



Qualitative System Dynamics Model for Analyzing of Behavior Patterns of SMEs

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Abstract

In Iran, the Small and Medium Knowledge-Based Enterprises (SMEs), in the development and shaping stage, face lots of problems. Before maturity and stability, they fail. Nearly a decade has passed since the science and technology parks' formation. They were seen as a mechanism for sustainable economic development based on knowledge; through the creation, support, and guidance of founded SMEs. Iranian officials and policymakers are seriously concerned about the sustainable success, development, and growth of these SMEs, which must be appropriate for the needs of Iran. Identifying the behavioral patterns of the stages of life (birth, growth, decline, etc.), which lead to inefficiency and decline, is essential. This helps to avoid mistakes and eventually reduces costs. This paper, using participative model building, tries to extract prevailed patterns that govern the behavior of SMEs in Yazd Science and Technology Park. This paper attempts to introduce positive leverage points for policymakers and senior managers who are responsible and also for SMEs, which are located in the park. Therefore, in this article, while drawing the behavioral patterns of SMEs, using qualitative system dynamics modeling, the structure governing the behavior of SMEs was drawn. This structure consists of four reinforcing loops and eight balancing loops. Finally, based on these loops, 12 corrective policies were proposed.

Keywords: Qualitative System Dynamics; Participative Model Building (PMB); Small and Medium Knowledge based Enterprise (SMEs); Yazd Science and Technology Park (YSTP).

1. Introduction

Economic-social development, rapid growth of science, and the subsequent development of high-tech industries in our world create new paradigms and challenges, such as:

- Rapid change of economic activity and economic instability;
- Increasing competitiveness in the knowledge based economy;
- Increasing economic globalization;
- Ascendency rate of change in high-tech industries;
- Changing composition of the labor force, which impacts on the economy, scientists, and technical specialists;
- Reduction and limitation of resources, such as natural and human resources;

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- Importance of new factors, such as the environment.

According to this, implementing strategies and policies that lead to balanced social-economic growth is essential.

In the last decade, country parks and technology incubators have played a key role in implementing development policies and strategic plans for growing countries [1]. As a result, taking into account the role of missions, programs, and their performance is critical for successfully implementing knowledge-based economic development policies [2]. Through participatory model building, patterns of behavior that govern the behavior of SME's in Yazd Science and Technology Park have been identified. The concept of science and technology parks and knowledge-based SME's, which are located in the park, will be explained. And then we briefly describe participatory model building and the method, which is used in this study. In the next step, we will explain qualitative system dynamics modeling (cause and effect diagram) of behavioral patterns (Archetypes) in SME's located in the park. And finally, we will provide ways to deal with challenges in these SMEs.

2. Science and Technology Park

The official definition by IASP, the International Association of Science Parks: A Science Park is an organization managed by specialized professionals whose main aim is to increase the wealth of its community by promoting the culture of innovation and competitiveness of its associated businesses and knowledge based SME's. To enable these goals to be met, a Science Park manages the flow of knowledge and technology amongst universities, R&D SME's, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities [3].

Many policy makers, name technology parks and incubators, as part of a strategy for national or regional development [4]. But science and technology parks are very expensive tools and just by proper planning and considering all aspects which effect on their success, particularly country's economic - social conditions, can be effective means in the development of country based on technology development. In last decades parks have played key role in the economic development of many countries. For example, science and technology parks in China with more than 30 percent of economic growth are considered main engine of growth and development [5, 6]. In knowledge based economy, the mission of the Science and Technology Park is playing a central role in creation and dissemination of knowledge, innovation, development and commercialization of technology. Parks do their mission in such following key roles:

- 1) Technological innovation
- 2) Commercializing research and development technology Results
- 3) Transfer of Technology
- 4) Developing human resources [6, 7].

Generally in Iran, parks due to the following strengths can provide desirable areas for economic development which is based on knowledge and technology.

- * Providing a set of incipient and talented SME's, to work in the field of science and technology.
- * Proximity to major universities and research centers, for better access to experts.
- * Regulatory and tax incentives, in the form of concessions in specific areas for parks and incubators.
- * Extensive domestic markets [7, 8].

Science and technology parks and incubators, managed in a business environment, are taking steps to develop a knowledge-based economy. This combination occurs via interaction with key elements of the park, or incubator center and supportive - guidance regulations, and of course system of performance evaluation. Figure 1 shows interaction of key elements of parks and technology incubators centers, with knowledge based SME's which are located in the parks.

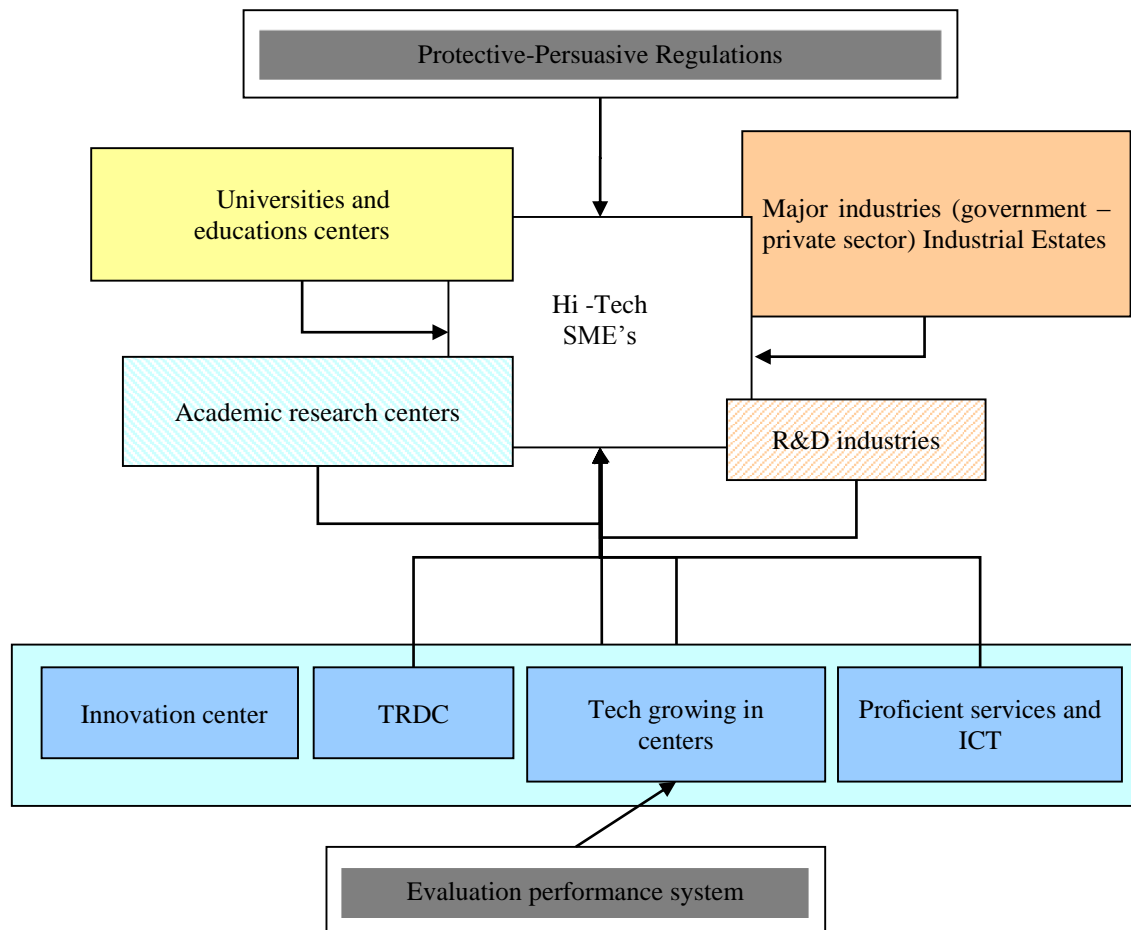


Figure 1. Interaction of key elements of parks and technology incubators centers, with knowledge based SME's which are located in the parks

3. Participative Model Building

From beginning, in system dynamics approach, the importance of client involving in process of modeling has been mentioned [9, 10]. A qualitative system dynamics is an approach to analysis and understanding of complex issues. It is used for developing robust strategies which are related to complex issues. Qualitative system dynamics evolution expresses that quality modelers, insist on mental processes. Mental models of stakeholders and experts, or the system being studied, can help to understand and create models [11]. Participative Model Building (PMB) refers to system dynamics modeling and also involving clients in process of model construction. Participative model building is a method which is based on systems thinking approach, and by involving stakeholders, through holding multiple sessions; looks for major and profound factors which impact on study of complex systems, associated with levels of uncertainty and ambiguity [12].

4. Research Methodology

The research team consisted of three people, each with knowledge of the system dynamics and role of facilitator, the modeler/reflector, and the gatekeeper.

There are different usages of participative model building. In this paper, method of Halbe [13] which is shown in Figure 2 is used. In this study, only steps to problem definition, Identification of stakeholders, and individual modeling; has been carried on.

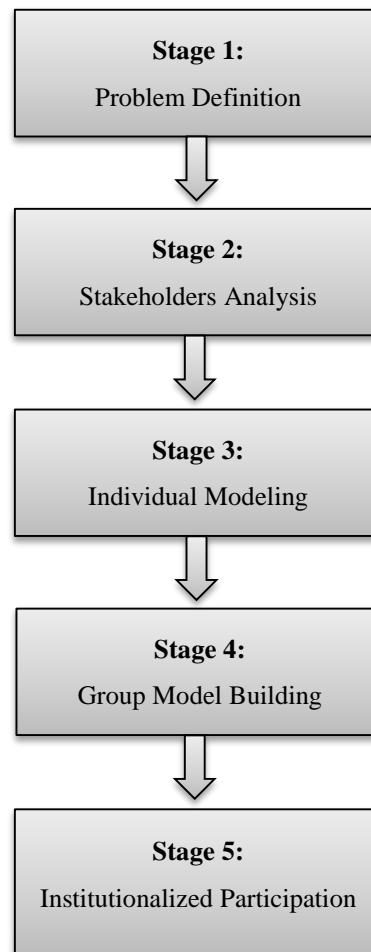


Figure 2. Participating modelling framework

The main stakeholders of this project were SME's. Criteria for project team in analyzing level, and for identifying stakeholders includes following these two criteria:

1. SME's located in the park, should have passed all phases (levels) of the park to use all mechanisms of park, and also should have reached maturity and passed various stages. In other words, SME's will be chosen that at least two years of their presence in growth center have passed, or stationed in the park.
2. These SME's should be the best in technical and financial criteria. In addition to desired criteria, Interview with SME's founder and director of growing center, reviewing documents, and finally minimum presence in park; will help to select appropriate firms.

In this study, we extracted cause and effects models by using semi-structured interview from six participants; include senior managers of small and medium enterprises selected in Yazd Science and Technology Park. Each interview lasted three hours.

5. Participative Model Building Results

Figure 3 shows behavior over time graph (BOT graph) for knowledge based small and medium enterprises in the park. All of these SME's have passed levels. In every level, similar happening occurred. This can be seen in following graph.

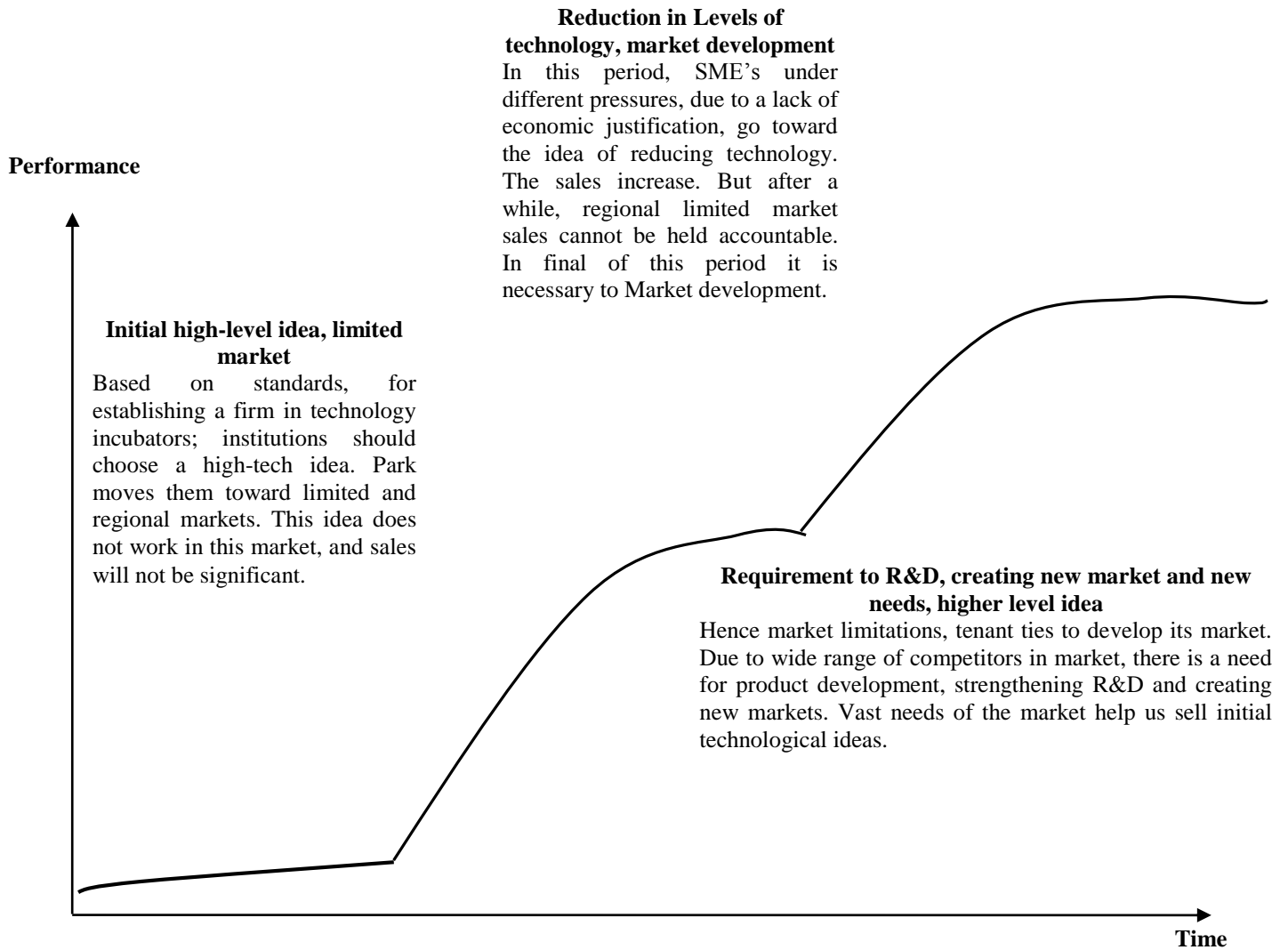


Figure 3. Behavior over time Diagram for knowledge based SME's

In following, according to individual interviews, cause and effect diagram of whole system is depicted. Diagram consists of four reinforcing and eight Balancing loops. We will explain them one by one.

5.1. Diagram of Changing Initial Technological Idea, Due to Lack of Market Interest

The diagram is composed of three balancing loops. In loop B1, proving primary resources which is commissioned by the park, causes the SME to just focus on its initial technological ideas. After that, they can prosper their idea which leads to R&D enhancement. After a while possibility for commercialization of the idea will increase; since the idea has turned into a product with more features and more innovation. On the other hand, too much emphasis on the idea and lack of systematic and scientific study of the market; cause technological ideas to be different with market needs. Consequently it will not provide different customers' needs and demands. As a result, the possibility of idea commercializing will decrease. Since company's focus is more on idea, and members often having no business abilities and trade communications; possibility for idea Commercialization is little. Capabilities and business communications, including business experience, ability in the field of human resources, administrative and human relations. Finally, by decreasing possibility of commercializing idea, idea commercialization faces with some Problems that affect sale. In other words, sale of initial technological idea, for lack of compliance with the requirements of the market and lack of proper marketing; will not be significant. Lack of sale, will lead to income gap. Income gap is difference between expected revenue of the park and real income which is earned by SME. At this time, due to lack of revenue requirements, Park puts pressure on SME. Since park is uncertain about ability of SME to repay provided facilities; even resources which must be allotted to the SME will be reduced. Finally this pressure leads to loss of SME's focus.

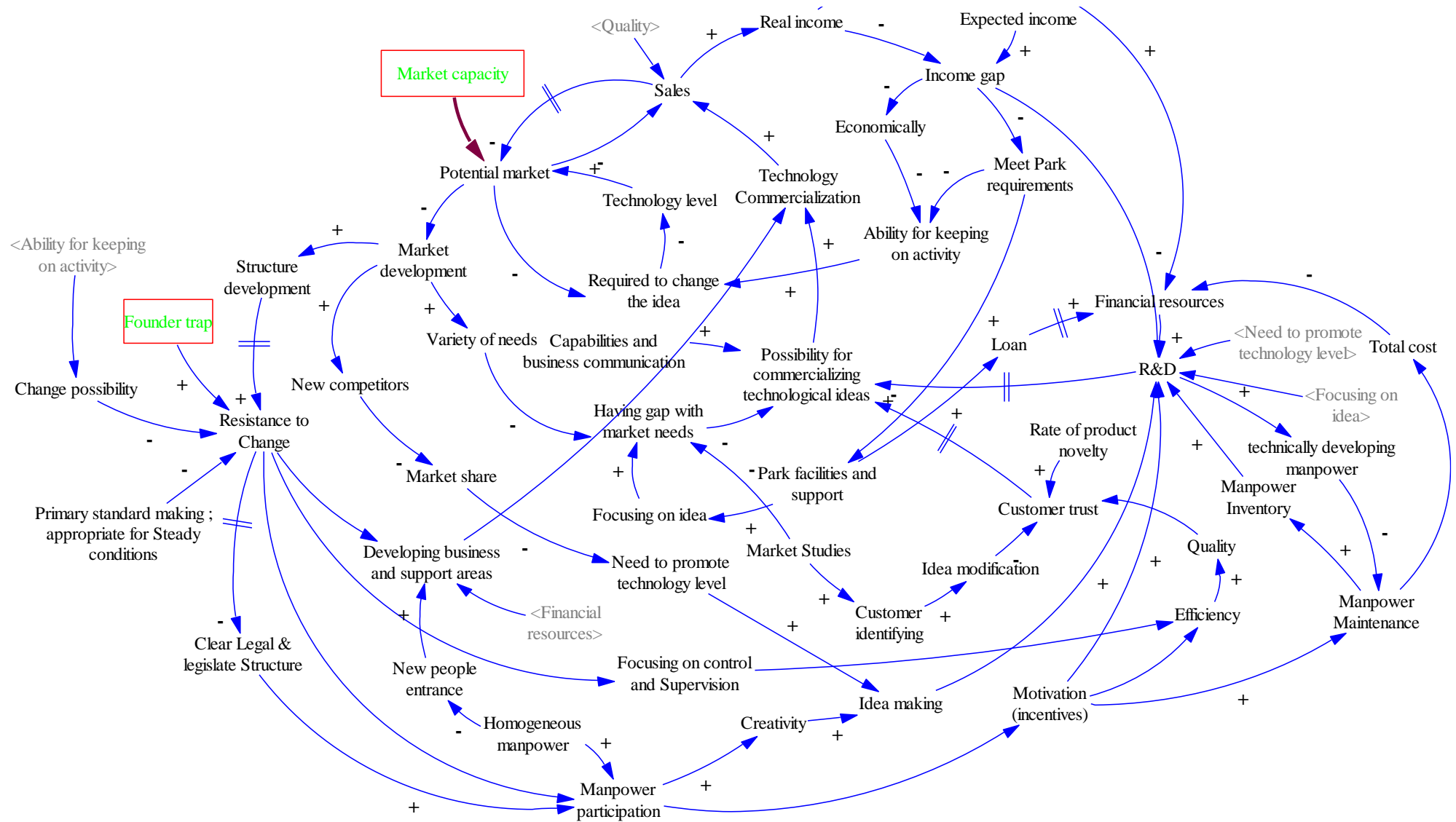


Figure 4. CLD of the system

As noted above, compliance with park requirements lead to pressures and costs for SME. One of the requirements of the park is related to human resources. All people must have insurance. This means having more cost. The more yield of SME losses, the more loan repayment rate increases. As a result, according to B2 loop, by reducing SME performance (failure to sell the idea), both pressure of the park and personal pressure from non-economic activities of SME; cause activity of SME face with some difficulty [14]. At this time, the SME will be forced to change its initial technological ideas. SME tries to lower its level of Technology, and by offering products that are more demanding in the market, gains better market. In this market ideas will be sold that, have lower level of technology. Thereby, income gap reduces and consequently, pressures will be reduced. This loop indicates patterns of Drifting Goals (Eroding Goals).

On the other hand, by reducing level of technology because of pressures for changing the idea, potential market increases and this increased potential market, reduces the necessity for changing the idea (B3 loop) [7].

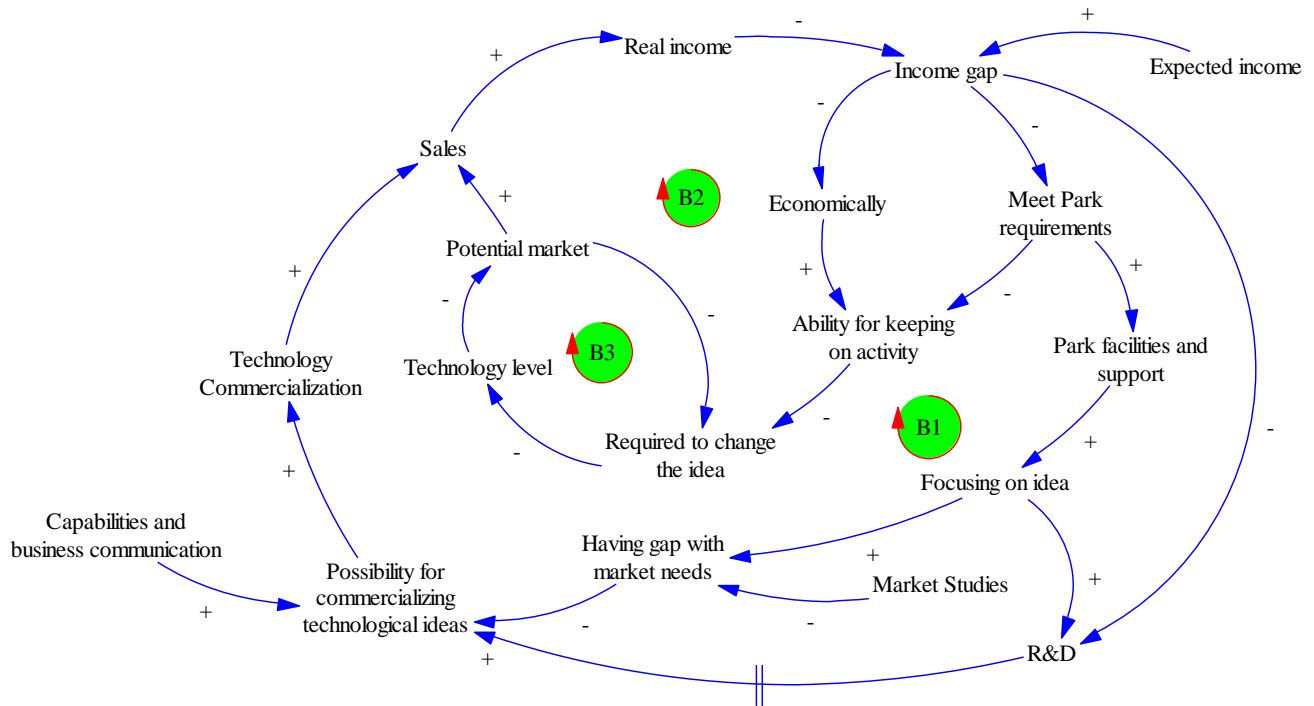


Figure 5. Loop of initial technological idea change, due to lack of market interest

5.2. Diagram of Imbalance in Resource Allocation, on Technical Development of Idea and Management Development

This diagram is composed of two balancing loops and one reinforcing loop. One of the park's facilities, which give to SME's, is loans. R1 loop states that, incorrect allocation of funds at start of firm working, which is usually spent on developing technological idea and strengthening R&D; is natural. This is because of pressure from park for selling central ideas of SME and also because of founder's little management knowledge.

Thus, by strengthening the financial resources which is allocated to the technical development part; R&D gets stronger and thereby the idea is to get more business opportunity. Product will be sold and again, the financial income from sales will be allocated in the same manner.

On the other hand, by Strengthening R&D; B4 loop will be formed. This loop explains that, by strengthening R&D, people skills and technical capacity enhance. Since management part does not provide sufficient incentives for individuals, they gradually leave the park. By reducing specialists, R&D sector will be eroded.

Unfortunately SME's don't analysis market properly. They have little information about customers' needs. Thereby, proper idea does not shape. The idea must be modified according to customer wishes. Because of idea novelty, getting customer confidence is one of essential point. As a result, lack of customer confidence leads to Disturbed idea commercialization. Ultimately, sales decreases (R2 loop).

This diagram shows "Success to the Successful" pattern. In this diagram, R&D has become more successful over the time and gets more resources. On the other hand, reduction of resources and support of administrative section, makes this sector weaker over time.

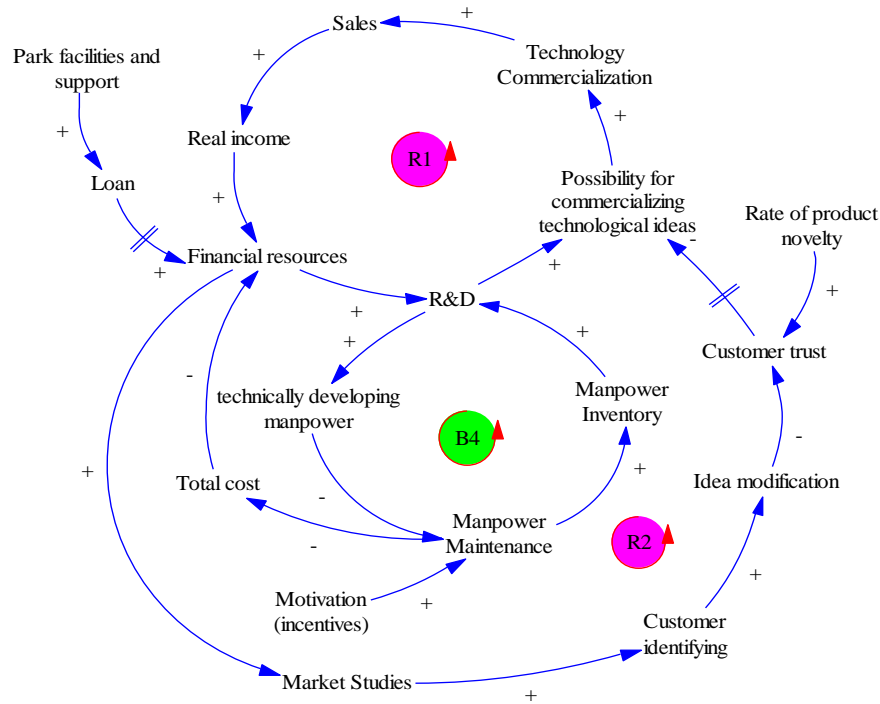


Figure 6. Allocation imbalance loop on technical development idea and management development

5.3. Diagram of Market Development and Utilizing Technological Ideas

The following diagram is composed of two reinforcing and balancing loops. According to B5 loop, by reducing level of technology, SME's will have seen an increase in sales. But it does not take much long. Due to the limited capacity of the existing market, sales will decrease. Market capacity constraint is because of SME's focus on regional limited markets. Since pressure by market capacity constraint, SME's encouraged to move towards greater regional markets. In R3 loop, by growing market SME reaches to market diverse needs and even which had no customer in limited market, finds demand. So on SME tries to commercialize its initial technological idea. With a wide variety of needs in a divers market, the gap between idea of SME and market requirements, may be reduced. Then possibility of commercialization will escalate. Thereby SME sale prospers and this increased sale alarm about market constraint.

R4 loop says that by market developing, SME faces with some new competitors. These competitors menace our market share. So SME tries to enhance its technology level for keeping and even increasing its market share. R&D strengthens and helps increase commercialization possibility. Ultimately by commercializing, sale will escalate. In long term, sale escalation leads to market limitation. As a result, opening and developing market to international markets is necessary.

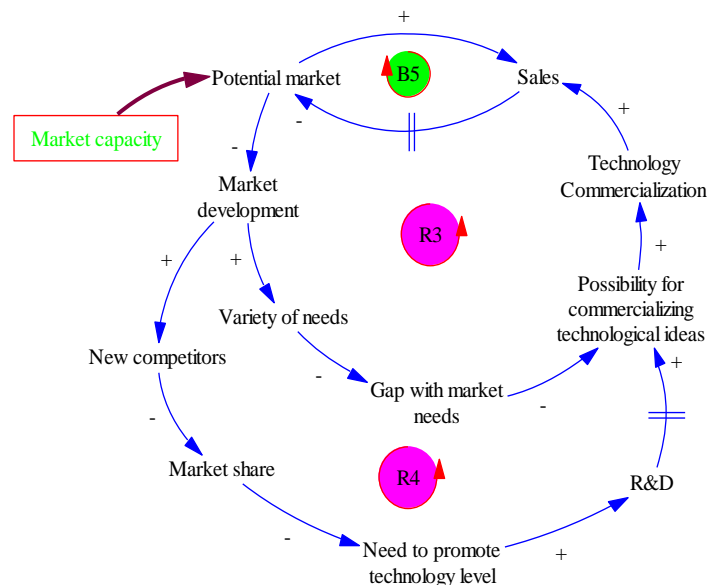


Figure 7. Market development loop and utilizing technological ideas

5.4. Market Development and Structure Changing Diagram

This diagram is composed of three balancing loops. With the increasing development of market, SME will also develop. Personnel working in SME's and ideas and products all will increase. Previous formed structure is not suitable for SME anymore and needs some changes. In B6 Loop, changing structure and giving scores or bonus to others, is difficult to founder of the SME and resist against it. Since in the beginning, focus was more on resources, and areas of management was not professional and most were run by the founder of the SME, resistance to change was very high. Change needs cost. If possibility of SME's activities continues decrease, thereby possibility of change will also decrease and then resistance will increase. As a result this strength will cease developing and strengthening of support and business part. By entering into market with a wide and varied range of competitors and clients, this area is of high priority and disregarding to that leads to decreased commercialization, and ultimately sale will reduce.

Initially starting SME, usually founding team is uniform and homogeneous. They are similar technically. At the first this homogeneity vigor technical knowledge, but in long term, avoids the arrival of new people with diverse skills (especially in business and management skills). Homogeneity strengthens technical manpower in organization and can increase R&D. In B7 loop, along with growing needs for development, legal structure does not form; due to resistance against change. Its consequence is reduction in labor force participation. Although in beginning, homogeneous labor force causes participation enhancement, but resistance against change, lack of authority delegation and participation; lead to reduction in staff. By descending in staff participation, we see staff commitment and ultimately creativity, reduce. Reduction in creativity, innovation and staff commitment; cause reduction in R&D [15-18]. When R&D loses it's strengthen, then SME poses little idea. Because of weakness in posed idea, possibility of their commercializing, decrease. Finally this loop impacts sale.

In B8 loop, original founders are still handling SME's with previous structure based on continuous monitor and control. This reduces the effectiveness of individuals and even founders. On the other hand, reduction in employee participation reduces their incentives and can lead to inefficiency. Employment inefficiency, decreases product quality. Low quality means poor selling.

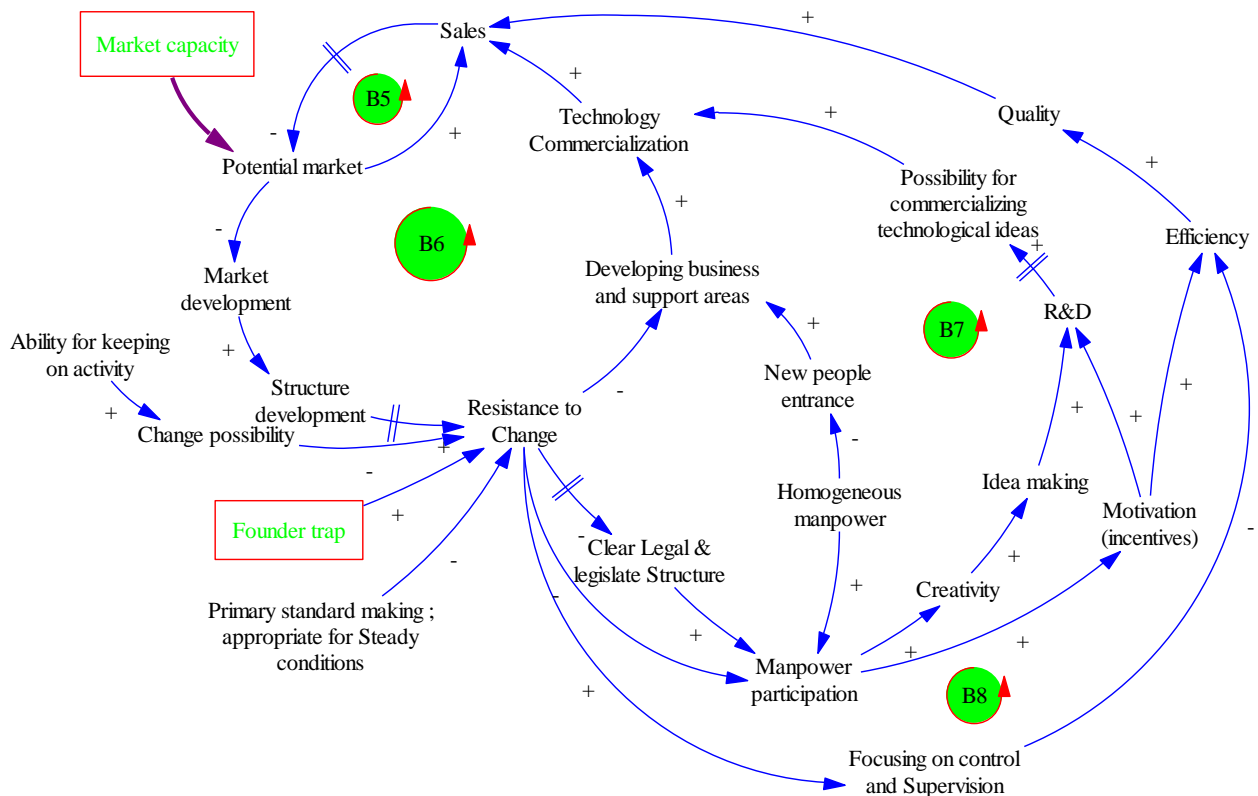


Figure 8. Market development loop and restructuring

5.5. Solutions

Considering dynamic behaviors of SME's (cause and effect relationships based on diagrams) which are located in the park, offers the following corrective policies:

- In implementing wide range of laws accomplice with continues assessments from SME's productivity in short terms (according to parameters diversity and effective variables on SME's productivity); we should set protective laws and regulations with high flexibility and freedom for managers of incubators;
- Using mentor mechanisms for coaching and leadership in whole levels of SME life. Mentor is like a solution for: managing financial allocations (during period of growing center), programing for existing in divers and different markets (time, type of market and e.t), consulting administrator in structure reform and style of management (fighting against founder trap and e.t);
- Spreading out administrative consulting, alongside existing advices, causes business area and workforce participation to improve; and control becomes reasonable;
- Balanced focus on development of technological idea and the development of market presence ability, especially in the field of human resource by SME's;
- Increasing period of assessment for growing SME's (located in growth center or incubator) with the aim of escalating the opportunities for SME's; Proportional with SME's activities on technological idea;
- Making access to large and diverse markets for early-stage growth companies; in order to reduce pressure of limited Regional markets which lead to reduction in level of technological idea;
- Changing structure of assessment and directing Supportive (financial) Facilities in order to both development of the market and technical development of idea, be balanced;
- Strengthening structure of human resource management, In order to maintain developed personnel;
- Park or growing center should focus on: providing marketing services, market research for SME's and facilitating connection to industry;
- Legal protection of ideas ownership, in the face of real market competition;
- Gradual removal of SME's from unrealistic business environment (Managed by the park or incubator) in order to prevent the quality gap between actual conditions;
- Developing structural - cultural factors, which suit with needs of knowledge based SME. In order to avoid founder trap and creative growth of SME's, by assessing located SME, including:
 - Emphasis on teamwork and team structure;
 - Creating specialty divers (technical ability along with directorial ability), among main forces of the SME;
 - Enriching main jobs;
 - Accepting and tolerating different tastes, in structure of SME;
 - To allow interact within the SME. (Free flow of ideas and perspectives of interaction);
 - Conflict solving to tolerate ideas which are new and impractical.

6. Conclusion

As previously stated, parks act as mechanisms that facilitate knowledge-based economic development and growth by acting as a bridge between universities, industry, and government. In this mission, parks and incubators (growth centers) take action in a managed and controlled environment in order to develop, protect, and guide SMEs (small and medium-sized enterprises).

In this paper, we have tried by using participative model building, systematic and comprehensive view and individuals' interview; extract prevailing behavior patterns in incubators in order to fundamentally explain their challenges and problems.

Diagram of behavior over the time and diagrams of cause and effect for existent patterns in behavior of SME's, indicated that: On one hand, part of the requirements, rules, and practices of technology parks and incubators, due to their lack of understanding of the underlying (in some cases, copying mechanisms and structures in parks and growth centers in developing countries, without careful assessment of the infrastructure and conditions, which govern their economic-social environment; in other words, disregarding the modeling of the mechanisms of technology transfer in software transition technology for parks and incubators), create some barriers that impede the development of knowledge-based SME's. On the other hand, improper structures for small and medium enterprises, their ways of management and operation, and their founders, strengthen their challenges and attenuate their improvement mechanisms.

Ultimately, explanation of behavioral results and problems caused in form of existent relations in cause and effect diagrams leads to some solutions. Therefore, positive and efficient leverages will be presented to politicians, SME's located in the park and high-ranked managers.

7. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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