Innovation and Technology Based Economic Development: Are There Short-cuts?

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Abstract – **Many regions in the world, in developed and developing countries are striving for advanced technological and economic development. In this paper, based on a study of university related start-up companies some of the main barriers for growth are described. The findings are then discussed in a wider context of economic growth and whether it is possible to advance at an accelerated pace. It is concluded that many of the developed countries started their economic growth patterns centuries ago which enabled them to develop critical mass in important areas for economic and technological development. Building up a critical mass takes time and it seems unlikely that underdeveloped regions will be able to find short-cuts to enhance their economic and technological status.**

Keywords - **Innovation, economic development, technological development**

I. INTRODUCTION

Developing countries such as India and China frequently have economic development plans covering several periods of 5 years. These plans typically address specific industries as target industries. For example Indonesia targeted the aerospace and shipbuilding industries as important industries for technological and economic development [1]. China is also targeting the aerospace industry [2]. Considering the limited commercial success of for example Indonesia's aircraft industry [3] it is questionable how effective the technological and economic development plans are. In the specific situation of Indonesia's aircraft industry development the lack of management has been viewed as a major hurdle [3]. This relates to the overall state of the nation and the availability of education or job training. Both can not be seen in isolation but instead, a more developed environment generally offers more education and training opportunities which enhance industrial capabilities etc.

It is not only developing nations that have economic and technological development plans. Even in advanced countries such as the USA, there are many regions with their own economic and/or technological development plan. Examples are Austin [4] and Albuquerque [5]. In many instances the technology based economic development plans involve substantial investments such as the more than $1 billion plan for Ohio [6]. Similar to the national plans of developing nations, these regional plans for technology based economic development also may include specific targeted industries [7]. In many instances there are also specific roles for universities since they are often viewed as an important resource for the knowledge economy. This is despite mixed findings with regard to the relationship of the existence of universities in a region and the economic wealth of that region [8-11]. Regardless of these investments and plans, regions in the USA have difficulty replicating the success of other regions such as Silicon Valley, Route 128 and the Research Triangle Park.

In this paper start-up companies will be examined to determine the barriers to growth of these companies. This may provide valuable insight with regard to what type of economic and technological development plans are feasible.

II. METHODOLOGY

Since start-up companies provide a lot of potential for financial and job growth and are therefore frequently targeted in regional economic development plans, this study investigates start-up companies. The findings represented in this paper are part of a bigger study that is focused on university related start-up companies. With regard to growth potential and local environment barriers to growth, these are not considered different from non-university start-up companies. The start-up companies were selected in a region in the USA which is not known for being advanced but which has plans for developing an innovation oriented regional economy [12].

In the first phase of the research each of the regional universities were contacted with a questionnaire related to the number of patents, start-up companies etc. that were produced [13]. In the second phase of the research, which is currently on-going, several of the university related start-up companies were contacted. For each company one of the founders of the company, typically the person who developed the innovation on which the company was based, was interviewed to determine the regional economic impact of the company and to determine how the company was initiated and what helped or hindered the companies development.

The interviews contained information on three sets of variables. The first group of variables related to the founding of the company and the type of company that was founded. This included for example, year of founding, number of founders, whether founders are still in parent organization, type of start-up (planned or

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spontaneous [14]), whether technology and/or people were part of the spin-off (based on [15]), and industry. The second group of variables related to the current situation of the company. This included for example, the main mode of operating (based on [16]), employee level, sales level, outward orientation (based on [17]), and funding mechanism.

This paper focuses on the third set of questions. These were related to the perception of the interviewee on two issues. First, what type of environment helps or hinders the *formation* of a start-up company. Second, once a start-up company is formed, what type of environment helps or hinders the *growth* of the start-up company? This led to four questions that were addressed in the interviews:

1. What factors facilitate the establishment of a start-up company?
2. What factors inhibit the establishment of a start-up company?
3. What factors facilitate growth of the start-up company?
4. What factors inhibit growth of the start-up company?

III. FINDINGS

Below, the findings are provided for six start-up companies. Table 1 provides some general characteristics.

TABLE I
CHARACTERISTICS OF START-UP COMPANIES

Company	Characteristics	
	Founded	Regional orientation
1	1996	Almost no regional customers
2	2003	Mostly regional
3	1987	Almost no regional customers
4	2002	Almost no regional customers
5	1985	International customers
6	1993	Local suppliers, international customers

Table 2 provides a summary of the responses for each of the companies for the first two research questions.

TABLE 2
FORMATION OF START-UP COMPANIES

Company	Characteristics	
	Facilitates formation	Hinders formation
1	Economic development organizations	Not enough local expertise to help start-ups, lack of funding
2	Good workers	Lack of capital
3	Skilled workforce	Not enough personnel available, lack of capital, lack of investment culture
4	Availability of technical consultants who can help with start-up issues	Insufficient high quality local engineers, scientists, venture capital firms, no local markets
5	Cost of operations, transport/roads, tax structure	
6	Access to research funding	Lack of financial infrastructure, lack of examples

Table 3 provides a summary of the responses for each of the companies for the last two research questions.

TABLE 3
GROWTH OF START-UP COMPANIES

Company	Characteristics	
	Facilitates growth	Hinders growth
1		Availability of management help, limited local patent lawyers have limited experience, limited availability of capital or limited risk taking behavior of capital providers
2	Local markets	Lack of investment culture
3	Stable workforce	Lack of local customers, lack of qualified sales/marketing people.
4	Cost of living	Lack of services, lack of attraction to world-class engineers and scientists
5	Continuous R&D to keep up	Management skills
6	Many local vendors	Poor infrastructure (roads)

IV. DISCUSSION

When looking at the results, the first thing that is striking is that although the companies involved were mainly start-up companies that were spin-offs from universities, barely any comments were made about university policies on patenting and how these helped or hindered. This is surprising considering the wealth of literature on the Bayh-Dole act and also the literature on university policies to encourage patent development and start-up companies, see for example [18-22]. This includes for example allowing spin-off companies access to university research laboratories and facilities [23].

With regard to the market, table 1 shows that most of the companies had customers outside of the region.

However, table 3 shows that this was an important factor for growth (if they exist) or not (if they don't exist).

Table 2 shows that having local expertise, i.e. development organizations and technical consultants, aids the formation of start-up companies as well as (maybe obviously) employee availability with appropriate skills. Local infrastructure and R&D funds also facilitate start-up formation. The latter is maybe more specific in this research because the start-up companies are all R&D oriented (university related).

Table 3 illustrates that some of these factors also help or hinder the growth of companies. For example local consultants, technical expertise, patent lawyers, workforce. Local customers (already mentioned for table 1), local vendors and infrastructure play a role as well. What is important for growth of companies but not necessarily for starting a company are three additional factors: cost of living, continuous R&D and management skills. The first is important to attract skilled employees into the region. The second factor played a role in the formation of the company but obviously R&D needs to continue for many of these technology oriented companies to remain competitive. Lastly, once the company is started it becomes necessary to focus more on the management skills.

In further analysis it is noticeable that many of the factors that are considered facilitators or barriers for starting-up a company as well as for the subsequent growth of the company are related to the local environment. Examples of these factors are the local availability of a skilled workforce, the experience level of local patent lawyers, the local investment climate, etc. However, each of these factors can be considered dependent upon the number of local start-up companies and/or technology based companies. For example, the local availability of high quality scientists and engineers is likely to be dependent upon the overall local demand for high quality scientists and engineers. Silicon Valley is an example of an area where there is a high demand for high quality scientists and engineers and consequently many high quality scientists and engineers are willing to move to that area because there are many job opportunities. The experience of local lawyers with patents is likely to be dependent upon how often they have to deal with patents. The availability of capital and the local investment climate is likely to be dependent upon the number of start-ups that occur, that is, the more start-ups and the more successful they are, the more likely that it will increase the availability of capital as well as have more sophisticated investors.

This indicates a pattern of mutual dependence which indicates that economic and technological development is a process that takes time to develop and where short-cuts are unlikely. An example that illustrates this is the development of the Research Triangle Park in North Carolina. This deliberately planned area [24] was launched in the 1950s but progress was slow for twenty years [25]. This raises two issues. First, what is required for a region so that economic and technological development can take place? Second, once this development takes place, is it possible to catch-up with other already developed regions in the world?

A. Critical Mass

Varga [26] provides an example of what is required in a metropolitan area before university technology transfer have a significant impact on the region. Varga examined a sample of metropolitan statistical areas (MSAs) and distinguished four different "tiers" based upon their innovation elasticity ranges. This elasticity represents the percentage change in innovations associated with a one percentage change in university research expenditures in the MSA. Although a one percent change in university research results in a 0.22 percent change in innovations in a typical first tier MSA, this value is only 0.009 percent in the fourth tier [26]. An average first tier MSA produces 116 innovations, a last category location can only obtain two of them [26]. Furthermore, a top category MSA employs 8,900 scientists and engineers in its research laboratories, 153,000 workers in its high technology production facilities and 76,000 employees in its business services organizations. The respective values in a typical fourth tier city are 220 scientists and engineers, 4,000 workers in high technology production facilities and 2,000 employees in business services organizations. In looking at these numbers it is obvious that even with substantial investments, for example from state governments, it will take time to develop the critical mass and short-cuts are not obvious.

B. Catch-up

Whether catch-up is possible depends on two things. First, how fast is the growth of the follower? And, second, what growth is the leader experiencing during the catch-up of the follower?

For the technological development in the aerospace industry it has been hypothesized that catch-up for developing nations has been particularly difficult because the developed nations are still experiencing high growth [27]. This relates to the concept of the technology S-curves. If the leader in the technology is still below the mid-point on the technology S-curve then catch-up will be difficult because the leader still has high growth which only increases the distance between the leader and the follower on the technology S-curve.

In a similar manner, Danielmeyer [28] and Danielmeyer and Airaghi [29] have looked at economic development of nations. They argue that the growth of nations, as measured by GDP per capita, follows exponential growth. For all nations together, there is a resulting envelope, which is the upper bound of all growth curves. This is nearly a pure exponential with a growth rate of only 1.3% per annum. This is the net result of all innovations, from the steam engine to the mobile phone [28]. Note that the first significant economic growth

occurred between 1500 and 1700 at an average growth rate of 0.52% (much lower than today's growth rate) [30]. This confirms the exponential curve found by Danielmeyer and it also illustrates that economic development in the currently considered developed nations has been a long process.

Danielmeyer [28] argues that higher growth rates, for example for developing nations, are possible based upon the fact that their current GDP per capita is lower than the upper-bound of economic growth. These countries can copy things from other countries (technology transfer) although, as pointed out previously, this isn't necessarily always successful [27].

Overall, it appears therefore that technological and economic development of countries or regions, for example through encouraging technology based economic development is a complicated process. First, any region or country that wants to use this strategy should realize that in order for innovations to get commercialized through start-up companies requires a certain environment, similar to what Varga stated as critical mass for university inventions. This critical mass is not something that can be easily build but requires time to develop. Second, even if a critical mass exists and economic and technological growth are possible, whether this really leads to a catch-up with the current economic leaders remains questionable. This is among other things dependent upon where the leaders are and whether they are for example still experiencing high growth themselves. As an example, the 2005 GDP per capita for the USA was $41,399. That for China was $7,204 [31]. A growth rate of 5% for the USA and triple that for China (15%) means that it would still take Chine roughly 20 years to have the same GDP per capita as the USA.

V. CONCLUSION

This paper started out by describing how many developing nations have economic and technological development strategies. Similarly many regions in developed nations have similar strategies. This was followed by a description of research which pointed out that many of the factors that help or hinder the establishment of technology based companies are related to the overall environment. Finally, additional literature was presented which illustrates that technological and economic development strategies, in particular related to catching-up with leading nations or regions, have to be based upon the local circumstances. Furthermore, to develop the required economic and technological environment is a long process. It is therefore unlikely that follower regions or nations are able to catch-up with the leading regions or nations unless the leading regions or nations enter the high portion of the S-curve, i.e. their economic growth slows down.

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