. Despite experiencing a major bubble in the late 1990s, and a smaller one in the mid-2000s, high growth Silicon Valley startups have transformed technological trajectories, disrupted existing industries, and produced some of the world's wealthiest companies in a short amount of time.[2]

The Silicon Valley-style "high growth startups" we are interested in are those attractive to venture capitalists, who operate at a different logic than traditional investment portfolios in Wall Street-style private equity or hedge funds. Top Silicon Valley venture capitalists (VCs) are not interested in typical steady growth firms, even if they may be growing at a healthy ten percent or even fifty percent per year, for example. Top tier VC portfolios are expected to produce one or two startups that account for the performance of the entire portfolio, of say 100 firms or so. VCs are in turn competing against each other vigorously for such returns (Thiel and Masters, 2014). Therefore, for VCs, identifying the truly fast growth firms is critical, and once the one or two firms are identified, the rest of the portfolio is sold off or folded. For a ten year fund, the first five years or so may have negative returns, but since the investors (limited partners) are locked into the ten year fund, so what matters is the performance at the end of the term, rather than the fund's performance at any given time. In the last few years of the fund, incredible rapid growth from the one or two high growth startups produce high returns for the entire portfolio. This is the type of "high growth startup" that we should focus on, since it is the logic that produced firms such as Yahoo, Google, Tesla, and the plethora of Silicon Valley firms that have generated profound industrial and technological shifts, as well as revenue and employment.

Since most analyses of startup ecosystems around the world implicitly or explicitly benchmark Silicon Valley, this paper will next take the key institutional features of Silicon Valley, then compare the same characteristics in Japan over time. However, anywhere compared to Silicon Valley along the parameters making Silicon Valley successful always produce the same conclusion: even if there have been improvements, there is a large gap between place X and Silicon Valley. This in of itself is not such a useful conclusion, so this paper will focus on concrete patterns and characteristics.

The institutional foundations of Silicon Valley can be summarized as the following (Kenny, 2000; Dasher et al., 2015): A) financial system centered on venture capital; B) a labor market providing high quality, diverse, and mobile human resources; C) industry-university-government interactions that generate streams of innovative ideas, products and processes; D) an industrial organization in which large, established firms and small startups grow together; E) a social system that encourages entrepreneurship; and F) professionals such as law firms and accounting firms that assist the establishment and growth of startups.

3. Japan's Large-firm Centered Postwar Economy: Success Followed by Disruption, Silicon Valley Dynamics of Competition

Japan's large-firm focused postwar political economic model was essentially at the opposite end of each of these features: A) bank-centered, then

2 For example, in 2015 Apple and Google had the highest market capitalizations, as well as the most cash held, of all companies in the world (Gornall and Strebulaev, 2015).

financial market enhanced financial system; B) long-term employment and seniority wages; C) corporate in-house R&D with limited university-industry ties; D) industrial organization focused on keiretsu structured centered on large firms; E) a social system focused on channeling the best and brightest to large firms; and F) lack of differentiation between traditional low growth small-medium firms and the potential for high growth startups. Thus, given this overall economic structure, it is not surprising that Japan's startup ecosystem with characteristics resembling Silicon Valley was slow to develop.

The period when Japanese firms arguably had the most impact on global competition was in the late 1970s and 1980s. The production paradigm of "lean production" from Japan's automobile sector affected manufacturing industries worldwide, Japanese firms were leaders in the semiconductor industry, they succeeded in commercializing numerous nascent technologies invented in the US, and they invented new product categories such as the pocket calculator and Walkman portable cassette player (Womack et al., 1991; Johnstone, 1999).

Many of the large competitive Japanese firms, notably Sony, Panasonic, Honda, and others were founded in the early postwar era. However by the 1970s and 1980s, the Japanese economic model was not conducive to founding high growth startup firms. This was not seen as a problem until an asset bubble burst in 1990, with Japan entering a prolonged period of slow economic growth punctuated by several recessions.

Silicon Valley and computer industry firms created new dynamics of competition. Modular architecture shifted the value from final assembly to constituent elements (Baldwin and Clark, 2000), and platform-based competition, enabled platform providers to benefit from third party products (Gawer and Cusumano, 2002). Winners from the computer industry, followed by computer networking, then the Internet, were most Silicon Valley venture capital backed startups.

American firms that adjusted successfully did so by pursuing high value through software, by embracing "open innovation" in which innovations outside large companies were brought in through M&A and working with startups (Chesbrough, 2003). They also pioneered cross-national production networks that enabled "designed in California, manufactured in China" production, even for high end IT products.

4. Japan's Startup Ecosystem: How it was in the 1990s

Observers of Japan's nascent startup ecosystem in the late 1990s noted the following (Imai, 1998). A) Venture capital markets were nascent, and since venture capitalists can only get returns through IPO or M&A of the startups they invest into, the lack of an IPO market or M&A activity made it unattractive. Moreover, most venture capital funds were created and operated by existing financial firms whose salaried employees were investing on behalf of the companies, leading to risk-averse portfolios that did not follow the logic of finding a couple truly massive growth firms. B) Japan's labor market for startups was constrained and illiquid, since the best talent went to large firms. C) University-industry-government linkages were weak in terms of spinning out startups, especially since the nation's top universities such as University of Tokyo, Kyoto University, and Tsukuba University were national universities, and faculty were public servants, constrained from working outside the university. Most universities had very little experience licensing technology outside as well, with Technology Licensing Offices lacking personnel and resources. D) Large firms were overwhelmingly engaged in "closed innovation," and seldom relied on M&A or purchasing products and services from startup

firms, making it difficult for startups to find crucial early, large customers. E) Entrepreneurship was not supported by Japan's social norms, with elite career paths limited to large firms and top government agencies, while joining startups was considered a second or third tier option. IT entrepreneurs of the late 1990s even discovered the need to sometimes convince the dubious parents of prospective new graduate hires that the latter were not making severe career mistakes. F) There was relatively little support ecosystem for startups, with accountants and lawyers having little if any experience with high growth startups, and little ability to the play the roles of deal-maker, advocate, advisor, and other functions that Silicon Valley professional firms provide.

Many observers' images of Japan's startup ecosystem remained frozen at this time. Yet, major changes have occurred since.

5. Japan's New Startup Ecosystem

As seen from mid-2016, Japan's startup ecosystem has developed considerably, as many of the characteristics of the overall economy have transformed to create a new environment.

Table 1. Silicon Valley startup ecosystem characteristics compared to Japan in mid-1990s, and Japan in 2016

Silicon Valley startup ecosystem characteristic	Japan in the mid-1990s: impediments	Japan in 2016: changes that facilitate startup ecosystem
Financial system: venture capital	Bank-centered, traditional financial markets	New small cap financial markets, growing VC industry, rise of independent VCs
Labor market: fluid, diverse, highly skilled	Long term employment with seniority ties creating illiquid labor markets. Best and brightest locked into large firms for entire career	Increasing labor mobility, especially in IT sector and with foreign firms. Lower prestige and opportunity with large firms
Industry-University-Government ties	Numerous formal regulatory constraints	Active efforts by universities, private venture capital, and government to spin out successful startups with university technology
"Open" innovation with large firms and small firm symbiosis	Closed innovation with large firms in-house R&D and uninterested in business with startups	Firms more interested in open innovation, participation in VC funds, business with startups.
Social system encouraging entrepreneurship	Entrepreneurship seen as low prestige vis-à-vis large firms and government	Rising attractiveness of entrepreneurship as large firms enter competitive crises, increases cases of successful startups
Professional services ecosystem	Small size of professional ecosystem	Law firms and accounting firms setting up startup-focused practice areas to foster and benefit from growing startup ecosystem

Table 2. Venture capital investment amounts (billions USD)

	2010	2015
Japan	1.29	1.11
Germany	0.97	0.87
France	0.80	0.84
UK	0.79	0.62
Israel	0.41	0.65
South Korea	0.96	1.78
EU Total	4.26	5.91
US Total	23.52	59.70
Silicon Valley	9.39	27.76

Source: Venture Enterprise Center, GVCA, BVCA, AFIC, IVC Research Center, KVCA
*Note that UK's data is as of 2014.

Japan's venture capital industry developed significantly. While the size remains far smaller than that of the US or Silicon Valley, the amounts are actually greater than other notable advanced industrialized countries such as France, Germany, and the UK.

The most important qualitative shift in Japan's venture capital industry has been the rise of independent VCs. The historical dominance of financial institution funds was criticized for not incentivizing investors to pursue high returns. By 2015 and 2014, however, the largest amounts of capital invested in new funds were for independent funds. In 2015, it was 35%, followed by corporate venture capital (CVC) at 28% and financial institution VCs at 18%. For the previous year, independent VCs received 42%, with CVCs receiving 43%. Some examples of independent VCs include World Innovation Lab, Globis Capital Partners, B Dash Ventures, and others.

An important driver of Japan's VC growth was the creation of small capitalization markets in the late 1990s. Two competing small cap markets were created in 1999, providing a stable source of exits in which VCs could realize returns from their investments. The relative cost of listing in Japan's small cap markets, Mothers and JASDAQ, is far lower than other Asian markets, and the scale is far smaller than the US NASDAQ (Riney, 2016). On the one hand, this hinders truly large high-growth firms from emerging, since once firms are listed at a smaller scale, they tend to become more risk averse and pursue stable rather than exponential growth. On the other hand, since it is easier to IPO in Japan than in the US, Japanese VCs may actually face a more predictable exit strategy environment (Riney, 2016).

The Innovation Network Corporation of Japan (INCJ) is a noteworthy government-spearheaded attempt to spark investments in Japan's startup ecosystem. Established in 2009, it was a 300 billion yen fund with 286 billion from the government and 14 billion from 26 corporations which include Japan's major corporations including Toyota, Canon, and many from the Sumitomo and Mitsubishi groups. Additional government guarantees of 1800 billion yen in loans enabled the INCJ to invest approximately 2000 billion yen total. The lifespan of INCJ is fixed at 15 years, and it is run by a mix of government officials and private sector participants. While some analyses may view this government-spearheaded fund as simply crowding out potential private investments, it may also be viewed as a having a legitimizing effect for startups and other venture capital firms such as WiL that have received INCJ investments.

Table 3. Amounts raised in IPO, small-cap markets in Japan, US

	Average (million $)		Median (million $)	
	Japan (Mothers/JQ)	US NASDAQ	Japan (Mothers/JQ)	US NASDAQ
2015	7.6	116.0	3.5	75.0
2014	8.7	121.6	5.7	65.0

Source: Tokyo Stock Exchange, NASDAQ

Labor mobility in Japan for high skilled workers increased significantly, improving the supply of talent pouring into the startup ecosystem. In the late 1990s, the government abandoned the "convoy" system of supporting financial institutions, and a series of failed banks, securities houses, and insurance companies released pools of elite workers into the labor force. At the same time, a rapid increase in the presence of foreign firms added liquidity to labor markets as they hired mid-career workers and introduced norms of high quality workers shifting jobs to advance their careers. The IT industry in particular experienced high labor liquidity among Japanese firms as well, with some high growth startups from the 1990s becoming large by mid-2000s.

Silicon Valley firms in Japan are a new source of entrepreneurs and Japanese startup ecosystem players. The founders of companies such as Wantedly, a social networking-based job recruiting service, and Freee, providing online accounting services for small-medium businesses, had worked at Facebook and Google, respectively. The founders of Soracom, providing a Internet of Things (IoT) infrastructure service platform, had previously worked at Amazon Web Services.

Even in traditional large firms, which traditionally "locked up" much of Japan's best talent, younger employees leaving to form their own companies have led to some notable startups, absorbing further employees as they grow. Cerevo, for example, a hardware firm that designs products that connect to the Internet to provide functionality was founded by a former employee of Panasonic, drawing engineers from almost all the major Japanese consumer electronics companies, such as Sony, Sharp, Panasonic, NEC, and others. UPQ, a consumer electronics startup founded in 2015 that made headlines by introducing 24 highly aesthetic design products in its first two months, ranging from smartphones to speakers, a glass keyboard, backpack with built-in battery for charging devices, a chair, and other things. The entrepreneur, Yuko Nakazawa, was in her mid to late 20s, and had initially worked for Casio to design their mobile phones, but left when Casio withdrew from the handset industry.

Industry-university ties strengthened considerably with regulatory shifts and reforms to national university legal structures. Japans' version of the US Bayh-Dole Act in 1999 enabled government funded intellectual property to remain with universities and research institutes, providing incentive for researchers to commercialize their intellectual property. Measures to support Technology Licensing Offices (TLOs) lowered the hurdles to commercialize technology, and in 2004 national universities became independent organizations, increasing flexibility of employment arrangements and outside consulting for professors and researchers.

Notable Japanese university spinoffs began to appear. For example, Cyberdyne, which grew out of Tsukuba University, produces robotic suits that assist human movement. Founded in 2004, Cyberdyne was a trailblazer, winning numerous awards in Japan and abroad, including the American Society for Artificial Organs, and the IEEE/IR Invention and Entrepreneurship Award. It worked with large German companies received accreditation from the European Commission in 2013, making it the world's first robotic remedial device. The company went public in March 2014 on the Mothers exchange. Founder Yoshiyuki Sankai did note, however, that had the company been founded in Silicon Valley, it would have grown much faster, since the early funding came from personal assets and bank loans during Japan's venture capital downturn in the early 2000s.

Spiber, founded in 2007, successfully created synthetic spider silk by decoding the genetic information of fibroin, a protein that is the main component of spider silk. The technology grew out

of a laboratory at Keio University, with then graduate student Kazuhide Sekiyama, along with then-undergraduate Junichi Sugihara making the discovery in early 2007 and starting the company later that year. Given the unfavorable investment climate immediately following the global financial crisis, it took them two years to make a technological breakthrough to produce artificial spider thread and subsequently secure venture capital funding. In 2012, the company entered into an alliance with an auto parts supplier for Toyota, Kojima Industries, and together they set up a factory for mass production.

At an earlier stage, NuProtein, founded by three professors and researchers at Nagoya University, invented a new methodology for synthesizing proteins. Called Protein Synthesis System 3.0 (PSST), compared to conventional methods that utilize e-coli which take about two weeks, PSST claims about fourteen times faster, fifty times the amount of yield, and a far greater array of proteins that can be synthesized. The researchers first made an academic impact by providing proteins synthesize for particular experiments, becoming co-authors on over ten top academic papers in journals such as Nature. The business is to sell protein synthesis kids and selling difficult to synthesize proteins such as hormones and membrane proteins, which are expected to be useful to discover new pharmaceutical products. The company received early financial support from New Energy and Industrial Development Organization (NEDO), and won startup pitch contests in Japan and Silicon Valley.

Japanese non-university research labs, in particular Riken, Japan's largest publically funded research lab, has also produced new basic research that has enabled venture capital backed startups. The most notable is Healios, which licensed a technology developed by Riken researcher Masayo Takahashi to use iPS cells to develop a regenerative therapy for age-related macular degeneration. While the Riken lab methods would cost an estimated $1 million per treatment, medical doctor and serial entrepreneur Tadahisa Kagimoto set out to develop a far lower cost line of cells using this technology. Founded in 2011, Healios received approximately 3 billion yen in funding from a group of Japanese firms involved in biopharma, including Sumitomo Dainippon Pharma, Nikon, Shin Nippon Biomedical Laboratories, and Tella. The company listed on the Mothers market in June 2015.

University-related VC funds UTEC (University of Tokyo Edge Capital), and Miyako Capital, affiliated with Kyoto University, have also been actively working to spin out technologies from these Japanese top universities into high growth startups. UTEC was established in 2004, with approximately $300 million in its funds, with 9 IPOs and 8 M&A exits by the end of 2015 among its 65 portfolio companies. Although still at an early stages of development, Miyako Capital was given $60 million from Kyoto University in 2015.

In terms of open innovation, large Japanese firms are increasingly embracing buying the services of startups partnering with them, and engaging in M&A. Overall M&A activity, not exclusive to startups, rose from 1707 in 2010 to 2285 in 2014 (Kariyazono, 2015). Newer firms tend to embrace M&A more easily, especially in the IT industry, allowing for new career paths. For example, Yusuke Asakura, a University of Tokyo graduate, worked for McKinsey, then started his own company making pre-smart phone cellular Internet service middleware. That company was purchased by social networking service provider Mixi, and Asakura eventually rose to CEO of Mixi when the latter was facing a downward spiral. Asakura successfully turned around the company, then left to start his next venture —still in his early 30s.

In terms of partnering with large companies, the aforementioned firms such as recruiting service Wantedly, and online business accounting service Freee found favorable environments. For Wantedly,

the need for large firms to recruit new talent, combined with large firms' significant recruiting budgets made Wantedly's subscription prices quite affordable for them, and enabling Wantedly to become profitable early on. Freee was able to enlist 1600 banks to integrate with their services in order to offer accounting services that integrated with banks.

Moreover, it is not only Japanese firms that are buying Japanese startups. While still a rare case, Japanese robotics startup Schaft was purchased by Google in 2013. Schaft was founded by University of Tokyo researchers focused on producing walking robots. Schaft entered the US DARPA Robotics Challenge, making headlines by dominating the trial round. However, once purchased by Google, the latter's philosophical opposition to receiving funding from DARPA, part of the US military, given to the competition's winner, pulled Schaft out of the final competition (Guizzo and Ackerman, 2014). This purchase represents a new pathway for Japanese startups, since top tier Silicon Valley firms such as Google have rarely purchased Japanese startups.

Thus, in terms of "open" innovation and the coexistence of large firms coexisting symbiotically with startups, Japanese large firms are increasingly the source of human capital, they have set up corporate venture capital funds in larger numbers, and they are less hesitant than ever before to partner with startups. Especially for traditional large firms, the challenge remains to make acquisitions an integral part of their strategies, with mechanisms to incorporate human capital that enters the companies through acquisition.

The attractiveness of entrepreneurship and working at high growth startup firms has increased significantly over the past two decades. For elite university graduates, the possibility of lifetime careers at large firms are less likely when the longevity of the firms themselves are in question. In the late 1990s, staid financial institutions such as the Long Term Credit Bank and Yamaichi Securities went bankrupt, most large electronics firms such as NEC, Fujitsu, Sony, and others lost in global competition for semiconductors, telecommunications, and consumer electronics, selling off or shuttering their operations in those areas. Consumer electronics firm Sanyo was sold to Panasonic, with many of its divisions sold to Chinese firm Haier, a massive accounting fraud was uncovered in Toshiba in 2015, and in early 2016, Sharp, once a front-runner in flat panel displays and consumer electronics such as mobile handsets, was sold to Taiwanese firm Foxconn. While stable jobs at large firms continue to be attractive, they are far less so than two decades ago. A list of the universities attended by founders of startups with top fundraising in 2015 reveal that almost all were from elite universities.

Numerous startup pitch contests and major events celebrating high growth startups have been taking place in recent years. Audiences number in the thousands, some are focused on having policy recommendation arms, and they often receive national news coverage. These organizations and events help legitimize and popularize a culture of high growth startups. Some include the annual New Economy Summit, launched in 2013, organized by the Japan Association of New Economy, set up by Japan's largest, listed online commerce company, Rakuten. The New Economy Summit invited prominent Silicon Valley entrepreneurs such as Larry Ellison, founder of Oracle, and the founders of startups such as Dropbox, Lyft, Box.com, and Andy Rubin whose company was bought by Google and became the Android platform. The Infinity Ventures summit, which began in 2009, brings hundreds of companies to Kyoto annually, and is a hub for investors, entrepreneurs, and large firms to meet. Less business focused and inspiration community building events such as Slush Asia, orchestrated by Finish firm Slush, took place in Tokyo in 2016. From the government, NEDO, which subsidized the

R&D of science and technology-based startups, pitch contest, the NEDO Technology Commercialization Program, featuring startups that entered several rounds of pitch competitions around the country. The first program took place in 2015.

Finally, Japan's startup support ecosystem is maturing, with an increasing number of support actors such as accounting firms and law firms not only providing services, but also actively orchestrating startup-focused events and services. For example, Tohmatsu Venture Support, a subsidiary of accounting firm Deloitte Tohmatsu, has been supporting weekly "morning pitch" events at 7am in Tokyo since 2011, expanding to other major cities as well. They provide many services to early stage startups free of charge, with the aim of fostering a vibrant startup ecosystem from which they can benefit. The company has also set up a Silicon Valley branch to help Japanese startups enter Silicon Valley.

While there is no comprehensive database of Japanese startups in Silicon Valley, ties between the Japanese startup ecosystem and Silicon Valley are strengthening.[3] Several Japanese were part of the programs at top accelerators such as Y Combinator and 500 Startups.

6. Conclusion

This paper has provided an update and broad context of Japan's startup ecosystem as seen in 2016. When compared to Silicon Valley, the ecosystem is still small in scale, but so is virtually every other startup ecosystem. Over time, the overall characteristics, regulatory structures, and social norms of Japan have shifted from being highly unfavorable to a vibrant startup ecosystem, towards a far more supportive environment.

Overall, it is reasonable to be optimistic about the trajectory of development for Japan's startup ecosystem. Some of the most obvious regulatory barriers were removed, and many of the industrial structural factors have evolved as numerous large firms have entered performance crises and experience uncertain futures. A generational shift is accompanying social normative changes that are becoming more supportive of entrepreneurship and high growth startups. Entrepreneurs and high growth startups are more celebrated in the popular media and in major events more than ever before. And an ecosystem of previously successful entrepreneurs and investors, combined with those that have experience in Silicon Valley and elsewhere, is becoming stronger. While another "tech bubble" burst of sorts centered around Silicon Valley may occur, leading to decreased venture capital financing for the short term, the fundamentals that push towards an increase in the quality and quantity of high growth startups are likely to remain.

In the future, if current trajectories hold, we should expect a growing number of successful startups and some distinctive R&D based and university technology based startups, supported by a stronger ecosystem of startup-related players, combined with more open large firms. Large firms are likely to produce more entrepreneurs who leave to seek better opportunities, and as more leave, the large firms that successfully harness high growth startups are likely to remain more competitive, leading to a positive reinforcement cycle.

*For more figures and data for the points made in this short paper, abridged due to space constraints, please see "Selected Facts and Figures of Japan's Startup Ecosystem," Stanford Silicon Valley – New Japan Project 2016. http://www.stanford-svnj.org/s/Japan-Startup-Ecosystem-Figures-and-Tables.pdf

3 The Stanford Silicon Valley – New Japan Project is compiling a database of Japanese startups in Silicon Valley. http://www.stanford-svnj.org

References

Baldwin, C. Y. and K. B. Clark (2000). Design rules. Cambridge, Mass., MIT Press.

Gawer, A. and M. A. Cusumano (2002). Platform leadership: how Intel, Microsoft, and Cisco drive industry innovation. Boston, Mass., Harvard Business School Press.

Chesbrough, H. W. (2003). Open innovation : the new imperative for creating and profiting from technology. Boston, Mass., Harvard Business School Press.

Dasher, R., N. Harada, T. Hoshi, K. E. Kushida and T. Okazaki (2015). "Institutional Foundations for Innovation-Based Economic Growth."

Feigenbaum, E. and D. Brunner (2002). Kigyo Tokku de Nihon Keizi no Fukkatsu wo! [Revive the Japanese Economy with Special Economic Zones!] (English title: The Japanese Entrepreneur: Making the Desert Bloom). Tokyo, Nihon Keizai Shinbun Sha.

Gornall, W. and I. A. Strebulaev (2015). "The economic impact of venture capital: Evidence from public companies." Stanford Graduate School of Business Research Paper (15-55)

Guizzo, E. and E. Ackerman. (2014). "Who is Schaft, the robot company bought by Google and winner of the DRC?" Retrieved June 1, 2016, from http://spectrum.ieee.org/automaton/robotics/humanoids/schaft-robot-company-bought-by-google-darpa-robotics-challenge-winner.

Imai, K., Ed. (1998). Benchaazu infura (The Infrastructure of Venture Companies). Tokyo, NTT Shuppan.

Johnstone, B. (1999). We were burning: Japanese entrepreneurs and the forging of the electronic age. Boulder, Colo., Basic Books.

Kariyazono, S. (2015). Japan as a Startup Nation. US-Japan Venture Capital Conference, Stanford University.

Kenney, M. (2000). Understanding Silicon Valley : the anatomy of an entrepreneurial region. Stanford, Calif., Stanford University Press

Kushida, K. (2001). "Japanese Entrepreneurship: Changing Incentives in the Context of Developing a New Economic Model." Stanford Journal of East Asian Affairs 1(1): 86-95.

Kushida, K. E. (2011). "Leading Without Followers: How Politics and Market Dynamics Trapped Innovations in Japan's Domestic "Galapagos" Telecommunications Sector." Ibid. 11(3): 279-307.

Kushida, K. E., K. Shimizu and J. Oi, Eds. (2014). Syncretism: Corporate Restructuring and Political Reform in Japan, Shorenstein APARC.

Kushida, K. E., J. Murray and J. Zysman (2015). "Cloud Computing: From Scarcity to Abundance." Journal of Industry, Competition and Trade 15(1): 5-19.

Okimoto, D. I. and T. P. Rohlen (1988). Inside the Japanese system: readings on contemporary society and political economy. Stanford, Calif., Stanford University Press.

Riney, J. (2016). "7 Things Investors & Founders Need to Know about the Japan Startup Ecosystem." Retrieved 2016, June 1, from http://500.co/japan-startup-ecosystem-founders-investors/.

Thiel, P. A. and B. Masters (2014). Zero to one : notes on startups, or how to build the future. New York, Crown Business.

Wiens, J. and C. Jackson (2015) "The Importance of Young Firms for Economic Growth." Entrepreneurship Policy Digest, Kauffman Foundation.

Womack, J. P., D. T. Jones and D. Roos (1991). The machine that changed the world : the story of lean production. New York, N.Y., Harper Perennial.

Science and Technology Trends
Fostering Startup Ecosystems

Role of Public Science in Fostering the Innovation and Startup Ecosystem in Singapore

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1. Introduction

In recent years, entrepreneurship has been increasingly regarded as an engine of growth for both developed and developing economies. In developed countries where real wages and employment have not kept pace with GDP growth, technology-based startups are seen to be crucial in creating value and jobs for the society. On the other hand, for developing economies which faced multiple societal challenges ranging from water pollution to poor sanitation, entrepreneurs are seen as potential innovators in solving social ills. According to a study commissioned by the Kauffmann Foundation, most of the new jobs from 2000 to 2010 in the US have been created by high-technology startups (Kauffman, 2012). As a city state with limited natural resources on small land area of less than 720 square kilometres, Singapore has recognised the significant role of entrepreneurship since its first encounter with the economic recession in 1985. In the 1990s, the country, as part of its economic structural reform, began to shift gear from its initial twin strategy of export promotion and foreign direct investment to that of advocating innovation and entrepreneurship, in addition to the liberalisation of various service sectors—finance, utilities and telecommunications.

In 1999, the Singapore government through its agency, National Science and Technology Board, set up the US$1 billion Technopreneurship Innovation Fund (TIF) to implement the new Technopreneurship 21 programme. The programme aimed to encourage entrepreneurship in technology by fostering a business climate that was conducive to investment and providing education that would inspire interest in technological innovations among students (NRF, 2016). Following the heavy losses suffered by the investment funds arising from the dot-com crash and 9-11 terrorist attacks in the early 2000s, there was limited entrepreneurial and investment activity in Singapore. To make a concerted effort to grow innovation and entrepreneurship in the city state, the Prime Minister's Office of Singapore set up a national programme, National Framework of Innovation and Enterprise (NFIE), in 2008. The objectives of NFIE were to commercialise leading-edge technologies developed by the public research institutes (PRI) and institutes of higher learning (IHL) of Singapore

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through the creation of new high-technology ventures. Since then, several schemes have been launched to attract different stakeholders to collectively build the startup community, comprising researchers, innovators, entrepreneurs, investors, incubators and accelerators.

By 2014, entrepreneurial activity has increased significantly. The prevalence rate of individuals in the working age population actively involved in start-ups, also known as the Total early-stage Entrepreneurial Activity (TEA) rate, rose from 5.7% in 2004 to above 11% in 2014, with Singapore emerging among the top five in TEA globally, after the US, Australia and Canada, according to the Global Entrepreneurship Monitor (GEM, 2016). There has also been a doubling in the number of Singapore-based startups in the technology sectors to 5,400 in 2014 from 2,800 in 2004 (SPRING, 2016). In Herrmann et al.'s (2015) worldwide study of startup ecosystems, Singapore was ranked among the top ten, moving up seven places from 2012.

This article will provide an overview of Singapore's innovation and startup ecosystem, discuss the role of the public science in the country's ecosystem strategy and its impact on economic growth. We will conclude with managerial implications and directions for future research.

2. Overview of the Ecosystem

In a recent review of startup ecosystem frameworks by the Aspen Network of Development Entrepreneurs (2013), several models were comparatively analysed along the dimensions of complexity and geographic unit of analysis. The framework used by the Babson Entrepreneurship Ecosystem Project led by Professor Daniel Isenberg was found to be more conceptual and flexible than the others, as shown in Figure 1. Drawing upon the Babson's framework (Isenberg, 2011), this section analyses Singapore's innovation and startup ecosystem.

Figure 1. Innovation and Entrepreneurship Ecosystem Framework

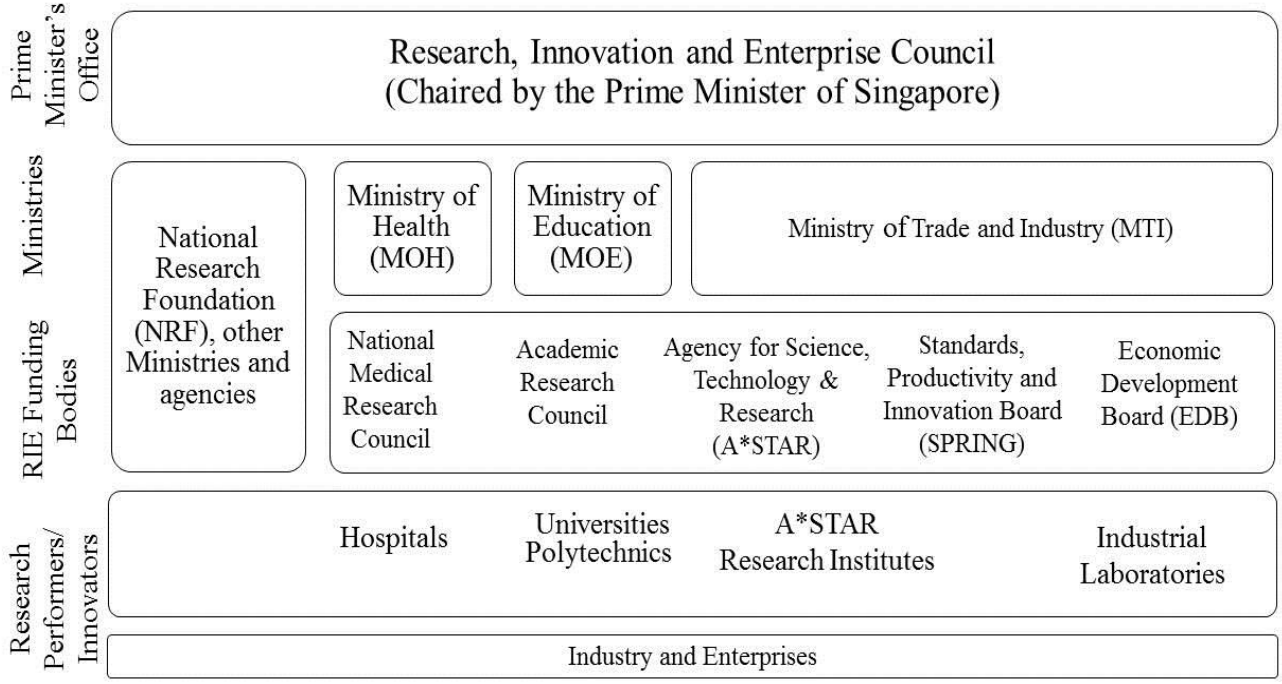
Source: Adaptation of Babson's Startup Ecosystem Framework, Isenberg (2011)

2.1. Government Policy

In 2006, the Singapore government set up the Research, Innovation and Enterprise Council (RIEC), chaired by the Prime Minister of Singapore, to advise the Singapore Cabinet on research and innovation policies, with a view to transforming Singapore into a knowledge-based society. The RIEC advocates research, innovation and enterprise (RIE) through knowledge creation initiatives such as the NFIE to drive new areas of innovation-driven economic growth. Figure 2 presents the key ministries and government agencies under the governance of RIEC that are responsible for funding a range of RIE programmes. These programmes are undertaken by research performers and innovators from the public and private research institutes, in collaboration with the business community.

To encourage risk-taking by innovators and entrepreneurs, Singapore has established venture-friendly legislation including bankruptcy laws, which have been modified since 1999 as part of Technopreneurship 21 Programme. According to Lee et al.'s study (2011) of 29 countries including Singapore over 19 years (1990-2008), there is a positive association between startup-friendly bankruptcy laws and the rate of new firm formation.

Figure 2. National Framework of Innovation and Enterprise (NFIE)



Source: NRF (2015)

In the study, Singapore's bankruptcy proceedings emerged as among the fastest (at 9.6 months versus an average of 29 months for all countries) and least costly (at 1% of debtor's estate value compared to an average of 13% for all countries), allowing bankrupt entrepreneurs to start afresh in liquidation. Reducing the duration of bankruptcy procedure down from an average of 29 months to 10 days could increase the probability of firm entry by 10 percentage points, while decreasing the cost from average of 13% to 1% of debtors' estate value could improve that by 11 percentage points.

To promote innovation and entrepreneurship, a regulatory framework of incentives including tax benefits have been put in place. For example, Singapore startups have been granted tax exemption of up to S$200k since 2005 while angel investors have been eligible for tax deduction since 2010 of up to S$250k for their investment in startups (IRAS, 2016). In 2016, the total tax rate of Singapore was 18.4% of profit, which was much lower than the average of OECD high-income countries at 41.2%, as provided by the World Bank. Corporate tax rate is known to have a large and statistically significant effect on new firm formation and investment. In fact, a rise in the effective corporate tax rate by 10 percentage points was found to decrease the average firm entry and investment rate by 1.4 and 2.2 percentage points, respectively, based a study of 85 countries including Singapore (Djankov et al., 2010).

Apart from venture-friendly legislation and regulatory framework, the Singapore government has set up PRI, investment institutions and financial support system to drive technology-based entrepreneurship. In particular, the Agency for Science and Technology Research (A*STAR) was established in 2002 to oversee more than 14 PRIs that conduct cutting-edge research in disciplines ranging from biomedical sciences to physical

sciences and engineering. By 2012, A*STAR has built a portfolio of more than 3,500 patents and was ranked second by the flagship journal of the Institute of Electrical and Electronics Engineers (IEEE), Spectrum, in the Patent Power 2013 Scorecards under the category of government agency. The public investment institutions and their support schemes are listed in Table 1.

Table 1. Summary of government schemes that support innovation and entrepreneurship

Agency	Year	Name of scheme	Type of scheme	Target stakeholders	Support Quantum
SPRING	2000	SPRING Startup Enterprise Development Scheme (SEEDS)	Equity Investment	Investors	up to S$2m (dollar-for-dollar matching) per deal
	2005	Business Angel Scheme (BAS)	Equity Investment	Business angels	up to S$2m (dollar-for-dollar matching) per deal
	2015	Sector Specific Accelerator (SSA)	Equity Investment	Accelerators	S$70m for the whole programme
	2008	Technology Enterprise Commercialisation Scheme (TECS)	Grant	Projects of innovators/ entrepreneurs	up to S$250k per proof-of-concept project/ S$500k per proof-of-value project
	2008	Young Entrepreneurs Scheme for Schools (YES!)	Grant	Schools	up to S$10k per school (total S$4.5m fund)
	2009	Incubator Development Programme (IDP)	Grant	Incubators or Venture accelerators	S$30m for the whole programme in 2009 (up to 70% qualifying costs)
	2012	ACE (Action Community for Entrepreneurship) Startups Grant	Grant	First-time entrepreneurs	S$50k ($7 for every $3 matching) per startup
National Research Foundation (NRF)	2008	Early-Stage Venture Fund (ESVF)	Equity Investment	Venture capital firms	S$140 million for the whole programme
	2008	The Technology Incubation Scheme (TIS)	Equity Investment	Technology Incubators	up to S$500k (85% of investment) per startup
	2008	Proof-of-Concept (POC)	Grant	Public research/higher education institutes	up to S$250k per proof-of-concept project
Infocomm Development Authority (iDA)	2010	iSTART: ACE scheme (Accelerate and Catalyse Entrepreneurship)	Grant	Tech startups	up to S$250k (50% of staff salary of 5 technical staff)

Source: Authors' compilation of scheme information from SPRING, NRF and iDA reports, press releases and websites.

2.2. Finance

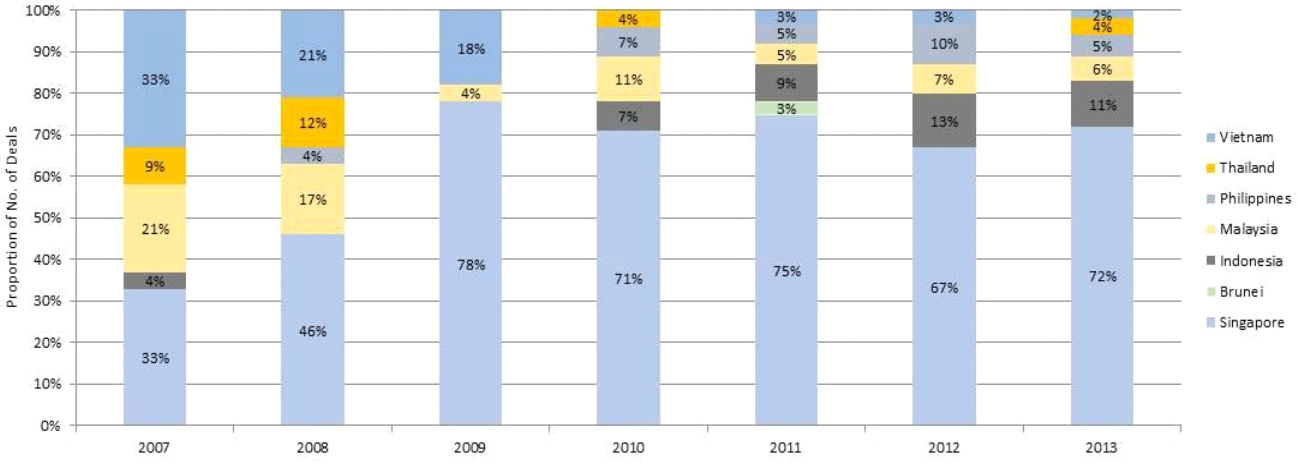
While public funds are the prevalent sources of fund for the seed stage of startups, there has been a steady increase in venture capital (VC) activities in the early stages of the startups. The vibrancy may be attributed to the government-supported Early Stage Venture Fund (ESVF) and related schemes that have been introduced from 2008 (refer to Table 1) to attract VC firms to invest in early-stage startups. According to a study by the Preqin and Singapore VC Association, the number of VC deals grew from 8 in 2007 to 73 in 2013, with a corresponding increase in the aggregate deal value from USD12 million to USD454 million. During the period, VC deals in Singapore dominated the ASEAN region with an annual average of 66% of the total deal count, as shown in Figure 3.

Since 2014, several banks started providing a range of loan products to startups. For example, the OCBC Bank of Singapore offered same-day approval for collateral-free loan of up to S$100k for young startups. The loan was provided as part of SPRING's Micro Loan Programme that would charge a minimum annual interest rate of 5.5%. Although this mode of financing would not need collateral, it would require a guarantor. Other banks that provide debt financing include DBS Bank's Micro Loan and United Overseas Bank's BizMoney.

2.3. Culture

Over the last decade, we have seen shifts in the cultural dimension of the startup ecosystem. The attitude towards entrepreneurship has become more favourable in Singapore. Comparing participants' responses in the GEM studies between 2004 and 2014, the proportion of respondents who reported that starting a business was a good career choice has increased from 49.1% to 51.7%. Those who felt that successful entrepreneurs were accorded high social status has also risen from 53.1% in 2004 to 62.9% in 2014. However, Singapore's scores for these two indicators of career choice and social status are comparable to the average of its Asia and Oceania region, at 52.3% and 59.7%, respectively, which in turn, are lower than those of the European Union region (55.6% and 68.8%) and North America (61.0 and 73.3%). It is apparent that the Asian culture is less inclined to create new ventures compared to the European and American culture. Singaporeans' fear of failure, on the other hand, remained low at around 38.6% in 2014, below the average of 42.8% across 27 countries (GEM, 2016).

Figure 3. Venture Capital Deals in ASEAN Region – Proportion by country, 2007-2014



Source: Preqin Venture Deals Analyst, 2014

2.4. Support

With strong support from the government agencies in IDP and TIS as detailed in Table 1, the Singapore ecosystem has witnessed a rapid expansion of infrastructural facilities (e.g., incubation centres, co-working space), professional services (e.g., legal, accounting, investment bankers, technical experts and advisors who work closely with accelerators) and non-government institutes (e.g., entrepreneur-friendly associations that organise hackathons and business plan competitions) set up to support innovation and entrepreneurship. Prior studies have shown that incubators providing access to physical resources, capital, network and office support could improve the survival rate of their participating ventures (Schwartz, 2013), while co-working spaces with accelerator support can promote entrepreneurship (Fuzi, 2015). By 2015, co-working spaces in Singapore have increased in number to 30, while accelerators has proliferated from one in 2010 to over 25. In response to attractive government policies, most of the accelerators came to Singapore shores in the last two years. These included international accelerators such as StartupBootCamp (founded in Copenhagen in 2010), collaboration between overseas accelerators and local companies, such as SPH Plug and Play - an accelerator operated jointly by local media firm SPH and US-based accelerator, Plug and Play, as well as local players like Lithan EdTech Accelerator and UNFRAMED. Some of the accelerators are more specialised. SPH Plug and Play, for example, specialised in media startups, while StartupBootCamp Fintech focused on financial technology.

2.5. Human Capital

Human capital is an essential resource in the ecosystem. There has been strong government emphasis on the development of R&D talent for technological innovation. In 2014, the number of Singapore research scientists and engineers (RSE) increased by a Compound Annual Growth Rate (CAGR) of 5.7% to 32,835 from 18,935 in 2004. The number of PhD RSEs in the public sector rose by CAGR of 9.2% from 3,282 in 2004 to 7,894 in 2014, while that in the private sector grew by CAGR of 8.4% from 781 in 2004 to 1,757 in 2014 (A*STAR, 2016). Entrepreneurship training was provided in schools to foster entrepreneurial mindset since early 2000, with strong government and community support. For example, the Ministry of Education and the private sector-led ACE committed S$15m in 2012 for schools to conduct structured programmes and internship opportunities, to equip 1,000 students with the relevant skills. While the quality of human capital is high in Singapore, the availability and costs of technical talent has been challenging for startups. Due to the small population at 5.54 million, the labour market has been tight with an annual average employment rate of 1.9% in 2015. Despite the country's open immigration policy, the shortage of human capital has been known as a bottleneck in the startup community. The time it takes to hire engineers in Singapore at 48 months is higher than that in the rest of the Asia Pacific countries (average 46 months), while the number of advisors with equity is also the highest at 1.27 mentors per startup in the region (average 0.94) (Herrmann et al., 2015).

2.6. Markets

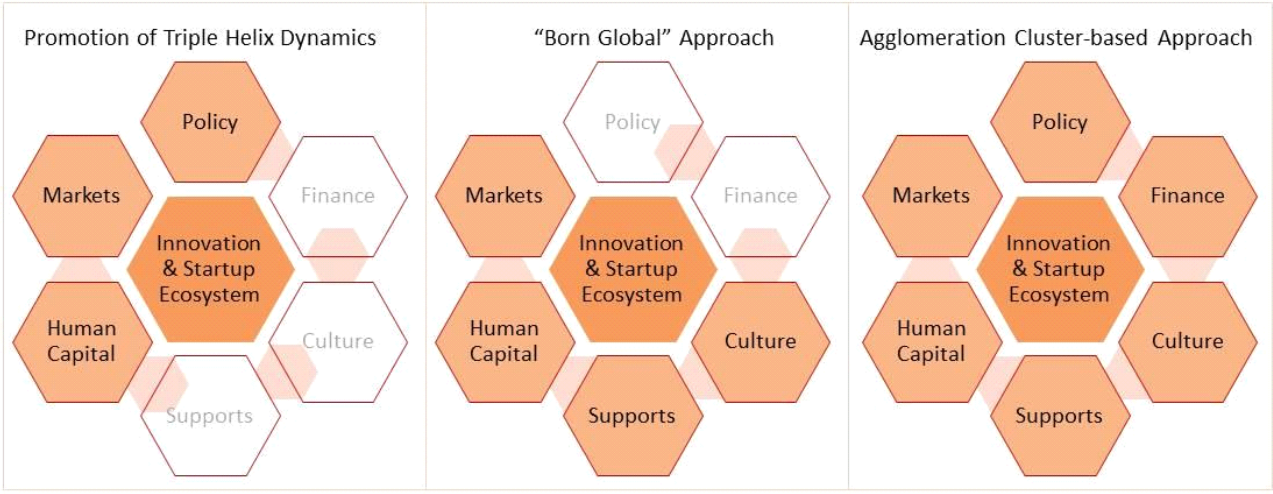
Singapore may have a small domestic market, but its strategic geographical location at the centre of the growing markets such as India and China, its multi-cultural society and pro-business environment have made it an attractive gateway to the Southeast Asian market. Local businesses have been able to reach out to overseas customers, with US, China and Indonesia being the top target

markets. More than 49% of their customers are foreign, which is higher than the average of 41% among the Asia Pacific region (Herrmann et al., 2015).

3. The Singapore Strategy

The development of innovation and entrepreneurship in Singapore is characterised by the dominant role of the city state. It can be argued that the ecosystem owes its existence to a series of strategic choices by policymakers as the nation shifted from a traditional manufacturing economy to a knowledge-based one. This section discusses three strategic approaches that have accelerated innovative entrepreneurial activities and shaped the way the ecosystem has evolved. It highlights how the strategy develops certain aspects of Isenberg's entrepreneurial dimensions, and leverages the intersectionality of the dimensions (Figure 4).

Figure 4. The Singapore Strategy



Source: Adaptation of Babson's Startup Ecosystem Framework, Isenberg (2011)

3.1. Promotion of Triple Helix Dynamics

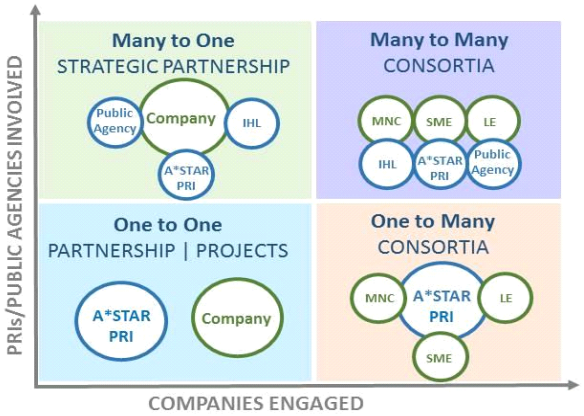
Etzkowitz and Leydesdorff (2000) positioned the Triple Helix model as a mechanism for describing the dynamics of institutional arrangements in national innovation systems. The basis for the Triple Helix Nexus is the interaction among three spheres– university, industry and government. Several perspectives have been explored on the emergence of the Triple Helix nexus in Singapore (Baber, 2001), highlighting how the nexus was sprung from a government platform to establish Singapore as a R&D-intensive hub.

The Triple Helix approach encourages government organisations and IHLs to engage with industry, emphasising collaborative modes of interaction. Industry involvement via technology commercialisation is also prioritised. The formation of public-private partnerships (PPP) channels R&D resources into industry-relevant areas and creates opportunities for new ideas, markets and businesses to be formed. To promote Triple Helix dynamics in Singapore, it was necessary to build a strong core of R&D capabilities in PRIs. Additionally, the government undertook to build infrastructures that support PPP projects and provide resources to bring innovations to commercialisation, corresponding to the Policy dimension of Isenberg's framework. On the part of the IHLs, the "third mission" assumed greater importance, with an industry lens being introduced

to both research and education. Leong et al. (2011) document the development of the entrepreneurial university model in Singapore's Triple Helix nexus. IHL researchers take on the role of innovators and graduates become potential entrepreneurs, corresponding to the Human Capital dimension. The PPPs created by Triple Helix dynamics foster the growth of networks, illustrating the Markets dimension.

The industry projects carried out by A*STAR highlight how Singapore has promoted Triple Helix dynamics in the ecosystem. Through unique PPP arrangements (see Figure 5), A*STAR and its PRIs have managed an extensive portfolio of projects that are highly complex and involve multiple partners and multiple levels within the government sector. The industry partners include multinational corporations (MNC), small and medium enterprises (SME) and local enterprises. The consortium projects are of special interest. These projects are field, application or industry-focused, and bring together scientists from all three Triple Helix spheres. An example is the EpiGen Consortium, which is an international alliance of the world's leading epigenetics researchers from A*STAR's Singapore's Institute for Clinical Sciences, and universities in Singapore, UK and New Zealand. In 2011, the EpiGen consortium embarked on a collaborative partnership with Nestle Research Centre and Nestle Nutrition.

Figure 5. Configuration of A*STAR industry projects



Source: A*STAR (reproduced with permission)

The Triple Helix approach also forms the basis for several initiatives undertaken to implement broader strategies for ecosystem development, which will be discussed in the following two subsections.

3.2. "Born Global" Approach

Singapore's small domestic market necessitates a global outlook for growth-stage start-ups. This limitation extends beyond access to distribution channels to issues of resource acquisition. In a study on Singapore high-tech startups by Wong et al. (2011), the fastest-growing startups revealed that the top challenges include recruitment of talent and the need to diversify their customer bases. While internationalisation is the answer, the cost of expansion is another frequently cited concern.

The internationalisation impetus for startups is recognised by policy makers, corresponding to the Policy dimension in Isenberg's framework. In the 2016 government budget, internationalisation is a key pillar for policies to assist startups to scale up. Two government agencies, SPRING and IE Singapore, have been providing internalisation assistance to Singapore startups in terms of establishing contacts and exploring markets abroad, supporting the expansion of the Markets dimension. Moving forward, the focus is on scaling up through digital internationalisation by building startups' capabilities in areas such as customer analytics and social media marketing. Startups with these capabilities are "born global" and can take advantage of the international digital economy to participate in global markets. To implement capability development strategies, government agencies work with industry associations and entrepreneurship facilitators such as accelerators and incubators, drawing on the Supports dimension.

The concept of "Born Global" also encompasses

inward-flowing talents and ideas, as the presence of overseas entrepreneurs and startups enriches the networks in the local ecosystem, further influencing the Markets dimension. Additionally, a more global outlook and the interactions between local and foreign entrepreneurs strengthen the Culture dimension. International exposure can mitigate the conservative attitudes towards entrepreneurship in Singapore society which has been documented in the GEM project.

A unique initiative that illustrates the Born Global approach is the National University of Singapore Research Institute (NUSRI) located in Suzhou Industrial Park, China. Founded in 2010, NUSRI facilitates cooperation between China and Singapore in research, education and enterprise activities. Drawing on Triple Helix dynamics, NUSRI provides a launchpad for Singapore and international startups to access the Chinese market. The NUSRI Incubator hosts over 15 Singapore startups on site, providing incubation services and networking opportunities with Chinese entrepreneurs, VCs and government officials. NUSRI also acts as a conduit for Chinese startups that are reciprocally attempting to enter the Singapore and ASEAN markets.

The Diagnostics Development (DxD) Hub also provides a platform for globalisation of Singapore startups. Led by A*STAR and launched in 2014, the DxD Hub brings together multiple stakeholders in Singapore's MedTech sector onto a common borderless platform to fast-track the development and commercialisation of diagnostic solutions. It integrates expertise across various segments of the industry by nurturing partnerships with and among companies, researchers, clinicians and regulators. The unique feature of the Hub is the early involvement of clinicians in the product development process, made possible by collaborations with hospitals, medical and clinical research centres. Through DxD Hub, startups and SMEs can access such public sector intellectual property (IP) that may otherwise be beyond their search scope. They can tap on the capabilities of larger industry players, including the many global MedTech companies in Singapore, to develop market-ready products that meet international regulatory standards.

To promote a "Born Global" mindset, policies have also been implemented to attract foreign entrepreneurs to start and operate new businesses in Singapore. The Entrepass (Singapore Entrepreneur Pass) scheme was launched in 2004, targeted at entrepreneurs with innovative business ideas. Assessment is based on merit and emphasises innovation content and growth potential. In 2011, NRF proposed a Global Entrepreneurial Executives scheme which aimed to attract entrepreneurs who have run high-growth companies in selected high-tech sectors to relocate their companies to Singapore. The entrepreneurs would contribute to the local ecosystem by providing guidance, mentorship and inspiration to local startups. Apart from these entrepreneur-specific initiatives, the talent augmentation policy and attractive tax structures have also been a magnet for innovators to come to Singapore.

A leading example of a foreign entrepreneur who has made significant contributions to the local scene is Eduardo Saverin, a Facebook co-founder. Since moving to Singapore in 2009, he has made several high-profile investments in local startups, including the online grocer Redmart and property portal 99.co. Roger Egan and Vikram Rupani, both non-Singaporeans with substantial corporate experience, met at the INSEAD Asia Campus in Singapore and decided to launch their startup, Redmart, here in 2011. Today, Redmart is one of the fastest growing e-commerce companies in Singapore, with regional expansion plans and jobs for several hundred employees.

3.3. Agglomeration Cluster-based Approach

The centrepiece of Singapore's strategy to accelerate the growth of the innovation and entrepreneurship ecosystem is the cluster-based approach. The building blocks of this approach are the agglomeration economies that arise when firms and people locate together. Contemporary theories on the economics of agglomeration have stressed the role of innovation and knowledge flows (Maskell, 2001), ideas explored in studies of dynamic entrepreneurial areas like the Silicon Valley. The Singapore experience presents a case of planned agglomeration to create an entrepreneurial cluster, with knowledge flows as the key mechanism for cluster development, and innovation and enterprise as the rents of agglomeration.

The cluster-based approach develops all six dimensions of Isenberg's framework. In describing industrial cluster development in Singapore, Wong et al. (2010) spell out five components which must be put in place for a knowledge cluster to be created:

1) Establishment of public science infrastructure, that is, universities and PRIs (Policy and Human Capital dimensions)
2) Attracting private sector to the cluster, including both the knowledge-intensive firms that form the core of the cluster and the supporting services that will surround them (Markets dimension). In the entrepreneurship cluster context, a key component of private sector supporting services are the investment firms (Finance dimension).
3) Establishing linkages with lead user markets (Markets dimension).
4) Facilitating knowledge flows and network links. This will include inter-sector networks, as well as creating platforms and mechanisms for collaborations (Supports dimension) and building social networks and communities of shared interest (Culture dimension).
5) Establishing a business environment and regulatory framework for the cluster to function. This will involve regulations and incentives (Policy dimension), infrastructure (Supports dimension) and resources (Finance dimension)

The cluster-based approach for ecosystem development is exemplified by the JTC Launchpad @ one-north project. The Launchpad was started in 2011 on the principle of co-locating all the key actors in the local technologically-based entrepreneurship scene in one space, conferring collective visibility on the community. The Launchpad kicked off with a single dilapidated building dating from the 1970s, Block 71 (Blk71) in the Ayer Rajah Industrial estate. In 2010, Blk71 was slated for demolition. In 2011, NUS Enterprise (a division of NUS that promotes innovation and entrepreneurship), Singtel Innov8 (the venture investing arm of telecommunications company Singtel) and the Media Development Authority of Singapore developed a collaboration to turn Blk71 into a central hub for tech startup activities. This illustrates a Triple Helix nexus strategy (Policy, Human Capital, Markets dimensions). The Blk71 initiative concentrated startups, investors (Finance) and facilitating organisations such as incubators and accelerators (Supports) in one space, to realise localisation economies. Regular networking events and an open-all-hours philosophy created a community where sharing and learning take place organically (Human Capital and Culture). Blk71 expanded rapidly with high take-up rates, and demand soon exceeded supply. In response, the government expanded the project to include Blk73 and Blk79, and

Launchpad @ one-north was officially launched.

In 2013, The Economist reported that the Launchpad was the highest-density hub of tech startups in the world. As at Nov 2015, it was estimated that the Launchpad was home to 21 VC firms, 19 accelerators and incubators, 13 facilitators such as industry associations and government agencies, and 220 resident startups, with dozens more in co-working spaces or incubation facilities. The situation is also dynamic as there is high frequency of new startups entering the Launchpad, and incumbent startups leaving as they grow and require more space.

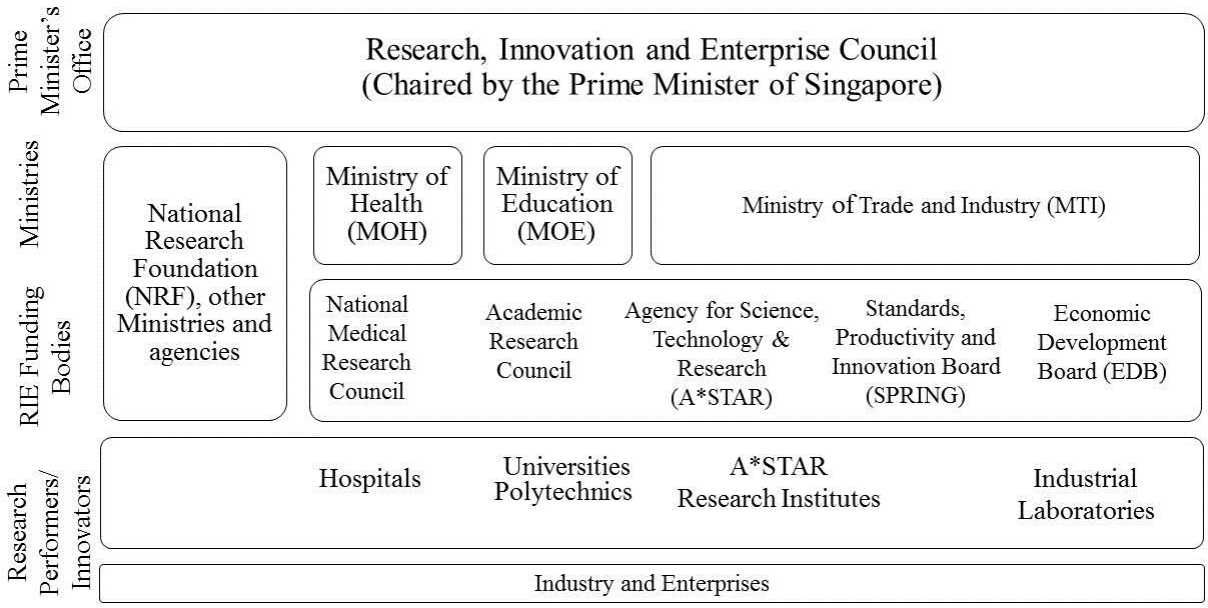
The physical location of the Launchpad is an important factor. The one-north district is adjacent to the Singapore Science Park, the Biopolis and Fusionopolis precincts. The Launchpad is across the road from several A*STAR PRIs and SPRING Singapore, the government agency that oversees promotion of entrepreneurship. The Launchpad houses incubation facilities by the two largest local universities – NUS Enterprise Incubator and NTUitive. The Launchpad is also home to A*StartCentral, an initiative by A*STAR that supports technopreneurial ventures by providing both hardware (e.g., engineering and life sciences facilities, equipment) and software (e.g., mentorship) assistance. Being the only life science infrastructure in Singapore, A*StartCentral takes a borderless approach in being accessible to innovations. The open-innovation engineering and life sciences community of A*StartCentral has also engaged partnerships with strategic investors looking at scaling up early-stage investments regionally. The concentration of public science and top-notch research talents in and near the Launchpad has not only produced innovations but also attracted large tech-based corporations to the area. These are the lead users for many startups, providing partnership opportunities and potential customer bases.

4. Impact

Given the hefty investment in executing Singapore's strategy to build the innovation and entrepreneurship ecosystem for the past decade, it is important to examine the impact it has made on the economy. A review of the innovation impact literature shows that there is no lack of studies on impact indicators and methods, with most focusing on single indicators such as patents or publications. However, policymakers are generally aware that the journey from investing in IHL/PRI to do public research and innovation through making an impact on the industry and economy is a long and tortuous one involving multiple stages with distinct stakeholders and risks at each stage. While indicators such as publications and patents are useful to demonstrate the inventive output of IHL/PRI, they do not show if and how the underlying knowledge of the patents eventually become commercialised into new product sales by the industry. It is therefore generally acknowledged that there is no single indicator that can present a complete picture of the economic impact of public science on the innovation and startup ecosystem. For holistic impact assessment, the RIE Impact Measurement framework is used in A*STAR, which considers the complex nature of the RIE value chain, to measure intermediate output and outcome at four different stages. The stages are (a) inventive output of IHL/PRIs, (b) commercialisation output of IHL/PRIs, (c) innovation of industry/ firms and (d) economic development, as highlighted in Cheah and Yu (2016). Figure 6 provides a summary of the framework and the indicators that are typically used by public and business policymakers to measure impact at each stage.

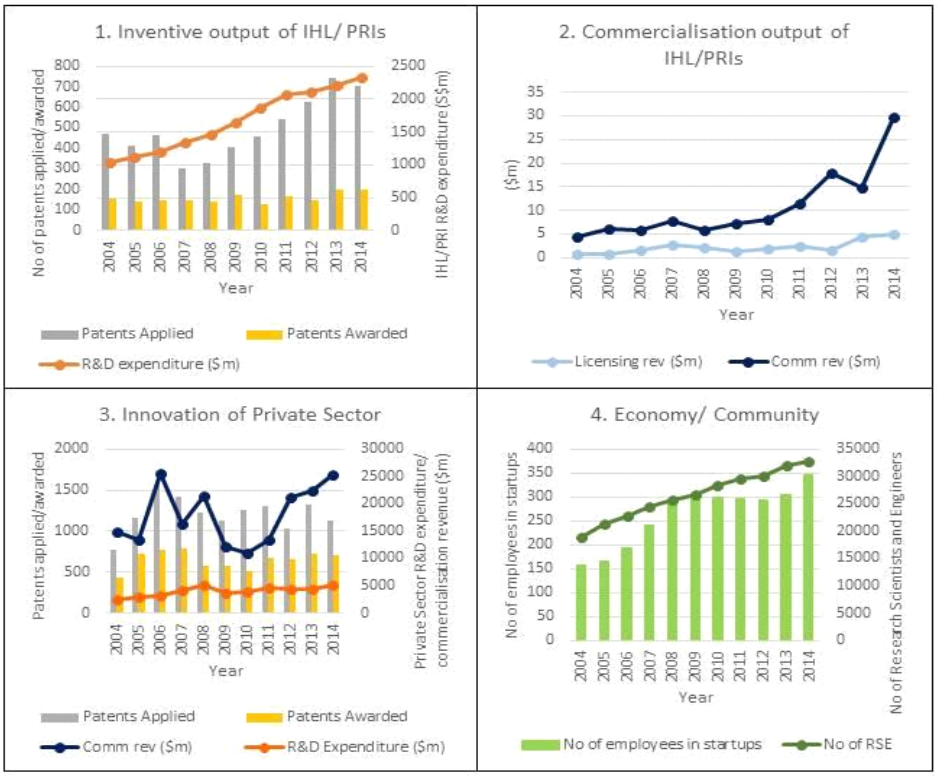
Applying the framework in Singapore's innovation and startup ecosystem, we have made several observations about the impact of public science at each of the four stages of Singapore's RIE value chain, as presented in Figure 7.

Figure 6. RIE Impact Measurement Framework



Source: Cheah and Yu (2016)

Figure 7. Results of RIE's journey



Source: A*STAR Annual National Surveys of R&D, 2004-2014 (A*STAR, 2016)

4.1. Inventive output of IHL/PRIs

R&D expenditures, patents applied and patents awarded are typically used to assess the inventive output of IHL/PRIs. In Figure 7, Chart 1 shows that, for the past decade, there has been a consistent increase of R&D expenditures from S$1,029.73m in 2004 to S$2,338.71m in 2014, with a corresponding rise in patent applications and awards from 469 and 156 to 707 and 196, respectively. In the same period, the number of tech-based startups grew from 2,800 to 5,400 (SPRING, 2016). While we acknowledge that early-stage technologies have higher level of uncertainty than those of later stage, the upside of the former is greater than that of the latter. It is evident that good science is crucial in the innovation and startup ecosystem as it provides strong technological knowledge/IP base for enterprises that can be potentially game-changing. The public sector therefore plays an important role in investing in the inventive output of universities/PRIs, especially in technology domains that are strategic to the country's wellbeing but require longer investment horizons than what can be accepted by the private sector.

4.2. Commercialisation output of IHL/PRIs

The commercialisation output of IHL/PRIs has seen a healthy trend from 2004 to 2014, as shown in Figure 7 Chart 2. The revenues that these institutions receive from licensing their IPs to companies have increased from S$0.84m to S$4.99m, while the revenue from commercialised products and processes attributed to R&D performed in Singapore grew from S$4.45m to S$29.76m. For the past decade, we see a closer alignment between research directions and industry needs, and corresponding increase in the commercialisation output of universities/PRIs. While there is an increase in tech-based startups during the same period, studies have shown that 50% of new businesses ceased operation by their fifth year in Singapore. Although a similar trend is observed in the US, the technology transfer organisations could play a bigger role in helping startups de-risk their commercialisation of public-funded R&D through gap-funding to raise the readiness levels of their technologies to meet industrial requirements.

4.3. Innovation of Industry/Firms

In the private sector, we see a positive trend of innovation input by the firms, as illustrated in the Chart 3 of Figure 7. R&D expenditures have increased from S$2,589.99m in 2004 to S$5,215.66m in 2014, and patent applications and awards grew from 777 and 433 to 1,131 and 707, respectively. A corresponding increase is seen in the innovation outcome of the firms in the same period, which reported steady growth from S$202.33m and S$14,925.22m to S$465.71m and S$25,207.55m for their licensing revenues from patents and new technologies developed in Singapore, and revenues from commercialised products and processes attributed to R&D performed in Singapore, respectively. While there is overall growth in both innovation input and outcome of the firms, the private sector-led R&D (ranges on average between 1.2% and 1.8% of GDP) still has much room for improvement, compared to the OECD average of almost 2.5% of GDP (OECD 2013). There is therefore a strong need to continue building the technological and business capabilities of local firms through education and triple helix networks.

4.4. Economic Development

The indicators that are typically used to measure impact on the community or economy are human capital and employment created by the startups from 2004 to 2014. During this period, the startup share of Singapore employment has increased from 7.1% (156,500 employees) to 9.5% (345,400), while the number of RSEs has grown from 18,935 to 32,835. It is evident from the Chart 4 of Figure 7 that the

startups in both tech and non-tech sectors have created employment for the local workforce. There is, however, a lack of data on their contribution to output, national income and GDP. Given the importance of startups, such data as well as those on firm's innovation outcome (e.g., no of new products, new product sales) should be collected, tracked, benchmarked and analysed to facilitate continuous enhancement of policy tools in supporting the startups.

4.5. Case Studies

The case studies presented in this section illustrate the success of Singapore's strategic approaches for innovation and entrepreneurship promotion.

One of the earliest A*STAR PPP consortia is the Aerospace Programme which was started in 2007. It is an example of a Many-to-Many collaboration structure which interfaces eight PRIs under the Science & Engineering Research Council (SERC) umbrella with an industry consortium comprising leading aerospace Original Equipment Manufacturers (OEM) and Singapore aerospace companies. Consortium projects are pre-competitive in nature and driven by industry needs. Via this programme, aerospace companies work bilaterally with A*STAR on commissioned or collaborative research. One member of the consortium is Rolls Royce, which has been present in Singapore since the 1950s and now contributes over 15% of the nation's aerospace output, with a local workforce of over 2,400 people. The company signed its first collaborative agreement with A*STAR in 2004 and the relationship has flourished since then. Rolls Royce has set up a joint Surface Finishing Lab together with A*STAR's Singapore Institute of Manufacturing Technology (SIMTech). Over 75 collaborative projects have been jointly undertaken by Rolls Royce and SIMTech.

A resounding success story emerging from the DxD Hub is InvitroCue, a company providing bioanalytic services using cell-based model and imaging algorithm. The technology originated from A*STAR, and was further developed and validated through collaboration with pharmaceutical companies, leading pathologists and research scientists from universities and PRIs. Co-founded by experienced serial entrepreneur, Dr Steven Fang, InvitroCue was established in 2012 as an A*STAR spinoff. In its early stages, it was supported through A*STAR's gap funding. The company was an early partner of the DxD Hub upon the platform's launch in 2014. Just two years later, in January 2016, InvitroCue was publicly listed on the Australian Securities Exchange. With market capitalisation valued at S$40 million, the company has doubled its sales growth in two years since 2014. Its marketing strategy was to sell its customised cell-based assay models to global pharmaceutical companies through collaborative partnerships and service-based contracts. The revenues secured through this strategy were used to support the development of the digital pathology service, which has been successfully deployed in global pharmaceutical companies and hospitals. This "born global" foresight was facilitated by the DxD Hub and the Triple Helix networks in Singapore's ecosystem.

Visenze is an active member of the Launchpad @ one-north community. The startup offers a machine-learning visual search and recognition solution that sprung from deep research conducted at the NUS-Tsinghua Extreme Search Centre. After being spun off from NUS in 2012, Visenze was first incubated on campus before moving to Blk71 in 2013. There, the company leveraged Singapore ecosystem's infrastructure. It received support from IE Singapore for internationalisation and from SPRING's Technology Enterprise Commercialisation Scheme, which was helpful as the founders bootstrapped and piloted their prototype to overseas customers, such as Rakuten in Taiwan. Today, leading e-commerce companies such as Zalora,

Flipkart, Lazada, Reebonz and Rakuten are using Visenze's technology in markets around the world. The company has won numerous local and global awards. It was lauded as the Most Promising Startup at the 2015 Emerging Enterprise Awards in Singapore, and won the Gold Award at the ASEAN ICT (Infocomm Technology) Awards 2015. While at the Launchpad, Visenze secured Series A funding. After graduating from the Launchpad, Visenze has moved to the nearby Blk67 and continues to contribute to the Launchpad community.

5. Conclusion

We presented three strategic approaches that have been pursued in Singapore. First, the innovation and startup ecosystem is anchored by Triple Helix dynamics. Within this nexus, public science and strong support from policy makers in promoting public-private-partnerships have been crucial. Closer links with industry align the public science agenda closer to commercial demands. Second, the strength of Triple Helix dynamics is the foundation for Singapore's strategy to create startups that are "born global". Leveraging the collaborative networks between these different actors, initiatives such as the DxD Hub and NUSRI Suzhou could be successfully implemented. Local tech startups are able to access foreign markets either through a physical launchpad as in the case of the NUSRI Incubator, or through virtual connections as in the case of the DxD Hub. Finally, the Launchpad @one-north project illustrates the planned agglomeration strategy to create an entrepreneurial cluster in Singapore. By co-locating all key stakeholders in the ecosystem within the same geographic location, the Launchpad has within three years gone from a half-abandoned site to the highest-density tech hub in the world. Triple Helix dynamics and public science have been essential in the Launchpad's achievements. A*STAR and the two largest local IHLs are prominently present, supporting dozens of startups at any given time.

We put forth four key messages from our examination of impact measures. First, it is evident that good science is crucial in Singapore's innovation and startup ecosystem. Given the vulnerabilities of Singapore as a small nation, strategic technology domains have been carefully identified for competitive advantage. The public sector plays an especially important role in the inventive output of IHLs/PRIs in these technology domains that would require longer investment horizons than are acceptable to the private sector. Second, there is a gap between the readiness levels of public science output and industry needs. The technology transfer organisations of IHL/PRIs could play a bigger role by providing gap funding to raise the readiness level of their technologies and help startups to de-risk the commercialisation of public-funded R&D. Third, there appears to be a relative deficit of technological and business capabilities among local firms which limit their absorptive capacity and innovation levels. There is a strong need to build capabilities through education and triple helix networks. Lastly, a thorough assessment of the ecosystem is hampered by a lack of data on the economic contribution of startups in terms of output, value added and innovation outcome. A measurement and data collection framework that is standardised across local and international research, innovation and enterprise promotion agencies should be implemented to systematically track such data so as to facilitate analysis, benchmarking and continuous improvement of policy tools in supporting startups.

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References

A*STAR. (2016). Annual National Survey of R&D, 2004-2014. Web. Jul. 2016. <https://www.a-star.edu.sg/Media/Publications/National-Survey-of-R-D.aspx>

Aspen. (2013). The Aspen Institute Entrepreneurial Ecosystem Diagnostic Toolkit. Web. Jul. 2016. <https://www.aspeninstitute.org/publications/entrepreneurial-ecosystem-diagnostic-toolkit/>

Baber, Z. (2001). Globalization and Scientific Research: The Emerging Triple Helix of State-Industry-University Relations in Japan and Singapore. Bulletin of Science, Technology and Society, 21(5), 401-408.

Cheah, S., & Yu, C. (2016). Assessing economic impact of research and innovation originating from public research institutions and universities—case of Singapore PRIs. Triple Helix, 3(1), 1.

Djankov, S., Ganser, T., McLiesh, C., Ramalho, R., & Shleifer, A. (2010). The effect of corporate taxes on investment and entrepreneurship. American Economic Journal: Macroeconomics, 2(3), 31-64.

Etzkowitz, H. & Leydesdorff, L. (1996). Emergence of a Triple Helix of university-industry-government relations. Science and Public Policy, 23, 279-286.

Fuzi, A. (2015). Co-working spaces for promoting entrepreneurship in sparse regions: the case of South Wales. Regional Studies, Regional Science, 2(1), 462-469.

GEM. (2016). Global Entrepreneurship Monitor Reports, 2004-2014. Web. Jul. 2016. <http://gemconsortium.org/country-profile/ 105>

Herrmann, B. L., Gauthier, J. F., Holtschke, D., Berman, R., & Marmer, M. (2015). The Global Startup Ecosystem Ranking 2015. Technical report, Compass.

IRAS. (2016). Inland Revenue Authority of Singapore. Web. Jul. 2016. <https://www.iras.gov.sg/irashome/Schemes/>

Isenberg, D. I. (2011). Introducing the Entrepreneurship Ecosystem Four Defining Characteristics. Forbes. Web. Jul 2016. <http://www.forbes.com/sites/danisenberg/2011/05/25/introducing-the-entrepreneurship-ecosystem-four-defining-characteristics/#32cc91fc38c435dd899938c4>

Kauffmann (2012). Kauffmann index of entrepreneurial activity 1996–2011. Web. Jul. 2016. <http://www.kauffman.org/~/media/kauffman_org/research%20reports%20and%20covers/2012/03/kiea_2012_report.pdf>

Lee, S. H., Yamakawa, Y., Peng, M. W., & Barney, J. B. (2011). How do bankruptcy laws affect entrepreneurship development around the world?. Journal of Business Venturing, 26(5), 505-520.

Leong, B., Wee, A., & Ho, Y.P. (2011). Is an Enterprise Framework Necessary for and Entrepreneurial University? A Comparison of Entrepreneurial University Technology Start-Ups in Singapore & Sweden. Science and Public Policy, 35(9), 647-56.

Maskell, Peter. 2001. Towards a knowledge-based theory of the geographical cluster. Industrial and Corporate Change, 10(4): 921-943.

NRF (2015). R&D Landscape in Singapore presentation by George Loh, Director (Programmes), NRF.

NRF (2016). Innovation and Enterprise Milestones. National Research Foundation (NRF). Web. Jul. 2016. <http://www.nrf.gov.sg/innovation-enterprise/innovation-enterprise-milestones>

OECD (2013). Southeast Asian Economic Outlook 2013: with Perspectives on China and India. OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/saeo-2013-en

Schwartz, M. (2013). A control group study of incubators' impact to promote firm survival. The Journal of Technology Transfer, 38(3), 302-331.

SPRING (2016). Appoints Seven New Accelerators to Support Start-ups in Emerging Sectors. SPRING. Web. Jul. 2016. <http://www.spring.gov.sg/NewsEvents/PR/Pages/SPRING-Appoints-Seven-New-Accelerators-to-Support-Start-Ups-in-Emerging-Sectors-20160517.aspx>

Wong, P.K., Ho, Y.P., & Singh, A. (2011). Study on High-Tech Start-ups in Singapore 2010. Report for National Research Foundation.

Wong, P.K., Ho, Y.P., & Singh, A. (2010). Industrial Cluster Development and Innovation in Singapore. In M. Tsuji and A Kuchiki (eds), From Agglomeration to Innovation: Upgrading Industrial Clusters in Emerging Economies. New York: Palgrave-MacMillan.

Science and Technology Trends
Fostering Startup Ecosystems

Fostering Startup Ecosystems in India

Nir Kshetri

1. Introduction

Because of India's improving entrepreneurial performance, some analysts consider the country as the next Asian miracle (Huang, 2008). The State's domination over the economy is gradually declining and there are some signs that the country is moving toward a market-oriented system. India has also set explicit policy and objective to become a leading business-friendly economy (World Bank, 2008).

Most impressive of all, in January 2016, the Indian government launched the "Startup India" program. The program seeks to provide a number of policy measures, initiatives and incentives in order to foster startups in the country. Tax exemption for startups for three years, a US$1.5 billion corpus fund to support startups, exemption of capital gains tax for venture capital investments, 80% reduction in patent registration fees and ensuring a 90-day window for startups to close businesses are among the top incentives the Indian government plans to offer to stimulate startups in the country (The Hindu, 2016).

Despite the above-noted positive trends, entrepreneurial activities are hindered by business-unfriendly labor laws, adverse corporate bankruptcy regulations and the lack of clear property rights (Economy Watch, 2014; GIPC, 2016; Hanstad, 2013; Kshetri, 2014). Moreover, many Indian entrepreneurs still struggle with a culture that looks down on capitalism and is indifferent to hard work, improvement and innovations (Kshetri, 2011b). Other challenges include a big entrepreneurial financing gap (ET, 2015) and the country's poor R&D and innovation performance (Economist, 2007; Kshetri, 2014).

The objective of this paper is to examine the current state of startups in India and analyze the key determinants. The paper is structured as follows. We proceed by first examining the current state of startups and SMEs in India. The section following this looks at the determinants of entrepreneurship and startups in the Indian context. The final section provides concluding comments.

2. The Status of Startups and SMEs in India

Startups and SMEs have played a key role in the Indian economy. India has the world's third-largest number of startups (ET, 2016b). According to the National Association of Software

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and Services Companies, the number of new companies launched in India grew by 40% in 2015 (Fortune, 2016). Likewise, as of the mid-2016, India was estimated to have more than 45 million SMEs, which accounted for about 40% of the country's gross domestic product (GDP) (ET, 2016b).

New organizational mechanisms such as incubators have helped startups to grow and bring innovative products and services into the market. As early as in 2010, it was reported that India had around 40 incubators, which mentored between four and 20 startups each (Chaudhary, 2010). One such incubator, Villgro (http://www.villgro.org/) reported that, as of the mid-2016, it mentored 119 startups. It also invested US$2.2 million seed money in these startups and helped them to raise investments of more than US$19 million.

Despite the above positive trends, India falls behind many other developing economies on important indicators related to startups and entrepreneurial activities. For instance, in terms of high-expectation business launchers per capita, India underperforms Brazil (Lewis, 2007). In the World Economic Forum's Global Competitiveness Report 2015-2016, India ranked 55th (WEF, 2016b). In the 2015 Prosperity Index, prepared by the London-based think tank, Legatum Institute, India ranked 99 out of the 142 economies analyzed (Legatum Institute, 2015). In the Legatum Prosperity Index's Entrepreneurship & Opportunity category, India's rank was 94.

A technology entrepreneur, who is also a Member of Parliament, pointed out two challenges that Indian startups have faced. The first obstacle concerns "government apathy, corruption and a complex approvals process". Others have argued that corruption is likely to make the Israel model of government funding for startups highly ineffective in India. Note that the Israeli government provides a highly supportive role to facilitate entrepreneurship. For instance, it is reported that 80% of the first US$500,000 for every idea identified is funded by the government. It is speculated that such a model "will lead to favoritism, cronyism and corruption" in the country (Shah, 2010).

Second, the country's entrenched corporates have exhibited a tendency to "oppose or kill startups which challenge them" (Chandrasekhar, 2016). Others have observed that a small number of well-connected industrialists have dominated the Indian economy and protected themselves from outside competition (Weitzman and Fontanella- Khan, 2011). For instance, about 10 families reportedly control more than 80% of the stock in India's largest corporations (Malhotra, 2009). Research has indicated that the 1991 reforms have had little or no effect in promoting SMEs and their development.

3. The Determinants of Entrepreneurship and Startups: The Indian Case

Determinants of entrepreneurship are the factors that affect entrepreneurial performance (Ahmad and Hoffmann, 2008). Prior research shows that the various determinants of startups and entrepreneurship development can be divided into three categories: a) Regulatory framework, b) Values, culture and skills, c) Access to finance, market, R&D and technology (Kshetri, 2014).

3.1. Regulatory Framework

Government policies and actions affect the costs, risks and barriers to competition faced by entrepreneurial firms and hence the range of opportunities that are potentially profitable. While there are a variety of mechanisms by which laws, regulations and policy would affect a country's entrepreneurial performance, this section focuses on four major aspects: Laws and regulations affecting business registration, corporate bankruptcy laws, labor regulations and property rights.

3.1.1. Laws and Regulations Affecting Business Registration

According to the World Bank's Ease of Doing Business 2016 Report (World Bank, 2013), India ranked 130 out of the 189 economies considered in terms of the regulatory climate for startups and entrepreneurship. To start a business, 14 procedures are needed to be completed which take 29 days and cost 17% of the country's per capita income. Note that for OECD high income countries, the averages are 4.7 procedures, 8.3 days and 3.2% per capita income respectively.

Despite this progress, however, red tape, bureaucracy and corruptions in the country, both at the national and state levels, lead to longer time, higher costs, and reduced speed and flexibility for entrepreneurs (Majumdar, 2004). In the Legatum Institute's survey in 2011, about 80% of Indian entrepreneurs viewed that corruption was getting worse (Sharma, 2011). The Wall Street Journal published a story about a X-ray entrepreneur, who reported that he was asked for bribes by government officials for everything such as speeding up his business permit (Sharma, 2011)

3.1.2. Corporate Bankruptcy Laws

Corporate bankruptcy laws are among the most discussed issues. Note that according to the World Bank, it takes 7 years to close a business in India compared to the OECD average of 1.7 years. Among the measures outlined in the program is a 90-day window for startups to close businesses. This reduction is a welcome improvement concerning this important determinant of entrepreneurship.

3.1.3. Labor Regulations

Indian labor market is governed by about 250 labor rules at the central and state levels, which make the country's labor laws are less flexible and less business-friendly than those of China. These laws arguably are restrictive in nature, hinder investments in the manufacturing sector and discourage firms from introducing new technology that might require reducing the workforce (Economy Watch, 2014). These labor regulations thus limit businesses' capacity to grow and compete in the global economy. In India, for instance, companies with more than 100 employees require government permission to dismiss workers (Kshetri, 2014).

3.1.4. Property Rights

Clear property rights would allow entrepreneurs to use the assets as collateral and thus increase their access to capital. Problems related to property rights are key challenges facing entrepreneurial development in India. Some argue that the lack of land ownership remains among the most important barriers to entrepreneurship and economic development in India. One estimate suggested that over 20 million rural families in India did not own land and millions more lacked legal ownership to the land where they built their houses, lived on and worked (Hanstad, 2013).

Indeed landlessness is arguably a more powerful predictor of poverty in India than caste or illiteracy (Hanstad, 2013). This issue is important because poverty reduction is considered to be one of the key impacts of entrepreneurship, especially in the context of developing countries such as India (Ahmad and Hoffmann, 2008; Kshetri, 2014).

Especially for entrepreneurial firms that rely heavily on intellectual property (IP), they face a unique challenge in economies with weak IP protection laws and enforcement mechanisms. According to the Global Intellectual Property Center's International IP Index 2016, India ranked 37 out of the 38 countries. Only Venezuela's IP index was worse than that of India (GIPC, 2016). India is characterized by ineffective intellectual property rights laws and enforcement mechanisms. A complaint among multinational drug companies is that Indian generics drug makers manufacture

counterfeits of patented drugs and sell them for a long time. Due to the Indian court system's slow and often ineffective response, multinational drug companies' legal attempts to stop the counterfeiters often take many years (Bhattacharya, 2015).

3.2. Values, Culture and Skills

3.2.1. Values and Culture

The underlying values and culture of a society affect the entrepreneurial patterns. Some argue that Indian society has a negative attitude toward entrepreneurship. Not long ago, an entrepreneur was viewed as someone that was unemployed and unemployable (Ganesh, 2016). Such a social stigma about an entrepreneur led to a preference for jobs in multinationals or the government sector (Kshetri, 2014). An observation is that the stigma of being an entrepreneur is gradually disappearing (Ganesh, 2016).

Of even more concern perhaps is how entrepreneurial failure is viewed. An executive of Google India noted: "And don't even think about what will happen if you fail as an entrepreneur. Socially, you will have lost your eligibility for marriage until you get a job. Financially, you'll be saddled with loads of debt, and politically, good luck on somebody acknowledging your entrepreneurial endeavor as real work experience. With all these challenges, one wonders why anyone bothers trying to become an entrepreneur in India?"

3.2.2. Entrepreneurial Skills

Studies have underscored the important role entrepreneurial skills play in the success of entrepreneurs. A study conducted with self-employed individuals enrolled in a Peruvian microfinance program indicated that even a little entrepreneurship training can significantly enhance the business performance (Karlan and Valdivia, 2006).

The lack of entrepreneurial education and training has been a matter of concern for the development of a startup ecosystem in India. About a third of the Indian population was estimated to be illiterate in 2016 (WEF, 2016a). An upshot of this is that Indian startups lack skills and experience to build scales and do sales, marketing, and product management (Rai, 2014). In a survey by Accenture among Indian enterprises, 53% of the respondents cited the lack of talent to be a key challenge in the deployment modern technologies such as big data and cloud computing. McKinsey estimated that India will need 200,000 data scientists in the near future (Fractal, 2015). India's No. 2 e-commerce site, Snapdeal.com said that the company has not been able to find the coders and other big data manpower it needs. The company has recognized the need for worldwide recruitment for experienced programmers dealing with big data, cloud computing and the software for interacting with customers and suppliers. In 2015, it hired a cloud specialist from a Silicon Valley startup. The company was expecting to hire 12 more. Snapdeal was also reported to be considering to establish a software development center in the U.S. and buying firms there in order to capture the needed manpower (Thoppil, 2015).

Due to the lack of entrepreneurial education in India, the country's successful companies invest heavily in employees through extensive training and development in firm-specific skills. One study found that firms in the country's IT industry provide 60 days of formal training to newly hired employees and they are paid during the period. Some firms go even further. For instance, Tata Consultancy Services is reported to have a seven-month training program for science graduates in order to convert them into business consultants, and every employee in the company gets 14 days of formal training annually (Cappelli *et al.*, 2010). Infosys has its own internal college to educate new employees, which trained 80,000 employees in "design thinking" as of the mid-2016. The goal is to make sure that its employees can advise on the design of IT systems rather than just taking instructions (Mundy, 2016).

3.3 Access to Finance, Market, R&D and Technology

3.3.1. Access to Markets

Access to and demands of an entrepreneurial firm's products in the domestic and foreign markets are a critical factor determining the attractiveness of entrepreneurial activities. In addition to private demand, procurement regulations and policies that give priority to new companies in government contracts for goods and services would create better opportunities for potential entrepreneurs. In the same vein, governments' export-promotion strategies in various countries have expanded entrepreneurial firms' opportunities in foreign countries (Kshetri, 2014).

Among other measures, a key component of the "Startup India" program is US$ 32 billion infrastructure spending in fiscal year 2016-17 to build 10,000 km of national highways and upgrade additional 50,000 km. The goal is to help SMEs' access to the huge India market.

Nonetheless there a number of market access barriers faced by SMEs and startups. As noted earlier, Indian economy has many characteristics of oligarchic capitalism, which have hindered SMEs' market access. It is also the case that various regulations hinder the access to the domestic market in India. For instance, there are taxes for bringing goods into a state, for taking them out of a state as well as for moving them within a state (Economist, 2008).

3.3.2. Access to Finance

Entrepreneurs need capital in all phases of business life. A critical practical challenge that most startups face is the ability to acquire the capital, from access to early seed funds to access to the stock markets. When there is limited credit availability and the entrepreneurs' initial capital requirements are substantial, low wealth households face higher barriers to starting an entrepreneurial venture.

Among the main sources of finance for startup are bank financing, the capital market, venture capital (VC or Venture), microfinance, crowdfunding, supply chain financing and informal financing (Kshetri, 2014). The formal financial market remains largely inaccessible to startups and SMEs. According to McKinsey, 43% of SMEs in India borrow from informal sources. They do so partly because of the lack of collateral and working-capital lines (Mukherjee, 2016).

According to a study conducted by research firm KPMG and Snapdeal, about 41% of SMEs in India lacked access to bank loans or other financial products offered by banks and other formal financial institutions. The study found that a financing gap of over US$43.5 billion existed in the Indian entrepreneurial landscape (ET, 2015). Observers have noted that potential entrepreneurs in India, who have graduated from a less well known university or those who belong to a poor family face difficulties in getting funding (Gandhi, 2010). The state banks have done little to promote productive entrepreneurship in India. A complaint often heard is that business merits play a little role in loan disbursements (Bikchandani, 2010). Lending is disproportionately oriented toward powerful economic and political interests such as influential family-owned groups.

In 2012, the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE) launched SME platforms, which has increased SMES' access to capital market. In the first two months of 2016, 21 SMEs filed documents with BSE and NSE to raise a total of US$27 million crore through IPOs (ET, 2016a).

According to Sa-Dhan, an association of microfinance institutions, the Indian microfinance industry was US$ 9 billion in the FY 2015-16 (The Hans, 2016), which is expected to reach to US$20 billion by 2019 (Shaaw, 2016). In the fiscal year (FY) 2015-16, the rural area accounted for 28% of the total loans disbursed by microfinance institutions (MFIs) (The Hans, 2016).

According to the VC analytics firm Tracxn, funding for startups in India amounted US$6.4 billion during the first nine months of 2015, of which online marketplaces attracted about US$3 billion of investments in 166 deals (Velayanikal, 2015). Prior researchers have described a number of difficulties that stand in the way of VC financing in India (Dossani and Kenney, 2002). Indian bureaucracy and regulations act as barriers to VC investments. Prior researchers have emphasized the importance of improving the environments related to tax, currency exchange and other policies in order to attract VC firms.

In this regard, the US$1.5 billion corpus fund is undoubtedly a welcome step. This "structured fund of funds" will invest in VC funds over four years, financed by the government and the state-owned Life Insurance Corporation (LIC) (Fortune, 2016). There are nonetheless some challenges to allocate this VC fund. Prior research has also emphasized the importance of rationalizing and improving the mechanisms to reduce risk if VC funds come from publicly held financial institutions, which are likely to be managed by risk-averse decision makers (Dossani and Kenney, 2002).

Crowdfunding, which involves raising small amounts of capital from a large number of individuals, is considered to be a major disruption in entrepreneurial financing (Kshetri, 2015). While crowdfunding is in infancy in India, it is becoming an increasingly important source of external finance for some Indian startups. One estimate suggested that there were 30 crowdfunding platforms (CFPs) in India as of the mid-2016 (newsx.com, 2016). As of June 2016, the Indian seed capital and angel investment platform, LetsVenture helped 70 companies raise US$27 million. The average deal size was about US$370,000 and the highest amount raised was US$1.33 million (Babu, 2016).

While some studies have shown that remittances are mainly used for consumption instead of investment activities, research has also indicated that households receiving international remittances tend to invest more in entrepreneurial activities than those not receiving remittances (Adams, 2006). Remittances contribute to entrepreneurship by increasing savings and promoting credit mobilization and other forms of investment. Remittance-receiving families often receive funds that are much larger than required for immediate expenditure. They thus deposit the excess funds in the formal banking system, which enhance the banking system liquidity. In India, which is the highest remittance-receiving country, remittances have led to the establishment of new businesses and social service organizations such as nursing homes and educational institutions (Abdelal *et al.*, 2008). In 2010, the Gujarat state's Chief Minister noted that the state's economy was growing despite the global financial crisis (GFC) due to increasing investments that were being made by the Indian diasporas (Kshetri, 2011a).

Supply chain financing is a new mode of financing in which companies collaborate with financial institutions to provide financing and other related services such as technical assistance, management, corporate governance, legal compliance to small firms in the company's supply chain (Kshetri, 2014). Another example is PepsiCo, which started supply chain financing in India in the 1990s through a contract farming arrangement with farmers in the Punjab state to buy tomatoes and chilies. Subsequently the company extended this model to other states and diverse agricultural commodities. It has collaborated with State Bank of India (SBI), which has provided credits at low interest rates to over 12,000 farmers in six states in India. In addition, PepsiCo has also collaborated with another Indian bank, ICICI to provide farmers with weather insurance (Kshetri, 2014).

In recent years, large players in the e-commerce sector are taking initiatives to improve the access of this form of financing to SMEs. In 2015, India's

largest e-commerce website, Snapdeal announced plans to disburse loans of around US$150 million to SMEs by March 2016 under its seller financing platform, Capital Assist. It was reported that the firm has teamed up with banks and non-banking finance companies for this purpose (ET, 2015). Flipkart has similar lending schemes. In the early 2016, Amazon India announced its plans to offer loans to key vendors selling on its portal. The sellers can apply for short-term working capital loans in order to buy more inventory and increase sales on Amazon.in (Maheshwari, 2016).

3.3.3. R&D and Technology

Access to technology greatly facilitates entrepreneurial activities. According to a 2012 report of the Internet Innovation and the Small Business and Entrepreneurship Council, a small business startup can save over US$16,000 by using high-speed broadband. For instance, high-speed broadband allows working from home rather than in the office, reducing costs associated with travel and office space (Kshetri, 2014). Similarly, due to lower startup costs for an online shop-front, Internet based technologies can provide small firms the opportunity to overcome the limitations of size and compete more effectively and/or in larger markets with bigger sized establishments.

In the World Economic Forum's 2016 Global Information Technology Report, India's overall rank was 91 (WEF, 2016a). While India ranked 8th in affordability of ICTs, only 15% of Indian households had Internet access and mobile broadband subscriptions per 100 people was just 5.5.

R&D would provide opportunities for high-quality entrepreneurship and enhance an entrepreneurial business's competitiveness. R&D would help create new inventions and innovations, which can be used to develop new products, services or processes. India lags behind industrialized countries and its neighbor China in terms of various indicators related to R&D and innovations. Due to India's poor R&D and innovation performance, some liken entrepreneurial activities in the Indian IT and offshoring industry to a "hollow ring". An Economist article notes: "India makes drugs, but copies almost all of the compounds; it writes software, but rarely owns the result. … [it has] flourished, but mostly on the back of other countries' technology".

4. Concluding Comments

To some extent, the 1991 economic reform facilitated and stimulated entrepreneurship in India. Likewise, entrepreneurs have generally welcomed the steps taken by the Indian government to stimulate entrepreneurship under the "Startup India" program launched in January 2016. The impact on the broad economy is, however, barely noticeable. While billionaires, oligarchs and state-owned companies are benefiting from privileges, the playing field is not level for SMEs and new venture startups, which face a host of barriers.

Severe and widespread poverty persists in the country while there is great and rising affluence among people working in the software and outsourcing sectors. In sum we cannot really take the existence of a few entrepreneurial firms in the Indian IT sector as proof positive that India provides a conducive environment for entrepreneurship. In fact, it is possible to draw the opposite conclusion on the basis of the fact that very little entrepreneurial impact is felt by the mass of the population.

Inappropriate regulatory elements and legal bottlenecks as noted above have severely hampered the productive entrepreneurial activities. While some influential entrepreneurs are in a position to take advantage of institutional holes, SMEs tend to be more adversely affected by the dysfunctional institutions. Overall, the structural inertia of the Indian economy has acted as a barrier to foster startups and modern entrepreneurship. Some observe

that reform inertia has been an obstacle for India to outperform China. Structural reforms are thus needed so that entrepreneurs are encouraged to start businesses and startups can compete more freely and fairly.

While entrepreneurial traits such as a high need for achievement, innovative thinking, creativity, breakthrough ideas, high risk-taking propensity, perseverance, and flexibility are more or less universal to become a successful entrepreneur, the ability to fit to the environment is probably even more important. The success of an entrepreneur interested in starting entrepreneurial venture in India hinges on the ability to learn and adapt to the unique Indian environmental contexts, overcome the challenges and take advantage of various incentives such as those available under the recent Startup India program. It is also important to note that a number of favorable changes are taking place from the standpoint of startups. These include more entrepreneurship friendly culture and regulations.

A related point is that important ingredients are missing in the Indian startups and entrepreneurship landscapes, which means that entrepreneurial firms need to take extra efforts and measures. As noted above, due to the lack of entrepreneurial education in India, the country's successful companies invest heavily in employees through extensive training and development in firm-specific skills. However, most startups often are not in positions to do what established firms such as Infosys, Tata Consultancy Services or Snapdeal do to recruit and train employees. This means that startups need to be prepared with this reality and plan accordingly.

References

Abdelal, R., Khan, A., and Khanna, T. (2008). Where Oil-Rich Nations Are Placing Their Bets. Harvard Business Review, 86(9), 119-128.

Adams, R. H. Jr. (2006). International Remittances and the Household: Analysis and Review of Global Evidence. Journal of African Economies 15 (Supplement 2), 396-425.

Ahmad, N., and Hoffmann, A. N. (2008). A Framework for addressing and measuring entrepreneurship. OECD Statistics Working Paper, January, <http://www.olis.oecd.org/olis/2008doc.nsf/LinkTo/NT000009FA/$FILE/JT03239191.PD>

Babu, V. (2016, June 5). Herd Mentality: Crowdfunding platforms are proliferating. And very different models are being tried out by different players. <http://www.businesstoday.in/magazine/corporate/crowdfunding-platforms-are-proliferating-with-models/story/232543.html>

Bhattacharya, S. (2015). India Plans to Streamline Intellectual Property Rights Process. Dec. 11, 2015. <http://www.wsj.com/articles/india-plans-to-streamline-intellectual-property-rights-process-1449834245>

Bikchandani, S. (2010). Israel Model Will Not Work in India. Mar. 10, 2010. <http://blogs.wsj.com/india-chief-mentor/2010/03/10/israel-model-will-not-work-in-india/>

Cappelli, P., Singh, H., Singh, J. and Useem, M. (2010). The India Way: Lessons for the U.S, Academy of Management Perspectives. 24(2), 6-24.

Chandrasekhar, R. (2016). 'Startup India' Action Plan: a good start, but Govt apathy, big corporates a hurdle. Jan. 25, 2016. <http://www.thehindu.com/business/Industry/startup-india-action-plan-a-good-start-but-govt-apathy-big-corporates-a-hurdle/article8148219.ece>

Chaudhary, D. (2010). startups in fund trouble, even as incubators hike early-stage funding. <http://www.livemint.com/2010/01/25215034/Startups-in-fund-trouble-eve.html>

Dossani, R., and Kenney, M. (2002). Creating an Environment for Venture Capital in India. World Development, 30(2), 227–253.

Economist. (2007). Imitate or die; Technology in China and India. 385(8554), 9.

Economist. (2008). Business: Unshackling the chain stores. 387(8582), 80.

Economy Watch. (2014) India's Restrictive Labor Laws Challenge Investors. <http://www.economywatch.com/features/Indias-Restrictive-Labor-Laws-Challenge-Investors.11-12-14.html>

Fortune. (2016). India's Modi Launches $1.5 Billion Fund for Startups. <http://fortune.com/2016/01/16/modi-india-startup-fund/>

Fractal. (2015). Big data talent shortage: How to bridge the gap? <http://www.fractalanalytics.com/news/big-data-talent-shortage-how-bridge-gap>

Gandhi, G. (2010). Indian Entrepreneurs Need a Hug:

Google's Gandhi. Feb. 16, 2010. <http://blogs.wsj.com/india-chief-mentor/2010/02/16/indian-entrepreneurs-need-a-hug-google%E2%80%99s-gandhi/>

Ganesh, K. (2016). A serial entrepreneur on why starting up is tough but every bit worth it. Jun. 26, 2016. <http://economictimes.indiatimes.com/small-biz/start-ups/a-serial-entrepreneur-on-why-starting-up-is-tough-but-every-bit-worth-it/articleshow/52919870.cms>

Global Intellectual Property Center (GIPC). (2016). U.S. Chamber International IP Index U.S. Chamber of Commerce. Washington, D.C. <http://www.theglobalipcenter.com/gipcindex/>

Hanstad, T. (2013). The Case for Land Reform in India. Feb. 19, 2013. <https://www.foreignaffairs.com/articles/india/2013-02-19/untitled?cid=soc-twitter-in-snapshots-untitled-02 2013>

Huang, Y. (2008). The next Asian miracle. Foreign Policy (167), 32-40.

Karlan, D., and Valdivia, M. (2006). Teaching Entrepreneurship: Impact of Business Training on Microfinance Clients and Institutions. Yale University.

Kshetri, N. (2011a). The Global Financial Crisis: Evidence from China and India. Thunderbird International Business Review, Special issue on the 2008 Financial Crisis, 53(2), 247-262.

Kshetri, N. (2011b). The Indian Environment for Entrepreneurship and Small Business Development. Studia Negotia, 56(LVI), 4, 35-52.

Kshetri, N. (2014). Global Entrepreneurship: Environment and Strategy. Routledge. New York.

Kshetri, N. (2015). Success of Crowd-Based Online Technology in Fundraising: An Institutional Perspective. Journal of International Management, 21(2), 100–116.

Legatum Institute. (2015). The Legatum Prosperity Index, London, U.K.

Lewis, G. (2007). Who in the World is Entrepreneurial? Fortune Small Business, 17(5), 14.

Maheshwari, R. (2016). Amazon plans to offer loans to Indian sellers. Feb. 10, 2016. <http://articles.economictimes.indiatimes.com/2016-02-10/news/70509905_1_amazon-india-collateral-free-loans-amazon-in>

Majumdar, S. K. (2004). The hidden hand and the license raj to an evaluation of the relationship between age and the growth of firms in India. Journal of Business Venturing, 19, 107–125.

Malhotra, H. B. (2009). Oligarchic Capitalism May Take Hold in India. Sep. 22, 2009. <http://www.theepochtimes.com/n2/content/view/22829/>

Moneycontrol. (2016). SMEs grow faster than big firms as India's economy gathers pace. Jun 11, 2016. <http://www.moneycontrol.com/news/economy/smes-grow-faster-than-big-firms-as-indias-economy-gathers-pace_6848841.html>

Mukherjee, A. (2016). A WhatsApp Moment for Asia's Banks. Jul. 3, 2016. <http://www.bloomberg.com/gadfly/articles/2016-07-03/a-whatsapp-moment-for-banks-in-asia>

Mundy, S. (2016). Indian IT services groups adjust to cloud and big data: Wipro, Infosys and Tata under pressure to adapt or be left behind. Jul. 5, 2016. <https://next.ft.com/content/9ad3b946-3d26-11e6-8716-a4a71e8140b0>

NewsX. (2016). Government to roll out new norms for crowd funding e-platforms. Jun. 5, 2016. <http://www.newsx.com/national/31166-government-to-roll-out-new-norms-for-crowd-funding-e-platforms>

Rai, S. (2014). India emerges as a hotbed of software product entrepreneurship. Apr. 9, 2014. <http://www.techrepublic.com/article/matchmaking-at-intech50-indian-software-product-startups-pitch-to-50-cios/>

Shaaw, R. K (2016). Banks' Bad Loans Turn Indian Stock Pickers to Consumer Lenders. Jun 7, 2016. <http://www.bloomberg.com/news/articles/2016-06-07/banks-bad-loans-turn-indian-stock-investors-toward-bajaj-sks>

Shah, H. J. (2010). Valuate the India Opportunity through Incubators, Demographics and PEG. Mar. 9, 2010 <http://blogs.wsj.com/india-chief-mentor/2010/03/09/valuate-the-india-opportunity-through-incubators-demographics-and-peg/>

Sharma, A. (2011). Bribes, Bureaucracy Hobble India's New Entrepreneurs. Jun. 7, 2011. <http://www.wsj.com/articles/SB10001424052970204479504576639233537716542>

The Economic Times (ET). (2015). Etailers like Snapdeal seek RBI approval to offer loans to SMEs. Oct. 16, 2015. <http://economictimes.indiatimes.com/news/economy/policy/etailers-like-snapdeal-seek-rbi-approval-to-offer-loans-to-smes/articleshow/49395754.cms>

The Economic Times (ET). (2016a). 21 SMEs file IPO papers in 2016, to mop up Rs 180 crore. Mar. 8, 2016. <http://economictimes.indiatimes.com/markets/ipos/fpos/21-smes-file-ipo-papers-in-2016-to-mop-up-rs-180-crore/articleshow/51305075.cms>

The Economic Times (ET). (2016b). Startup: Over 400 entrepreneurs queue up for tax benefits. Jun. 16, 2016.

<http://economictimes.indiatimes.com/small-biz/startups/startup-over-400-entrepreneurs-queue-up-for-tax-benefits/articleshow/52781886.cms>

The Hans India (The Hans). (2016). Micro finance heavily skewed in favour of India's urban quarters. Jul. 04, 2016. <http://www.thehansindia.com/posts/index/Business/2016-07-04/Micro-finance-heavily-skewed-in-favour-of-Indias-urban-quarters/239708>

The Hindu. (2016). Top 10 takeaways from Modi's speech at Startup India launch. Jan. 16, 2016. <http://www.thehindu.com/business/top-10-takeaways-from-modis-speech-at-startup-india-launch/article8114318.ece>

Thoppil, D. A. (2015). India's Snapdeal Says the Country Doesn't Have the Programmers It Needs. May 28, 2015. <http://blogs.wsj.com/indiarealtime/2015/05/28/snapdeal-says-india-doesnt-have-the-programmers-it-needs/>

Velayanikal, M. (2015). What are the hottest sectors for venture capital in India this year? Oct. 22, 2015. <https://www.techinasia.com/hottest-sectors-venture-capital-india-infographic>

Weitzman, Hal and Fontanella-Khan, J. (2011). US and India: the squeeze on small business. May 31, 2011. <http://www.ft.com/cms/s/0/33de9812-8b8f-11e0-8c09-00144feab49a.html#axzz1PgAoaEbA>

World Bank. (2008). Doing business 2008: India, Bhutan, and Sri Lanka Lead South Asia's jump in reform.

World Bank. (2013). Doing business 2013: Smarter Regulations for Small and Medium-Size Enterprises. <http://www.doingbusiness.org/reports/global-reports/doing-business-2013>

World Economic Forum (WEF). (2016a). The Global Information Technology Report 2016: Innovating in the Digital Economy

World Economic Forum (WEF). (2016b). The Global Competitiveness Report 2015-2016. <http://reports.weforum.org/global-competitiveness-report-2015-2016/>

Science and Technology Trends
Fostering Startup Ecosystems

Malaysia's Startup Ecosystem: A Work in Progress

Siri Roland Xavier

1. Introduction

The startup ecosystem in any nation is subject to and formed by numerous factors. It would be naïve to suggest a fixed formula given that both the external and internal scenarios are in dynamic flux. The challenges faced by startups may be due to a number of factors relating to lack of resources (finance, technology, skilled labor), the scale of their businesses, that is, lack of economies of scale and scope, lack of networks, higher transaction costs relative to large enterprises, and experience of domestic and international markets and lack of entrepreneurial zeal and knowhow. Added challenges may include their locations which may be less than ideal due to the geography and political delineations that contain those economies. These factors can add up to a substantial competitive disadvantage.

Given those challenges this brief discussion will firstly ascertain Malaysia's current entrepreneurial context via a review of its entrepreneurial framework conditions and its early stage entrepreneurial activity i.e. startup rates. Then the current ecosystem will be reviewed highlighting the basic ecosystem necessities that have been installed. Lastly recommendations are put forward, given the gaps identified, whilst emphasizing greater attention for initiatives that can better support a startup ecosystem.

2. Malaysia's Entrepreneurial Framework Conditions

It is important to have a gauge that allows for an understanding of where one is. In Malaysia one method of assessment is afforded by the Global Entrepreneurship Monitors (GEM) methodology. This survey research comprises The National Entrepreneurship Survey (NES) and the Adult Population Survey (APS) and it allows for a comparison of the results between opinions of the experts and the behavior of a population i.e. its attitudes, aspirations and activity. This provides interesting information given that, in many cases, their opinions differ, especially with regards to the existence of entrepreneurial opportunities or to the entrepreneurial capacity of each nation. These differences are useful for policy makers to help them adjust and improve the strategy and design of public

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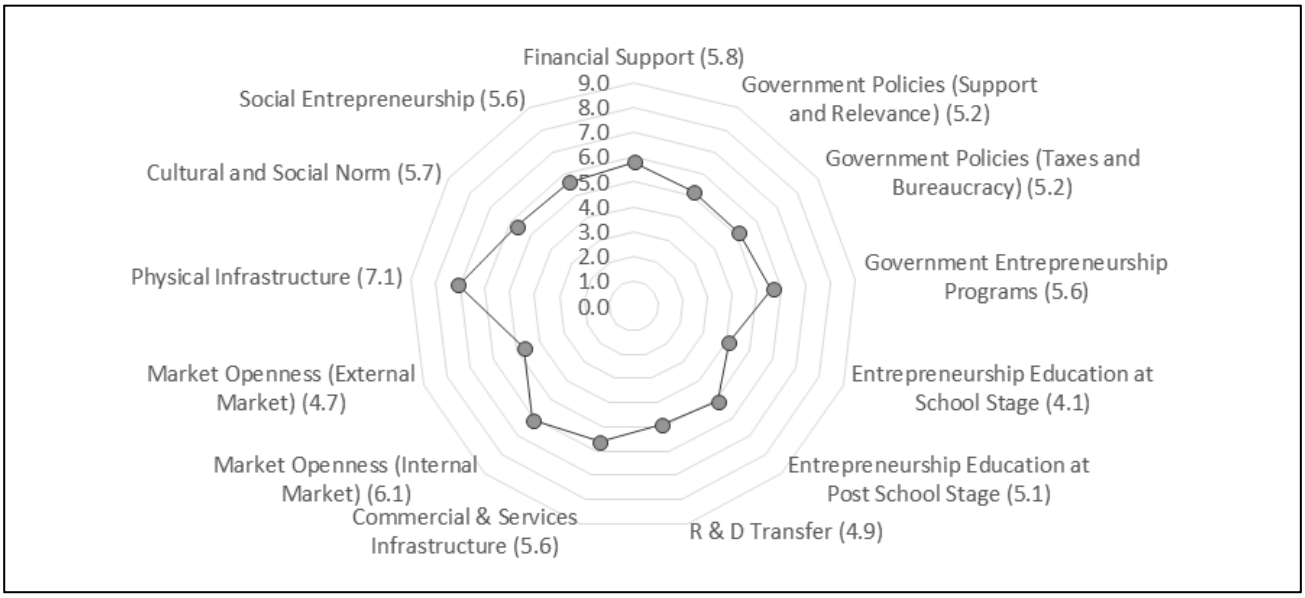
Figure 1. Expert ratings on Malaysia's entrepreneurship framework conditions (2015)



policies to encourage entrepreneurship, to improve entrepreneurial education, to analyse market conditions and other relevant aspects which have a profound effect on the business creation processes. A key starting point for Malaysia is an assessment of its Entrepreneurial Framework Conditions (EFCs) which captures a set of factors that shape entrepreneurial activity as illustrated in Figure 1.

This is different for each country as their context is necessarily nuanced differently with unique consequences (see Appendix A for country comparisons).

The NES used to survey the above conditions was carefully designed and refined to capture informed judgments of national key informants regarding the status of EFCs in their own countries. National and regional experts were selected on the basis of reputation and experience.

The EFCs can be considered an indispensable part of the puzzle in understanding business creation. The state of these conditions directly influences the existence of entrepreneurial opportunities and entrepreneurial capacity and preferences, which in turn determines business dynamics.

The first EFC reviewed is Entrepreneurial Finance. This refers to the availability of financial resources-equity and debt-for small and medium enterprises (SMEs) (including grants and subsidies). Based on the GEM global report 2015, Guatemala is lowest and Malaysia is highest followed by India. Finance for entrepreneurship is a key condition for entrepreneurship where government support can make a real difference.

National policy refers to the extent to which public policies give support to entrepreneurship. This EFC has two components. Firstly the general policy of governments i.e. where entrepreneurship is treated as an important factor for economic growth. Malaysia's experts obviously do not regard their government's general policy for entrepreneurship as sufficient (it is ranked 10^{th}) as compared to Belgium which scores the highest and Korea the second highest of the 62 economies surveyed. Secondly the national policy concerns regulations for entrepreneurship i.e. where taxes or regulations are either size-neutral or encourage new and small and medium enterprises. Regulations and taxes can stifle growth for established organisations but new

and smaller or even micro enterprises will usually not be able to survive. In national regulations Switzerland scored the highest and Malaysia is ranked 7th.

Government entrepreneurship programs refers the presence and quality of programs directly assisting SMEs at all levels of government (national, regional and municipal). Such programs range from skills training to networking opportunities for entrepreneurs. Malaysia ranks 5th, Korea 10th and Luxembourg ranks the highest.

Entrepreneurship education is measured in two segments i.e. entrepreneurship education in primary and secondary schools and entrepreneurship education in institutions of higher learning or post-secondary levels. This would include vocational and technical colleges, universities and business schools. It considers the extent to which training in creating or managing SMEs is incorporated within the education and training system at all levels. Interestingly the opinion of experts (within each country) rated Malaysia 13th for school and 11th for post school stages whilst Philippines was rated highest for post school and 2nd highest for school stage. This underscores a key shortcoming in Malaysia's EFC.

R&D transfer here refers to the extent to which national research and development will lead to new commercial opportunities and is available to SMEs. This is important for creating and infusing innovation into SMEs. Malaysia was ranked 5th and Switzerland was ranked 1st. The Global Competitiveness Report considers Innovation and Business sophistication as the two key pillars for an innovation-driven economy, and R&D transfer support by governments will feed directly into this.

Commercial and Legal Infrastructure is rated based on the presence of property rights, commercial, accounting and other legal and assessment services and institutions that support or promote SMEs. Malaysia was ranked 12th and Canada the highest.

Entry regulations is measured across two key components. Firstly Market Dynamics which is the level of change in markets from year to year. Market changes refers to changes seen in markets for consumer and business to business goods and services. Malaysia experiences lower changes and is ranked 10th whereas Korea is ranked 1st followed by China as the 2nd. Secondly Market Openness indicates the extent to which new firms are free to enter existing markets. A lack of anti-trust legislation, high cost of market entry and other blockages can prevent the new firms from entry into markets. Malaysia is ranked 13th and Netherlands is ranked the highest.

Physical Infrastructure refers to the ease of access to physical resources-communication, utilities, transportation, land or space at a price that does not discriminate against SMEs or startups. Malaysia is ranked 9th and Switzerland is ranked the highest for this EFC.

Cultural and Social norms indicates the extent to which social and cultural norms encourage or allow actions leading to new business methods or activities that can potentially increase personal wealth and income. Risk taking propensity, creativity and innovation and locus of control are some of the key measures of an entrepreneurial culture. Malaysia ranked 8th and Israel was ranked the highest for entrepreneurial culture by their experts.

The EFC comparisons across 62 countries that conducted the GEM study provides a measurement, comparison and benchmarking for Malaysia. It provides a starting point for understanding the ecosystem within which Malaysian startups operate. The tables in Appendix A below will provide a wider global view as each countries EFC is traced against EFC's of countries across differing economic stages i.e. factor-driven, efficiency-driven and innovation-driven type economies.

3. Startups and Total Early Stage Entrepreneurial Activity

A primary measure of entrepreneurship used by GEM is the Total Early-Stage Entrepreneurial Activity (TEA) rate. TEA indicates the prevalence of individuals engaged in nascent entrepreneurship and new firm ownership in the adult (18 - 64 years of age) population. As such, it captures the level of dynamic early-stage entrepreneurial activity in a country and this does allow for an objective assessment of Malaysian startup activity.

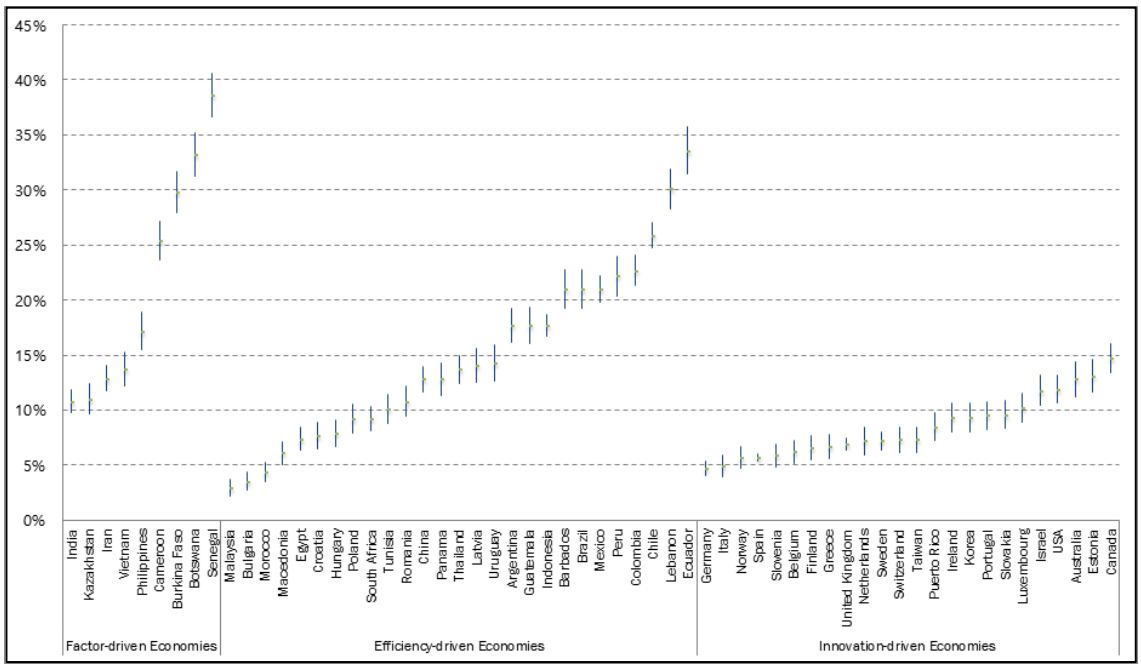
Every person engaged in any behaviour related to new business creation, no matter how modest, contributes to the national level of entrepreneurship. However, it is important to recognise that startups and entrepreneurs can differ in their profiles and impact. GEM uses a range of indicators that describe the unique, multifaceted pattern exhibited in each society. It is therefore important to consider not just the number of entrepreneurs in an economy, but other aspects such as the level of employment they create, their growth ambitions, and the extent to which groups such as youth and women are participating in entrepreneurial activity when considering an entrepreneurship ecosystem.

Figure 2 below outlines the TEA rates by economic development.

Malaysia is rated highly by Global Entrepreneurship Monitor (GEM) experts for its good infrastructure, access to finance and good internal market dynamics (GEM, 2015). Added to this, the SME sector has been growing in the last decade, having outpaced economic growth.

This has helped push up the contribution the sector makes to the gross domestic product (GDP) (SME, 2014). Despite this, fewer Malaysians are starting new businesses. When compared to similar economies, the country has a low and declining early-stage entrepreneurship (TEA) rate, having fallen from 7.0% in 2012 to just 2.9% in 2015. This has been accompanied by a decline in the number of Malaysian adults that view entrepreneurship as a good career choice (Timm, 2015; Malaysian Policy Brief, 2016, publication pending).

Figure 2. TEA rates by economic development (GEM, 2015)

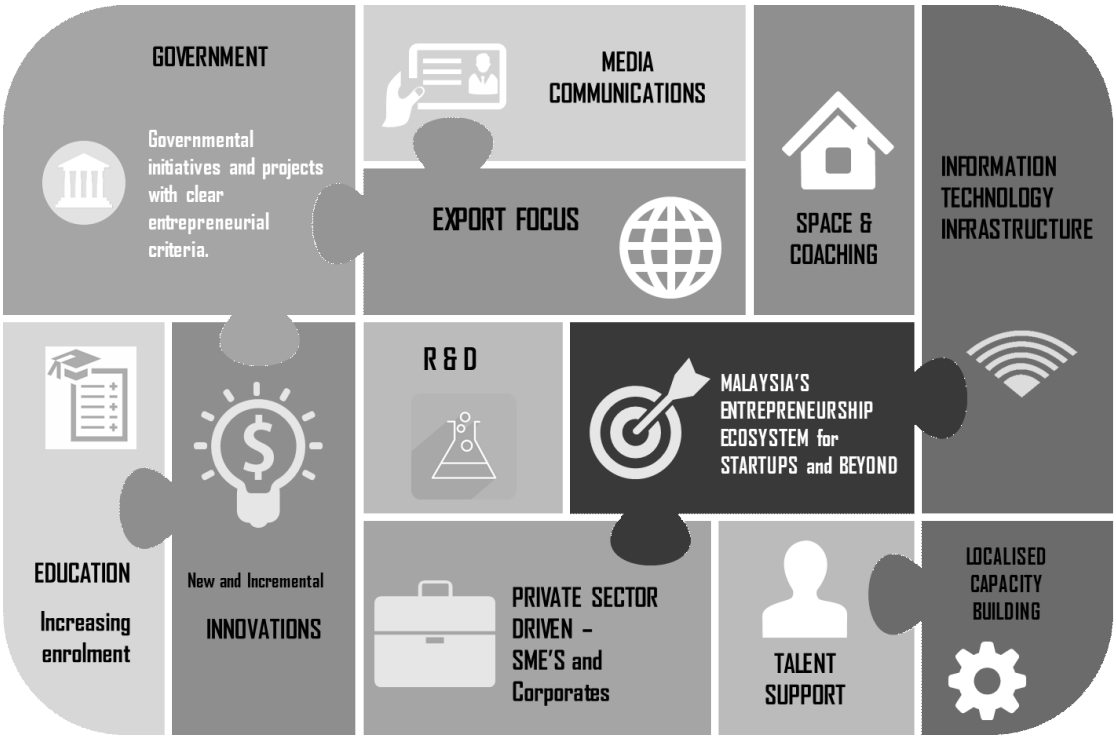


4. Malaysia's Entrepreneurial Ecosystem: Meeting the Bare Necessities

Malaysia has been fortunate as government policy has been geared towards providing the key fundamentals for entrepreneurial development especially for startups. Figure 3 below briefly illustrates the Malaysian ecosystem installed via government policies and private sector initiatives to enable such support.

The below fundamental eleven factors has allowed startups in Malaysia a supportive environment. How ever based on our above analysis and experts feedback some aspects of the above ecosystem will require improvements or added emphasis when bench-marked against the global economy.

Figure 3. Malaysia's entrepreneurship ecosystem to build overall entrepreneurial capacity and foster startups



5. Conclusions and Recommendations

It is often questioned to what extent government should be involved. There have been numerous arguments for and against government as mere gate-keepers and to a limited extent as gate constructors. However the latest longitudinal studies do show that government policies, rightly engaged, can boost high-growth entrepreneurship. It has been shown that policy initiatives that are selective, impose milestones and focus on capacity boosting are able to accelerate new firm growth (Autio and Rannikko, 2016).

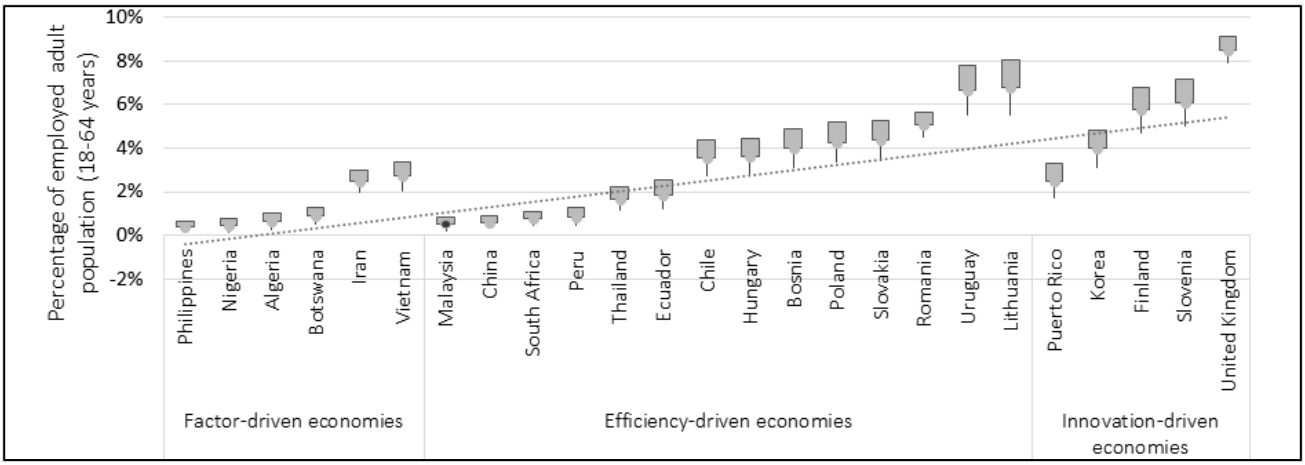
The TEA in Malaysia is low and it is indicative of fewer new startups. This is not necessarily a negative. Rather Malaysia now needs to emphasize quality over quantity of startups. Again we need to start from where we are rather than simply adopting 'successful' approaches other nations have applied. Economies are diverse in terms of level of economic development, including factor-driven, efficiency-driven and even innovation-driven economies (based on the World Economic Forum's (WEF) Global

Competitiveness Report categories). Using an assessment of the challenges and successes in other economies in each of these categories, some key policy improve-ment opportunities for Malaysia as an efficiency-driven economy in transition to an innovation economy is to;

- Emphasize Science, Technology, Engineering and Math (STEM) learning along with creativity and innovation management.
- Encourage and incentivise innovation especially technology-based innovation in startups.
- Emphasize high growth and sustainability type opportunities; think scalability, replicability and long tailed type operations.
- Assist startups in linking into global economies (e.g. USA, China and India) to become part of the growing global supply chains of multinationals.
- Support/move startups into value-addition sectors with an emphasis on higher end services e.g. finance, insurance, taxation and integration services.
- Work towards quality of enterprises as opposed to quantity. Support R&D efforts that offer high end growth opportunities that create regional/global companies. The result will be much less new businesses but the quality of those who actually startup will be higher and consequently result in higher job creation and sustainability. This is where we need to infuse our resources. The global scenario does offer many lessons including that it is not the quantity of businesses that matter but the high growth value added quality that counts (Shane, 2009).
- Encourage greater collaboration with regional and international R&D initiatives.
- Attract, incentivise and retain talent for key industries that are strategically important for the economy, thus emphasizing Entrepreneurial Employees Activity (EEA), where Malaysia has a low score, as much as independent new business activities (see Figure 4 below).

The solution would be to recalibrate our emphasis and make the entrepreneurial employee activity (EEA) (GEM, 2013) equally important. Entrepreneurial Employee Activity or EEA is defined by the GEM EEA Report 2013 as 'employees developing new activities for their main employer, such as developing or launching new goods or services, or setting up a new business unit, a new establishment or subsidiary. The scope adopted is therefore broader than new organization creation; however it excludes employee initiatives that mainly aim at optimizing internal work processes'.

Figure 4. Entrepreneurial Employee Activity (EEA), by phase of economic development



This employee working within an organisation could be provided the same incentives as given to new startups. However it will be for innovation efforts or spin off organisation for their employers. This approach has the added benefit of the EEA having a mentor in addition to other subsidiary resources for the new spin off venture. New monitoring mechanisms may be put in place that ensures that both the employer and employee benefits. The employee benefitting is an important aspect as they are the source of ideas and innovation and should be the ones working the project.

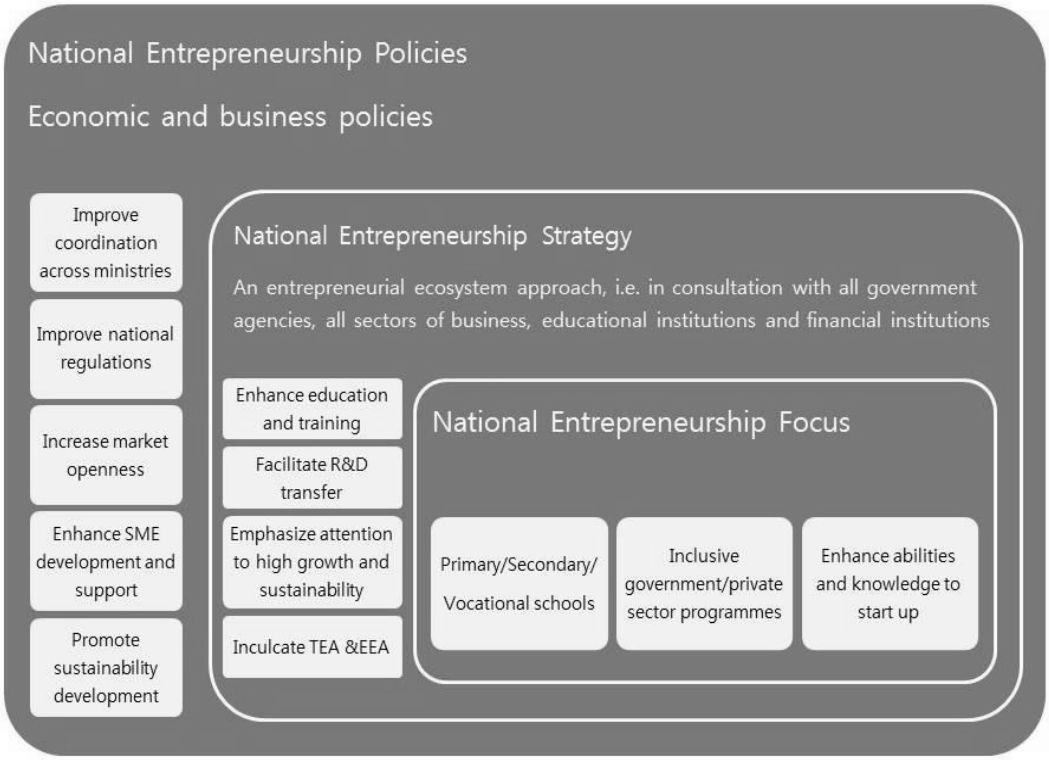
Based on the inherent shortcomings and challenges for Malaysia we can sum up the opportunities for a cascading national entrepreneurship policy, strategy and focus as follows in Figure 5 below.

The future challenges for Malaysia is to close the gaps within the Entrepreneurship Framework conditions. This will require a rethink and revamp of our national entrepreneurship policies as regards our economic and business climate. Key areas would include to improve the coordination amongst ministries, improve national regulations, increase market openness, enhance SME development and support policies and promote sustainable development. Sustainability development here refers to women and youth entrepreneurship focus, environmental protection and continuous evaluation of the effectiveness of implementation and meeting of expected outcomes both for startups and entrepreneurial employees.

The above assessment and recommendations will require keen motivations that can further build on some of the successes Malaysia has gained thus far. Fortunately Malaysia has both a keen private sector and a motivated government that continue to play a positive role in developing its ecosystem.

A statement by Prof. Datuk Seri Dr. Md Zabid Haji Abdul Rashid (President & Vice Chancellor, Universiti Tun Abdul Razak) sums up this position when he stated, "A nation needs to have an entrepreneurial ecosystem whilst inculcating within its citizens an entrepreneurial mind-set. This is largely achieved by a proactive government that facilitates and enables private sector-driven initiatives."

Figure 5. A Proposal of a Cascading National Entrepreneurship Policy, Strategy and Focus Approach for Malaysia



References

Global Entrepreneurship Monitor (GEM). (2015). Retrieved from <http://www.gemconsortium.org/country-profile/86>

SME Corporation Malaysia (SME). (2014). SME Annual Report 2014. Retrieved from <http://www.smecorp.gov.my/index.php/en/resources/2015-12-21-11-07-06/sme-annual-report/book/7-annual-report-2014/2-annual-report>

Timm, S. (2015). "Turning good vibes into entrepreneurs". Small Business Insight, 26 November 2015, Retrieved from <http://www.smallbusinessinsight.org/blog/turning-good-vibes-into-entrepreneurs>

Autio, E., and Rannikko H. (2016). Retaining winners: Can policy boost high-growth entrepreneurship? Research Policy, 45(1), pp. 42-55.

Shane, S. (2009). Why encouraging more people to become entrepreneurs is bad public policy. Small Business Economics, 33(2), pp. 141-149.

Global Entrepreneurship Monitor (GEM). (2013). GEM 2013 Global Report, Retrieved from <http://www.gemconsortium.org/report>

Appendix A

Entrepreneurial framework conditions, by region, 2015
(Weighted average: 1 = highly insufficient, 9 = highly sufficient)

Economy	Stage	1	2a	2b	3	4a	4b	5	6	7a	7b	8	9
Botswana	2	4.1	4.2	4.1	4.1	4.2	4.9	3.8	4.2	4.9	3.5	5.0	4.7
Burkina Faso	1	3.6	3.7	4.7	4.0	1.9	4.6	2.9	4.9	4.4	3.8	4.8	4.7
Cameroon	1	3.6	4.5	3.8	4.4	3.0	4.7	3.6	5.2	4.1	4.0	5.1	4.7
Egypt	3	3.5	3.3	3.1	3.3	1.6	3.1	2.9	4.2	5.1	3.8	6.3	3.8
Morocco	3	4.3	3.6	3.6	3.8	1.8	3.3	3.1	5.0	4.7	3.7	7.0	3.7
Senegal	1	3.6	4.1	4.9	4.1	1.8	3.9	2.4	5.3	3.3	3.9	6.4	3.8
South Africa	3	4.0	4.1	3.1	3.0	3.1	4.2	3.4	4.9	4.5	3.9	5.9	3.4
Tunisia	3	4.2	4.1	2.7	3.6	1.7	3.4	2.8	5.8	6.9	2.9	6.7	4.1
Africa		3.8	3.9	3.7	3.8	2.4	4.0	3.1	4.9	4.7	3.7	5.9	4.1
Australia	5	4.0	3.7	4.2	4.2	3.7	4.2	3.7	5.1	4.7	4.7	6.5	4.8
China	3	4.9	5.8	4.4	4.4	2.6	5.0	4.1	4.3	7.2	4.3	6.9	5.0
India	1	5.7	5.5	3.9	4.5	4.1	5.1	4.3	5.0	5.7	4.8	6.2	5.5
Indonesia	3	4.9	5.1	4.4	4.8	4.4	5.9	4.9	4.8	6.2	4.6	5.2	5.8
Iran	2	3.3	3.8	3.3	2.1	2.8	3.4	3.0	2.8	5.9	3.1	6.6	3.7
Israel	5	5.1	3.7	2.5	3.9	3.0	4.3	4.4	5.6	4.1	3.5	6.4	7.4
Kazakhstan	4	3.6	5.3	4.5	4.3	3.5	4.3	3.1	4.8	6.0	4.1	5.9	5.0
Korea, Republic of	5	3.9	5.8	4.6	5.0	2.8	4.0	3.6	4.0	7.3	3.3	7.0	4.9
Lebanon	4	5.2	3.3	4.1	4.2	4.3	4.9	4.2	5.6	4.4	4.2	4.4	6.3
Malaysia	4	5.8	5.2	5.2	5.6	4.1	5.2	4.9	5.6	6.1	4.7	7.2	5.8
Philippines	2	5.1	3.9	2.9	3.6	5.0	6.3	4.1	5.2	6.1	4.1	5.5	5.7
Taiwan	5	4.7	4.4	4.5	4.1	2.9	4.2	4.1	4.4	5.8	4.2	7.3	4.8
Thailand	3	4.2	4.0	4.0	3.7	3.6	4.3	3.9	4.8	6.4	4.1	6.4	5.5
Vietnam	1	3.5	4.3	4.6	3.5	2.5	4.2	3.9	4.7	6.1	4.2	6.9	5.4
Asia&Oceania		4.5	4.6	4.0	4.1	3.4	4.7	4.1	4.7	5.9	4.1	6.3	5.3
Argentina	4	3.1	3.0	1.9	3.7	3.0	4.8	3.7	4.7	5.6	3.8	5.8	4.9
Barbados	4	3.1	3.7	2.5	3.5	2.6	4.5	2.9	4.8	4.4	3.6	6.1	4.3
Brazil	4	3.9	3.7	2.2	3.4	2.1	3.8	2.9	4.2	5.0	3.5	4.7	3.9
Chile	4	3.5	4.6	5.4	5.4	2.4	4.9	3.5	4.7	3.4	3.8	7.5	5.1
Colombia	3	3.2	3.8	3.4	4.3	2.9	5.3	3.5	4.1	4.1	4.2	6.2	5.2
Ecuador	3	3.4	4.7	3.2	4.4	3.7	6.2	3.7	4.9	3.7	4.2	7.6	5.8
Guatemala	3	2.8	2.6	3.2	3.3	2.1	4.6	2.8	4.2	3.2	3.3	6.1	4.3
Mexico	4	4.0	4.8	3.7	5.1	2.6	5.4	4.1	4.7	5.4	3.6	6.3	5.0
Panama	4	3.3	2.7	5.5	3.7	1.9	3.7	3.2	4.4	4.2	4.4	7.1	5.2
Peru	3	3.0	3.1	3.0	3.7	3.0	5.0	3.0	3.7	3.8	3.8	5.6	5.0
Puerto Rico	5	3.3	4.1	2.2	3.3	2.0	4.2	2.9	4.6	4.3	3.7	5.5	3.8

Uruguay	4	3.7	3.4	3.7	5.1	2.0	4.6	4.2	5.1	3.2	4.1	6.2	3.6
Latin America &Caribbean		3.4	3.7	3.3	4.1	2.5	4.8	3.4	4.5	4.2	3.8	6.2	4.7
Belgium	5	5.3	6.5	3.2	4.8	3.1	5.4	4.6	6.2	4.8	5.1	6.4	4.1
Bulgaria	3	4.4	2.9	4.8	3.4	2.6	4.2	3.6	5.2	3.6	3.9	6.8	3.5
Croatia	4	3.3	2.8	2.0	3.2	1.9	3.5	2.9	4.3	6.1	3.0	6.5	2.6
Estonia	5	4.9	3.8	4.9	4.9	4.2	4.8	4.5	5.2	5.2	5.1	7.5	5.7
Finland	5	4.3	5.4	4.9	4.6	3.9	4.2	3.9	5.7	5.4	4.6	7.6	4.5
Germany	5	4.3	4.3	3.9	5.6	2.7	4.1	4.0	5.9	4.5	5.2	6.4	4.2
Greece	5	3.0	2.9	2.3	2.8	2.7	4.6	3.8	4.5	5.0	3.1	6.1	3.6
Hungary	4	4.0	2.7	2.4	3.2	2.3	4.3	3.6	4.4	5.5	3.8	6.1	3.2
Ireland	5	5.4	4.9	4.8	5.9	3.6	4.9	4.6	6.1	3.9	5.2	6.8	5.4
Italy	5	4.0	3.1	2.4	3.3	3.0	4.3	3.9	4.3	4.3	4.2	5.1	3.5
Japan	5	4.2	5.0	3.7	4.1	2.3	4.2	4.5	3.5	6.5	4.3	6.9	3.8
Latvia	4	4.5	3.7	3.8	4.7	4.0	5.4	3.5	6.1	4.8	4.5	6.7	4.8
Luxembourg	5	4.1	5.3	5.6	6.0	3.5	5.4	5.4	6.0	3.8	5.5	6.8	4.1
Macedonia	3	4.0	4.0	4.6	4.4	3.6	4.9	4.1	5.1	5.7	3.7	6.5	4.1
Netherlands	5	5.7	5.4	5.8	5.8	4.9	5.6	5.1	5.9	5.0	6.0	7.4	5.7
Norway	5	4.2	3.7	4.3	4.4	4.1	4.1	4.2	5.5	5.2	4.2	6.8	4.7
Poland	4	4.7	4.6	3.4	4.6	2.5	3.9	3.5	4.5	6.4	4.6	6.8	4.4
Portugal	5	4.7	5.0	5.8	4.7	5.6	4.7	5.3	4.6	5.4	5.0	3.5	5.2
Romania	3	3.4	3.6	3.5	3.8	3.9	4.5	3.7	6.0	4.2	4.0	4.9	4.1
Slovakia	4	4.3	3.7	3.4	3.7	3.4	4.2	3.2	5.5	4.1	4.2	7.0	3.5
Slovenia	5	4.2	4.0	3.1	4.5	2.8	3.9	3.8	4.7	5.3	3.8	6.4	3.4
Spain	5	4.0	4.0	3.8	4.8	3.5	4.2	3.9	4.4	4.4	4.3	5.1	4.4
Sweden	5	4.7	4.0	3.9	4.6	3.8	3.9	4.0	5.1	5.7	4.5	7.5	5.0
Switzerland	5	5.3	5.7	5.8	5.9	4.9	6.2	6.2	6.3	4.5	5.7	7.9	5.8
Turkey	4	3.8	4.4	3.4	4.1	2.2	5.2	4.2	5.1	5.6	3.9	6.5	5.3
United Kingdom	5	5.4	4.6	4.4	4.5	4.0	5.0	4.2	5.0	5.0	4.7	5.9	5.3
Europe		4.4	4.2	4.0	4.5	3.5	4.6	4.1	5.3	4.9	4.5	6.4	4.4
Canada	5	5.2	4.7	5.2	5.0	4.1	5.3	4.3	6.3	3.8	4.9	7.0	5.9
USA	5	5.4	4.4	4.6	4.1	3.5	4.4	4.2	5.4	5.6	4.4	7.1	6.8
North America		5.3	4.5	4.9	4.5	3.8	4.8	4.2	5.9	4.7	4.6	7.0	6.4
GEM		4.2	4.2	3.9	4.3	3.1	4.5	3.8	4.9	5.1	4.1	6.3	4.7

1 Entrepreneurial finance
2a Government policies: support and relevance
2b Government policies: taxes and bureaucracy
3 Government entrepreneurship programs
4a Entrepreneurial education at school stage
4b Entrepreneurial education at post school stage
5 R&D Transfer
6 Commercial and legal infrastructure
7a Internal market dynamics
7b Internal market burdens or entry regulation
8 Physical infrastructures
9 Cultural and social norms

Development stages

1 factor driven
2 transition to efficiency driven
3 efficiency driven,
4 transition to innovation driven
5 innovation driven