R&D Paradox in Innovation and Entrepreneurship:

Swedish Paradox Revisited in Korea

I. Big R&D Investment but Poor Its Outcome

R&D expenditure has been rapidly increased over ten years in Korea. As seen [Table 1] below, the ratio of R&D spending to GDP was recorded 4.15% in 2013 as the second highest ratio among the OECD countries. While Israel was the top (4.21%), Japan the third (3.48%), and Finland fourth (3.31%). An average growth rate of R&D expenditure was 7.3 % during 2011-2013, which was substantially greater than even high income OECD countries such as Germany (2.7%), Japan (1.5%), USA (-3.8%).

[Table 1] GDP Share's on R&D Spending

Countries	2000	2005	2008	2009	2010	2011	2012	2013
Finland	3.24	3.32	3.54	3.74	3.72	3.63	3.43	3.31
Germany	2.39	2.42	2.60	2.72	2.71	2.79	2.87	2.93
Israel	3.96	4.08	4.38	4.15	3.95	4.10	4.24	4.21
Japan	3.00	3.30	3.46	3.35	3.25	3.38	3.35	3.48
Korea	**2.18**	**2.62**	**3.12**	**3.29**	**3.46**	**3.74**	**4.02**	**4.15**
UK	1.72	1.63	1.68	1.75	1.69	1.69	1.63	1.63
Sweden	na	3.39	3.49	3.41	3.21	3.22	3.28	3.30
USA	2.62	2.50	2.76	2.81	2.73	2.76	2.80	na
OECD	2.13	2.15	2.29	2.33	2.29	2.33	2.37	2.39

Resource: OECD (2014)

However, the productivity of the R&D expenditure has been lower than what it was

expected although the expenditure has been heavily increased for long time. Such a phenomenon was also founded in Sweden before, called ‘Swedish paradox’ (Ejermo and kinder, 2006). The Swedish paradox has been appeared again recently in Korea.

The productivity of the Korean R&D investment has been fluctuated around the bottom line in term of technology trade balance and the ratio of receipts to payment of the technology trade. The technology trade deficit was amount to $5.7 billion in 2012 while some advanced countries have enjoyed big technology trade surplus in the same year. The USA’s technology trade surplus was amount to $35.9 billion, Japan’s one $28.5 billion, the UK’s $22.6 billion, and Germany’s $8.4billion. Another index representing R&D productivity, the ratio of technology receipts to payment of the Korea was only 1.5 in 2012, comparing the USA 3.9 at the same year. These numbers implies that the productivity of the R&D investment was not so efficient in Korea.

II. To Need R&D Investment Accompanied by Entrepreneurship

The modern economic growth theory tells that R&D is one of the important factors in line with others: human capital, spill-over effects for high-technology, government policy like favorable tax systems (Romer, 1986, 1990, Aghion and Howitt, 1992). So many countries have started to increase R&D investment to strengthen their innovation potentiality, which in turn leads to higher growth rates and more jobs. Some countries attained higher growth rates with higher R&D productivity but others did not. Why other countries failed?

According to OECD (2014 a), the R&D spending of the Korea performs well in terms of the total number of scientific publications, ranking for some years around 12th globally. It also shows that Korea is a leading country internationally in regards to the number of patent applications filed by universities and research institutes. Nevertheless, the technology trade balance has been big deficit.

Many researchers have shown that R&D investment itself does not automatically to transform into the innovative economy. (Ejermo and kinder, 2006, Bitard, 2008, Edqist, 2010). In order to successfully transform into the innovative economy entrepreneurship should be promoted to enhance R&D’s productivity and to lead higher economic growth rates.

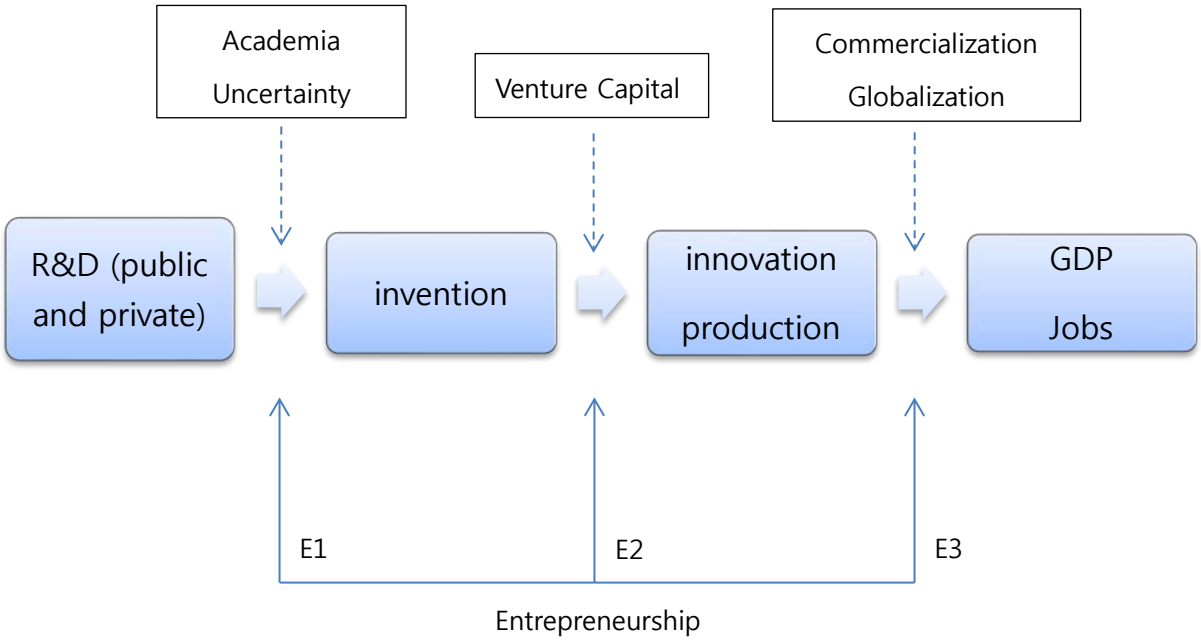
Low productivity of R&D is closely associated with the low level of entrepreneurship in Korea. For instance, in Korea only 1 in 4 technologies developed through state-funded R&D

projects is transferred to private companies. In addition, fewer than 1 in 10 such technologies actually make it to the market in form of services and products. Aware of the problem, the Korean government has stepped up efforts to facilitate the commercialization process. It has set up various institutions and programs followed by the government subsidies including start-up incubation centers, industry-academic collaboration foundations, technology licensing offices at universities and technology holding companies. But these efforts have not been founded quite successful. There was a missing factor or entrepreneurship. All processions regarding to R&D investment invention, commercializing of invention, and production require entrepreneurship.

R&D itself contains risk and uncertainty, which means that entrepreneurial activities are required. Even though R&D investment is completed processes of invention, commercialization, and production process are not successfully fulfilled. All R&D spending does not bring business profit. R&D investment productivity will be low but for an appropriate entrepreneurship. The [Figure 1] shows that R&D investment needs entrepreneurship in various processes over time.

In general, R&D investment requires a big amount of money for a long period, implying that its rewards usually come true for the future time. There will be a low probability in high-tech sectors but for adventure spirit or entrepreneurship (as seen E_1 in Figure1). In most case, high and innovative technology is associated with the basic and fundamental science. The basic and innovative technology itself cannot be utilized into commercialization at once, which means that the reward of huge amount of R&D expenditure will be low for the short period. Additional extra big money is to be invested until commercialization. At this stage venture capital is often mobilized into such an innovative invention. Without sufficient venture capital there will result in low level of commercialization. Entrepreneurship is needed again at this commercialization stage as seen E_2 and $_{E3}$ in Figure 1.

[Figure 1] Interrelations between R&D spending and its rewards



As we seen Figure 1, there will be low R&D productivity even with big R&D investment but for entrepreneurship, sometimes called Swedish paradox. Such a Swedish paradox phenomenon has been appeared in Korea in recent years. The Korean has been faced with declining trend of the entrepreneurship in recent years. Further clearer understand of the R&D process, some numerical equations are employed as below.

III. Empirical Evidence and Policy Implication

1. Empirical Model and Its Analysis

Let the production function augmented with R&D and entrepreneurship be expressed as follows. Let a variable 'A' represent multiplicative meaning of innovation, technology, and productivity. The variable A is affected by various factors including R&D investment, high-tech, human capital such as scientist and engineers, venture capital, entrepreneurship, government supporting policies, social safety network, among others. Let a variable X include all factors mentioned above except the stock of R&D(R). In turn, R&D(R) can be expressed as a function of entrepreneurship (E). The productivity of R&D(R) will be stagnated at the low level but for appropriate level of the entrepreneurship (E). Thus an alternative production function can be expressed as follows.

$$Y = A(R(E), X)F(K,L,R(E)) \quad (1)$$

$$dY_E = (A_R dR + A_R R_E dE + A_X dX)F(K,L,R) + A(F_K dK + F_L dL + F_R dR + F_R R_E dE) \quad (2)$$

Where Y: GDP, K: physical capital, L: labor, E: entrepreneurship, R: R&D spending.

Let dY be defined when entrepreneurship (E) is missed in equation (2) or dE = 0.

The variable of dY is certainly smaller than dY_E, which in turn the productivity for dY is also smaller than that of the corresponding variable dY_E. Some researchers including Ejermo and Kander(2006), Frelin (2013), Bitard and Edqaist (2008), and Edquist (2010) addressed that R&D spending itself did not automatically to bring high productivity but for entrepreneurship.

By utilizing equation (2), we can set up empirical regression equations as follows.

$$\text{Growth} = ß_0 + ß1R + ß_2K + ß_2L + ß_2X + \varepsilon \quad (3)$$

$$R = \alpha_0 + \alpha_1 \text{growth} + \alpha_2 E + \alpha_3 Z + \mu \quad (4)$$

Where Z = {other control variables like tax exemption and government policy like reducing regulation, etc}

Empirical regression analysis for OECD countries will be done by employing equation (3) and (4) with two stage simultaneous equations, comparing Korean case with some OECD countries.

Empirical Results to be Here!

2. Policy Implication Suggested

(1) **Promoting entrepreneurship**

The entrepreneurship has been declined recently in Korea, which might be due to the declining growth with the global recession, risk avert social attitude, low level of social safety net, aging population structure, among others. There are also many barriers to entrepreneurship such as lacking idea, skill, market, fund, skilled labor, and governmental regulations, among others. Most barriers could be cleared by entrepreneurs except the government regulation. Thus the most urgent thing to do by the government is to reduce regulation barrier. Various regulations usually impact negatively on entrepreneurial activities

for a long time. OECD (2014) created an index for the barriers to entrepreneurship (BEI), composite of three sub-indicators weighted equally: administrative burdens on start-ups; regulatory and administrative capacity; and barriers to competition. BEI represents restrictiveness on a scale from 0, least restrictive, to 6, most restrictive. According to [Table 2], the barrier to entrepreneurship has been reduced for last ten years, but it is still substantially high in Korea, comparing other European countries as well as USA and Canada.

[Table 2] Barriers to Entrepreneurship Index (BEI)

	BEI (2003)	BEI (2013)
New Zealand	1.61	1.18
United States	1.64	1.23
Netherlands	1.92	1.19
Canada	1.44	1.34
Denmark	2.12	1.26
Finland	1.77	1.55
Japan	1.69	1.67
United Kingdom	1.81	1.48
Germany	2.24	1.51
Sweden	1.99	1.71
Norway	1.88	1.69
Korea	**2.22**	**1.88**
Israel	na	2.50

Resource: OECD, “Entrepreneurship at a Glance 2014”

Another problem regarding to the low entrepreneurial activities is associated with too big share of necessity start-up, which is typically short of innovative idea and technology (see Table 3). Most businesses are concentrated in some specific sectors like food and restaurant and retail services. It is necessary to induce from necessity start-up to opportunity. Thus the government supporting policy (fund allocation) should be switched towards the opportunity start-ups.

[Table 3] Reasons for business start-up

	opportunity start-up	family business	Necessity star-up
Denmark	76.00	10.00	10.00
Netherlands	67.00	13.00	11.00
Finland	66.00	10.00	20.00
Israel	58.00	16.00	13.00
Norway	57.00	13.00	20.00
Sweden	56.00	20.00	13.00
United States	54.00	14.00	26.00
United Kingdom	53.00	7.00	30.00
Japan	46.00	22.00	22.00
Germany	46.00	19.00	28.00
Italy	43.00	25.00	20.00
China	43.00	11.00	42.00
Korea	21.00	14.00	63.00

Resource: OECD, “Entrepreneurship at a Glance 2014”

(2) **More venture capital from private angel capital market.**

In Korea venture entrepreneurs have heavily depended on banking loans instead of resorting to angel fund or venture capital, partially due to weak development of venture capital market. The stock of venture capital is very low, comparing with other advanced countries. Most funds for high technology have been composed of the government subsidy and bank loan with favorable lower interest. Bank loan will be more financial burdens than venture capital when innovative projects are not successfully commercialized. For the innovative R&D projects venture capital should be more mobilized. The Korean government is needed to provide some favorable incentives like tax exemption, reduction of regulations, among others. The Korea Fund of Funds (KFoF) was introduced in 2005 for the Korean venture and innovative start-up entrepreneurs. The KFoF was based on the special act “Special measures for the Promotion of Venture Business” for the purpose of stable capital source for venture investment. But most resource of the KFoF has been from the government budget, not from the private capital market.

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(3) Towards Entrepreneurial R&D Supporting Policy

The public R&D distribution has been focused on the ‘equity basis’ not on toward ‘entrepreneurial or venture basis’. Many SMEs have been distributed with small amount of money for a very short period, which in turn brings low research productivity. Commercializing R&D output takes longer time and involves also risks. Thus entrepreneurs need support throughout the entire commercialization process, ranging from the start-up phase to the final stage of bring their products to the market (especially global market). This means that government and related institute need change their approaches and set up collaborative and integrated supporting systems. The government also needs to promote technology financing to help SMEs secure funding based on accurate appropriate of their technologies. For most SMEs, the lack of funding is the biggest obstacles to commercialization of the R&D output.

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