



Role of Complementarity between Factors of Innovation In Generating Innovation Output

AbdulQuddus Mohammed

Research Scholar, INEPAN, Warsaw, Poland

abdulquddus.md@gmail.com

ABSTRACT

Innovation is a process and the outcome of creating new products/services, processes, new technology, and opening of new markets or new way of organizing business and solutions. Innovation is something original, new and has value. It is a catalyst for the growth of the company and the economy of the country. Successful innovators always tried to look for the new ways to satisfy their customer needs by means of improved quality, price, durability, satisfaction and appeal. Innovations will help the firms by increasing investment, improvement in processes, development of infrastructure and invention of new products / services / tools / techniques. For a society innovation will bring comfort and convenience and a sense of modernization. Innovation is supported by innovative activities such as R&D, design, acquisition of capital goods and patents. This paper argues that there is a complementarity between innovation activities and the reasons for the complementarity through literature review.

Keywords- Innovation, factors of innovation and complementarity

I. INTRODUCTION

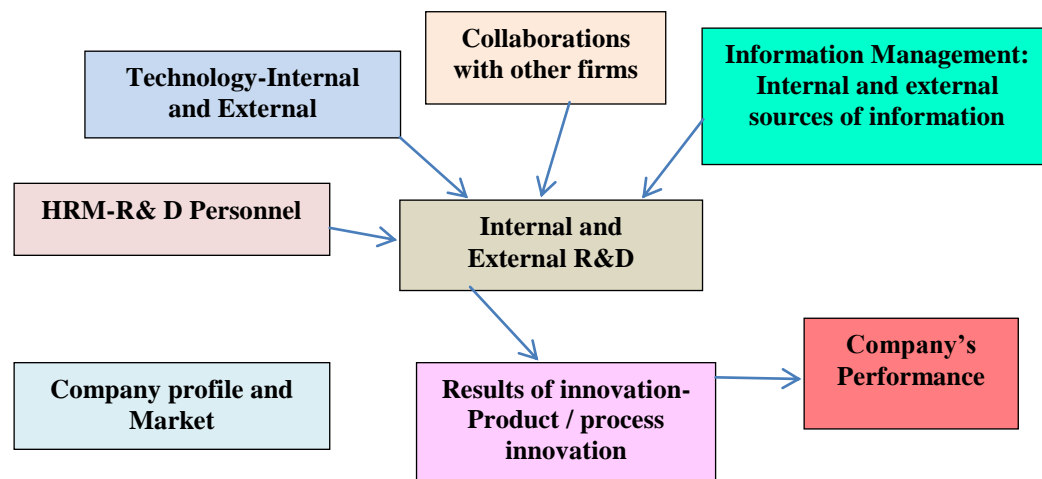
Innovation is a process of discovery, learning, and the application of new technologies and techniques. It aims to continue economic and productivity growth by transforming knowledge into a variety of economic activities, and ultimately in the improvement of living standards. Unambiguously, majority of the economic and social progress of the past few centuries has benefited from technological inventions and achievements. The significant role of innovation, which is thought to be brought about through research and development (R&D) activities carried out by profit-seeking entrepreneurs in the productivity performance, was elaborated in the endogenous growth theory (Aghion and Howitt, 1998). According to Coe and Helpman et al. (2009) a large part of the world's R&D activity is carried out by firms located in developed countries, particularly the more powerful member countries of the OECD. And the significant performance of R&D in explaining firm productivity of developed economies has been demonstrated in a number of empirical studies (Hall, Griliches et al., 1986).



What is innovation? Bill gates said “never before in history has innovation offered promise of so much too so many in so short a time”. This is true in terms of modern innovations like Internet, gadgets, camera, airliners, television have changed the way of society. We will not be able to explore further without defining what is innovation? Simply, innovation can be defined as a process and the outcome of creating new products/services, processes, new technology, and opening of new markets or new way of organizing business and solutions. Innovation is something original, new and has value Schumpeter, J, A (1943). What are the types of innovation? Clayton Christensen (2011) at Harvard Business School categorized inventions into three types: Inventions that companies develop to stay in the market are called sustaining products and services. They are also called as incremental inventions. For example, Maxwell House came out with a dark roast version, it introduced a sustaining innovation. While a new flavor, it was only a variation on their existing products that customers could instantly understand. When a firm invents to significantly improve the existing category of products / services, it is called breakout offerings. For example, breakout innovation was General Foods’ line of International Coffees, which added gourmet flavors to the instant coffee category and elevated the at-home coffee experience. Disruptive innovations are a big idea that disrupts the current market and attracting customers with a new idea. For example, iPod changed the way we listen and buy music. And Starbucks has obviously been a disruptive innovation, turning coffee into a destination experience worth paying a lot more for. Why innovation? What are the benefits of innovation? From an organizational perspective, innovations will bring positive changes in effectiveness, efficiency, productivity, quality, competitive advantage to the firm. It is a catalyst for the growth of the company and the economy of the country. Successful innovators always tried to look for the new ways to satisfy their customer needs by means of improved quality, price, durability, satisfaction and appeal. Innovations will help the firms by increasing investment, improvement in processes, development of infrastructure and invention of new products / services / tools / techniques. For a society innovation will bring comfort and convenience and a sense of modernization. Innovation is supported by innovative activities such as R&D, design, acquisition of capital goods and patents.



II. WHAT ARE INNOVATION ACTIVITIES



Factors like Technology, HRM, Financial Management, Company profile, collaborations, and information management affect innovation activities. Those activities determine innovation results, affecting firm's performance.

Company Profile (size and the market structure)-I believe that there is a positive relationship between the profile of the company (size) and R&D activities; as it is a direct effect on innovation and size influence R & D activities this assumption is acknowledged by the Oslo Manual (2005) . Market structure also will have influence on innovation activities, S. Sengupta (1998) and H. R. Greve (1999) argues that there is a direct relation between innovation activities of a firm and the barriers to entry, and environment, attractiveness and concentration of industry. *Human Resources Management*- There cannot be an innovation without people, as it directly affects the organizational ability to innovate, this argument is substantiated by Hurley and Hult (1998) and the other studies (R. D. Dewar and J. E. Dutton) proved the fact that organizational issues such as centralization, formalization and structure and specialization factors related with the arrangement of jobs in the organization are directly related with the innovation ability of the organization. *Finance*- the amount of direct and indirect costs associated with the R&D activities has direct influence on innovation Z. Griliches (1979). *Collaboration*-It's important to collaborate with the concerned parties involved to bring economies of scale, bringing new ideas, avoiding duplication and also to effectively promote the innovation bring significant benefits to business R. Narula and J. Dunning (1997). Definitely mutual collaboration will help the companies to be successful in innovation. *Internal and external technologies* available to firms



are important factors in strengthening the innovative capabilities of the company. Companies that have reasonable technologies will definitely have advantage in not only producing more innovative products, but also in its commercialization [4]. *Information Management*- it is the most important factor that will help the management of the firm to take right decisions related to innovation. Decisions are based on information gathered from market conditions; change in customer preferences, competitors, economic conditions, there is relationship between these factors and the innovation process of the firm C. Camisón (1999). Three factors related to information management are the use of internal information, the use of market related sources of information (clients, providers and competitors) and other sources of information (scientific reviews, industrial associations, conferences, etc.) (Alvaro Gómez). Internal and External R&D activities are necessary for technological innovation and key factors that can contribute to success in innovation results and the performance of the firm and contribute in achievement of radical innovations that provide competitive advantage Z. Acs, L. Anselin and A. Varga (2001) .

III. COMPLEMENTARITY OF INNOVATION ACTIVITIES

Establishing complementarity and identifying the sources for complementarity are both critical to managing the innovation strategy. When innovation activities are found to be complementary, this implies that it is less efficient to concentrate on one activity at a time. In the face of complementarity among activities, it is hard to understand the decision of a firm on how to organize an individual transaction, without taking into account the other activities the firm performs in its innovation strategy. For example, when a firm decides to buy a technology license, it needs to analyze whether it appropriates with its existing activities. Viewed from the firm's perspective rather than the individual transaction, buying technology and doing own R&D could possibly be complementary activities. Ghemawat (1999) studies the case of Nucor, a US steel mill, which combines innovative human and capital resource management practices with a low-cost strategy. Similarly, Ichniowski and Shaw (2003) study the effects of human resource management practices on productivity in a sample of steel finishing lines. Both these studies find that there are important complementarities between different human resource management practices and the strategy of the firms. Firms that are able to combine these activities properly significantly outperform their counterparts in the industry. Hence, understanding complementarity between these activities is crucial for firm performance and ultimately for firm survival rates.

A number of studies report casual empirical evidence consistent with complementarity among innovation activities. The Sappho study identified successful innovative firms as those that developed better internal and external communication networks, allowing a more efficient use of external know-how (Rothwell, 1977). While examining the critical success factors of 40



innovations, Freeman (1991) found that external sources of technical expertise combined with in-house basic research that facilitate these external linkages were crucial in explaining success of the innovation. This suggests a strong complementary relation between in-house basic knowledge development and external knowledge acquisition. Similarly, firms performing in-house research drew most heavily upon the public research associations set up after World War I in the UK. These research associations were intended to assist firms in technical matters. Firms without any internal research facilities were expected to use these research associations most heavily. On the contrary, the research associations served as an important complementary source of scientific and technical information for firms performing in-house R&D. Further evidence on complementarity comes from examining the payment streams for licenses where the flows are primarily between firms performing in-house R&D and not from firms that lack any in-house R&D capabilities to firms that have strong in-house R&D programs.

The complementarity between internal and external sourcing is more rigorously explored in Arora & Gambardella (1994), where they identify two effects from internal know-how. On the one hand, internal know-how is necessary to screen available projects. On the other hand, internal know-how serves to effectively utilize the assessed external know-how. Using scientific know-how as a proxy for the former and technological know-how for the latter, they find support for both hypotheses about complementarity between internal and external know-how sourcing. This evidence suggests that the R&D orientation of the firm might be an important driver of the observed complementarity between internal and external technology acquisition. (Rosenberg, 2001) as well identifies the absorptive capacity of a firm by its basic research orientation. He puts it as follows: "A basic research capability is often indispensable in order to monitor and evaluate research being conducted elsewhere." Viewed in its capacity to absorb external information efficiently into the in-house innovation activities, basic research will act as an important driver for complementarity. Blonigen and Taylor (2000) also identify two possible hypotheses for the effect of R&D activities of the firm on its acquisition strategy. While internal R&D and technological acquisitions are substitutes leading to a negative relationship between the two, internal R&D stimulates synergy gains from potential targets, and thus supposes a positive relationship. Both hypotheses are supported for a panel of US electronics firms, using R&D intensity to test for the former hypothesis, and R&D expenditures for the latter. Cassiman and Veugelers (2002) also provide evidence for internal know-how development and external sourcing to be combined at the firm level. In addition, they show that the choice of innovation activities strongly depends on the appropriation opportunities. Veugelers and Cassiman (1999) uncovers the reverse relation, namely that external sourcing stimulates internal R&D expenditures, at least for firms with internal R&D departments. This finding further reinforces the hypothesis of complementarity between internal and external knowledge sourcing. Finally, Arora and Gambardella (1994) examine the complementarity among external sourcing strategies of large firms in the biotechnology industry. They study four types of external sourcing strategies for large chemical and pharmaceutical companies in biotechnology: agreements with other firms, with universities, investments in and acquisitions of new biotechnology firms. They find evidence for complementarity between all types of external sourcing strategies, even after correcting for a set



of firm characteristics. Furthermore, the correction for firm characteristics suggests that large firms with higher internal knowledge, measured by number of patents, are more actively involved in pursuing any strategy of external linkages.

The multiple links between internal R&D capabilities and external technology acquisition suggest that external technology sourcing is typically embedded in the wider innovation strategy of the firm. Within this wider innovation strategy, there are also other activities that the firm might use to build up and exploit its technology-base, besides the traditional buying of technology through licensing or R&D contracting. Compared to market transactions and internal development, R&D cooperation allows a faster, cheaper, and lower risk mode of accessing new technology, while exploiting partner complementarity and actively managing the transfers of know-how between partners (a.o. Pisano (1990)). The inherent reciprocity allows the risks of partner opportunism to be manageable, reducing transaction costs (Oxley (1997)). We will consider an innovation strategy that includes R&D cooperation as evidence of simultaneous buy and sell activities of the firm (see Granstrand et al. 1992). Most studies provide strong evidence for R&D active firms to be more active in R&D cooperation (Kleinknecht & van Reijnen (1992), Colombo & Gerrone (1996)). However, Dutta & Weiss (1997) find a negative correlation which they attribute to the need to protect “tacit know how”. None of these papers, when assessing causes and effects, properly account for the simultaneity between own R&D and R&D cooperation arising from complementarity. Using a simultaneous equations framework, Kaiser (2002) finds a positive but only weakly significant effect of cooperation on own R&D expenditures. Cassiman and Veugelers (2001) provide evidence of a strong positive effect of own R&D activities on cooperation in R&D, but after controlling for endogeneity, this effect is less significant. However, the appropriation regime does affect the decision to cooperate significantly.

Successful innovation is based on innovation strategy of the firm which will combine the innovation activities [3], Are innovation activities / factors complementary? Why are innovation activities / factors complementary? Yes, there is complementarity between innovation activities, Cassiman, Veugelers [12] argued in their research on Belgian manufacturing firms that there is complementarity between firms internal R&D and external technology sourcing activities and furthermore, they found that there is strong positive correlation between different innovation activities. Results of their research also shown that the companies with complementary innovation activities of combined internal, external knowledge are able to benefit of generating higher innovative output rather than companies who focus on either using own R&D or buying technology based on external technology market will have low probability of being successful in absence of complementary innovative activities..

IV. DISCUSSION AND CONCLUSION

All above literature proves that external sourcing of technology is rooted within innovation strategy of the firm. It's not only limited to traditional buying of technology through licensing or contracting but also to manage the risks of partner opportunism and reducing costs Pisano, G at



the same time some companies also engage in internal development, R&D cooperation allows a faster, less costly and lower risk mode of accessing new technology.

There is also complementarity between the type of I (1990) incentives schemes for research activities within research teams in pharmacy companies Holmstrom and Milgrom (1991). Offering ideal incentives for multidimensional effort choices by researchers implies providing equal marginal incentives, i.e. high powered or low powered, for all possible activities by the researcher, leading to complementarity in the type of incentives schemes observed within the same team.

Why the invention activities are complementarity? As shown in above literature, The main reason for the complementarity is most of the innovation activities are part of one innovation strategy and belong to one coordinated organizational system. And the research and development orientation of the firm and approximation of regime are important factors. Some company's complementarity between innovation activities is a source of competitive advantage for the firm, management of innovation strategy is based on the identification of the sources of complementarity and once we know that these activities are complementary, it's important to readjust the whole invention strategy of an established company because of its increased complexity. For example, if Apple wants to reduce the prices of its mobile phone (low cost leadership), it has to bring drastic changes in readjusting its production cost and HR cost because both these costs are complementary. Therefore, the innovation process, i.e. managing the complementarity between the different innovation activities, can be an important source of sustainable competitive advantage.

REFERENCES

- Alvaro Gómez Vieites, José Luis Calvo (2011), A Study on the Factors That Influence Innovation Activities of Spanish Big Firms, Technology and Investment, pp 8-19. doi:10.4236/ti.2011.21002
- Arora, A. and Gambardella, A., 1994, Evaluating technological information and utilizing it: Scientific knowledge, technological capability and external linkages in biotechnology, Journal of Economic Behavior and Organisation, 91-114.
- Blonigen, B. and C. Taylor, 2000, R&D activity and acquisitions in High Technology Industries: evidence from the US Electronics Industry, NBER Working Paper



- Bruno Cassiman, Reinhilde Veugelers, Complementarity in the Innovation Strategy: Internal R&D, External Technology Acquisition, and Cooperation in R&D, "Innovation and Supermodularity" in Montreal, the Strategic Management Society Conference 2000 in Vancouver, the Applied Econometrics Association Meeting 2001, Brussels
- C. Camisón, "Sobre cómo medir las competencias distintivas: Un examen empírico de la fiabilidad y validez de los modelos multi-item para la medición de los activos intangibles," First International Conference, Management Related Theory and Research: An Iberoamerican Perspective, 1999
- Clayton Christensen (2011) Types of innovation, available from <http://www.fastcodesign.com/1665186/there-are-three-types-of-innovation-heres-how-to-manage-them>
- Freeman, Ch., 1991, Networks of Innovators: a synthesis of research issues, Research Policy, 499-514.
- Ghemawat, P. and G. Pisano, 1999, Building and Sustaining Success, in Ghemawat, P. (ed): Strategy and Competitive Landscape, Prentice Hall
- H. R. Greve, "The Effect of Core Change on Performance: Inertia and Regression toward the Mean," Administrative Science Quarterly, Vol. 44, No. 3, 1999, pp. 590-614. doi:10.2307/2666963
- Holmstrom, B. and Milgrom, P. 1991, Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership and Job Design, Journal of Law, Economics and Organization, 7, 24-52.
- Ichniowski, C., Shaw, K. and G. Prennushi, 2003, The Effects of Human Resource Management Practices on Productivity: A Study of Steel Finishing Lines, American Economic Review, 87, p.291-213
- J. V. Baldrige and R. A. Burnham, "Organizational Innovation: Industrial, Organizational and Environmental
- OECD & Eurostat, "Oslo Manual, Guidelines for Collecting and Interpreting Innovation Data, the Measurement of Scientific and Technological Activities," 3rd Ed., A Joint Publication of OECD and Eurostat, Paris, 2005.
- Pisano, G., 1990, The R&D boundaries of the firm: an empirical analysis, Administrative Science Quarterly, 35, 153-176



- R. D. Dewar and J. E. Dutton, “The Adoption of Radical and Incremental Innovations: An Empirical Analysis,” *Management Science*, Vol. 32, No. 11, 1986, pp. 1422- 1433. doi:10.1287/mnsc.32.11.1422
- R. F. Hurley and G. T. Hult, “Innovation, Market Orientation and Organization Learning: An Integration and Empirical Examination,” *Journal of Marketing*, Vol. 62, No. 3, 1998, pp. 42-54. doi:10.2307/1251742
- R. Narula and J. Dunning, “Explaining International R&D Alliances and the Role of Governments,” *Merit Working Paper Series 97-011*, 1997.
- Rosenberg, N., 1990, Why do firms do basic research (with their own money)?, *Research Policy* 19, 165-174.
- Rothwell, R. et al. 1974, Sappho updated: Project Sappho: phase II, *Research Policy*, 258-291.
- S. Sengupta, “Some Approaches to Complementary Product Strategy,” *Journal of Product Innovation Management*, Vol. 15, No. 4, 1998, pp. 352-367. doi:10.1016/S0737-6782(97)00106-9
- Schumpeter, J, A (1943), *Capitalism, Socialism and Democracy*, Routledge, pp 81-84
- Veugelers, R., 1997, Internal R&D expenditures and External Technology Sourcing, *Research Policy*, 26, 3, 303-316.
- Veugelers, R., and B. Cassiman, 1999, Make and Buy in Innovation Strategies: Evidence from Belgian Manufacturing Firms, *Research Policy*, 28, 63-80
- Z. Acs, L. Anselin and A. Varga, “Patents and Innovations Counts as Measures of Regional Production of New Knowledge,” *Research Policy*, Vol. 31, No. 8-9, 2002, pp
- Z. Griliches, “Issues in Assessing the Contribution of R&D to Productivity Growth,” *Bell Journal of Economics*, Vol. 10, No. 1, 1979, pp. 92-116. doi:10.2307/3003321