The Missing Link: In-depth QCA analysis by Science-Linkage Data

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Extended Abstract

(1) Introduction:

Innovation is commonly motivated via inventor's idea and it finally spawn to the market. But, it's still questioning how and why innovation emerges and how we encourage its ecosystem continuously. In my study, I aim to verify these arguments; (1) how scientific network emerges successful destructive innovation? (2) Do star scientist (key inventor and/or researcher) who involves successful destructive innovation yields deliverables more than the average among the scientific network?

(2) Literature Review:

The current study mainly focused on the economical impaction of the existence of star scientists but it did not describe concretely how and why star scientist emerges his enforcement and advantage among the institution and even the academic competition for mid/long term. Addition, (Roach and Cohen, 2012) investigates the role of patent and its citation data for tracing knowledge creation process, but it did not only verify the knowledge flow directly, but it also focus on prior technologies.

(3) Research Methodology

To realize the role of scientific sources for destructive innovation, I pick up the case of path-breaking drugs invented in Japan which listed in table 1.

To check the knowledge flow between scientific sources and path-breaking drugs and its star scientists, I made network analysis and QCA analysis. Procedures are constituted from;

(1) Firstly, identifying the star scientist of path-breaking drug by patents and/or scientific paper's bibliographic information. Hence, star scientist in this study is virtually the corporate scientist who discover and identify the core of blockbuster drug.

(2) Oral interview with star scientist to ensure the essential scientific sources for path-breaking drug.

(3) Summarizing the activity of scientific paper/patents of star scientists then taking the snapshot of internal/external network flows for certain time window to realize scientific flow between the inside and the outside of organization.

(4) If knowledge flow cannot be detected by procedure (2), then focusing on backward citation data to aim to trace scientific contribution for the invention.

(5-1). Identifying core-patent [basic patent] /paper [basic paper] via star-scientist which essential to invent the drug.

(5-2.) then, to check that scientific source could be traced via core-patent and/or core-paper. In doing so, I'll check JPO patent data (references and main body) and USPTO patent data (front page and main body).

Brand Name in Japan	Company	FDA Approval Date	Global Sales (2012, Millon Dollar)	Key inventor and researcher interviewed	Indications
Compactin	Daiichi Sankyo	N/A	N/A	**Akira Endo**	Coronary Artery Diseases, Hypercholesterolemia
Mevalotin	Daiichi Sankyo	1987.4	300	Kazuhiko Tanzawa	
Actemra	Chugai	2010/1	921	**Yoshiyuki Ohsugi**	Castleman's Disease, Juvenile Idiopathic Arthritis, Rheumatoid Arthritis
Aricept	Eisai	1996/11	1098	**Hachiro Sugimoto, Yoichi Iimura, Yoshiyuki Kawakami**	Alzheimer's Disease
Prograf	Astellas	1993/4	1884	**Toshio Gotoh**	Lupus Nephritis, Myasthenia Gravis, Rheumatoid Arthritis
Actos	Takeda	1999/9	1431	**Hiroyuki Okada**	Non-Insulin-Dependent Diabetes Mellitus
Onon	Ono	1995/3	272	**Hisao Nakai**	Allergic Rhinitis, Asthma, Respiratory
Cravit	Daiichi Sankyo	1993/10	468	**Isao Hayakawa**	Bacterial Infections
Blopress	Takeda	1999/3	2983	**Yoshimi Imura**	Congestive Heart Failure, Hypertension
Leuplin	Takeda	1992/7	1356	**Hiroaki Okada**	Endometriosis, Metastatic Prostate Cancer,Precocious
Crestor	Shionogi	2003/8	6253	**Haruo Koike**	Cardiovascular, Hypercholesterolemia
Harnal	Astellas	1993/7	629	**Touichi Takenaka**	Benign Prostatic Hyperplasia

Table1. List of Path Breaking Drugs invented in Japan
(Source: Medtrack, basic patent/paper information)

(4) Main Findings

No	Brand Name in Japan	Discovery Year	Scientific Contribution for initial discovery research	Target has been identified in discovery research?	Has Mechanism of Action been identified?	Do Lead Scientists existed in research institute of United States in corresponding area?	Method of Screening and Synthesis	Scientific Contributor of Pre-Clinical Study	Scientific Contributor of Clinical Study
1	Compactin	1973	Cholesterol synthesis of HMG-CoA reductance inhibitor	Yes		Yes		Dr. Yamamoto from Osaka University, Brown and Goldstein (for Cholesterol synthesis Mechanism analysis)	Dr. Mabuchi from Kanazawa University
2	Mevalotin	1979		Yes		Yes			
3	Crestor	1991	chemosynthesis	Yes	Yes	Yes			Dr. Kono from Hiroshima University
4	Actemra	1992	Joint Research in Calfornia Davis University			Yes	Osaka University and MRC (United Kingdom)		
5	Onon	1985	Discovery of LT and method of synthesis	Yes	Yes		Harvard University		
6	Aricept	1986	Colin Hypothesis	Yes			Tsukuba University and CADD		
7	Leuplin	1983	Discovery of LH-RH		Yes	Yes	Osaka University		
8	Bropless	1990				Yes	Kyoto University		
9	Cravit	1985			Yes		Facilities for optical resolution		
10	Harnal	1980	Clinical Study of alpha-blockage drugs					Tokyo University	
11	Actos	1986					Nagoya Univetsity		
12	Prograf	1984	Research in National Cancer Institute			Yes		Chiba University	Dr. Starz from University of Pittsburgh

Table2. List of Path-breaking Drugs and its scientific sources

(Source: interview with key inventor/researcher, core literature and patents for each path-breaking drugs)

Table2 shows how scientific sources of path-breaking drugs accumulated and what's the essential scientific sources for R&D process of path-breaking drugs. In sum, scientific discoveries mainly lead by the university and/or research institute emphasizes the star scientist in pharmaceutical company as following path; (1) it shows mechanism of action and target of illness, (2) it supplies research facility for discovery program and synthesis method of molecular, (3) it guides clinical study for path-breaking drugs and (4) it finds new target illness for path-breaking drugs.

And, table 3 show the percentage of cover rate in which that core patent and/or core paper indicates scientific sources for path-breaking drugs. It suggests that (1) there is duration between issued year of core-patent and core-paper. Usually, Core-patent issues 3-4 years earlier than core-paper. (2) References data of core-paper reflects the half of scientific sources. (3) Front page of US patents and References data of JP patents did not include scientific source. (4) Main body, especially the session of novelty of invention and prior knowledge, includes 30-40 percent of scientific sources.

Drug (Brand Name in Japan)	Basic Paper (in Year)	Basic Patent (in Year)	Number of Scientific Sources	Coverage rate of scientific sources in basic paper	Coverage rate of scientific sources in US Patent		Coverage rate of scientific sources in JP Patent	
					Front Page	Main Body	References	Main Body
Compactin	1976	1976	4	25% (=1/4)	0%	50%	0%	50%
Mevalotin	1986	1980	3	67% (=2/3)	0%	0%	0%	0%
Crestor	1997	1991	0					
Aricept	1992	1988	2	25% (=1/4)	0%	25%	0%	50%
Crabit	1986	1980	2	50%	0%	0%	0%	25%
Actos	1986	1990	0					
Blopress	1993	1991	0					
Prograf	1985	1992	1	0%	0%	0%	0%	0%
Onon	1987	1985	1	100%	0%	50%	0%	50%
Leuplin	1988	1984	2	50%	0%	0%	50%	50%
Actemra	1988	1988	5	40%	0%	33%	0%	25%
Harnal	1984	1980	2	50%	0%	50%	0%	0%

Table3. List of Path-breaking Drugs and the corresponding rate of scientific sources
(Source: interview with key inventor/researcher, core literature and patents for each path-breaking drugs)

(5) Conclusions

Star scientists has strong external network for each R&D process of path-breaking drugs. It might help the scientists to accumulate scientific sources for path-breaking drugs, which is consistent with evidence of oral interview. And star scientist has connectivity with foreign distinguished academic researchers, which also emphasize the role of knowledge accumulation. But, if the essential knowledge has been established in prior of time, it is hard to trace by patent's front page data. And if the scientific discovery by scientist in the university and invention process by star scientist in the firm are connected or occurred in the same timing, knowledge path could not be only verified by 1st-tier co-authorship data of star scientist in the firm, but it is also traceable via main body of invention and/or citation front page information of basic paper of the invention. But, the coverage rate of scientific sources has risen by using the citation information in the main body of patent or basic paper.

(6) Implications

From these findings, there are some implications that governmental financial and human-relational supports for basic science should be continued as scientific source of innovation in the perspective of science and technology policy, and there should be some implementations that is connecting entrepreneurial capability by firm and academic research activities by university/institution. In this sense, star scientist should be acted as "gatekeeper" whom imports external knowledge from academia and to stimulate internal absorb capability of the firm. In doing so, management team should (1) give authority him/her to have flexible research activities and/or (2) enforce and control him/her research with explicit and tangible research strategies. In fact, including Statin's case, some path-breaking drugs developed in Japan are based on researcher's informal research activities called as "Yami-Kenkyu."

As policy implication for patent-based study, the current study only focus on the science linkage between patent and paper by using citation information embed in front page. But through the result, there should be a mechanism that covers the bibliographic information argued in main body especially in the section of novelty of invention.