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Cluster Formation and the Policy for Start-Up Firms: A System Dynamics Approach

บทคัดย่อ

บทความนี้นำเสนอผลกระทบของนโยบายที่ก่อให้เกิดปัจจัยสนับสนุนต่อการจัดตั้งกลุ่มธุรกิจ (cluster) โดยใช้หลักการด้านพลศาสตร์ระบบ (system dynamics) ซึ่งเป็นรูปแบบการพัฒนากลุ่มธุรกิจ ประกอบด้วย ความสัมพันธ์ระหว่างข้อจำกัดของทรัพยากรการดำเนินงาน ตำแหน่งงาน จำนวนผู้ว่างงาน ค่าจ้างค่าตอบแทน ความต้องการของตลาด และความสามารถในการผลิตต่อการเจริญเติบโตของกลุ่มธุรกิจ ผลการศึกษาพบว่าปัจจัยหนุนในการเริ่มกิจการจะส่งผลสำคัญให้กลุ่มธุรกิจสามารถขยายขนาดและลดเวลาในการพัฒนาลง อย่างไรก็ตาม ถ้านโยบายที่นำมาใช้สนับสนุนธุรกิจใหม่ก่อให้เกิดปัจจัยลบที่สำคัญต่อธุรกิจหลักที่มีอยู่เดิมขนาดของกลุ่มธุรกิจจะลดลง และจะใช้เวลาในการพัฒนากลุ่มธุรกิจนานมากกว่าการไม่มีปัจจัยเสริมให้ธุรกิจเปิดใหม่และถ้านำนโยบายที่นำมาใช้เพื่อสนับสนุนธุรกิจเปิดใหม่ก่อให้เกิดปัจจัยลบต่อธุรกิจหลักอย่างมาก การพัฒนาของกลุ่มธุรกิจจะไม่เกิดขึ้น

คำสำคัญ: การจัดตั้งกลุ่มธุรกิจ

Abstract

This paper studied the effects of policies that provide benefits for start-up firms of the cluster formation, using a system dynamics approach. The cluster development model consists of the interactions of limited resources, workers, jobs, unemployment, wages and salary, market demand and production capacity to the growth of the cluster. The results indicate that providing benefits to the start-up firms can enlarge the cluster size, and shorten the time to develop the cluster, if these benefits do not cause disadvantages, or cause small disadvantages for mature firms. However, if mature firms suffer significant disadvantages from the benefits provided for start-up firms, the cluster size will be reduced, and the cluster will take a longer time to develop than one without the benefits. If the disadvantages the mature firms have from the benefits for start-up firms are substantial, the cluster will not develop.
Keywords: System dynamics, industrial cluster, cluster formation, startup firms policy

Introduction

Clusters are another method of creating competitive advantage, not only for the firms in those clusters, but also for the country where the clusters are located. Clusters offer opportunities for the firms to increase productivity, reduce costs, create innovation, stimulate new business formation, acquire competitive resources and observe future trends (Porter, 1998).

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They will also raise the employment rate, enhance the Gross Domestic Product (GDP), increase the likelihood of transforming salaried workers into entrepreneurs, improve real incomes and stimulate economic growth for the country (Norman and Venables 2004; De Blasio and Di Addario 2005). Many governments in different countries view cluster developments as a key issue. However, many of them do not succeed.

A great deal of research focuses on cluster development, firms 'strategies to develop clusters and government policy to encourage cluster creation. However, most studies are based on static and open-looped perception of the cause and effect of each factor of the cluster formation, without including the feedback effect from the cluster to those factors. Therefore, the present research approach will target the effects of the factors involved in cluster creation, using the dynamics feedback involvement approach.

This study uses a system dynamics approach to understand the behavior of cluster formation and related factors. System dynamics is a tool, that incorporates feedback loops with a dynamic perspective, to explain complex situations (Sterman 2000). The system dynamics model will be simulated, based on iteration calculations. The simulation process will calculate the value for each variable in the first round, and then iterate the calculation, based on the new value. As a result, a system dynamics model can present the results of simulation, with the integration of the feedback effect. The system dynamics model can be extensively applied to research which observe growth or change over time, such as the growth of a city (Forrester 1974) and the growth of a biotechnology firm (Morecroft, Lane et al. 1991). System dynamics are also used in policy studies, as it can clearly illustrate the effect of the policy, in both the short-run and the long-run. Good examples of using system dynamics to evaluate a policy are the health policy to control polio (Thompson and Tebbens, 2008), and the climate policy (Fiddaman, 2007).

In this study, we are creating a conceptual system dynamics cluster model, which involves the factors of resources, workers, jobs, unemployment rate, average salary, market demand, and production capacity. Based on this model, we conducted the simulation with the different levels of benefits provided for startup firms, and with different levels of disadvantages the mature firms suffer from these benefits. Our aim was to understand the effect on the cluster formation.

The results indicate that providing benefits for startup firms always increases the size of the cluster and shortens the time to develop a cluster, if the disadvantages for mature firms from these benefits are not considered. The cluster is still larger and grows faster, if the disadvantages mature firms suffer are small. However, if the level of disadvantages for mature firms from the startup firms 'benefits is significant, the cluster will be smaller and will take a longer time to develop, than one without the startup

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firms' benefits. In the case when the disadvantages are extremely large, the cluster will not be developed.

The findings indicate that, the government should implement policies providing benefits for startup firms, without imposing significant disadvantages on mature firms. Setting up industry-specific training institutes and universities to train workers in clusters, and providing tax breaks for startup firms, seem to be the correct and appropriate policies.

This paper is structured as follows: The first section will examine previous studies on cluster formation patterns, and factors that affect the cluster. The next section will discuss the policies that stimulate cluster creation, based on current research. Section 3 to 7 will provide details of the cluster model that was developed in this paper, the terminology, the scope of the model, assumptions and limitations, the links between each factor, the simulation results and finally, a discussion on the results and implications for government policies. The last section deals with the conclusions.

Cluster Formation-pattern and Related Factors

Cluster creation is based on agglomeration economies-increasing return in spatial form-of firms with homogeneous needs. When a cluster starts forming itself, an increasing return will enhance the benefits for existing firms in the clusters and attract new firms. This process will strengthen clusters and clusters will be locked-in (Arthur, 1994). However, cluster growth is limited by "Cluster Resource Capacity", which are the essential resources for cluster formation and upgrading (Groothuis, 2005; Mertz & Groothuis, 2006).

Feldman and Francis (2004) divide cluster formation into three stages. In the first stage, the region is inert and there is no significant entrepreneurial activity. The movement will start when there are external and unanticipated factors, that lower the cost of entrepreneurship. Then the cluster will begin to form. A characteristic of this second stage is an increase in entrepreneurial activity, such as the interaction between entrepreneurs and the surrounding environment. Entrepreneurs may alter the environment by setting up institutions, that stimulate further innovation. The last stage is when the location gains the reputation as the place "to be" for particular industries.

The factors that can assist cluster development and attract new firms to invest in the cluster, are specific to the type of industry. For high-tech industries, skilled labor with specific knowledge and expertise is a major factor, that affects the decision-making regarding the location. However, the location for high-tech industry tends to be based on the location of technological innovations, because the mobility of technology is limited in the early period (Feldman & Francis, 2004). Brenner (2005) argued that process innovation helps in cluster creation for every industry, not only for high-technology industries, while product innovation does

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not exhibit a significant effect. Brenner (2005) also postulated from the empirical study, that close co-operation between firms with suppliers and universities, is observed in the area where the cluster is developing.

De Blasio and Di Addario (2005) studied the effect of clusters on workers, and found that workers gain benefits from the clusters, because they have a higher chance of being employed, and are more likely to develop their own businesses. Clusters also increase the job mobility of blue-collar workers, but it is reduced for white-collar workers. The return on education inside the cluster is lower than outside the cluster, except for workers with elementary education or less.

General Policies for Cluster Development

The government can play, and should play, a major role in encouraging cluster development. Porter (2000) stated that the government has a role in facilitating cluster development and upgrading. Norman and Venables (2004) also indicate that government policy has a significant role in cluster development. Without a government policy, the number of industrial clusters will be too many and each cluster will be too small, which means the output is lower than the level necessary to maximize world welfare.

The government can encourage cluster development and upgrading, by removing obstacles and constraints, regarding human resources, infrastructure and regulation. To be more specific, Porter's (2000), based on a diamond model, suggested that government should locate related departments around clusters, attract foreign investment to clusters, provide export promotion and reduce barriers to local competition, provide education and research facilities that target specific cluster-related knowledge and enhance infrastructure, and encourage pro-innovation regulation. Government should also provide testing and product certification infrastructure, or act as buyers, create supporting industries, by sponsoring a cluster-specific forum, attract cluster-specific suppliers and service providers, and set up free trade zones, industrial parks or supplier parks.

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Terminology in the Model

In this model, some terminology in used to present and illustrate the behavior of the cluster. The definitions used are listed below

Terminology	Definition
Type of firms	
• New firms	Firms which are newly established and unfamiliar with the business environment. New firms are smaller, hire fewer people, and produce fewer products than mature and declining firms
• Mature firms	Firms which have been established for a period of time, are familiar with the business and the competitive environment, are still growing and are still competitive with other firms. Mature firms will use more resources, hire more people, and produce more products than the other two categories.
• Declining firms	Firms which have already passed the mature stage and have stopped growing. Declining firms will utilize existing resources, such as brand image or existing innovation, without creating new competitive resources.
Resources	
• Land	Land represents a limited resource for business operations, similar to labor.
• Job coverage	Represents the supply and demand of labor. It is calculated by dividing the number of experienced workers, by the total number of jobs. Job coverage also represents the unemployment rate of the clusters. The higher the job coverage, the higher the unemployment rate.
• Average salary ratio	The ratio between the average salary of this cluster and the average salary of other industries.
Market Demand and Production Capacity	
• External market demand	Market demand, that is not created or affected by the cluster.
• Internal market demand	Market demand, that is created or affected by the cluster.
• Demand coverage ratio	A variable to present the demand and supply of products, calculated by dividing the total product that the cluster produces in a year, by perceived market demand.
• Worker efficiency	The number of products one worker produces in a year.

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Scope, Assumption and Limitation of the Model

This generic cluster model consists of the size of the cluster, the workers who are willing to work in this cluster, job availability, resource limitation, average wages and salaries of the workers who work in this cluster, production capacity and market demand.

The size of the cluster is measured by the total number of firms, in all stages in the cluster. In this model, firms are classified into three groups –new firms, mature firms and declining firms. The firms in each stage are assumed to be homogeneous. No particular firm has a greater reputation or higher technological advancement than other firms in the same stage. Firms are always established in this cluster as new firms, and then grow to maturity and later, become declining firms. No firm can miss out a stage. New firms can enter the cluster, without the limitation of investment capital. We also assume that there is no risk perception involved in the decision-making process of establishing firms in this cluster.

The workers in this model are the people who, whether employed or not, want to work and are ready to work in this cluster. The workers are assumed to be homogenous. Every worker has the same opportunity and ability to find a job. No insider or social networking is involved in this model.

Job availability is the number of jobs that are available in the cluster. We assume that all jobs are homogeneous. All jobs require the same qualifications and all workers are qualified for any job. In the case of job reduction or a layoff, all firms will reduce the number of jobs at the same rate, and current employees will be laid off randomly.

Resource limitation is represented by land availability. We assume that the cluster is located in an area such as an industrial park, which has a limited land area and is not easily expanded. We also assume that all buildings are one story buildings and that there is no vertical expansion.

The wage of workers in the cluster is based on the average wages in other industries. We can assume that workers in this industry earn the same wages as the overall industrial average before the simulation. The salary will be adjusted, based on the supply and demand of labor –job availability, and the size of the experienced labor pool. The wages for this cluster has no effect on the overall industrial wage. Moreover, the overall industrial wage is not increased over time.

The market demand comes from two sources –external market demand and internal market demand. Both internal and external market demand are the same. Customers, whether they are from external or internal market demand, are homogenous, have no preference, and purchase the products randomly.

We assume that there is no political risk or exchange rate risk involved in this model. Moreover, we assume that the interest rate and inflation rate are zero. The operating costs and the prices of all products are the same. Therefore, customers will

purchase products randomly. There is no trade barrier, such as a tariff or a quota, involved in this model. The transportation costs from the production location to both external and internal customers are equal.

Casual loop diagram of the cluster: the relationship between each factor

We present a casual loop diagram, shown in Figure 1, to illustrate the relationship between each of the factors involved in the behavior of the cluster. The factors shown in the casual loop diagram include the cluster size, land, job availability, workers, average salary, production capacity and market demand.

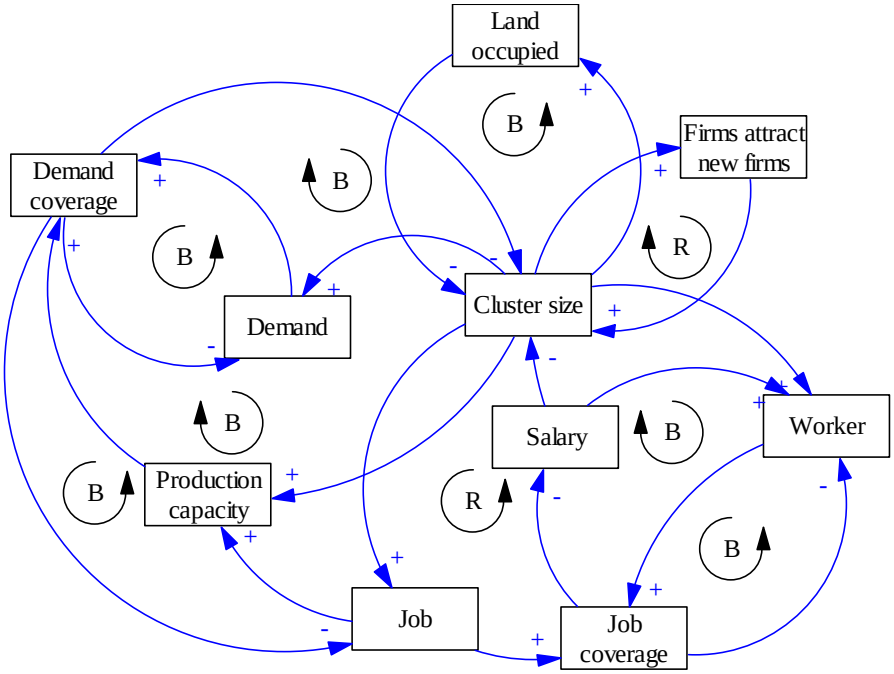

Figure 1 Casual loop diagram showing the relationship between each cluster-related factor.

The first two cause and effect loops are the reinforcing loop between current cluster size and the entering of new firms, and the balancing loop between the cluster and the land, as shown in Figure 2. We assume that the attractiveness of the cluster is related to the size of the cluster. The bigger the size of the cluster, the more firms come into the cluster. For the land area, the cluster occupies more land when it grows. As the area of land diminishes, the price of land will increase, which will reduce the growth of a cluster.

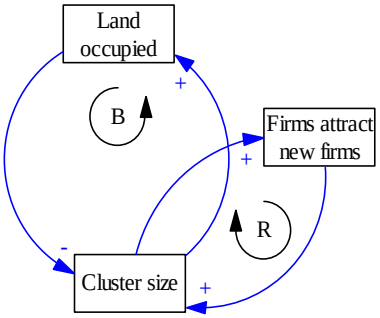

Figure 2 The reinforcing loop between the current cluster size and new firms, and the balancing loop between the cluster size and a limited land area.

The nested loop, shown in Figure 3, is the relationship between cluster size, the number of jobs, the number of workers, and the average wage. As the cluster grows, it attracts more workers willing to work in the cluster, and also creates more jobs. Comparing the number of workers with the number of jobs, we obtain the job coverage. If the job coverage is higher than one, it produces unemployment. In an unemployment situation, it will reduce the average wage of workers in the cluster, and also reduce the number of new workers coming into the cluster. The reduced salary also attracts new firms to invest in the cluster.

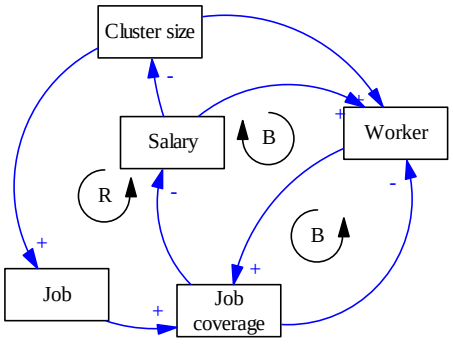

Figure 3 Loops between cluster size, jobs, workers and average salary.

Figure 4 shows the connection between the cluster size, market demand, number of jobs and production capacity. Part of the demand is created by the firms in the cluster. Production capacity is calculated from the number of firms in the cluster and the number of jobs. Comparing the market demand

and the production capacity, we obtain the demand coverage ratio. If the demand coverage ratio is higher than one, it shows that the production capacity exceeds the market demand. An overproduction situation reduces the number of new firms coming into the cluster, and also forces the firms to reduce production, by reducing the number of jobs. On the other hand, if the demand is higher than the production capacity, unfulfilled demand has a chance to switch to a substitute product, which will reduce the total demand the next time.

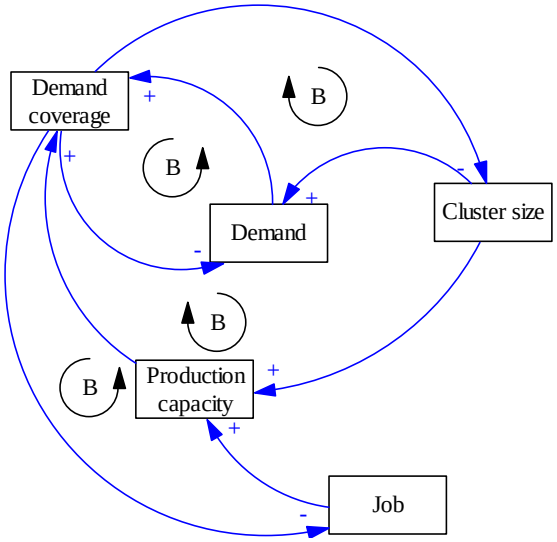

Figure 4 Nested loop between cluster size, number of jobs, production capacity and market demand.

Simulation of the Model

To understand the effect of each policy, on the behavior of the cluster and the related variables, we will use the "base run" as a control case, with no implemented policy. We will set up scenarios which represent each different policy. The results from each scenario will be compared with the "base run", to identify the effects of the policies.

Scenario 1: Increase Benefits for Startup Firms

In this scenario, we study the effects of providing benefits for startup firms on the cluster formation. The benefits are incorporated in the model at a lower rate of failure for new firms. "SC1_050" and "SC1_150" are the cases that the failure rate of new firms is reduced by 50%, and increased by 50% consecutively.

The results indicate that the lower failure rate for new firms, as a result of providing benefits for startup firms, will make the cluster larger, and take less time to fully develop, (see Figure 5). However, the lower failure rate of new firms does not have a significant effect on the workers in the cluster, as indicated by an insignificant difference in average wage ratio and job coverage, (see Figure 6).

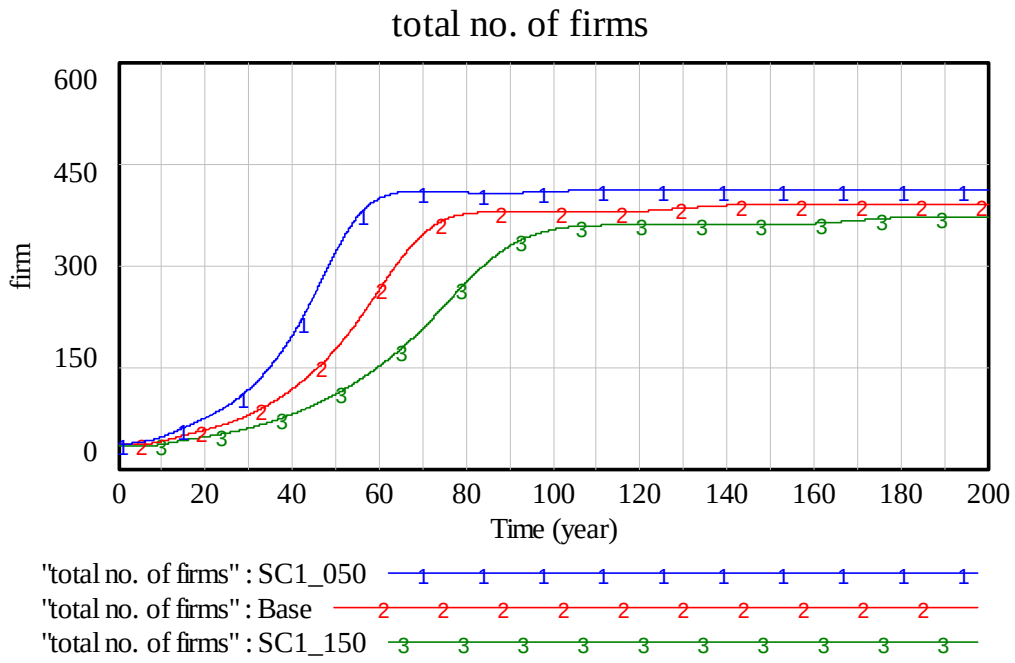

Figure 5 The effects of the failure rate of new firms on the size of the cluster.

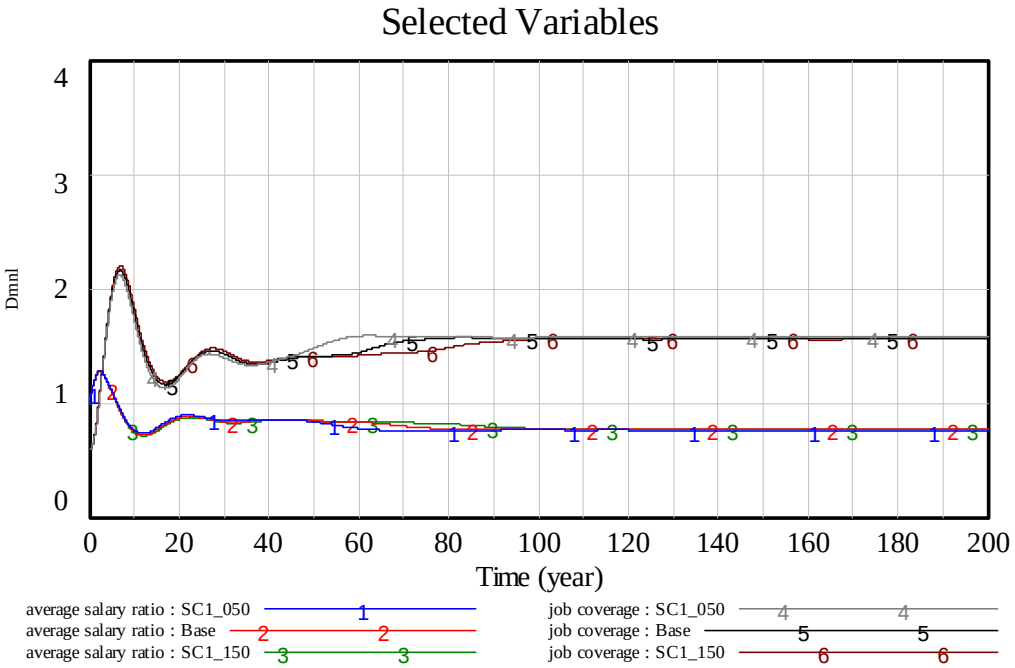

Figure 6 The effects of the failure rate of new firms on the wage salary ratio and job coverage ratio.

Scenario 2: Disadvantages of mature firms caused by the benefits provided to start-up firms

In this scenario, we study the case that benefits for start-up firms create disadvantages for mature firms. The disadvantages of mature and declining firms are incorporated in the model, as a higher failure rate for mature and declining firms.

We fix the failure rate of new firms at 50% lower than the base case, and vary the level of disadvantages the mature and declining firms suffer from these benefits. "SC1_050 ", "SC2_050 ", "SC3_050 "and "SC4_050 "are the cases in which the mature and declining firms have no disadvantage, low, medium, and high disadvantages from the benefits of startup firms consecutively.

The results show that the size of the cluster is reduced, and it takes longer time to reach equilibrium, when the mature and declining firms suffer more disadvantages caused by the startup firms 'benefits. In the case "SC4_050 "which represents the case that mature and declining firms suffer high disadvantages from the benefits, the cluster fails to develop, as see Figure 7.

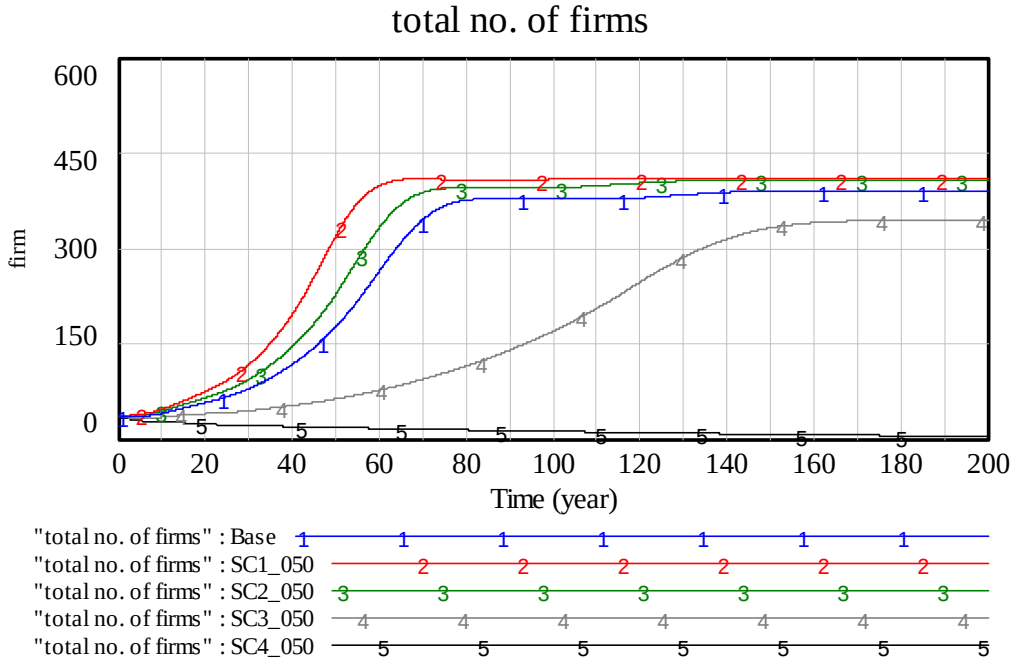

Figure 7 The effect of disadvantages of startup firms' benefits on the size of the cluster.

The effect of the disadvantages for mature firms from startup firms 'benefits on the workers is significant, when the cluster is not developed. In Figure 8, the job coverage is lower and the average salary is higher than in the other cases, if the cluster is not developed. This means that the benefits cause greater disadvantages for mature and declining firms.

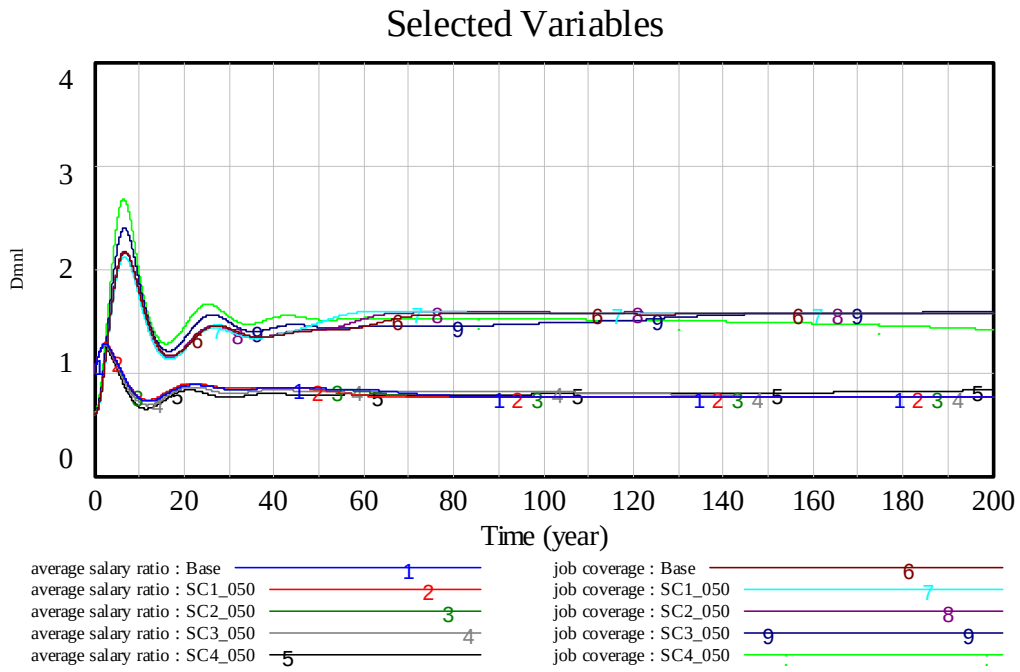

Figure 8 The effect of disadvantages of startup firms' benefits on salary and job coverage.

A Discussion of the Results and Implications for Government Policy

The results shown in the previous section, indicate that providing benefits for startup firms is always good for the cluster. The cluster will grow larger and faster, if the disadvantages for mature firms from these benefits for mature firms are not considered. When the disadvantages for mature firms are considered, the cluster will grow larger and faster than if the disadvantages for mature firms were small. However, if the startup firms 'benefits cause large disadvantages for mature firms, the cluster will be smaller, and will take a longer time to develop, or will not develop in the worst case scenario.

In order to encourage cluster development, the government must implement policies to assist the startup firms, without causing significant disadvantages for the mature firms. Creating training institutes and universities to train workers in specific industrial techniques and knowledge is the right approach. Workers in the startup firms within the cluster can gain specific knowledge more rapidly, which will reduce operating costs and shorten the experience curve for startup firms, while not causing disadvantages for mature firms.

Another policy that will enhance cluster development is tax breaks. Tax breaks can encourage more investment within the cluster from startup firms, and reduce the chance of failure for the new firms, because it will lower operational costs. Even though the mature firms suffer disadvantages from the unfair

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competition, the cluster will still grow larger and faster if the number of tax breaks is not significant.

Conclusion

We have studied the effects of government policies aimed to benefit the start-up firms on the cluster development, using the system dynamics approach. Based on the model, the different level of benefits and the different level of disadvantages, the mature firms have from these benefits, have been analyzed.

Without considering disadvantages for mature firms from the startup firms 'benefits, providing benefits for new firms will always increase the size of the cluster, and shorten the time to develop the cluster. The cluster will still grow larger and faster than the one without the benefits for startup firms, if the mature firms have few disadvantages from these benefits. However, if the disadvantages from the benefits the mature firms suffer are considerable, the cluster will be smaller and will take a longer time to develop, than the one without the startup firms ' benefits. If the benefit costs are extremely high for the mature firms, the cluster will not develop.

To encourage cluster development, the implemented policies should focus on providing benefits for startup firms, without creating significant disadvantages for the mature firms. Setting up industry-specific training institutes and universities is the right approach, as it will lower the operating costs and shorten the experience curve for the startup firms, while not causing disadvantages for mature firms. Another suitable policy is tax breaks. Providing a number of tax breaks is not large enough to create significant disadvantages for mature firms, and the cluster still develop faster and get bigger.

In order to pursue this research further, the model can be applied to a specific industry in a particular country. Moreover, many factors have been neglected in this paper, but can be included in future research. Among the omitted factors in the present study, the capital requirement to set up the firm, the macroeconomic situation, and barriers to entry and exit to and from the industry, are worth mentioning.

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