Reform of National R&D Structure under Economic Crisis : The Irony Korea

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〈 Contents 〉

1. Notion of NSI

Why some nations exhibit higher rate of economic growth? Why and how some nations are more productive than others? Is that ever possible latecomers can pass forerunners ahead through technological innovation? These questions are of paramount importance to developing countries but are intractably complex to answer, encompassing numerous variables and assumptions for explanation and/or prediction. In fact, the subject has been one of the central concerns of economists under the name of gap theory, catch-up theory or leapfrogging theory(Fagerberg, 1987; Krugman, 1995).

If we restrict the discussion to the technological impact on economic and social

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growth, the notion of national systems of innovation(NSI) is highlighted as an emerging strand of thought in innovation research(Lundvall, 1992; Nelson, 1993; Porter, 1990). NSI can be defined as the structural and functional profiles of a nation that underlie technological innovation and economic performance. In this context, the aforementioned questions may be rephrased as why and how some nations are better off than others in terms of innovative capacity?

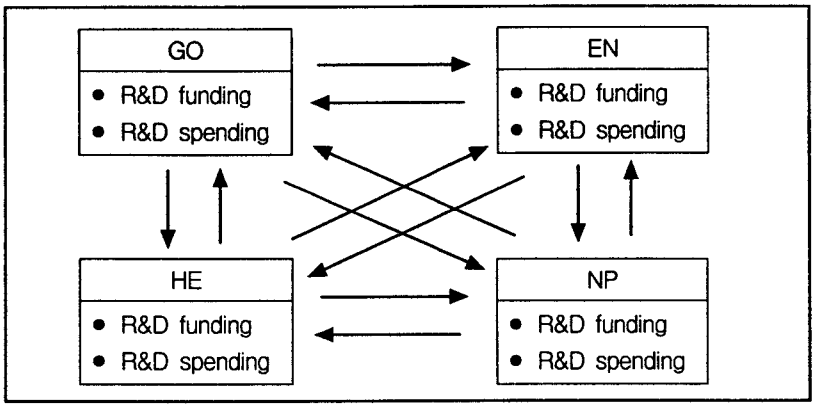
The utility of this systems approach is attributable to comprehensiveness and flexibility. It can accommodate such related but narrower concepts as paradigm(Kuhn, 1970; Dosi, 1982; Freeman and Perez, 1988), regime(Nelson and Winter, 1982), or network(Freeman, 1991). Furthermore, the spectrum of systems approach is maneuverable enough to embrace such evolutionary notions as trajectory (Dosi, 1982), guidepost(Sahal, 1985) and life cycle(Abernathy and Utterback, 1975).

2. R&D Flow Structure

Based on the national specificity and asymmetry in terms of economic and social profiles, NSI attempts to identify technological determinants that explain the idiosyncratic growth performance or competitive edges.

Unfortunately, however, national profiles are too complex and diverse to derive a unified representation of the system, posing the problem of modeling and classifying NSI. Along this line, Park(forthcoming) employed R&D flow structure as a representative indicator of NSI and presented an inductive taxonomy of NSI of OECD member economies. In that research, R&D flow structure of a country is defined as the domestic flow of R&D expenditure among major actors such as government(public research), higher education(university research), enterprises (private research) and non-profit organizations(see Figure 1). It should be acknowledged that the use of R&D structure as the proxy of NSI is subject to limitation since it accounts for only the input side of NSI and thus may not offer convincing explanation of the innovative performance. Nonetheless, it collectively delineates the prime contributors and pipelines of the system that govern the overall innovative capability.

〈Figure 1〉 National R&D Flow Structure



Note : Go=Government/Public Research Institure, En=Private Enterprises
He=Higher Education, NP=Non-Profit Organization

The four prime actors serve as either the origin of R&D fund(supply) or the user of R&D fund(demand). The interconnectivity among respective actors can be measured by the relative ratio of R&D flow to gross domestic expenditure on R&D, namely GERD. By doing so, national R&D flow structure can be expressed as the following 4×4 relative flow matrix, where rows indicate percentage of outflow (supply) of R&D expenditure and columns denote percentage of inflow(demand) among actors:

$$F_c = [f_{ij}]_c \quad where, f_{ij} = \frac{r_{ij}}{R}$$

Here, R is GERD and rij is R/D flow amount from actor i to j.

3. Taxonomy of NSI

Based on the structural similarity of R&D flow, measured as the Pearson correlation coefficient, countries can be grouped together. The data set on national R&D profiles was extracted from the OECD database(OECD, 1997). In total, 23 national profiles for the latest year available(mostly 1993 or 1994) were included, as summarized in Appendix.

Given the relative flow matrix above, the closeness of R&D structure between two countries is measured by the correlation coefficient. These successive pair-wise computations result in the structural similarity matrix. Specifically, a 23 ×23 structural similarity matrix is constructed as follows;

$$S=[S_{m,n}], \quad \text{for } m,n=1,2,\ldots\ldots,23$$

Here, S is symmetric square matrix whose respective element $s_{m,n}$ is the Pearson correlation coefficient between the m-th country and the n-th one. The coefficient of 1.0 denotes the perfect coincidence whereas 0.0 means the complete contrariety between two countries in terms of R&D structure.

Applying the agglomerative hierarchical clustering method based on average clustering criterion, seven distinct clusters were obtained thereby 23 countries were assigned to relevant affiliations. The full details of clustering process is not described here but the outcomes were consistent regardless of clustering criteria and thus the stability of grouping was confirmed.

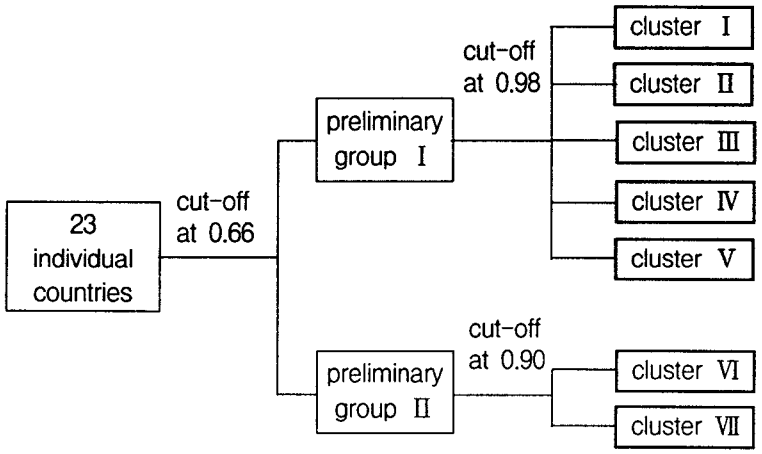
Initially, two primary groups, enterprise-leading group and government/education -leading group, were identified. These two groups shared little in common in terms of R&D flow structure. The first group, consisting of 17 countries, is characterized by the central role of private firms with respect to both R&D funding and spending. In the second group, composed of 7 countries, public sector and higher education sector function as the focal point of R&D structure. By iterating the clustering process, the first group is further divided into five sub-clusters whereas the second group is separated into two sub-clusters. 〈Figure 2〉 illustrates the dendogram of the clustering process. 〈Table 1〉 summarizes the characteristics of respective clusters.

4. Ill-Balanced Structure of Korea

From now on, we will focus on the case of Korea. The R&D enterprise of Korea has gone through an evolutionary process of expansion and divergence in line with industrial advancement. The trajectory can be delineated by the interactive and

supplementary relationship between public and private research. From 60s through 70s, public sector, especially government-funded research institutes(GRIs) broke new ground and constructed skeleton of the national R&D system. Turning into 1980s, however, private firms embarked on indigenous R&D soon to overtake public research. The registration statistics of private research institutes(PRIs) was unparalleled in history, taking 10 years to reach 1000, 4 years to reach 2000 and 2 years to reach 3000.

〈Figure 2〉 Dendogram of Hierarchical Clustering



〈Table 1〉 Taxonomy of R&D Structure

Cluster Number	Cluster Description	Representative Countries
I	Enterprise-government funding and Enterprise-education spending	USA, Germany, UK
II	Enterprise-government funding and Balanced spending	France, Italy, Denmark
III	Balanced funding and Education spending	Sweden, Swiss, Belgium
IV	Balanced funding and Balanced spending	Australia, Canada, Spain
V	Enterprise-dominating	Japan, Korea
VI	Government/Education-dominating	Iceland, New Zealand, Mexico
VII	Government funding and Education spending	Greece, Portugal, Turkey

In terms of R&D expenditure, the share of public sector was predominant up until 1970s. It was 1982 when the share of private share became equivalent to that of public sector. Since then, private sector has dominated public sector. As noted in the above taxonomy, Korea now exhibits an extreme case of imbalance whereby private firms account for a lion's share, 78%, of gross R&D expenditure. This structure surely is an ill-balanced one, compared to advanced economies(see <Table 2>).

<Table 2> International Comparison of Public: Private R&D Expenditure Ratio

	Korea('96)	USA('96)	Japan('96)	Germany('96)	France('95)	UK('95)
Public : Private	22:78	34:66	21:79	37:63	44:56	33:67

Source : MOST

V. Sensitivity of Private R&D to Business Cycle

One may ask why the imbalance between public and private is really considered a problem. One may argue it is groundless to blindly advocate the Western model. However, the critical problem of the Korean structure is due to its high sensitivity to business cycle.

The empiricism postulates that private R&D investment be notoriously sensitive to business cycle. Private firms tend to retrench R&D investment at the initial stage of economic recession but expand R&D investment at the latest stage of economic recovery. The hypothesis turns out true in Korea which now is suffering from an unprecedented economic depression. Firms are being transfigured into slim and flat shapes. Among others, R&D centers are being put in the forefront of this trend. A recent survey reports that more than 80% of Korean firms are planning to cut down R&D budget(STEPI, 1998). The same survey predicts that firms will curtail about 12% of R&D investment in 1999. Human resource base is another source of anxiety. High-caliber researchers are already seeking for overseas employment or moving to foreign firms. More seriously, fresh graduates are being put in the backlog of unemployment. This trend will erode the growth potential and weaken the industrial competitiveness.

The vulnerability of the Korean structure has been invisible under prosperity but now is disclosed under depression. Private R&D in nature is quite reactive to business cycle. Therefore, public R&D should be considered not only a remedy for market-failure but also a shock-absorber against cyclic instability. This is why the balance between public R&D and private R&D is emphasized.

VI. Opportunity for Structural Reform: The Irony

The contraction of private research is by no means desirable. Ironically, however, the current economic depression renders an unexpected opportunity for structural reform. If the government can expand public research or at least keep up the current pace, a balanced structure may be achieved in the near future. To this end, we carried out a spreadsheet simulation to predict the changes in the national R&D structure of Korea. Broadly, three possible scenarios were postulated: (1) increase public, decrease private, (2) increase public, maintain private, (3) maintain public, decrease private. As of 1996, the ratio between public and private was 22:78. Taking this ratio as initial value at the end of 1998, we projected the future ratios for the next seven years(see 〈Table 3, 4, 5〉 respectively).

Clearly, the first scenario achieves the target level, 30% of public share, in the shortest period of time. Probably, however, the most realistic scenario would be the third one, keep up the public investment since it is extremely difficult, if not impossible, to increase the governmental budget under economic depression. Even in that scenario, the target ratio will be achieved in four years, assuming that the private investment decreases by 10% every year.

〈Table 3〉 Projection of Scenario 1: Increase Public-Decrease Private

Year	10%, -10%	10%, -5%	5%, -10%	5%, -5%
1998	22	22	22	22
1999	26	25	25	24
2000	**30**	28	28	26
2001	34	**31**	**31**	28
2002	39	34	35	**30**
2003	44	37	38	32
2004	49	41	42	34

〈Table 4〉 Projection of Scenario 2: Increase Public-Maintain Private

Year	5%, 0%	7.5%, 0%	10%, 0%	12.5%, 0%	15%, 0%
1998	22	22	22	22	22
1999	23	23	24	24	25
2000	24	25	26	26	27
2001	25	26	27	29	**30**
2002	26	28	29	**31**	33
2003	27	29	**31**	34	36
2004	28	**31**	34	37	40

〈Tabe 5〉 Projection of Scenario 3: Maintain Public-Decrease Private

Year	0%, -5%	0%, -7.5%	0%, -10%	0%, -12.5%	0%, -15%
1998	22	22	22	22	22
1999	23	24	24	25	25
2000	24	25	26	27	28
2001	25	26	28	30	32
2002	26	28	30	33	35
2003	27	30	33	36	39
2004	28	31	35	39	43

Note: values in each cell indicate the percentage of public share

7. Conclusions

A majority of experts agree that the current depression will not be a temporary one since it stemmed from the structural deficiency of the Korean system, rather than from the temporary cyclic wave. If so, the right prescription is not the makeshift tactic but the structural reform. Granting that drastic reform is by no means a panacea, restructuring is necessary and welcome in R&D enterprise. In the course of reform, the governmental role is crucial.

When the private R&D is reactive to business cycle, the public R&D should be proactive. It is critical time for the Korean government to expand, at least to maintain, public R&D budget. Simultaneously, it is important to maintain a balanced portfolio, between long-term and short-term, between basic and industrial, of R&D projects and to secure a stable national R&D funding mechanism.

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Appendix

country: USA					
	GO	EN	ED	NP	Total
GO	8.01	10.10	9.92	1.68	29.71
EN	0	54.23	0.66	0.36	55.25
ED	0	0	11.60	0	11.60
NP	0	0	0.72	2.72	3.44
Total	8.01	64.33	22.90	4.76	100

country: Japan					
	GO	EN	ED	NP	Total
GO	8.86	0.88	6.39	1.35	17.48
EN	0.22	62.69	0.47	2.37	65.75
ED	0.00	0.00	12.37	0.01	12.38
NP	0.00	0.09	0.03	4.27	4.39
total	9.08	63.66	19.26	8.00	100

country: Germany					
	GO	EN	ED	NP	Total
GO	11.96	5.04	13.87	0.10	30.97
EN	0.10	52.02	1.24	0.03	53.39
ED	0	0	15.11	0	15.11
NP	0.17	0.16	0	0.20	0.53
Total	12.23	57.22	30.22	0.33	100

country: France					
	GO	EN	ED	NP	Total
GO	16.99	8.54	12.00	0.11	37.64
EN	0.82	45.53	1.75	0.21	48.31
ED	0.03	0.01	12.84	0.07	12.95
NP	0.01	0.02	0.04	1.03	1.10
total	17.85	54.10	26.63	1.42	100

country: England					
	GO	EN	ED	NP	Total
GO	11.64	7.08	9.76	1.01	29.49
EN	1.27	48.10	1.10	1.51	51.98
ED	0.03	0.03	13.26	0	13.32
NP	0.32	0	1.77	3.12	5.21
Total	13.26	55.21	25.89	5.64	100

country: Canada					
	GO	EN	ED	NP	Total
GO	14.85	4.28	16.07	0.31	35.51
EN	0.29	37.14	2.43	0.23	40.09
ED	0	0	21.77	0	21.77
NP	0	0	1.62	1.01	2.63
total	15.14	41.42	41.89	1.55	100

country: Italy					
	GO	EN	ED	NP	Total
GO	17.19	4.68	16.02	0	37.89
EN	0.27	44.20	0.81	0	45.28
ED	0	0	16.83	0	16.83
NP	0	0	0	0	0
Total	17.46	48.88	33.66	0	100

country: Australia					
	GO	EN	ED	NP	Total
GO	20.82	0.75	19.06	0.51	41.14
EN	1.09	33.26	0.50	0.07	34.92
ED	0.10	0.01	20.33	0.01	20.45
NP	1.60	0.17	0.77	0.95	3.49
total	23.61	34.19	40.66	1.54	100

country: Belgium					
	GO	EN	ED	NP	Total
GO	4.64	4.10	15.78	0.23	24.75
EN	0.06	52.03	3.18	0	55.32
ED	0	0	19.70	0	19.70
NP	0	0	0	0.23	0.23
Total	4.70	56.13	38.66	0.46	100

country: Denmark					
	GO	EN	ED	NP	Total
GO	13.78	2.79	16.49	0.05	33.11
EN	0.49	44.20	0.34	0.01	45.04
ED	0	0	17.68	0	17.68
NP	1.48	0.95	0.94	0.80	4.17
total	15.75	47.94	35.45	0.86	100

country: Finland					
	GO	EN	ED	NP	Total
GO	16.22	2.90	14.60	0.15	33.87
EN	1.41	46.69	0.76	0.03	48.89
ED	0	0	16.28	0	16.28
NP	0.12	0.03	0.28	0.53	0.96
Total	17.75	49.62	31.92	0.71	100

country: Greece					
	GO	EN	ED	NP	Total
GO	16.99	8.54	12.01	0.11	37.65
EN	0.82	45.53	1.74	0.21	48.31
ED	0.03	0.01	12.83	0.07	12.94
NP	0.01	0.02	0.04	1.03	1.10
total	17.85	54.11	26.62	1.42	100

country: Iceland					
	GO	EN	ED	NP	Total
GO	31.08	1.51	20.84	1.86	55.29
EN	3.38	15.37	1.05	0	19.79
ED	0	0	21.88	0	21.88
NP	0	0	0	3.03	3.03
Total	34.46	16.88	43.77	4.89	100

country: Ireland					
	GO	EN	ED	NP	Total
GO	8.35	6.31	9.37	0	24.03
EN	1.24	57.75	2.48	0.22	61.69
ED	0	0	12.77	0	12.77
NP	0.86	0.14	0	0.50	1.51
total	10.45	64.20	24.63	0.72	100

country: Mexico					
	GO	EN	ED	NP	Total
GO	37.69	0.03	23.95	0	61.67
EN	0	5.98	1.06	0	7.04
ED	0	0.00	30.70	0	30.70
NP	0	0.23	0.56	0	0.79
Total	37.69	6.24	56.27	0	100

country: Netherlands					
	GO	EN	ED	NP	Total
GO	14.07	3.18	18.24	1.38	36.87
EN	2.08	37.73	0.38	0.31	40.50
ED	0.79	0	19.18	0.29	20.26
NP	0.16	0.73	0.55	0.93	2.37
total	17.10	41.64	38.35	2.91	100

country: New Zealand					
	GO	EN	ED	NP	Total
GO	31.53	1.70	15.59	0	48.82
EN	3.33	22.18	0.94	0	26.45
ED	0.02	0.09	22.84	0	22.95
NP	0.25	0	1.53	0	1.78
Total	35.13	23.97	40.90	0	100

country: Portugal					
	GO	EN	ED	NP	total
GO	15.57	1.53	26.58	3.51	47.19
EN	1.21	15.04	0.16	0.76	17.17
ED	0	0	27.71	0	27.71
NP	0.01	0	0.41	7.51	7.93
total	16.79	16.57	54.86	11.78	100

country: Spain					
	GO	EN	ED	NP	Total
GO	15.06	4.45	19.88	0.08	39.47
EN	0.64	35.97	1.64	0.04	38.29
ED	0	0	21.63	0	21.63
NP	0.01	0.05	0.11	0.44	0.61
Total	15.71	40.47	43.26	0.56	100

country: Sweden					
	GO	EN	ED	NP	total
GO	3.05	5.37	17.61	0.03	26.06
EN	0.15	50.70	1.08	0.01	51.94
ED	0.01	0	20.61	0	20.62
NP	0.00	0.10	1.21	0.06	1.38
total	3.21	56.17	40.51	0.10	100

country: Swiss					
	GO	EN	ED	NP	Total
GO	3.01	0.98	18.42	0.44	22.85
EN	0	54.91	0.35	0.09	55.35
ED	0	0	20.11	0	20.11
NP	0	0.09	0.62	0.98	1.69
Total	3.01	55.98	39.50	1.51	100

country: Turkey					
	GO	EN	ED	NP	total
GO	5.51	0.02	33.63	0	39.16
EN	0.04	13.69	5.47	0	19.20
ED	0	0	40.32	0	40.32
NP	0	0.10	1.22	0	1.32
total	5.55	13.81	80.64	0	100

country: Korea					
	GO	EN	ED	NP	Total
GO	14.32	2.05	2.36	0.53	19.26
EN	3.45	64.24	1.32	1.06	70.07
ED	0	0	6.81	0	6.81
NP	0.55	0.17	0.23	2.91	3.86
Total	18.32	66.46	10.72	4.50	100