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EFFECTS OF TECHNOLOGICAL REGIME AND INDUSTRY LIFE CYCLE ON THE NEW FIRM: EMPIRICAL STUDY OF KOREAN MANUFACTURING FIRM

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Abstract: *Firm dynamics is influenced by its own competency as well as by the industry environment surrounding it. The factors involving industry environment can be divided into the time dependent inter-sectoral variety and the time independent intra-sectoral variety. This paper refers the former to technological regime, and the latter to industry life cycle by which the effect of industry environment on the new firm dynamics can be thoroughly analyzed afterwards. Data used in the analysis is obtained from the 200,000 observations made from Korean manufacturing companies newly entered into the industry from 1994 to 2002. The result shows that the entry is influenced by both technological regime and industry life cycle, and that the growth and survival can be dictated by industry life cycle.*

Keywords : *Technological regime, industry life cycle, firm entry, new firm growth, new firm survival, firm dynamics, Korean manufacturing firm*

Field: *Industrial Economics*

1. INTRODUCTION

This research is motivated by phenomena of dynamic differences, which means that each industry differs in the type of evolution across industries and over time. Geroski (1995) called them 'between' industry variation and 'within' industry variation, respectively. Research question is what factors between 'nature' and 'nurture' properties of the industry cause those differences. Nature is exogenous environmental factor such as technological regime or industry life cycle, and nurture is endogenous self determination for survival such as managerial assets, patent, innovation behavior, and so on. Multi-dimensional perspectives are needed to properly answer the research question.

The rapid economic development in Korea past 30 years has been successfully achieved through initiatives from Korean government and private firms in a short period of time. Stiglitz (1996), Lee, *et al.* (2008) and Kang (2008) investigated that factors

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leading to success are summarized as technical catching-up, high productivity, precedence in export and management efficiency in private firms. Conventional economic theory such as "price" determined from supply and demand cannot fully explain the economic miracle in Korea. It is rather promising to take an alternative step in evolutionary economics.

Lee, *et al.* (2008) stated that it is important to state that the evolution in knowledge due to technology and innovation can lead to the evolution in the economic system. Because of this, market tends to evolve toward the dynamic equilibrium in which each market player changes its quality over time. It is suggested that the economy has its own mechanism inducing self- change due to endogenous causes rather than exogenous causes. This concept of dynamics from Neo-classic imposes a difficult task to explain the evolution in the modern knowledge economy.

This study aims to figure out the relationship between innovation patterns and new firm dynamics based on micro evidences. The sources which cause firm-, industry-, and economic system-specific characteristics are able to be decomposed into five areas of factor: (1) Technological Regime of the industry (Underlying innovation patterns); (2) Developmental stage of the industry life cycle; (3) Dynamic managerial resources of the firms in the industry; (4) Characteristics of industrial production technology; (5) Heterogeneities among firms.

The remaining sections are organized as follows: Chapter II reviews important previous literatures on firm dynamics. Chapter III deals with data and models used in the study, and examines descriptive statistics of variables. Chapter IV verifies the industry evolution as in entry, growth, survival from theoretical background. It includes why each analysis is important, how the analysis is performed, and what are the implications from results on its topic. Chapter V summarizes results from theoretical discussion to analytical output to draw conclusions and implications.

2. LITERATURE REVIEW

The present study intends to derive determining factors in the evolution of Korean manufacturing economy based on major theories in the evolution economics. Theoretical background involving further discussion begins with: (i) Industry Evolutionary Theory; (ii) Industry Life Cycle Theory. Many works have been carried out theoretically as well as practically in the Industry Evolutionary Theory after Nelson and Winter (1982), and Winter, *et al.* (2003). As for industry life cycle theory, the pioneering work by Klepper (1996; (1997) has been verified by other researches. However, it should be noted that the current study discusses the effect of resources on the development of an industry in the industry level dynamics.

2.1 Technological Regime and New Firm Dynamics

Technological Regime is industry-specific technological conditions (underlying knowledge condition). It is defined by the combination of the properties of technological opportunities, appropriability of innovations, and cumulativeness of technical advances, and it can be proxy by innovation pattern of the industry. Technological Regime is classified that entrepreneurial regime and routinized regime depending on total innovation rate and small-firm innovation rate. If small-firm innovation rate is larger than total innovation rate in a given industry, then the industry is under entrepreneurial regime. Why it is important? Technological regime identifies the differences of technology across industry.

Nelson and Winter (1982) claimed that the industry-wise difference of industrial evolutions lays in underlying knowledge conditions, what is called technological regime. Winter (1984) defined that "An entrepreneurial regime is one that is favorable to innovative entry and unfavorable to innovative activity by established firms" and "A routinized regime is one in which the conditions are the other way around".

Breschi, *et al.* (1998) explained that the innovative activities of a technological sector are specified as the outcome of different technological regimes implied by the nature of technology. The technological regime is defined by the combination of: (1) technological opportunities; (2) appropriability of innovations; (3) cumulativeness of technical advances, and (4) the property of knowledge base. Lim and Lee (2001) suggested that technological regimes are defined to classify the patterns of technological catching-up from Korean industries, and which are defined as fluidity of technological trajectory, frequency of innovation, and access to external knowledge base.

Dosi, *et al.* (1995) stated "the inter-sectoral variety in the observed industrial structures and dynamics can be interpreted on the grounds of underlying specificities in the process of technological learning-which is called technological regime, and of the process of market interactions-i.e. the market regime".

Malerba (2007) pointed that there existed inter-sectoral differences in the rate of technical change, market structure and organization of innovative activity. He claimed that "In some sectors innovative activities are concentrated in a few firms, the stability of innovators is relevant and new innovators are rare. In other sectors the patterns of innovation are distributed across a wide population of firms, with a high turbulence in innovative activity, and new innovators coming from every quarter. These two different patterns of organization of innovative activities, which could be labeled Schumpeter Mark II and Schumpeter Mark I, have been found in several industries and are quite robust for the same industry across countries…".

How one can measure technological regime of a certain industry concretely? Technological regimes of industry are divided into two distinct regimes depending on underlying technological conditions of the industry. The innovation rates are presumably a more reliable measure of innovative intensity. Acs and Audretsch (1988) and Acs and Audretsch (1989), and Audretsch and Acs (1990) argued that distinct technological regime was existed according to innovative intensity. And the technological regime was able to be explained by the difference between small-firm innovation rate and total innovation rate. If small-firm innovation was larger than total innovation rate, then the regime was regarded as an "entrepreneurial regime", and opposite case was defined as "routinized regime".

2.2 Industry Life Cycle and New Firm Dynamics

Klepper (1996) suggested framework of product life cycle to explain the phenomena of firm dynamics. Business uncertainty is high, and production oriented innovation is performed in the formation stage of industry. Business incentives are relatively larger to small-sized firm than incumbent. Process oriented innovation is leaded in the mature stage of industry. And the number of firms is stabilized after shakeout stage. And Klepper (1997) studied the model in automobile industries in US, and he confirmed his theory.

Gort and Klepper (1982), Klepper and Graddy (1990), and Klepper (1996) settled up the evolutionary theory of a new industry to explain the history of the diffusion of 46 products, and classified II to IV stages of industry life cycle in their model. Malerba *et al.* (1996) and Malerba (2007) are used similar concept in their studies.

In this paper, it is put to test the effect of industry life cycle on the new firm dynamics. It analyzes the effect of the inherent characteristics in the nature, not nurture, on the entry, growth, and survival of firms, which are put under the primary exogenous environment, closely relating to the competitions.

Industrial evolutionary stage is identified depending on market opportunities to realized profit. The chances rely on the growth rate of total industry sales and the growth rate of the number of firm. Each industry is identified four distinct stages including introduction, growth, mature and decline stages. In this paper, market demand is extended to market competition. Industrial growth means the changes of market demand and potential opportunities to firms to grow at the viewpoint of industrial economies. The growth of the number of firm stands for existence of the excess profit to individual firm as a market participant. However, number of market influence is related to the market competitions in the perspective of firm-level. Market competition is a two-sided factor with demand and production environment.

3. DATA AND METHODOLOGY

3.1 Data

For the empirical analysis, a cohort-level data is used for the analysis of firm growth while a firm-level data for the analysis of firm survival. The cohort dataset is drawn from the firm dataset, and Table 1 shows dataset for each empirical study.

Table 1
Used Dataset of Each Empirical Analysis

Analysis	*Level of Analysis*	*Data set*
Entry	Cohort Level	Pseudo Panel
Growth	Firm Level	Original Panel
Survival	Firm Level	Original Panel

3.1.1. Firm Panel

Longitudinal data to observe firm's behaviors are used the Annual Report on Mining and Manufacturing Survey which is plant-level data provided by Korean National Statistics Office. Database covers all plants with five or more employees in 389 to 467 at the KSIC (Korean Standard Industry Code) five-digit level manufacturing industries for each year, 15111 to 37200 discontinuously, except for Tobacco industry. It is an unbalanced panel dataset with new firm for each year, during 11 years from year 1993 to year 2002. Totally, above 200 thousands observations are contained, and which include entering, exiting, and surviving firms. All of the level value is deflated by industrial production deflator.

Time spans are divided into 1994 to 2002 for overall period, 1994 to 1996 for pre-financial period, and 2000 to 2002 for post-financial period. Baseline years of analysis period are 1994 for pre-financial crisis, and 2000 for post-financial crisis. 27 thousands, 20 milthousands, and 22 thousands observations are used for cohort-level analysis for entry and growth, firm-level analysis for growth, and firm-level analysis for survival, respectively.

3.1.2. Pseudo Panel

Pseudo panel data is needed to analyze on entry process because the entry is defined as the number of entrants within a given closed set. For the entry analysis, it is necessary to firstly define a meaningful close set to measure the entry, then to have a cohort dataset from the already defined sets. A proper grouping of cohorts should be in order, and the data of its members could be aggregated as a whole.

Aggregating firms to groups of firms is called pseudo panel data. Deaton (1985), Heshmati and Kumbhakar (1997), and Verbeek (2007) pointed that aggregation of data leads to aggregation bias. Therefore, well-defined cohort and weighted method are important to avoid aggregation bias. Kang, *et al.* (2008) used weights to create pseudo panel data that minimizes the aggregation bias.

A cohort is defined by time-invariant attributions as a group with fixed membership. Individual cohort has 11-digit unique code in this study:

$$INDR = 10000000000*Year + 1000000*KSIC + 10*R\&D + Size$$

where 4-digit for Year, 5-digit for KSIC, 1-digit for plant's R&D Dummy, and 1-digit for Size Class are used. Indicator have 1994 to 2002 year codes, 398 to 467 5-digit industries for each year, 0 or 1 (in case firm spends its budget for R&D) R&D dummy, and 1 to 5 size class based on average worker, 5 to 10 for 1, 11 to 50 for 2, 51 to 100 for 3, 101 to 300 for 4, and more than 300 for 5. 27,000 individual cohorts are created in actual, contrastingly approximately 0.83 million in original firm panel. Almost original firm data becomes 1 over 31 times in tabloid pseudo panel. All of the variables in cohort are calculated by average value of the fixed member firms. Pseudo panel might have aggregation bias which is caused by different number of observations in group. Each entity in pseudo panel should be are weighted to compromise the distortion by simple reduction. In this case, weighting value is root square of number of observations in each cohort to avoid aggregation bias. This is the same weighting method with Kang, *et al.* (2008).

3.2 Methodology

Analytical models are constructed based on three theories such as technological regime, industry life cycle and resource based view. Empirical studies are entry, growth and survival. Each analysis is performed overall and sub-period such as pre- and post-financial crisis. And both of fixed effect model and random effect model for entry and growth panel regression are established and examined Hausman test, and we choose fixed effect model from the result of test.

Panel regression is performed to estimate entry process of firms from pseudo panel. Dependent variable is number of entrant firms in the cohort. And explanatory variables are inferred from the perspective of three theories and control measure.

Relative size of small-firm innovation rate comparing total innovation rate is used to consider the influence of technological regime. The method is small-firm innovation rate divided by total-firm innovation rate. If two industries have is same value of small-firm innovation rate, higher value of small-firm innovation rate is occurred in the industry which has total innovation is lower. The aim to adopt this kind of method is to reflect the cross sectional differences of small-firm innovation patterns. Larger value of small-firm innovation ratio means that the industry has stronger characteristics of entrepreneurial regime.

Any explanatory variable is not considered in order to include the theory of Resource-Based View. Because of this is the debate on average rate of entry to industry, not firm's decision whether it enter or not into the market. For the analysis on the effects of resource based view, the information on candidate decision unit and their decision to enter are needed. The data used in this study, there is no information on entry decision. Because of the only information on successfully entered firm and their managerial resources is included in the dataset.

The variable related on innovation pattern which is measure innovation rate is used to analyze the effect of characteristics on technical change in a given industry. In terms of industrial life cycle, the combined variable is used, and which is able to be decomposed into growth of industrial production and growth of the number of firms in the industry. The control variables for industrial environment are capital intensity and concentration. HHI(Herfindahl-Hirschman Index) is used to put the condition of concentration.

ENTRY

Model specification for entry examination is as below:

$$Entry^{it} = f(x_{tr}^{it}, x_{lc}^{it}, x_{ic}^{it}),$$

where Entry is a dependent variable which represent number of entrants in a given industry *i* at time *t*. And x_{tr}^{it}, x_{lc}^{it}, and x_{ic}^{it} are independent variable set which are the categories of technological regime, industry life cycle and industry characteristics, respectively. *i* denotes a given industry and *t* expresses a given year.

GROWTH

Model specification for examination is as below:

$$\text{Firm Growth Rate}^{ijt} = f\left(x_{tr}^{it}, x_{lc}^{it}, x_{ic}^{it}, x_{fc}^{it}\right),$$

where Firm Growth Rate is a dependent variable which is growth rate of a given firm in a given industry at time *t*. And $x_{tr}^{it}, x_{lc}^{it}, x_{ic}^{it}$, and x_{fc}^{it} are independent variable set which are the categories of technological regime, industry life cycle, industry characteristics and firm characteristics, respectively. i and j denote a given industry and firm, and t expresses a given time. Dependent variable is the revenue growth rate of a firm. The growth rate at time t represents the share of revenue increment at t with respect to revenue at t-1.[3]

SURVIVAL

Model specification for examination is as below:

$$\text{Survival Hazard}^{ij} = f\left(x_{tr}^{it}, x_{lc}^{it}, x_{ic}^{it}, x_{fc}^{it}\right),$$

where Survival Hazard is a dependent variable which is survival time of a given firm in a given industry. And $x_{tr}^{it}, x_{lc}^{it}, x_{ic}^{it}$, and x_{fc}^{it} are independent variable set which are the categories of technological regime, industry life cycle, industry characteristics and firm characteristics, respectively. *i* and *j* denote a given industry and firm, and expresses a given time. Cox regression model is used for the survival analysis.

Dependent variable is hazard to firm. How we can detect firm survival or dead? In the survey data, the entry and exit of plants are identified based on the plants appearing and disappearing in the data over time. Entry and exit of plants due to spin-off, split, merger, and acquisition could not be distinguished from ordinary turnover of plants with the available plant level data base. A plant is the most disaggregated unit of significant production and employment in manufacturing industry and plant turnover is an important source of resource reallocation, from the perspective of the national economy. Observation of plant level dynamics might be as important as firm level dynamics.

4. EMPIRICAL RESULTS

4.1 New Firm Entry

The way to interpret on the empirical results is start with overall-period analysis, and then comparisons on pre- and post- financial crisis which are decomposed analysis of overall analysis. Table 2 shows the results from panel regression on entry.

Table 2
Result of Entry Analysis for New Firm

	Overall		*PRE*		*Post*	
Total Innovation Rate	-10.11	***	-13.23	***	-3.02	
Small Innovation Rate	17.95	***	15.41	**	25.89	***
Growing Industry	0.56	***	0.62	***	0.90	***
Mature Industry Dummy	0.71	***	0.79	***	1.08	***
Contracting Industry dummy	-0.16	**	0.02		0.22	
Capital Intensity	-0.01	***	0.00		-0.02	***
HHI	-2.21	***	-1.08	***	-2.00	***
Log Industry Sales	3.33	***	2.23	***	3.75	***
Industry Growth Rate	-0.01	**	-0.02	***	-0.04	***
Constant	-16.43	***	-9.44	***	-23.64	***
R-sq	0.14		0.07		0.11	
F	407		49		77	
Obs	26,712		8,950		8,995	

Technological Regime and Entry

The effect of industry technological regime on the new firm entry becomes significant which is consistent with the result where the new firm entry poses the positive impact under entrepreneurial regime while the number of new firm entry is small under routinized regime. This exactly matches exactly with the hypothesis from the technological regime theory.

Industry Life Cycle and Entry

The analytical result shows that the number of new entry increases in the growing and mature industry whereas it decreases in the contracting industry, which is in accordance with industry life cycle theory.

Control Variables and Entry

Among industries with high HHI for a particular company, the new entry is restrained while it is encouraged according to the increased size of the industry. The number of new entry increases in the industry with a low capital intensity as well.

4.2 New Firm Growth

Table 3 shows the results from panel regression on new firm growth.

Technological Regime and Growth

The effect of technological regime on the new firm growth is insignificant. The growth of new firm slows down under entrepreneurial regime for the overall time span of the analysis. It is rather inconclusive whether it reflects a temporary or continuous phenomenon from Korean economic restructuring during Korean financial crisis of the late 90's. Upon employing expanding time series analysis, one can arrive at a conclusion.

Table 3
Result of Growth Analysis for New Firm

	Overall		*PRE*		*Post*	
Total Innovation Rate	3.10		-9.22		3.91	
Small Innovation Rate	-8.63	*	-3.08		3.27	
Growing Industry Dummy	0.19	***	-1.31	***	-0.10	
Mature Industry Dummy	0.07	***	-1.74	***	0.35	
Contracting Industry Dummy	-0.14	***	-0.36		0.01	
R&D(y-1) Dummy	-0.65	***	-2.28	***	0.89	***
Capital Intensity	0.00	***	0.02	***	0.00	
HHI	0.05	**	0.11		0.11	
Log Industry Sales	-0.09	**	-0.53	***	0.04	
Industry Growth Rate	0.00	***	0.00		0.00	
Constant	1.69		9.15		2.31	
R-sq	0.01		0.03		0.01	
F	59		13		2	
Obs	200,977		21,326		17,521	

Industry Life Cycle and Growth

The growth potential of a new firm remains high in the growing and mature industry, but not in the contracting industry. It is, however, worth noting that the growth potential deteriorates in the growing and mature industry from the result for the overall time span including Korean financial crisis which, in turn, shows the business environment surrounding a new firm goes through a rapid transformation.

Control Variables and Growth

The innovation in a new firm shows a negative effect on the firm growth while the new firm's growth can be favorable for the industry with a high capital intensity and with a high HHI for a particular company.

4.3 New Firm Survival

Table 4 shows the results from panel regression on survival.

Technological Regime and Survival

For the overall time span, the survival of a new firm is more likely under the routinized regime where the large sized company takes the lead in the innovation. This contradicts

Table 4
Result of Survival Analysis for New Firm

	Overall		*PRE*		*Post*	
Total Innovation Rate	-6.93	**	-0.99		-11.62	
Small Innovation Rate	0.36		1.72		-5.67	
Growing Industry Dummy	-0.03	*	0.20	***	0.15	***
Mature Industry Dummy	0.07	***	-0.07		0.32	
Contracting Industry Dummy	0.13	***	-0.46	***	0.06	***
R&D(y-1) Dummy	-0.24	***	-0.21		-0.29	
Capital Intensity	0.00	***	0.00	**	0.00	*
HHI	0.04	***	-0.05	**	0.07	***
Industry Growth Rate	0.00		-0.01		0.01	
Startup Size	-0.01	***	0.00		-0.01	***
Constant	0.00	***	-0.01		0.00	***
Likelihood Ratio	946.19		92.31		219.00	
Obs.	201,889		22,132		17,543	

existing papers expecting the new firm's entry is more active and its survival is more likely under entrepreneurial regime.

From the previous analysis, the new firm entry is more encouraged under entrepreneurial regime. This leads us to believe that the new firm entry and exit simultaneously took place on numerous occasions in the Korean economy in the late 90's. It shows many new firms were sacrificed in the process of restructuring during Korean financial crisis.

Industry Life Cycle and Survival

For the overall time span, a new firm tends to survive much longer in the growing industry while it is not the case in the mature industry. A different set of results is obtained when the time span is split up into pre- and post- Korean financial crisis. The survival of a new firm is less likely in the growing industry both in the pre- and post-time span analysis. A new firm likely survives much longer in the contracting industry in the pre-time span while it is the opposite in the post-time span. Even though the effect of industry life cycle on the survival of a new firm can be different depending on the time span used in the analysis, it is important to notice that the industry life cycle has a meaningful impact on the survival of a new firm.

5. CONCLUSIONS

Industry environment faced to firm affects significantly to firm dynamics. New firm entry is influenced by both technological regime and industry life cycle, but growth and survival is dependent only on industry life cycle. In other words, entry show an unique pattern per each industry, and growth and survival show the heterogeneous patterns to be time-variant even in the same industry.

From the policy-makers point of view, it is necessary to make a differentiated industry-wise plan when designing industry promotion policy. Even under the same economic regime, economic environment faced to a firm is different due to its unique underlying technological capability. In addition, dynamic policy should be developed in accordance with industry life stage rather than industry depending policy.

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APPENDIX

1. Descriptive Statistics of cohort level variables

		No. of Entry Firm	Total Inno. Rate	Small-firm Inno. Rate	Growing Industry	Mature Industry	Contracting Industry	Capital Intensity	HHI	Industry Sales	Industry Growth Rate
Food	Mean	9.37	0.01	0.01	0.49	0.19	0.19	6.76	6.63	12.93	0.63
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.60	3.54	6.62	0.90
	Max	166.79	0.33	0.33	1.00	1.00	1.00	81.94	9.18	15.39	140.94
	Std.	17.67	0.02	0.02	0.50	0.39	0.40	7.32	1.05	1.36	7.47
Fiber, textile	Mean	16.03	0.00	0.00	0.39	0.12	0.28	9.22	5.89	12.94	0.22
	Min	0.00	0.00	0.00	0.00	0.00	0.00	1.91	3.86	7.52	0.91
	Max	193.64	0.05	0.04	1.00	1.00	1.00	51.88	9.11	15.41	73.38
	Std.	28.05	0.00	0.00	0.49	0.33	0.45	7.08	0.92	1.15	2.82
Clothes	Mean	25.34	0.00	0.00	0.49	0.13	0.27	21.23	6.08	12.98	0.14
	Min	0.00	0.00	0.00	0.00	0.00	0.00	4.75	4.00	8.51	0.90
	Max	355.17	0.06	0.06	1.00	1.00	1.00	125.69	8.94	15.36	6.08
	Std.	51.53	0.01	0.01	0.50	0.34	0.44	13.50	0.95	1.50	0.66
Bags and shoes	Mean	18.84	0.00	0.00	0.25	0.20	0.36	19.20	5.63	13.34	0.00
	Min	0.00	0.00	0.00	0.00	0.00	0.00	2.24	3.91	8.59	0.82
	Max	136.38	0.02	0.02	1.00	1.00	1.00	35.22	8.83	14.80	3.51
	Std.	30.15	0.00	0.00	0.43	0.40	0.48	5.96	0.97	1.29	0.38
Wooden products	Mean	13.75	0.00	0.00	0.40	0.07	0.30	8.48	6.02	11.87	0.08
	Min	0.00	0.00	0.00	0.00	0.00	0.00	2.33	3.35	8.09	0.58
	Max	153.24	0.03	0.01	1.00	1.00	1.00	22.26	8.66	13.97	1.60
	Std.	23.02	0.00	0.00	0.49	0.26	0.46	3.50	1.06	1.30	0.28
Pulp and paper	Mean	12.73	0.00	0.00	0.43	0.12	0.25	7.79	6.06	13.45	0.07
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.73	4.22	11.25	0.50
	Max	170.24	0.33	0.01	1.00	1.00	1.00	20.02	8.81	14.87	1.22
	Std.	24.22	0.02	0.00	0.50	0.32	0.43	2.77	0.99	0.90	0.26
Publication and press	Mean	19.87	0.00	0.00	0.45	0.13	0.22	16.84	5.80	13.15	0.19
	Min	0.00	0.00	0.00	0.00	0.00	0.00	4.83	3.48	8.69	0.89
	Max	260.81	0.14	0.14	1.00	1.00	1.00	183.73	9.01	15.24	15.21
	Std.	37.60	0.01	0.01	0.50	0.34	0.42	12.73	1.14	1.26	1.15
Petroleum based products	Mean	2.90	0.05	0.01	0.39	0.22	0.24	8.56	7.40	13.28	0.10
	Min	0.00	0.00	0.00	0.00	0.00	0.00	3.28	6.45	8.54	0.77
	Max	17.13	0.33	0.03	1.00	1.00	1.00	14.68	8.78	17.26	2.40
	Std.	4.14	0.09	0.01	0.49	0.41	0.43	3.26	0.79	2.27	0.42
Chemical compounds	Mean	6.36	0.02	0.01	0.49	0.16	0.21	6.51	6.80	13.29	0.15
	Min	0.00	0.00	0.00	0.00	0.00	0.00	1.48	4.88	6.41	0.87
	Max	81.49	0.33	0.33	1.00	1.00	1.00	85.35	9.03	16.51	5.84
	Std.	10.14	0.03	0.02	0.50	0.37	0.41	5.66	0.89	1.70	0.54
Plastic and rubber	Mean	18.26	0.00	0.00	0.49	0.13	0.21	6.42	5.79	13.58	0.13
	Min	0.00	0.00	0.00	0.00	0.00	0.00	2.51	4.16	8.52	0.78
	Max	170.73	0.09	0.05	1.00	1.00	1.00	22.87	8.59	15.65	4.02
	Std.	30.92	0.01	0.00	0.50	0.34	0.41	2.46	1.11	0.99	0.47
Base metal industry	Mean	8.99	0.01	0.01	0.45	0.10	0.24	6.44	6.54	12.36	0.24
	Min	0.00	0.00	0.00	0.00	0.00	0.00	1.29	3.21	6.74	0.98
	Max	166.13	0.32	0.24	1.00	1.00	1.00	46.11	9.19	15.81	28.61
	Std.	20.17	0.03	0.03	0.50	0.30	0.43	5.75	1.30	1.56	1.65

		No. of Entry Firm	*Total Inno. Rate*	*Small-firm Inno. Rate*	*Growing Industry*	*Mature Industry*	*Contracting Industry*	*Capital Intensity*	*HHI*	*Industry Sales*	*Industry Growth Rate*
Ferrous and non-ferrous metal	Mean	8.04	0.01	0.01	0.50	0.09	0.21	8.15	6.75	13.48	0.37
	Min	0.00	0.00	0.00	0.00	0.00	0.00	1.83	5.16	8.79	0.92
	Max	88.49	0.18	0.18	1.00	1.00	1.00	31.77	9.12	16.78	19.95
	Std.	13.05	0.02	0.01	0.50	0.29	0.40	3.63	0.96	1.69	1.87
Metalworking industry	Mean	18.14	0.00	0.00	0.55	0.11	0.23	8.28	5.63	13.17	0.22
	Min	0.00	0.00	0.00	0.00	0.00	0.00	1.26	3.35	9.09	0.89
	Max	208.73	0.30	0.30	1.00	1.00	1.00	21.05	9.10	15.86	25.08
	Std.	32.28	0.02	0.02	0.50	0.31	0.42	3.72	1.24	1.04	1.57
Machine industry	Mean	14.37	0.00	0.00	0.51	0.10	0.22	8.18	6.21	13.11	0.80
	Min	0.00	0.00	0.00	0.00	0.00	0.00	2.93	2.85	8.30	1.00
	Max	286.95	0.04	0.04	1.00	1.00	1.00	38.40	8.71	15.59	300.16
	Std.	24.84	0.00	0.00	0.50	0.30	0.41	3.38	1.06	1.14	13.77
Computer and business machine	Mean	8.49	0.01	0.00	0.53	0.06	0.12	7.05	7.76	13.13	1.56
	Min	0.00	0.00	0.00	0.00	0.00	0.00	1.10	5.65	10.22	0.95
	Max	76.21	0.11	0.01	1.00	1.00	1.00	45.46	9.20	16.17	35.09
	Std.	13.04	0.01	0.00	0.50	0.24	0.33	7.30	0.83	1.64	5.71
Electrical machinery industry	Mean	12.84	0.00	0.00	0.55	0.13	0.18	10.82	6.22	13.18	0.19
	Min	0.00	0.00	0.00	0.00	0.00	0.00	1.33	4.49	9.25	0.70
	Max	167.61	0.11	0.11	1.00	1.00	1.00	62.62	8.77	15.57	2.60
	Std.	20.90	0.01	0.01	0.50	0.34	0.39	5.80	0.79	1.17	0.41
Electrical components industry	Mean	15.44	0.01	0.00	0.57	0.08	0.12	5.72	7.00	14.11	1.76
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.73	4.79	7.75	0.56
	Max	189.68	0.27	0.27	1.00	1.00	1.00	27.08	8.86	17.11	245.59
	Std.	24.02	0.02	0.01	0.49	0.27	0.33	4.47	0.91	1.52	17.90
Precision industry	Mean	8.34	0.01	0.01	0.49	0.12	0.22	10.40	6.57	12.00	0.26
	Min	0.00	0.00	0.00	0.00	0.00	0.00	2.04	4.48	8.63	0.74
	Max	98.12	0.08	0.08	1.00	1.00	1.00	33.11	8.68	13.58	6.36
	Std.	12.77	0.01	0.01	0.50	0.33	0.41	5.37	0.97	1.02	0.97
Automobile	Mean	18.87	0.01	0.01	0.51	0.11	0.25	9.67	6.34	14.10	0.34
	Min	0.00	0.00	0.00	0.00	0.00	0.00	1.65	4.07	6.91	0.93
	Max	233.89	0.17	0.17	1.00	1.00	1.00	56.53	8.98	16.96	6.75
	Std.	39.36	0.03	0.02	0.50	0.31	0.43	10.78	1.48	1.84	1.06
Other transportation manufacturing	Mean	7.32	0.01	0.01	0.36	0.16	0.25	14.02	7.28	12.77	0.54
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.62	3.98	5.61	0.93
	Max	101.44	0.28	0.28	1.00	1.00	1.00	70.34	8.92	16.72	24.92
	Std.	13.39	0.03	0.02	0.48	0.37	0.43	14.86	1.10	1.92	2.82
Furniture	Mean	11.69	0.01	0.00	0.41	0.09	0.29	14.79	6.25	11.87	0.15
	Min	0.00	0.00	0.00	0.00	0.00	0.00	1.30	4.39	6.62	0.83
	Max	245.35	0.18	0.08	1.00	1.00	1.00	637.57	8.83	14.82	7.28
	Std.	24.63	0.02	0.01	0.49	0.28	0.45	42.59	0.90	1.36	0.66
Reproductive	Mean	14.77	0.00	0.00	0.82	0.06	0.07	7.84	5.65	12.52	0.31
	Min	0.00	0.00	0.00	0.00	0.00	0.00	3.06	4.49	10.78	0.06
	Max	68.59	0.00	0.00	1.00	1.00	1.00	18.38	6.91	13.47	1.87
	Std.	18.63	0.00	0.00	0.39	0.23	0.25	4.35	0.67	0.87	0.43
Total	Mean	13.01	0.01	0.00	0.48	0.12	0.23	9.40	6.32	12.99	0.39
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.60	2.85	5.61	1.00
	Max	355.17	0.33	0.33	1.00	1.00	1.00	637.57	9.20	17.26	300.16
	Std.	25.47	0.02	0.01	0.50	0.33	0.42	13.09	1.13	1.46	6.52

2. Descriptive Statistics of firm level variables

		Firm Growth Rate	*Total Inno. Rate*	*Small-firm Inno. Rate*	*Growing Industry*	*Mature Industry*	*Contracting Industry*	*R&D (y-1)*	*Capital Intensity*	*HHI*	*Industry Sales*	*Industry Growth Rate*
Food	Mean	0.87	0.00	0.00	0.50	0.17	0.16	0.08	9.20	5.91	13.30	0.21
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	3.74	6.62	0.98
	Max	97.22	0.50	0.50	1.00	1.00	1.00	1.00	7941.54	9.21	15.35	137.57
	Std. Dev.	3.99	0.01	0.01	0.50	0.38	0.37	0.27	86.60	1.11	1.09	3.42
Fiber, textile	Mean	0.84	0.00	0.00	0.38	0.10	0.30	0.03	10.07	5.43	13.54	0.13
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	3.96	8.72	0.65
	Max	93.90	0.06	0.06	1.00	1.00	1.00	1.00	5569.89	8.91	15.37	7.54
	Std. Dev.	3.69	0.00	0.00	0.49	0.30	0.46	0.18	56.00	0.88	1.18	0.63
Clothes	Mean	0.72	0.00	0.00	0.45	0.20	0.23	0.01	20.56	5.48	13.96	0.08
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.71	8.04	0.92
	Max	83.50	0.09	0.09	1.00	1.00	1.00	1.00	19484.38	8.97	15.09	7.53
	Std. Dev.	3.38	0.00	0.00	0.50	0.40	0.42	0.11	140.72	0.93	0.97	0.48
Bags and shoes	Mean	0.80	0.00	0.00	0.30	0.20	0.41	0.04	19.53	5.29	13.50	0.03
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	4.06	6.52	0.93
	Max	99.47	0.03	0.03	1.00	1.00	1.00	1.00	679.12	9.21	14.72	2.96
	Std. Dev.	3.81	0.00	0.00	0.46	0.40	0.49	0.19	34.35	0.81	0.64	0.20
Wooden products	Mean	0.71	0.00	0.00	0.42	0.08	0.28	0.02	12.30	5.40	12.35	0.04
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	3.53	8.09	0.62
	Max	87.59	0.03	0.02	1.00	1.00	1.00	1.00	1075.22	8.66	13.88	1.93
	Std. Dev.	3.28	0.00	0.00	0.49	0.27	0.45	0.14	32.60	1.17	1.19	0.23
Pulp and paper	Mean	0.63	0.00	0.00	0.37	0.24	0.15	0.04	8.68	5.32	13.75	0.03
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	4.38	11.24	0.59
	Max	93.02	0.02	0.01	1.00	1.00	1.00	1.00	708.70	8.38	14.84	1.33
	Std. Dev.	3.32	0.00	0.00	0.48	0.42	0.36	0.19	21.84	0.92	0.88	0.16
Publication and press	Mean	0.59	0.00	0.00	0.43	0.08	0.29	0.02	15.42	5.21	13.47	0.15
	Min	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.02	3.87	6.83	0.92
	Max	85.16	0.03	0.03	1.00	1.00	1.00	1.00	2646.79	9.21	15.12	99.74
	Std. Dev.	2.97	0.00	0.00	0.50	0.28	0.45	0.15	50.06	1.10	1.08	2.03
Petroleum based products	Mean	0.35	0.01	0.01	0.39	0.29	0.13	0.17	10.28	7.01	12.66	0.12
	Min	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.14	6.55	9.02	0.77
	Max	11.21	0.06	0.06	1.00	1.00	1.00	1.00	141.88	8.78	13.95	5.63
	Std. Dev.	1.23	0.01	0.01	0.49	0.45	0.34	0.38	19.75	0.50	1.22	0.69
Chemical compounds	Mean	0.87	0.01	0.00	0.54	0.18	0.14	0.20	7.64	6.27	13.66	0.15
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	5.06	7.98	0.79
	Max	91.76	0.47	0.47	1.00	1.00	1.00	1.00	1914.92	9.09	16.49	8.45
	Std. Dev.	4.03	0.01	0.01	0.50	0.38	0.35	0.40	32.14	0.76	1.32	0.44

		Firm Growth Rate	*Total Inno. Rate*	*Small-firm Inno. Rate*	*Growing Industry*	*Mature Industry*	*Contracting Industry*	*R&D (y-1)*	*Capital Intensity*	*HHI*	*Industry Sales*	*Industry Growth Rate*
Plastic and rubber	Mean	0.71	0.00	0.00	0.52	0.08	0.18	0.08	7.53	5.41	14.06	0.15
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40	8.20	0.81
	Max	89.81	0.10	0.06	1.00	1.00	1.00	1.00	6779.02	8.68	15.56	5.56
	Std. Dev.	3.02	0.00	0.00	0.50	0.27	0.38	0.27	60.88	0.75	0.80	0.32
Base metal industry	Mean	0.74	0.00	0.00	0.42	0.12	0.24	0.08	9.07	5.27	13.35	0.09
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.26	6.19	1.00
	Max	85.17	1.00	1.00	1.00	1.00	1.00	1.00	2811.16	9.21	15.77	56.29
	Std. Dev.	3.16	0.02	0.02	0.49	0.32	0.43	0.27	55.26	1.35	1.38	1.36
Ferrous and non-ferrous metal	Mean	0.94	0.00	0.00	0.48	0.19	0.14	0.07	9.58	6.32	14.19	0.26
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	5.36	8.79	0.93
	Max	86.24	0.18	0.18	1.00	1.00	1.00	1.00	520.96	9.16	16.76	21.94
	Std. Dev.	4.17	0.01	0.01	0.50	0.39	0.35	0.25	22.43	0.66	1.35	1.47
Metalworking industry	Mean	0.74	0.00	0.00	0.47	0.15	0.16	0.05	11.02	4.90	13.55	0.09
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	3.60	9.56	0.89
	Max	97.07	0.16	0.16	1.00	1.00	1.00	1.00	2110.72	9.11	15.80	25.46
	Std. Dev.	3.26	0.00	0.00	0.50	0.36	0.37	0.22	38.92	1.02	0.87	0.48
Machine industry	Mean	0.76	0.00	0.00	0.46	0.09	0.24	0.11	9.87	5.68	13.67	0.21
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.12	8.18	1.00
	Max	98.66	0.05	0.05	1.00	1.00	1.00	1.00	2637.70	8.81	15.56	401.46
	Std. Dev.	3.42	0.00	0.00	0.50	0.29	0.43	0.32	29.11	1.38	1.01	5.68
Computer and business machine	Mean	1.32	0.01	0.00	0.52	0.02	0.09	0.22	7.46	8.17	14.48	1.08
	Min	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.01	5.84	10.08	0.96
	Max	72.36	0.11	0.02	1.00	1.00	1.00	1.00	1318.69	9.20	16.02	37.42
	Std. Dev.	4.77	0.01	0.00	0.50	0.13	0.29	0.41	37.02	0.72	1.56	4.38
Electrical machinery industry	Mean	0.89	0.00	0.00	0.53	0.12	0.21	0.13	13.74	5.96	13.76	0.14
	Min	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.02	4.79	9.45	0.71
	Max	93.96	0.18	0.18	1.00	1.00	1.00	1.00	2799.55	8.65	15.48	2.58
	Std. Dev.	3.68	0.00	0.00	0.50	0.33	0.41	0.34	37.96	0.60	1.06	0.35
Electrical components industry	Mean	1.19	0.00	0.00	0.55	0.05	0.15	0.19	8.45	6.73	14.97	0.40
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.07	7.75	0.61
	Max	98.61	0.27	0.27	1.00	1.00	1.00	1.00	1034.99	9.13	17.06	14.05
	Std. Dev.	4.51	0.01	0.00	0.50	0.22	0.36	0.39	25.55	0.78	1.19	1.01
Precision industry	Mean	0.77	0.01	0.01	0.43	0.13	0.18	0.17	12.65	6.18	12.22	0.19
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	4.71	8.35	0.79
	Max	76.07	0.09	0.09	1.00	1.00	1.00	1.00	1038.78	8.75	13.57	7.05
	Std. Dev.	3.19	0.01	0.01	0.50	0.34	0.38	0.38	33.43	0.94	0.78	0.65

		Firm Growth Rate	*Total Inno. Rate*	*Small-firm Inno. Rate*	*Growing Industry*	*Mature Industry*	*Contracting Industry*	*R&D (y-1)*	*Capital Intensity*	*HHI*	*Industry Sales*	*Industry Growth Rate*
Automobile	Mean	0.84	0.00	0.00	0.51	0.02	0.25	0.10	8.34	4.79	15.80	0.18
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	4.15	6.20	0.89
	Max	90.20	0.17	0.08	1.00	1.00	1.00	1.00	3737.20	9.09	16.96	5.33
	Std. Dev.	3.40	0.01	0.00	0.50	0.15	0.43	0.30	69.70	0.76	0.99	0.37
Other transportation manufacturing	Mean	0.76	0.00	0.00	0.49	0.17	0.15	0.06	37.05	6.14	13.37	0.54
	Min	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.04	4.30	7.88	0.69
	Max	59.33	0.15	0.10	1.00	1.00	1.00	1.00	2056.42	9.08	16.72	46.03
	Std. Dev.	3.06	0.01	0.01	0.50	0.38	0.36	0.24	91.59	1.31	1.29	3.78
Furniture	Mean	0.74	0.00	0.00	0.43	0.09	0.28	0.06	12.34	5.80	12.88	0.09
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	4.94	6.00	0.90
	Max	94.43	0.14	0.14	1.00	1.00	1.00	1.00	1949.06	8.89	14.57	8.27
	Std. Dev.	3.16	0.01	0.00	0.49	0.29	0.45	0.23	30.22	0.73	1.32	0.50
Reproductive	Mean	1.07	0.00	0.00	0.51	0.29	0.20	0.04	8.67	5.49	12.50	0.25
	Min	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.03	4.75	9.80	0.52
	Max	87.49	0.00	0.00	1.00	1.00	1.00	1.00	624.85	6.96	13.31	1.41
	Std. Dev.	5.11	0.00	0.00	0.50	0.45	0.40	0.20	33.06	0.65	0.68	0.44
Total	Mean	0.79	0.00	0.00	0.46	0.13	0.22	0.08	11.96	5.58	13.69	0.16
	Min	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.12	6.00	1.00
	Max	99.47	1.00	1.00	1.00	1.00	1.00	1.00	19484.38	9.21	17.06	401.46
	Std. Dev.	3.52	0.01	0.01	0.50	0.33	0.42	0.26	64.71	1.11	1.23	2.36