PROCESS AND PRODUCT INNOVATIONS: A THEORETICAL APPROACH

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Abstract

In this paper, first, we expressed the reasons how the firms decide and choice whether the process or the product innovation investment that they supposed to attempt. Then, the economic fundamentals of the firms' decisions explained in developed models. Within this respect, the capacity and the capability of the firms has taken into consideration as the major determining factors of innovation targeted research and development (R&D) investment decisions. The human capital source and existence of the knowledge management system accepted as the other determining crucial factors. Besides, the organizational structure also required to adapt in R&D processes accordingly to the type of innovative activity. Despite similarity of the inputs in model equations, due to the differences in the extent of the innovative activities, the derived outputs appeared quite different from each other. The outcomes of the each type of innovations reflects the peculiarity of the R&D investments.

Key words: *Product and process innovations, tacit knowledge, spillover effect, knowledge management, organizational structure.*

JEL Classification: L15, M11

1. INTRODUCTION

As it's discussed in economic growth literature, gaining competitive power, increasing and even to remain the market share should be achieved only by rising the productivity and turnover. This could be seen as a requirement of globalization in economic activities. Because, globalization brought drastic competition conditions in last two decades that have been necessitate the number of firms to make R&D works and/or accumulate the previously developed new technologies in the world level. Hall, Bronwyn H. and others (2008:16) examined international competition as a process that prompt R&D intensity which is strongly effects the innovation activities. In Acharya and Keller's research (2008:15,18,19), trade generates both major selection process and technology spillover which in turn imports in highly R&D industries affects positively to the domestic productivity. This spillover effect contributes the follower countries to go ahead of the rival firms in innovative activities. Thereby, technological developments contributes positively also to the improvement of the skilled level of human sources in both of the firms and the economies.

The capabilities and conditions, related with the realization of R&D investment, should vary accordingly to the economies, sectors and firms. Within this respect, existence of both the explicit and the implicit knowledge are forming as the major determining instruments af R&D works. Nevertheless, since "the knowledge input" has diminishing return, it has subject to depreciate in time and requires renewed continuously (Kurtoğlu, 2006). Thereby, acquiring new knowledge i.e. additon to the stocks, and to protect the market share, requires new R&D investment at least

equal to the annual depreciation rate which otherwise decline in the share of accumulated knowledge should be indispensible.

Knowledge input analysing in Hall's (2007) study, as the capital that has depreciate in time. According to the author, "curent measured stock of knowledge capital acquired or purchased as patent, licence etc. depends on past depreciation". Knowledge stock that has been embodied in the patents, licences etc., should be consider as the basic indicator and the outcome of the innovations. However, firms staying in the market differentiated in terms of the scale economies, market share, experimentation and efficiency in R&D activities. And the existing level of human capital, as a major input, effects to the capacity and ability of firm' R&D decisions. But, despite being the major component and making the highest contribution to the cost of R&D works, the human input is not "the only" determining factor of the R&D based innovation works.

In this case, what kind of economic fundamentals, other than the human source, affects the firms' decisions on process or product innovations targeted R&D investment. Why and how firms decide innovation targeted R&D activities. How the consumer demand conditions should be effective, and how the firms reacts such kind of demand related market signals. To overcome these questions requires the existence of the certain conditions and the capacities, such as the higher possibility of R&D investment cost covering expected returns and high rates of yields.

Here in this study, while the economic fundamentals of firms' decisions are examining, the firms decisions on whether to purchase the previously developed technologies or to invest the process or the product innovation targeted R&D projects are going to analyse as well. And as a new contribution to the theoretical aspect of endogenous growth literature, the impacts of organizational structure, and an efficient knowledge management system on innovation activities introduced in the models.

The paper is organized as follows. The literature provided in the next section. In section 3 the models described and analyzed. And we conclude the study in section 4. Appendix A and B presents the projections of two different innovation initiatives.

2. LITERATURE AND THEORETICAL APPROACH

2.1. Literature

The new product improvements and transfer of the previously developed technologies has been discussing in most of the innovation literature. Within this respect for example, Schumpeterian theory to the economic growth assumes that "increase in total factor productivity (TFP) varies proportionally with research intensity" which is tested and corrected as its' assumed direction (Madsen, 2008). On the other hand, there are similarities between the approaches of Aghion and Schumpeter on relationship between competition and innovations. In the Aghion approach, while competition encourages the most efficient firms to innovate, in Schumpeterian model only the incumbent firms having market power in emerging markets that are closer to the frontiers, and should have incentive to innovate when faced with potential foreign entrant(Gorodnichenko and others, 2008:3, 7, 29).

In Acemoglu and the others' paper (2008:18-19, 22-25), innovations examined in the ligt of the "firm' experimentation, whether they had more or less experimented. According to the authors, firms receive stronger signals, on the success probability of one of many potential research projects and decides when and which project to implement, and always experiment earlier. Within

this respect, patents considered as the instruments provide correct incentives and encourage one of the firms experimentation and to innovate. Other firms should be copy by purchasing the successful innovations with exclusive rights to the innovators. Then, it suggested that a convinient patent system can implement optimal allocations.

The study of Harrison and the friends (2008), on firms' innovative activities between 1998-2000 in four major European countries, i.e. France, Germany, Spain and UK; examine the research results of firms's innovative activities which the number of firms ranged from 849 to 4.631. According to the figures given in the study, while the majority of the manufacturing firms in France and Germany held process and product innovation activities, the share of the innovator firms in Spain and UK stayed less than fifty percent. The conditions quite diferent for the service sector firms, with the shares below fifty percent, in the same period and the same countries. The share of product innovator firms has find higher than the process innovators' in either of the two sectors in all the sample countries.

While new technologies stems from investments in human capital related education, training and research and development activities in Ehrlich's study (2007:3), Morone and Testa, (2008) analyzed the investment in knowledge creation and knowledge diffusion as the only sustainable way regaining the competitiveness.

Human resources, R&D works, innovations and spillover effects are positively and significantly associated with productivity growth in the studies of Harden and the friends (2008), Harrison and the friends (2008), Tressel (2008), Tang and Le (2006), Bottazzi and Peri (2007), Pianta and Vaona (2007), Acharya and Keller (2008), Kirbach and Schmiedeberg (2008).

In Jones(2008), the productivity differences between rich and poor countries explained by "the embodied knowledge" which equated to the technology and loaded deeper into the mind in rich countries. In Acharya, and Keller's (2008) paper, the competition and learning impact of imports examined by emphasizing the technology spillovers and selection for domestic productivity. The institutions considered as the key determinant to the total factor productivity improvements in Coe, Helpman and Hoffmaister (2008) that they impact the benefits from R&D spillover and human capital, and contribute to form the economic growth.

Sources of knowledge spillover and the effect on economic and social activities discussed in some other related innovation literature. Bottazzi and Peri (2008:503-509) emphasize that generated knowledge stock by technological leader countries has a particularly strong effect on productivity growth and innovation of the followers. The spillover effect on productivity express in Guiso and Scivardi (2007:72) with the knowledge spillover models that predicts agents can learn from other agents then increase their own productivity.

In Ekholm and Hakkala' study 2007:537 the authors emphasize that "while R&D activities generates positive productivity spillovers and social returns on private entities it is unclear whether these spillovers are mainly arise when knowledge is implemented in production". In Sanchez-Choliz and friends (2008:243); "pace of diffusion would also be determined by the rate of consumer learning and by changes in demand".

2.2. Theoretical Approach

The knowledge production structure of the firms as the outcome of human capital investment level of previous terms which is mostly determined by the firm management. The accumulated

knowledge as the unique creative production factor, supposed to be the most valuable input, contributes, via innovation targeted R&D activities, to strengthening the competitive power of the firms. Thereby, knowledge production decision should be considered as the crucial process for the firms. However, there should be some certain constraints to acquiring the knowledge which is effect the decision processes of the firm management, whether they should choice previously invented technologies or to work on creativity based initiatives.

In Garicano's (2007) model, knowledge accumulation process has considered as the process that allows rise in utilization of the knowledge which is realized via properly settled firm organization. And knowledge generating activities begin; a) when the production volume and market size expands in time, and if the current technology and the knowledge acquired become inadequate, and then the process exhibits decreasing returns, b) agents decide how much to invest for inventions and possibility of the economy determines the profitability of innovation investments. Greater the R&D diminishing return, it requires that quicker the production of new knowledge, and the shorter the cycle becomes i.e, greater the creative intensity.

Following this, the most important aspect at this point has seen as transfering the produced knowledge to the R&D processes. Because, better facilitation of working peoples' individual capabilities has in turn, contributes more to the competing power both of the firm and the economy. Since, having been the creative knowledge functions as the major force behind the innovations it requires being produced and managed. Therefore, the knowledge production and management systems supposed to be settleded as a corporate policy in the competitive firms (Kurtoğlu, 2007).

The knowledge accumulation process includes both of the dissemination of previously produced and embodied knowledge in patents, books etc., and new manifestated tacit knowledge. While the former most of the time, related with the process innovation initiatives, the latter plays dominant role in product innovation R&D activities. The major designated functions of the knowledge management system should be determine "the required, the possessed and the shortage of the knowledge levels". On this account, together with the effect of organizational structure the existence of knowledge management system introduced in the models, analyzing in below section third.

3. THE MODELS, PROCESS AND PRODUCT INNOVATIONS

Within the context of the models introduced herein, the efficiency yielding peculiarity of the model variables changes, due to different content of the independent variables, accordingly with the process and the product innovation cases.

The basic predictions for the models are as follows;

- there are number of firms works within the competitive/open economy
- the certain number of firms with adequate capacity in the economy that keen to involve for realizing product and process innovations
- competitive product market conditions provide convinient environment for innovation targeted R&D activities
- beside the most efficient, large and frontier firms, the new entrants, either domestic or foreign, compete also for entering the market, and gaining competitive power

- proper conditions with respect to size of the economy, per capita income level and demand for innovated goods
- the availability of human capital, knowledge stock, R&D experimentation and capacity are at convinient level in the economy
- adequacy of institutions and infrastructures, and economic policy executaions are encouraging.

3.1. Process Innovations

The first model analyze the process innovation targeted R&D investment which is based on adoption of new technologies and expressed as function of the five basic variables.

Pr□□k□s□m□o□q□ı

where; Pr is the output of the renewed particular product/process, produced after purchasing the previously developed technologies embodied in patents, and/or developed in the firm. During the process innovation works, firms employs the specified-below given inputs. The variable k is the knowledge input, facilitated during adaptation of the previously innovated goods or services which in the form of patents, by human capital.(Kurtoğlu, 2007, Hempell and Zwick, 2008: 333) The contribution of k, to the form of Pr should be stay within a certain lower limit, because it has used mostly in adaptation process of patent imitation rather than creating new idea. s is the dissemination of the technology embodied in previously improved and patented products/services that allows replacement of the one which the company currently operates.

m is the knowledge management system that accepted works efficiently, and have significant impact on the success of imitation and adaptation process. o is the organizational structure including ICT uses, and q is the other conventional production factors such as the physical capital, the labor, the land and the natural resources. The coefficient □□□□□□, captures the degree of impact, i.e. the fractions of the related independent variables over the dependent variable respectively in the equation. The greater the share of related coefficient the higher the contribution to the innovated output**.** □is the error term that influence to the Pr as the endogenous and the exogenous considerations other than the main variables.

The major outcomes of the model 1 that illustrated in Exhibit 1 (appendix A) are; increased unit labor productivity, in turn relative decrease in required input use, and lower prices/higher profit, improvement in the product/service quality, efficiency/total factor productivity (TFP) increases, settlement and rise in the market share. Spillover effect plays the major role to form both of these outcomes and the output Pr in model-1, and implies that the contribution of variable s which act as the core variable, and the effect supposed to be clearly higher than the other variables. This should be ensured, most of the time, via the effect of purchased, imitated and adapted technologies from the outside sources which could be replaced with the older one that the firm has already employs. Knowledge flow also indicating via skilled workers' mobility.(Lenzi, 2009) Besides, due to the transferred, relatively new technological adaptation, the effect of ş to the skill level and/or knowledge stock of the company and workers, would be incremental in general as well.

The variable k acts only during the adaptation process of patented new technologies to form the licenses and implementing the license agreements. The impact and the contribution of the

coefficient □ on Pr should be lower compare to □ in this model. Because, □reflects the license fee of s which is include the previous term' knowledge cost that supposed to be higher than the cost of k.

The effect of coefficients □, and□, supposed to be lower than the former two cases. With the contribution of variable m it could be possible to determine the required level, the available amount and the gap of the knowledge input. After this ascertainment, firms supposed to decide whether to invest in innovative R&D works or not. Variable □ explains the consistency conditions among the various firm sources and facilities such as; human source, technological capacity, firm management, existing level of ITs and other organizational capabilities that reflects the realization conditions to the innovation targeted R&D works.

The total effect of q supposed to vary with the size of R&D activity. While the effect of capital factor which is due to requirement of financial resources should be a certain level, the impact of unskilled labor, due to the nature of R&D works, should be lower or in marginal level. For example, in Hall and others' study (2008:13) it's argued that such a capital investment as purchasing of new equipment should contribute significantly to process innovation.

Then, we should symbolize the outcomes of the model(1) as follows;

related with the unit labor productivity and marginal revenue,

$$Lv1>Lv0 \quad (2)$$

These are the unit labor productivity after and prior to the process innovation applications, respectively.

Similarly;

$$MR1>MR0 \quad (3)$$

and

$$MC1=P1<MC0=P0 \quad (4)$$

where MRs are the marginal revenue, MCs are the marginal cost of total production functions, and Ps are the prices, to the similar terms as of the previous statement of illustration (2).

Then, these effects allows to increase the total factor productivity and contribute some improvements in market share of the firm, compare to the previous situation.

3.2. Product Innovations

Although, our second innovation model bases on the equation formed by the same inputs those are given as in model-1, the share and the effect of most of the coefficients and the variables, due to the nature of the two types of innovative activity are quite different in content and in functionality.

Herein model-2, the firms faces higher cost of human capital due to longer time for R&D initiatives but receiving higher return due to the creativity comparing with the former model-1**.** The main reason of this is the human capital's intense efforts and contributions during the R&D process that focusing and intensifying on searching new inventions, instead of limited effort that spended during adaptation of the previously developed and patented technologies in first model. In Hempell and Zwick' (2008: 333) study, it's stated that stronger the participated human capital

in the form of tacit knowledge, higher the productivity of firms and their innovation performance obtained.

We set the model-2 as;

Pd□□k□s□m□o□q□ . □)

where, Pd is the innovated new product, k is the creative tacit knowledge embodied in human capital and utilized and transfered into the innovated product/process with increased employee participation during the R&D works. As the core variable, k is represents higher level of knowledge stock and human capital compare to model-1. s is given the externally spilled over knowledge that experimented and embodied in variety of explicit knowledge such as patents, scientific studies, conferences, and other sources that purchased and/or acquired by the firm. o is the organizational structure in terms of both location and working conditions that comprise also R&D partnership possibilities, and use of increased range and contents of ITs. Althought m is represents and serves as in the same direction with the model-1, herein, its contribution, due to the considerable impact on coordinated knowledge use during the innovative work process, supposed to be higher comparatively, q is vary accordingly to the peculiarity of the innovative activity.

The major outcomes and the output of model-2, that illustrated in Exhibit 2(in appendix B) formed quite different from which the one received as the result of process innovation works. Higher the impacts, accept □ and as the only variable s, of all of the coefficients to dependent variable in the model, higher the value added should be achieved.

By symbolize;

Because of;

Pd(□+□□□□>Pc(□+□□□□ (6)

Then, it becomes;

PdVa>PcVa, (7)

The main reason of the output differences, both in mean of content and functionality between two models is the time lenght and related cost of the R&D projects. The cost of last unit of time spend in R&D works is increasing function of the total spended time that increase as the time length extends and cause to rise in total cost of R&D expenditures. Because, as it's assumed, researches in product innovations takes longer time than the process innovations, and then the total cost of Pd becomes higher which in turn transfers into the innovated products' prices.

However, adjustment of the previous technologies in generally requires less employed human capital, less time and lower risk than the creativity targeted R&D activities. Therefore, time cost and failure risks of R&D investments are the major factors affecting the firms' R&D investment decisions on product innovation whether they choose or not. These additional costs of time and risks for product innovation targeted R&D works should inevitably transfers into the price of new innovated goods which is supposed to be higher than the prior technology embodied goods or services. Thereby, Pd, with the advanced technology should have higher monopoly rent and markup in the current market conditions.

In Ehrlich' (20007:13) study, increased returns of the invented goods explained with the impact of free trade and the scale economies phenomenon. According to the author; " since free trade and

open economy conditions effectual, investment in new production process or new products is subject to scale economies that make their returns higher in larger markets." With the new product the firm should have more chance to find new markets and expand the market share, since the new product submits more welfare than the conventional one that consumers already have. In Antonelli and Calderini, 2008:25, Morone and Testa's (2008:325) study it's stated that the innovated new products attracts new consumers and shift some of the consumers away from the products of rivals or cause reduction in production cost and prices.

Hence, the inventing firm can benefit such a monopolistic competiton market until incumbents and/or new comers either as an imitator or as the innovators enters the market. Besides, rises in efficiency, market share and turnover are seen as the other comparative advantages for the innovators.

4. CONCLUDING REMARKS

In this study, first, the economic fundamentals of the firm decesions related with R&D investments, explained, that the firms choice whether targeting the process or the product innovations. Within this respect, both the capacity and the cability of the firms has considered as the major determining factors. Then, in developed models, beside the human capital sources, the existence of knowledge management system and, the flexibility and adaptability of the organizational structure as the other crucial determinig factors are taken as the new endogenous variables.

The available explicit knowledge or the exposible tacit knowledge which are new to the investor firm, considered as the core input for the R&D activities in the models. By entering the knowledge management system into the models, it has assumed that the possibility of categorically identifying and determining the required, the existing, and the inadequacy level of the knowledge input could have been increased. In this way, facilitating the spillover effect and utilize the tacit knowledge capacity efficiently supposed to be raised in corporations. Because, efficiency of this knowledge production and management process contributes positively to the accumulation of knowledge input and innovation targeted R&D activities. Coherence with the theoretical aspect, it's required that structured and a good knowledge management system supposed to maintain also continuity in spillover and knowledge renewing efforts. Renewing the organisational structure also required for responsive and a succeesfull innovative activity.

When the introduced models compared, what first realized is the different content of the outputs that vary accordingly to the type of innovative activity. The results, actually reflects the impact and the contributions of the variables. For example, while spillover variable acts as the primary dominant factor in process innovation works, the role of tacit knowledge has seen as the key determining factor in product innovation activities.

In a successful product innovation, the firm should have secure a patent that gives a monopoly rent and larger markup. Furthermore, rises in market share, turnover, employment level and total factor productivity should be achieved as well. Nevertheless, since the process innovations achieving only by copying the previously developed technologies, the yields are not consistent with the product innovation cases, and supposed to have less returns.

On the other hand, "the political stability" also effects the basic economic indicators such as interest rate, exchange rate, and investment decisions including R&D investments which in turn contribute to better utilization of both of the intellectual properties and human capital sources.

Thereby, the relationship between "policy and R&D efficiency" should be included in the endogenous growth models that would be subject to the future studies.

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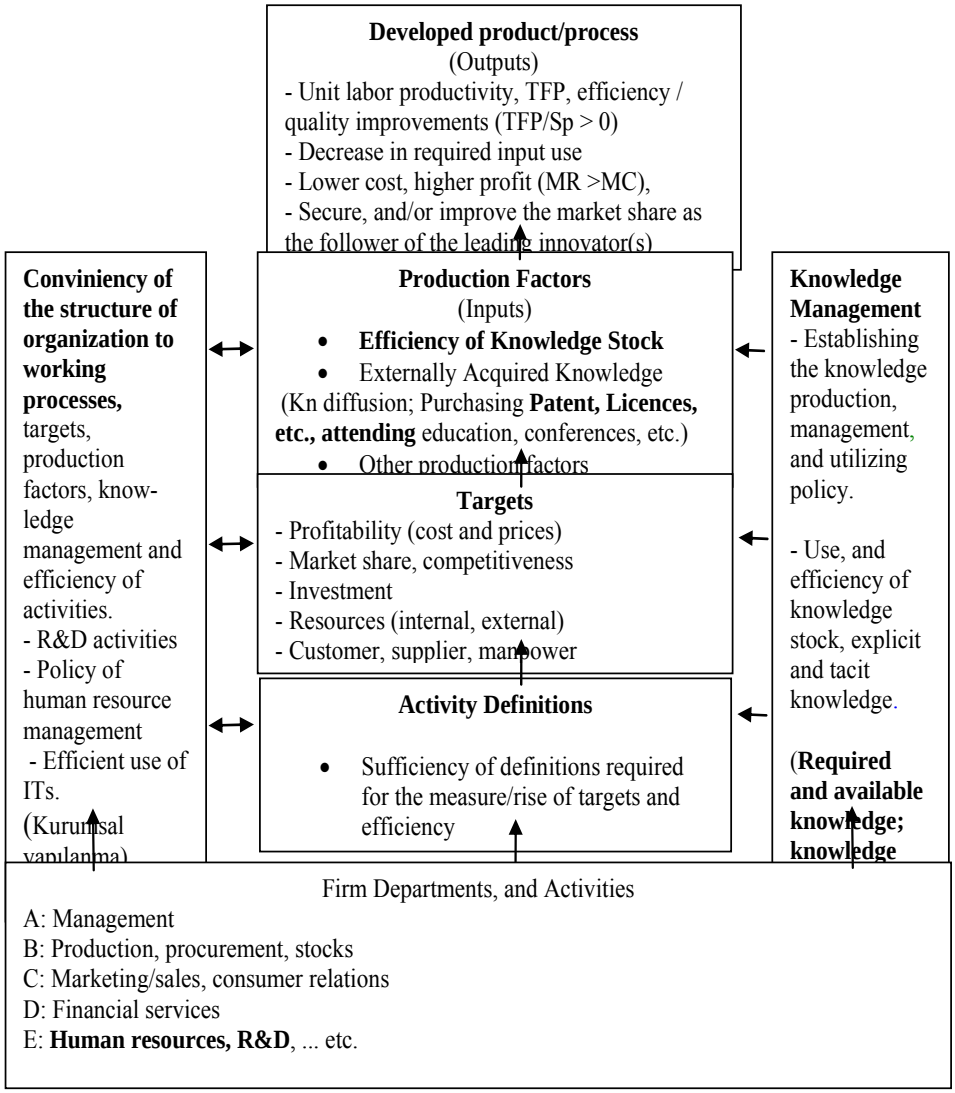
APPENDIX A: Exhibit 1**:**

Efficiency in Firm Operations; Activity Definitions, Targets; Process Innovation/Imitations Organizational Structure and Knowledge Management



APPENDIX B:

Exhibit 2:

Competitiveness; R&D Process, Product Innovations, Organizational Structure and Knowledge Management