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Dynamics of Knowledge Based Industries in Korea

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Abstract

The purpose of this paper is understanding dynamics of knowledge based industries in Korea and suggesting policy recommendations for supporting those industries. Following KIET's (1999) definition of knowledge intensity, this paper classified industries in Kyung Ki Province according to several knowledge indicators including R&D activity and human capital content. Having classified industries, this paper investigates growth dynamics of knowledge based industries in Kyung-Ki Province. Based on surveys on some 280 knowledge based industries in Kyong-Ki province, growth path of those industries were identified using path analysis. Using the growth path and coefficient identified by the analysis, system dynamics model was build to simulate dynamics of knowledge based industries in Kyong-Ki Province in Korea. With the model, further analysis was made to investigate some policy measures that can promote knowledge based industries.

1. Introduction

There is an increasingly widespread view among scholars and policymakers that in the new global economy, innovation in the uses of people, capital, and ideas is the key to competitive advantage and long-term economic growth. It has been argued that industries that traditionally led the nation's economy is gradually giving way to industries whose success is based on knowledge and innovation rather than larger-scale manufacturing muscle. In Korea, average real growth rate of knowledge based industries from 1991 to 1999 was 13.7%, showing a high growth rate compared to average 4.1% growth rate of other industries(Chosun Newspaper, 2000.4.4). In this new economy, knowledge based change has created an economic environment in which science and technology play a critical role in generating economic growth(Gera, 1997). This paper investigates growth dynamics of knowledge based industries in Kyung-Ki Province in Korea. Based on surveys on some 280 knowledge based industries in Kyong-Ki province, growth path of those industries were identified using path analysis. Using the growth path and coefficient identified by the analysis, system dynamics model was build to simulate dynamics of knowledge based industries in Kyong-Ki Province in Korea. With the model, further analysis was made to investigate some policy measures that can promote knowledge based industries in Korea.

2. Knowledge Based Industries

1) Classification of Knowledge Based Industries

There is no standard definition of knowledge based industries yet. Most researchers have attempted to classify industries according to their knowledge intensity based on a single characteristics for measuring knowledge. Beck, for example, calculates a knowledge ratio for U.S. industries by assessing the proportion of professional, engineering, technical, scientific, and senior management staff (Beck, 1992). The Department of Finance in Canada identifies

high-knowledge industries by accounting for the employment of so-called high-knowledge workers. The study uses the proportion of total weeks worked in an industry by workers with a university degree as an indicator of knowledge intensity(Canada, the Department of Finance, 1992).

Lees and Has combines several knowledge indicators based on R&D activity and human capital content. Three indicators of R&D activity are considered: R&D expenditures by industry; the proportion of R&D personnel in total employment and the proportion of professional R&D personnel in total employment. The measurement of human capital content also takes into account three indicators: the ratio of workers with postsecondary education to total employment; the ratio of knowledge workers to total employment and the ratio of the number of employed scientists and engineers to total employment. Lee and Has rank industries by each of the six indicators and divide industries into three knowledge groups; high-knowledge industry, low-knowledge industry, and medium-knowledge industry (Lee & Has, 1996; Gera, 1997). This definition of knowledge based industries has advantage of considering R&D activity as well as human capital content while most of previous definitions were based on a single characteristic for measuring knowledge.

Similarly, KIET (Korean Institute for Industrial Economic and Trade) classified knowledge based industries according to knowledge intensity of industry. The knowledge intensity was measured on the basis of both R&D intensity and human capital intensity. Intensity of R&D activity was measured by the number of research institute, proportion of R&D expenditures among total sales, R&D expenditure per researcher, and by the number of researchers per 1000 employees. Human capital intensity was measured by the proportion of employees with high education level, proportion of full time researchers among total researchers, and by the proportion of professional technicians among total employees. Following this definition of knowledge based industries, KIET classified 25 knowledge based industries in Korea.

2) Knowledge Based Industries in Kyung Ki Province

Following the KIET's definition of knowledge based industries, several industries were classified as a knowledge based industries and six industries were selected as knowledge based industries in Kyung Ki province on the basis of average growth rate and future growth prospect; semiconductor and computer, fine machinery, information and communication industry, fine chemistry, software industry, and internet business. Among these six types of industries, 280 industries from four types of knowledge based industries were surveyed. Distribution of surveyed industries and their growth rates are shown in <Table1> and <Table2>.

<Table 1> Distribution of Surveyed Industries

	Frequency	%
Fine machinery	66	23.6
Fine chemistry	78	27.9
Information and Communication Machine	80	28.6
Computer and Semiconductor	56	20.9
Total	280	100

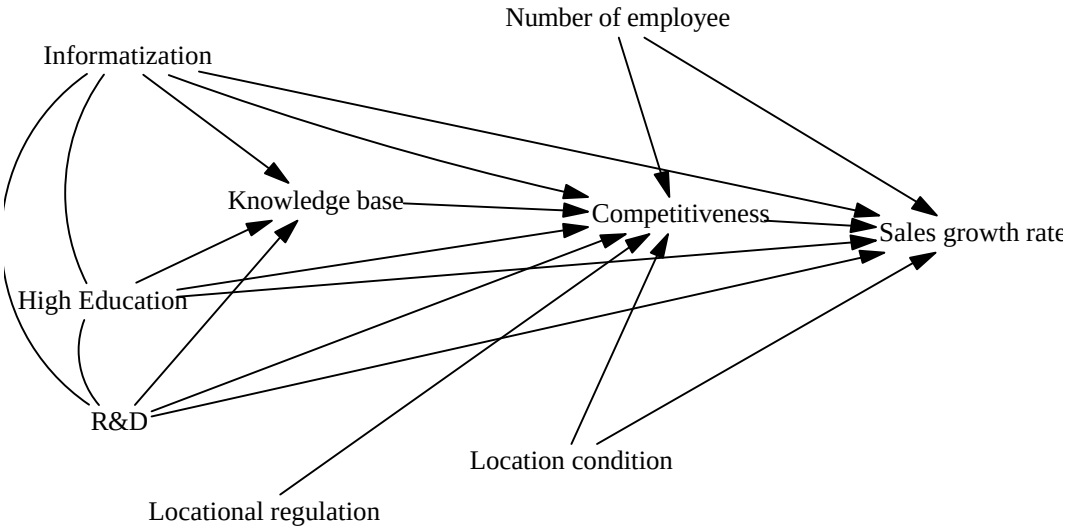
<Table 2> Total Sales and Sales Growth Rate by Industries

Type of industries	Total sales 1998	Total sales 1999	Sales growth rate
Fine machinery	305.1	461.83	0.32
Fine chemical	864.16	1338.5	0.32
Information and communication machine	491.85	685.96	1.27
Computer and semiconductor	422.08	504.57	0.87
Total average	524.6	784.2	0.70

3. Growth Path of Knowledge Based Industries in Korea

Growth path of knowledge based industries can be modeled as shown in the following <Figure1>. Growth of knowledge based industries can be represented by its sales growth. The sales growth is largely affected by product's competitiveness, number of employee, and by locational condition. In addition, sales growth was assumed to be affected by the degree of informatization, employee's educational level and by the size of R&D investment. The number of employee can be regarded as an indicator that represent the size of marketing employee and capital size.

<Figure 1> Path Model for Knowledge Based Industries

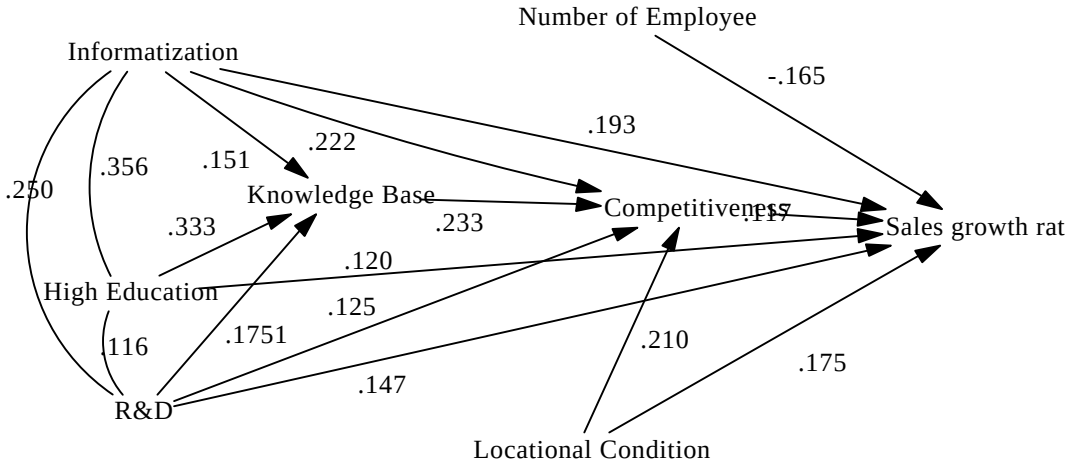


The model was built on the assumption that informatization, educational level, and R&D expenditure can affect sales growth rate directly and indirectly via intermediate variable, competitiveness.

Path model of knowledge based industries in Kyung Ki Province was estimated as shown in the following <Figure2>. Paths with small coefficient was removed from the model and

coefficient was re-estimated.

<Figure 2> Path Analysis of Knowledge Based Industries in Kyong-Ki Province



Coefficient on each path shows beta coefficient, a standardized coefficient. Thus, even though these coefficients does not provide any real life meaning, it does allow us to compare magnitude of each variables effect on sales growth rate.

The path analysis shows that industry's knowledge base is affected by educational level of employee, R&D expenditure, and informatization in order of magnitude. Competitiveness of industry is affected by knowledge base, informatization, R&D expenditure, and locational condition.

Initially, there was a causal path from location regulation to competitiveness. But the path was removed in the final analysis because the coefficient (it was a negative one though) was too small. The coefficient was a negative one, meaning that stronger location regulation lead to weakening industrial competitiveness.

Sales growth rate is most strongly affected by informatization followed by location condition, number of employee, R&D, and by employee's educational level. One notable thing is that the sales growth rate is negatively affected by the number of employee. This result shows that company with larger employees shows slower sales growth rate, meaning that sales growth rate of small business with small number of employee is much higher than that of business with large number of employees. Following Table shows total causal effect including direct and indirect effect of each variable.

<Table 3> Direct and Indirect Effect of Variables on Sales growth rate

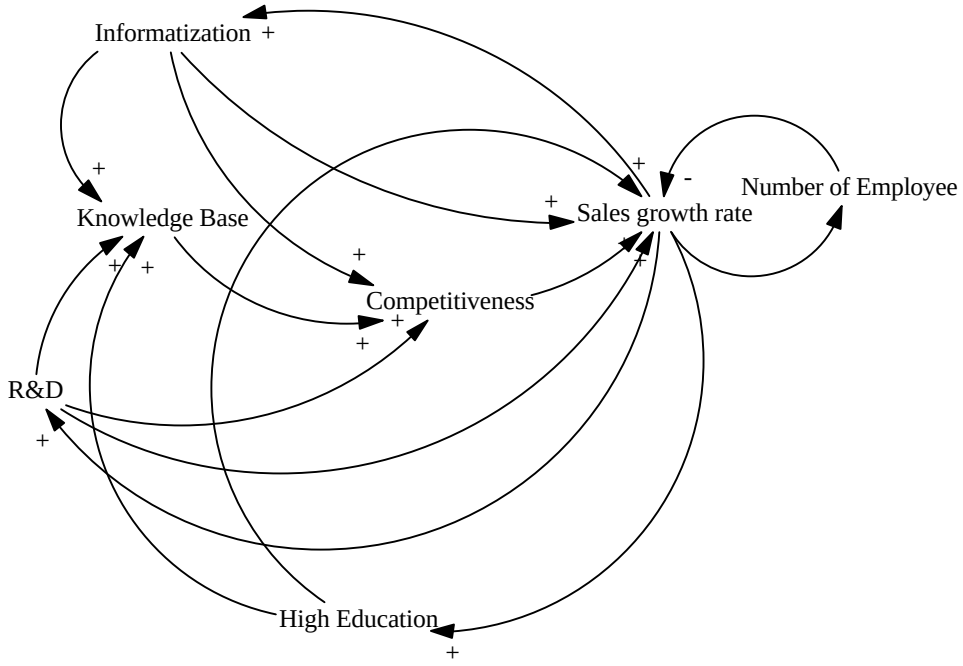
Variables	Direct Effect	Indirect Effect	Total Causal Effect
High Education	.125	.009	.134
Informatization	.193	.026+.0041	.223
R&D investment	.147	.0047+.0146	.166
Knowledge base		.027	.027
Number of employee	-.165		-.165
Location condition	.175	.0245	.199
Competitiveness	.117		.117

<Table 3> shows variables that affect strongly on the sales growth rate. Those variables are informatization, location condition, R&D expenditure, educational level of employee in order of strength. Thus, this path analysis suggests that in order to boost up knowledge based industries of Kyung Ki province in Korea, policy that can improve informatization of each company, location condition, R&D investment, supplying high quality of labor need to be implemented in order of importance.

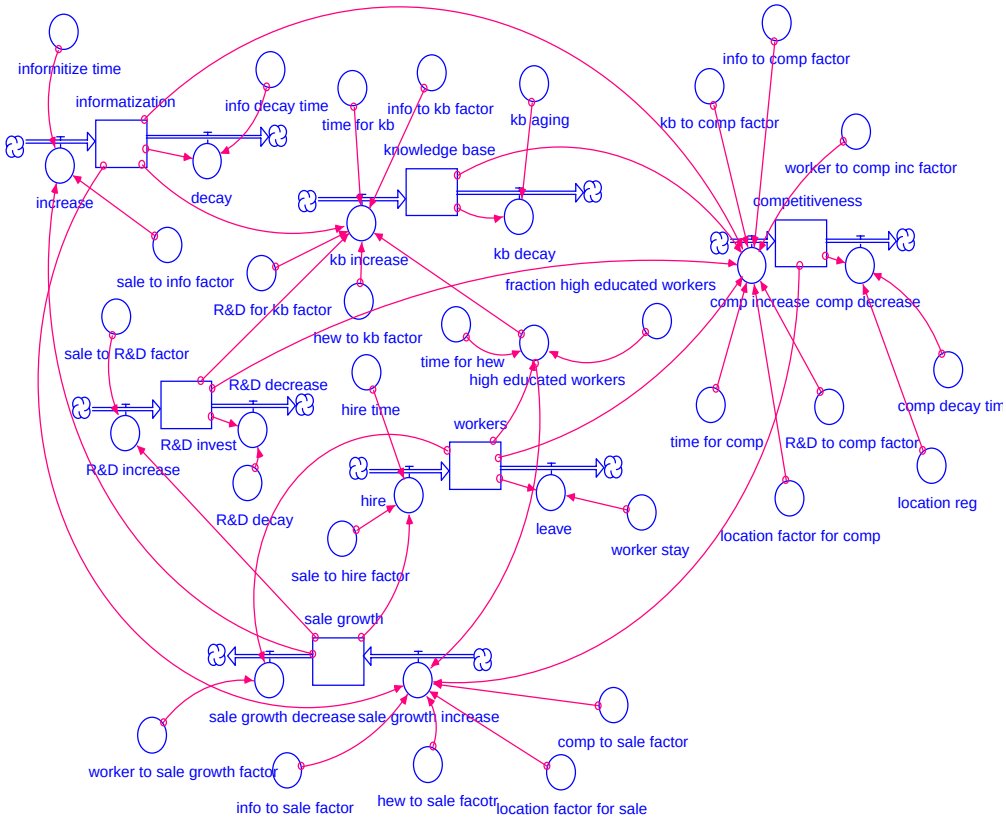
4. Dynamics of Knowledge based industries in Korea

System dynamics model was build based on growth paths identified in the path analysis explained above. Causal loop diagram and flow diagram are shown in the following figures. Beta coefficients and correlation coefficient of path analysis were used as parameters in the system dynamics model.

<Figure 3> Causal Loop Diagram of Knowledge Based Industries



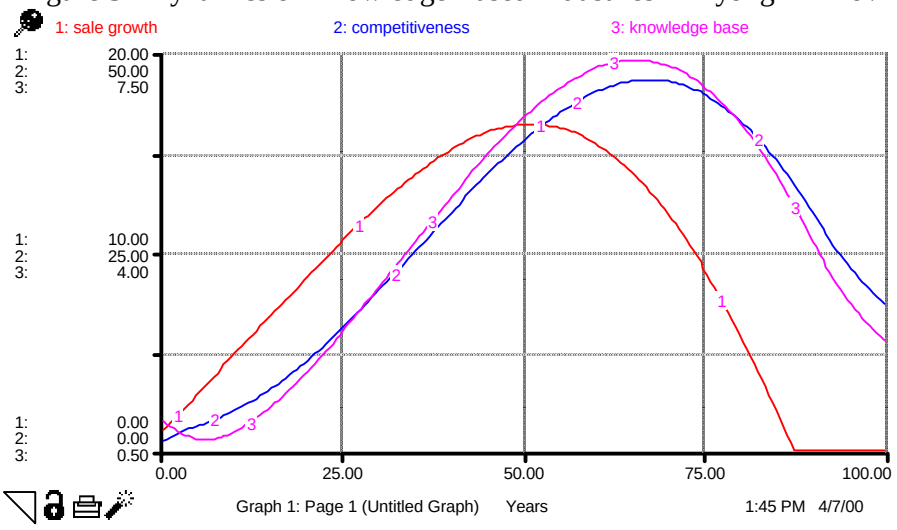
<Figure 4> Flow Diagram of Knowledge Based Industries

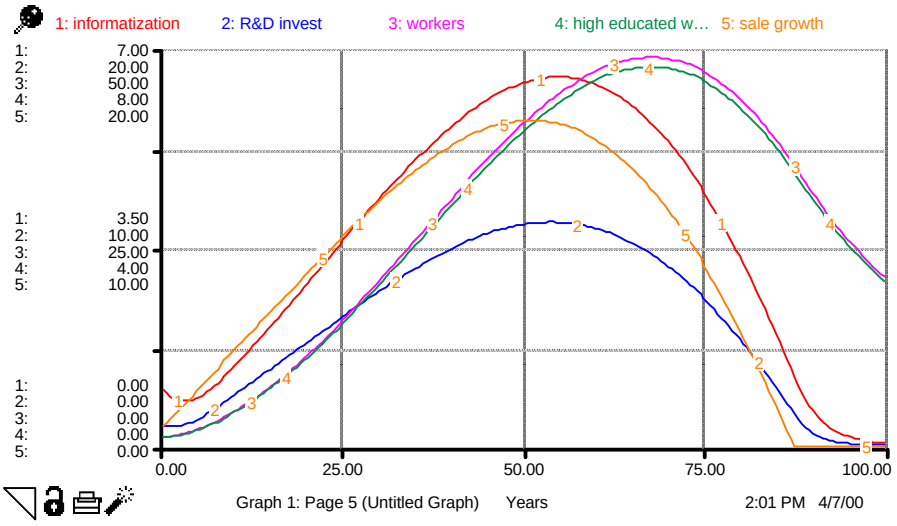


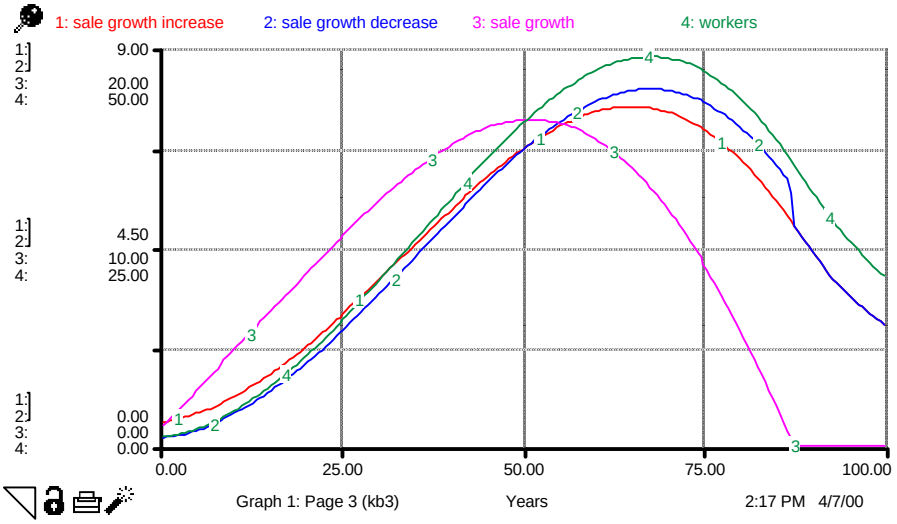
Simulation results of this model are shown in the following figures. One notable dynamic behavior of the model is that sales growth rate is increasing rapidly from the beginning and then collapsing fast after middle of the simulation. However, competitiveness and knowledge base of industries are increasing even after sales growth rate began to decline. This dynamic behavior indicates that there are other factor that make sales growth rate decreasing. The third figure of the <Figure 5> shows that 'sales growth rate' begins to decrease as 'sales growth decrease rate' begin to exceed 'sales growth increase rate'. Since 'sales growth decrease rate' is affected by the number of workers, it may be fair to say that the negative effect of rapidly increased number of workers on 'sales growth rate' exceeds positive effect of several variables (including informitization, high education, R&D) on sales growth rate from the middle of the simulation period, causing a decrease in overall sales growth rate.

This result suggests somewhat different policy implication than what could be obtained by the result of path analysis. In order to boost up knowledge based industries, the most important policy direction may be preventing industries from getting too big and avoid disadvantages that could resulted from large business size such as organizational red tape and lack of vitality or resiliency in the rapidly changing environment.

<Figure 5> Dynamics of Knowledge Based Industries in Kyong-Ki Province in Korea







5. Discussion

With path analysis of knowledge based industries in Kyong-Ki province in Korea, several policy measures were suggested for supporting and booming up those industries. They include policy measures for strengthening informatization of individual company, improving location conditions where companies are located, facilitating R&D investment, and providing human resource development program for higher quality of workers in those industries.

One notable results with the path analysis was that a number of employees in company was negatively related to the sales growth rate of company. Implication of this result can be interpreted that sales growth rate of small business is much higher than that of large business.

With system dynamics model based on the paths and coefficient identified by the path analysis, some policy implication that are different from path analysis were obtained. Even though supportive measures for knowledge based industries are important for boosting those industries, more important measures seems to be related with keep business size small enough to maintain its vitality and resiliency under the turbulent environment. In other words, as long as the information orientation of industries is high, location condition is good, R&D investment is high, quality of employee is high, knowledge based industries grow fast from the beginning. However, this engine of growth seem to be deteriorated as the number of workers in the company gets larger. Mechanism of how larger employee size could lead to lower sales growth rate was not identified in this study. However, it has been repeatedly pointed out in researches that small business can make a more adaptive change to a rapidly changing consumers' demand and environment without organizational inertia. Decrease in sales growth rate in turn, leads to is decreasing informatization, R&D investment, and proportion of high educated workers in the industries which in turn, further decrease sales growth rate.

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