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The Knowledge Factor, the Components and the Innovatıons

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Abstract

In this study, the knowledge as the production factor considered as the function of the variables of employed human capital, technological spillover, and information technologies, and analysing within the context of the determined model assumptions. Within this respect, the factor variables employed in R&D works, are going to investigate either as an independent variable and as the complements that interacts with the other variables or the factor components. The firms engage in product and process innovations targeted R&D investments which have quite different composition in terms of the input and nature of the output. Therefore, the combination of the optimal factor components should be change accordingly together with the kind of innovative activity. Then, the marginal return to the invented products varies. The firms' R&D investment decisions should be effected by both of the availability level of factor variables and macro-economic conditions. On the other hand, related with the supply conditions of the research and development (R&D) sources, the external environment beside the firm's own capacity, should also be effectual. Thereby, while the human capital intensity states the absorption and the adaptation capacity of new technologies which compose of the major capabilities internal to the firm, the basic external environment has forms from the existence of the facilities such as the legislation on intellectual property rights, availability of financial, legal and institutional means that should be effectual on the R&D investment and technological improvements.

Key Words: *Knowledge Factor Components, Human Capital, Knowledge Spillover, Information Technologies, Product and Process Innovations.*

Introduction

The accelerated changes in the base of competition from price to technical inventions, essentially forcing the firms to use "the knowledge input as a production factor". The fundamental economic reason behind this outcome having been the productivity improvements by employing the knowledge factor efficiently. The R&D sectors, and the information and communication technologies (ITs) are the leading activities employing the knowledge factor extensively. The knowledge factor is arising as the major affecting factor to the innovations as the output of the R&D operations and the fast improvements in ITs.

While the current skill composition of the employed human capital (Lh) effects the efficiency and accumulation of the knowledge factor, it also plays crucial role to succeed in facilitation of the other factor components, the knowledge spillover (Sp), and the ITs. Within the certain circumstances there are bilateral interaction between the human capital (h) and the other factor variables or the components. This relationship effects the marginal cost and the marginal return to the knowledge factor employed in product and process innovation activities.

When the firm's current level of knowledge stock relatively higher, the positive effect of the Sp and the IT should be expected on firm's own R&D activities, due to the conditionals which the knowledge stock creates, the increasing marginal rate of return, and the increasing scale effect. The higher marginal return should be realized due to increasing returns to each of the factor components that in turn allows to reduced marginal cost of the production. Then, to achieve the possibility of increased contribution of the components, Lh, Sp, IT, to the accumulation of the knowledge factor. Then get the higher marginal return and entails reduced unit cost of innovated goods and as the result, better competitive conditions to stay in the market should be ensured.

This paper is organized as follows. The definition of knowledge factor and the factor components given in section two. The model and the related literature analyzing in section third. Then the fallowing section deals with the concluding remarks.

The Knowledge Factor, the Components and Innovations

The Knowledge Factor, the Components

We define the knowledge factor as the intellectual contributions of human capital employed in R&D, and other business processes such as production, management and marketing activities that have realized by utilizing; worker' own tacit knowledge, skills, adequacies, values, observations, experiences etc., and the available knowledge or technology stocks including information technologies, either belongs to the firm or acquired via spillover. By definition "the knowledge as a production factor" should be taken as the endogenized factor in both R&D activities and the production related sectors, but the comprised components of Lh, Sp, and ITs vary in terms of initial internality/externality conditions, those are which analyses in detail within the context of the model presented in the next section.

Under the circumstances, accumulated cost of the components, comprised by wage payments to the skilled workers, the costs of acquiring the externally created and diffused knowledge and the ITs. Accordingly, marginal cost of the knowledge factor comprise of the components' marginal costs but vary with the kind of R&D activities whether targeting the product or process innovation. Product and process innovations are the knowledge factor intensive activities to the firms and industries. (Griffith and oth.,2006:10) The shares of the factor' components, due to the different peculiarities of the R&D woks, vary with the kind of the innovation. Thereby, compose of "the optimal factor components" which in turn effects the yields of the productivity driven R&D based final products change accordingly to the type of innovative works.

The factor combination, in terms of securing the factor efficiency, requires gathering the optimal factor components coherent with the innovative activity. The dimension of the optimal factor components, as initial conditions to increment and maximize the factor's efficiency, requires to countervailing the due cost of each component that already have done at time t-1. Hereafter, adjustment of the components throughout the R&D processes should be an organizational matter for the firms to be tackled.

The R&D works and the factor market conditions or availability of the components Lh, Sp, IT are bilateral effectual phenomenon. While the conditions in component markets and R&D investment decision process affecting each other, the variables Lh, Sp, and IT are serves as each other's complements in the meantime. The degree bilateral requirements of the knowledge factor and the R&D activities should be determined in such a free market environment in which the necessity coincides within the range of relevant supply and demand conditions. Thereby, availability of the knowledge factor in the economy to use in the R&D activities should determine with the interaction of the demand for R&D works, and supply of the factor components. Because not only the concordance of specified R&D environment but also the supply and demand conditions of the factor components effect the R&D investment decisions.(1)

Product and Process Innovations

i. Product innovation efforts comprise of the activities that allow creating new product, and decreases in the production cost via creativeness and exploration of the new knowledge. This, usually associates with the new innovated goods, the quality enhancement of existing products and the creation of new markets.
ii. Process innovation is defined as the imitation/absorption efforts, to include all activities that lower a firm's production costs through internalizing the externally created new knowledge. Thereby, the firms gains in rationalizing or increasing the flexibility in production activities, and improvements in the quality and performance of production or deliveries systems. By definition, while this kind of innovation demands R&D works to application of new process as commercially, it does not require to attend a new patent. (Wiethaus, 2006:572; Evangelista R. and Mastrostefano, V., 2006:249; OECD/Eurostat, 2005)

Theoretical Predictions and Hypothetical Analysis to Component Optimality

The Literature Review

What kind of conditions affecting the R&D decisions of the firms that they supposed to choice the innovation type whether product or process one they have targeting. Despite the demand and the supply conditions are the major determining factors of the innovation strategies of the firms, they should merely tend to behave and act toward the innovations whenever the other market conditions appropriated. The required factor components should be available in desired level. But, difference in the composition of the factor components could be arise due to the different prospects of the relevant supply and demand conditions to the firm, and also the differences in the firm size together with the market size. Thereby, type of R&D investment decisions would have affected by these conditions.

Demand for R&D Resources and Absorptive Capacity

While availability of the knowledge factor component functions as the key determining factor in firms' R&D decisions, other macro economic conditions also have substantial effect on R&D works. Such conditions as the size of the economic activities, the level of knowledge/technology stock, and the convention of competing have to be considered within the context of the absorptive capacity; which could be specified as the prerequisites to the R&D works. Conditions to R&D demand and the absorptive capacity of innovations discussed quite detail in innovation related literature.

Jefferson and oth., (2006:350) emphasize that the regulatory environment, incentive structure, and ownership structure are given as the affecting factors to the demand for R&D resources revealed. Innovation absorptive capacity of economies investigated in detail in Evangelista and Mastrostefano (2006). According to the authors (2006:250,251), concentration in innovation activities changes with the technological appropriateness level of the firms. The presence of the strong appropriateness conditions favours to the formation of highly concentrated industries and markets. In the conditions with less or limited appropriateness, there must have been the barriers such as; the economies of scale and scope in R&D, tacit nature of less formalized innovations and the cases which associates to high investment in fixed capital and embodied technology.

On the other hand, the authors gives also the sector specific nature of innovations which could be related with the innovation absorptive capacity; as the structure of industry-specific technologies, role of institutions, networks, process of generation and diffusion of knowledge. The other obstacles faced by firms to innovate specified in the mentioned study of Evangelista and Mastrostefano (2006:261) as; the lack of financial resources, qualified personnel, and information on technology and markets.

In Lall's research (2003:9,10), the absorptive capacity with respect to the stimulation of private innovations, discussed within the range of the presence of intellectual property rights (IPRs). The market share for particular innovative activity in global R&D sectors, and the level of demand creating purchasing power to the new products in local market are seen as the major factors that explains the strength of IPRs. Besides, the availability of deployment conditions of new technologies, considered as the other economic benefit providing element. The presence of such conditionals, in return, should have positive effect on absorptive capacity to the means of improving the R&D activities.

Supply of R&D Resources

The R&D investment decisions of the firms aims to allocate their resources efficiently in the sense that to get the maximum cost reductions. Having been the scale economy and higher profitability should create required funding to the R&D operations. Such internal capabilities as an important source of innovation finance should have crucial effect on R&D decisions. The most effective internal sources, other than financial facilities to the firm R&D activities, are the existence and the utilization of the knowledge factor components. Presumable, larger companies ensure the required level of knowledge factor with higher probability. Associated with the firm R&D targets; the human capital intensity, the absorption and adaptation capacity of externally created technology and facilities to implement the ITs should be designed and planned in the organizational structure of the firms.

R&D investment plans is seen as the function of conditions and expectations such as the sales, the profits, and the industry concentration in Jefferson (2006:346). As R&D decisions considered as the productivity improvement endeavours for the firms, supply of the firm sources arises as an important determining factor. Beside the internal sources either financial or other than financial facilities, external environment through knowledge diffusion affect the supply of R&D resources as well. For example, a strong patent protection, by restraining the imitation possibilities, induce the firms facing restrictions to execution of the R&D decisions.

In Jefferson and others (2006:350) the matter discussed within the respect of funding the R&D activities and shareholder base of the firm. According to the authors; either the profitability and retained earnings which is considered as the partial determining factors to the firm R&D supply or outside financing and the ownership structure should be effective on the R&D investment operations.

Cooperations with the other actors and the stakeholders operating in the market contributes to endogenize externally created knowledge via spillover. This examined in the research of Leeuwen, G.V. and Klomp, L. (2006:373, 374). The authors highlights that the firms may absorb knowledge from the environment via supplier-producer-customer interactions or may build up and maintain their own knowledge bases via R&D investment and R&D co-operation.

The Model

Endogenous growth literature analyse the economic growth within the context of continuity in technological developments which have attributed to the creativeness of the skilled human capital as the major productive source. In the model presented here in this study, human capital (1) considering as an endogenous variable, and analysing as the inputs interact each other variables/components, and then the knowledge factor forms. The other components included herein this model Sp, and IT are the variables either exogenously or endogenously created but internalized during the R&D activities via human capital, and embodied in the output as the result of innovation activity. (2)

The model arguments denoted in an equation;

$$Kn = \beta Lh, \lambda Sp, \delta IT \qquad (1)$$

where, the dependent variable Kn refers to the knowledge factor, and independent variables/or factor components Lh, Sp, IT respectively refers the human capital, the knowledge spilled over and the information technologies. The coefficients , λ, δ gives the elasticity's of the related variables that effects Kn.

We predict that there are number of competitive firms works in the sectors and in free market conditions, and involves to the product (i) and the process (j) innovation activities. Firms employs knowledge factor as the only/major production factor which is consist of the

(1) For example; in Ehrlich' study (2007:8), "effective human capital formation" or as it's considered here in this study, conditionality to the supply of the component 'Lh', related with the educational attainments and expenditures, accepted as an "input".
(2) IT would be either external or internal to the non-IT producing sector in initial term of the R&D process.

The IT figures in Mendonça's research (2006:789) given as; "non- IT sectors' contributions to the increase in IT patents counted as 27 % of total IT patents in the period 1981-96 in the US".

Components, Lh, Sp, IT given in equation 3.1. The demand for the goods which derived from both type of the innovations and the profitability of these goods that serves as incentive to the firms, considered large enough to stay in the market for the firms. The firms operate in economic sectors supposed to involve to the (i), and the (j) type of R&D activities due to the requirement to meet the consumer demand formed by the changes in consumer tastes and preferences.

Firms should employ the factor components in innovation activities with the aim of having more profitable and larger market shares than the current level. Therefore, reaching to this target requires focusing on the R&D activities that considered being productive and creative. On the other hand, the components by interacting each other, acts as the complements, and

Stimulates, effects, and contributes to the efficiency both of themselves and to the form of Kn. Thereby, higher the qualification/adequacy of the components, due to increased consistency, allows higher the positive contribution of the efficiency of the other component. Since the nature of the R&D activities vary with the type of the innovations, the quantity, the content and dispersion of the components should have differentiated accordingly. Under this assumption, we could make two predictions.

First; both of each component' marginal effect and the level of the complement, depends on the elasticity of the knowledge factor (Kn) with respect to the related components. The coefficients, β, λ, δ represents the relevant elasticity of the Kn with respect to the components as given in equation (1), and assumed changes across the innovations, in line with the industry characteristics.

Following this, secondly, we could predict that the combination of optimal factor components, βLh, λSp, δIT changes both with and within the type of innovative activity. The reason of this is the changing features of the key components that required to be employed parallel to the characteristics and type of the innovations whether targeted to the patented new product or an imitated good (3).

The only difference on combination of the optimal components related with the innovations comes from the accumulated marginal costs and returns to the components. This originates and reflects the difference between the market value of innovated/patented final good and the price of imitated good developed during the process innovation. The major reason to that the research activities related with product innovations requires relatively more comprehensive creativeness and prolonged period of the time. Thereby, the return received from the invented goods should be higher due to the monopolistic price structure under the patented/protected mark-up system which supposed to become widen throughout the markets. That is;

$$MPi > MPj \quad (2)$$

Proofs to these predictions examined within the respect of the conditionals to innovations, given in section 4.2 .

3) In a process innovation activity; for example, due to execution of new international banking regulations and governance rules, while the spillover component should be the key, for the activities such as to publicize the audited annual balance sheets and the financial reports of the companies the other compenent, the ITs should be the key. For the product innovation cases it has considered that most of the time, Lh should be the key component.

Variables, and Analysis to the Predictions

Human Capital

There are various definitions on human capital in knowledge/human capital related literature. Ling and Jaw (2006:380-381), define human capital as the workforce who possess critical knowledge, skills and talents for a firm's success. Further emphasize on human capital given in mentioned study as; a) human capital theory relates with 'investment decision on training and education', b) resource-based view of the firm theory alleges that 'competitive advantage can be achieved through the leverage of a firm's human capital', c) in the transaction cost economy theory, human capital 'employed in the most efficient way'. In Ehrlich (2007) 'the creative knowledge' explained as the knowledge which flows out of ideas, originating with scholars, scientists, inventors and entrepreneurs.

Some of the researchers argue that the human capital should be employ in three different areas. In Ellis and Roberts (2002), the human capital should work in production and R&D works or engaged in education. The skilled level of the workers employed in production sectors, requires being coherent with the technological development level of physical capital goods employed in the same sector.

However the labours employed in R&D sector should be hired in order to assess, and improve the new knowledge which derived from the relevant technologies and spillover process then use it in innovation or enhancing activities of the quality and productivity of the existing products. Therefore, the skilled level of R&D labour requires being compatible with the nature the technological level. To create the competitive advantage, employing the skilled human capital, either in the R&D works or in the adaptation process of diffused knowledge arise as a crucial factor.

Sutthiphisal (2006:3) deals that the existing appropriate technical skills or human capital among the population, significantly effects the inventive activities. The human capital in Kurtoğlu (2006), considered as basic source of the knowledge factor for either the cases of knowledge accumulation or spillover. In Ehrlich (2007:3), the continuity of knowledge accumulation related with the level of investment in education. Such a high level of education investment ensures that next generations should benefit as the productive knowledge rises. Recent studies also deals with the relationship between skill level of human capital and productivity. In Tang and Wang's research (2005), the authors emphasized the empirical results to the productivity increases which positively correlated with the university graduate or the level of educational attainments of employees.

In this study, human capital considered as one of the three components of "the knowledge input" which is also accepted as a production factor. Within this respect, the variable Lh, employed in innovation activities both as a direct component, and as the complement to the other components. Employing the component Lh, directly in the R&D investment function as the internal variable. Introduction of the variables Sp and ITs which initially external to both of the product and process innovation activities, should be utilized via Lh, then becomes internal. So, while the creativity characteristics of Lh stand out first within the product innovation activities the complementary feature of the variable prevails in process innovation cases.

Because of the contribution of the component Lh to the invented/patented products, an important difference between the marginal values of patented and imitated goods constitutes (equation 2). Then, Lh become the essential variable with respect to accumulation of knowledge factor and the technological improvements. The coefficient β in relation with the innovation activities, i and j, become;

$$bi > bj \quad (3)$$

In the mean time, this reflects the price-mark-up difference between the two kind of innovations. The patent-determined mark-up is the ultimate incentive to the human capital investments in (i) that is originated by the creativeness of the component Lh. Then, we conclude that such an incentive would encourage and stimulate (i) targeted R&D investments.

The policies which bring about improvements in quantity and quality of the skilled human capital should have also positive effects on accumulation of knowledge input in the economy. An increased investment incentives to the human capital, by enhancing policy interventions on schooling in general and encouraging notably to the vocational high school/college, and university education, serve as the structural conditionality to secure the increases in accumulated marginal returns. High rate of return to the human capital investment argued in Ehrlich's (2007:9-10), as the engine of growth, and related directly with the free market conditions in which resource allocation decisions given in market, operates under the relevance of related legislations (4) and the executions.

Within the respect of inventions, the efficiency of human capital depends on the system of higher education which is whether specified and interact with the desired technological progressive fields of the economy. Therefore, in order to attaining to the demanded technological development, the policies related with the vocational/university education and industrial performance/technological efforts, ought to be coherent with each other.

Knowledge Spillover

The knowledge/technological stock created by the other firms and/or economies in previous periods that would be spillover and acquired mostly by purchasing while it's in the form of citations from patents, licences, know-how, consultancy services, publications, and via international trade, direct foreign investments, and attending to the seminars, conferences, panels, congresses, etc. As one of the major way of the knowledge diffusion, facilitation of the process innovation via imported and imitated technology transfers, significantly contributes to the economic growth. There are numerous studies in knowledge related literature in which the spillover effects examining in relation with the competitiveness and productivity improvements. For example, Cameron deals with the situation in his (2005) study, by emphasizing that the diffusion effect make possibly higher growth rates to the follower country compare to the technological frontier country.

In Cincera, M.(2006:676), technological spillover regarded as one of the determinants of productivity together with the firms' own R&D stocks. According to the author, the effect of the former has been found positive and significantly higher than the latter's. In Yao (2006:121) spillovers, together with the R&D, and other firm characteristics, taken as the human capital investment or knowledge input. However, Saaskilahti (2006:716), argue that a fraction of R&D output is authors the industry stock as well the academic and industrial spillover contribute to spilled over to the rival firms without any cost or

4) The regulations given Ehrlich's (2007) as; "the rule of law, protection of property rights, (including intellectual property), less regulated labor markets, and greater openness to external trade and immigration" compensation. The spillover activities seen as part of the scientific output in Adams and Clemmons (2006: 22) research. According to the authors the industry stock as well the academic and industrial spillover contribute to scientific output.

In any case, spillover of the externally created knowledge would effect positively to the innovator firms' R&D costs, by allowing the firm to reduce the R&D expenditures, due to the adaptation of previously innovated and imitated technologies. Here, this effect taken relatively higher in process innovation case compare to the product innovations. The reason of this approach depended upon to the assumption that "the elasticity of knowledge factor with respect to the coefficient □□ considered higher to the imitation case."

That is;

$$\lambda j > \lambda i \qquad (4)$$

Elasticity of the coefficient λ, suppose to be higher compare to the other coefficients' β and δ, in imitation, and it becomes; ; $\lambda j > \beta j$ and $\lambda j > \delta j$. Then, Sp arise as the major component of knowledge input for the process innovation case which contains higher marginal product, compare to Lh and ITs. And facilitation of the other factor components of Lh and IT, contributes and complements to the adaptation of the imitation process, but with lower marginal products. Thereby, optimal combination of factor components should be provided accordingly.

When the elasticity of Kn with respect to the other components, Sp and IT in both of the sectors, i,j , appropriated equal, so that the coefficients becomes equal $\beta i = \beta j$ and $\delta i = \delta j$ and the marginal products of Lh and IT should be equalized. Following this, and with determining effect of equation (4), the accumulated marginal product of the knowledge factor and, the market price for the final output of imitation targeted R&D activities should be higher in (j). Then it becomes;

$$MPj > MPi \qquad (5)$$

The condition illustrated in equation (5) should occur, under the relevance of certain circumstances, which caused by the difference, only in the Sp effects of the two sectors.

Information Technologies (ITs)

Both of the hardware and software industries are included within the content of ITs sector. While the software consist of the programs related with the personal computer software-operating systems, media player software, hardware comprise of microprocessors, computers, cable and wireless networks of internet and telecommunication, and related instruments, equipments, materials.

The relationship between the pattern of ITs' adoption throughout product and process innovations and productivity improvements is found positively in the searches of Evangelista and Mastrostefano (2006:255), Maliranta and Rouvinen (2006:613), Papaioannou and Dimelis (2007:188, 192).

Mendonça (2006:778, 780), deals with the development of electronic microprocessors which has considered as the key invention behind the IT revolution, and gives explanatory figures in detail on the subject, for US economy. The author emphasize, by ascribing the Jorgensen (2005), that "the contribution of ITs to the productivity improvements in the US has reached almost fifty percent in five years term of 1995-2000." (5)

IT adaptation causing both of the relative abundance of skilled labour accumulation and increased wages.(Beaudry and others, 2006: 27.) Besides positive effects on productivity, using IT stimulates the creativity and innovation activities also, due to the skilled human capital intensive structure. In OECD search (2003: 39-40,57), a positive impact of ITs on labour productivity and some evidence found that IT capital had larger impacts on labour productivity than other types of of capital. The contribution of IT manufacturing to aggregate productivity growth in technology leading five developed economies i.e.; US, Japan, Sweden, Ireland, Finland and Korea explained as the percentages of ranging from 0,45 to 1.02 in 1996-2001 period.

In the research of Asai (2006), IT capital stock, together with the non-IT capital stock taken as the complementary of each other and that both of these capital stocks are considered as a substitute for labour. These ascertainment implies that use of ITs functions just as the real production factor. Here in this study, ITs considering as a component to the knowledge factor and the complement to the other components Lh and Sp. However, as it's analyzed in Mendonça (2006), the IT component of the firms' patent based technology portfolio changes by industry. This explains the level of marginal return to coefficient δ that should be change with the peculiarity of the sectors in which degree of the intensity the IT component employed. This implies that the optimum utilized level of the coefficient, δ vary, parallel to the feature of the industry in which the R&D works activated.

Concluding Remarks

In this study, as we considered 'the knowledge' as a production factor, and presented the model equation in which the knowledge input taken as dependent variable, and comprised as the function of three independent variables, Lh, Sp, and ITs. Within the context of the model, while the literature related with the variables investigating, the relationship between knowledge factor and independent variables examined by interacting the components each other.

Due to the peculiarities of the sectors in which the innovation activities held, and the knowledge factor correlated with; the elasticity of the knowledge input with respect to the components' coefficients, β, λ, δ, differentiated, and "the optimal factor components" taken as the function of the interaction of supply and demand conditions. The major reasons behind the changes in the "combination of optimal factor components" are taken as the sector specific conditions of the industries and distinctions in the scope of the innovative activities.

As it's argued as the central prediction in the model, increasing returns to the knowledge factor originates not only from the creativeness of the human capital but also the contributions of the other factor components, Sp and IT. Regarding with the model assumption, to secure the knowledge factor having increased return, three of the components supposed to be functionalized effectively during the product and process innovation targeted R&D works.

(5) In the same study Mendonça analysing further, how the ITs developing outside IT sectors, i.e. in non-IT industries such as; photography, photocopy, motor vehicles and parts, aerospace, and machinery. The non-IT sectors contribution to the increase in IT patents accounted 27 percent in the period 1981-1996.

The return to the knowledge decomposes accordingly to the innovations. Because of the marginal returns differentiates with the innovated products; those are the one based on the patent-backed R&D outputs with the higher mark-up prices, and the other determined by the imitated/adopted products with relatively lower prices.

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