How Innovations affect Firm's Productivity? A literature reviews

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Abstract-*Improving productivity is one of the vital tasks of an enterprise in the era of globalization. In which, innovation is widely considered as an essential solution to enhance the firm's productivity. However, there is still much controversy between concept as well as the measurement of innovation. Besides, the impact of innovation on firm's productivity is questionable, and most studies have focused on the direct effect. This paper has comprehensively analyzed the impact of innovations on productivity, including both direct and indirect impacts. Accordingly, direct effects through private rate of return reflect the investment efficiency of firms, the indirect impact through social rate of return reflects the overall impact of innovations on society and is interested in the governments. The study also reviewed three direct impact measures, the link between them and the important role of R&D consortium in improving regional and global productivity.*

Keywords- *Innovations; Productivity; Research and Development; R&D Consortium; Economic Models; Rate of Return*

1. INTRODUCTION

In the current globalization era, competitive pressure is very strong in all field of business, especially those in the manufacturing sector. Consequently, improving productivity is one of the vital strategies for increasing the competitiveness of enterprises.

Measurement of investment efficiency is one of the most important issues for policymakers, researchers, especially business managers. In practice, measuring investment efficiency is a crucial step influencing future investment decisions. However, it should be noted that different participants are interested in non-identical issues in research and development. Accordingly, researchers are often concerned about socio-economic efficiency. Economists, managers focus on the efficiency of the private sector. Business owners are interested in profitability, which is the basis to help them make investment decisions (Hall et al., 2010)[13].

Further, the concept and measurement of innovation, as well as productivity, are debatable. Each stage of development, these concepts have changed to fit the reality of economic activity. This change also entails an adaption of measurement methods that lead to inadequate and complicated productivity analysis.

In addition, because of fierce competition in business activities, innovations are always considered as an essential process to keep firms growing. However, innovations are costly, and it also does not warrant the expected results. Hence, not all firms can afford investment for innovations, especially small and medium enterprises. Therefore, the decision to invest in innovations, or buy innovations usually cost times to give.

On the other hand, the impact of innovations on productivity is not likely to be positive since it depends on the investment efficiency and purpose. Enterprises actually have many alternative methods to capture innovations. They can invest in R&D, buy a part or completed innovations or invest in other channels such as human resources by hiring experienced employees or Chief Executive Officers. That is also a popular trend nowadays. For innovations, there are 04 firm groups: (i) invest in R&D to use only for themselves; (ii) investment in R&D for use and sell; (iii) invest in R&D solely for sale; (iv) buy innovations. For each of these firm groups, the impact of innovations on productivity is different.

More importantly, the impact of innovation on productivity is not only direct but also indirect. Direct impact refers to companies directly investing in R&D and then use it to improve firm productivity. However, the innovations outputs of a firm can influence the rest of the industry and society through spillover. This indirect effect helps small and medium enterprises have more choices and promotes the development of society. Therefore, when studying the effects of innovations on productivity, it is dangerous to study just the direct effect, while ignoring the indirect effect. Previous research has shown that the direct impact of innovations, through R&D, has a strong and obvious impact on the productivity of the enterprise. However, indirect effects are not entirely studied. Therefore, this paper provides a comprehensive analysis of the possible channels that innovations can influence productivity.

This paper includes three two sections. The first part introduces the concept of innovation, productivity as well as measurement methods. The second part describes the impact of innovations on productivity, not only direct effect, but also indirect impacts. Further, the author also introduces an interactive platform of innovation, so-called R&D consortia, which is the current leading trend over the world.

2. DEFINITIONS AND MEASUREMENTS OF INNOVATION AND PRODUCTIVITY

2.1. The concept of innovation and its measurements

One first definition of innovation was developed by Schumpeter (1934)[28]. Accordingly, Innovation can be defined as "the introduction of a new good, or a new quality of a good" and innovation process is the introduction of a new method of production. The measurement of innovation at this time is mainly done by surveys. The most famous work is the UK's 15-year Science Policy Research Unit study (1970-1984), which included 4,000 innovations in the manufacturing sector (Freeman and Soete, 1997) and the 1980s study of Acs and Audretsch for US firms, which involved 8000 US innovations (US Small Business Administration program - SBA). In order to be more conducive to innovation research, SBA has redefined innovations as "a process that starts with an invention, proceeds with the invention of a new product, process or service to the marketplace". This definition provides economists with a better view of innovations. Accordingly, innovation not only includes the production process, but also organizational and market change (National Research Council, 2014)[24]. This definition is particularly useful in measuring innovations in non-manufacturing sectors.

In addition, both surveys measured innovation as an observation unit. The analysis is based primarily on the data of the innovative firms and ignores the fact that data from non-innovative companies can also be useful. On the other hand, measurement problems are one of the weaknesses of the study of innovations when it lacks consistency between studies. To be able to deal with this problem, Oslo Manual (OECD-Eurostadt, 2005)[25] considers innovations as "An innovation is a new or significantly improved product or process in business practices, workplace organization or external relations". This has been a common definition in the current. Accordingly, innovations are measured through "innovation activities", including R&D expenditure, capital investment (patents) and training (R&D employees).

2.2 The concept of productivity and its measurements

Productivity is widely acknowledged as the number of outputs per unit of input (Hall et al. 2010)[13]. This is also a common method to calculate productivity. There are two ways to measure productivity. The first is to measure productivity through labor input, also called labor productivity. Accordingly, productivity is calculated through the growth of output per unit of labor used. This has the advantage of being easy to calculate and data availability. From a macroeconomic perspective, it can be used to calculate both the market and non-market sectors of the economy. However, this calculation only reflects the change in output based on the labor input, so this is a weak indicator that can reflect firm productivity. The second way is to measure productivity through the change of all input simultaneously, also called total-factor productivity (or multi-factor productivity). This index is measured by the growth of output per unit of inputs used.

Productivity is initially measured as a function of production as follows (Cobb and Douglas, 1928)[3]:

$$Qit = A_{it} L_{it}^{\alpha} K_{it}^{\beta} \quad (1)$$

Where *Q* is the output; *L* (labor), *K* (capital) are production inputs. *A* is the total factor productivity, *i* is the entity, while *t* is the time. For calculations and measurements, the economists take logarithm this equation:

$$LogQ_{it} = LogA_{it} + \alpha LogL_{it} + \beta LogK_{it} \quad (2)$$

Set $LogQ_{it} = q_{it}$, $LogA_{it} = a_{it}$, $LogL_{it} = l_{it}$, $LogK_{it} = k_{it}$, equation (2) can be expressed as follow:

$$q_{it} = a_{it} + \alpha l_{it} + \beta k_{it} \Rightarrow TFP = a_{it} = q_{it} - \alpha l_{it} - \beta k_{it}$$

α and β are the elasticity of labor and capital respectively on the output. They are usually fixed and determined by technology.

Total-factor productivity is a favorite indicator since it can reflect the volatility of all inputs; therefore, it is the more appropriate method to reflect productive efficiency than labor productivity. However, the TFP calculation should include deflation and quality adjustment (Hall, 2011)[14].

Additionally, another important issue in calculating productivity is output measurement. The output is commonly measured by sales, value-added or gross output. Three different ways of calculation may lead to unidentical results. Gross output is the value obtained when combining both inputs (labor and capital) and intermediate inputs. Value-added is the output acquired when combining labor and capital. Sales are gross output minus inventory. In these three ways, value-added is most commonly used for three reasons: (i) the materials-output ratio is heterogeneous; (ii) it is challenging to calculate intermediate inputs; (iii) limited data availability (Hall et al., 2010).

3. RELATIONSHIPS BETWEEN FIRM' INNOVATIONS AND PRODUCTIVITY

Innovations can improve productivity in two ways. Firstly, it can directly improve productivity by increasing quality, reducing production costs, or improving outputs in some way. The results of innovations are used for the firm itself and thus increase profits, lower prices, and improve the efficiency of resource allocation. This channel is also called "direct effect". Secondly, innovations can affect the rest of the industry or society through spillover effects. Accordingly, when a business performs innovations, the rest can also gain many benefits through the purchase of products or the dissemination of knowledge or trained human resources. This is a so-called "indirect effect".

However, it must be noted that the effect of innovations on productivity is not the same between firms, industries or even when we used a different measurement. In fact, this impact depends on many things, such as firm strategy and characteristics, specific project innovations and macroeconomic conditions. Hence, in this chapter, the author tries providing comprehensive evaluations.

3.1 Modeling the direct relationship between innovations and productivity

There are three major methods for modeling the direct relationship between innovations and productivity.

**** Augmented Production Function:***

Extending the Cobb-Douglas function, we have a new equation as follow:

$$Q'_{it} = A'_{it} L_{it}^{\alpha} K_{it}^{\beta} I^{\delta}$$

Where *I* is innovations. Following the above procedure, we have:

$$q'_{it} = a'_{it} + \alpha l_{it} + \beta k_{it} + \delta i_{it}$$

$$\Rightarrow TFP = a'_{it} = q'_{it} - \alpha l_{it} - \beta k_{it} - \delta i_{it}$$

Through the above equation, we can see that, in case of other factors remaining, innovations can directly increase production output. However, productivity improves or reduce depending on the change of output level and input cost. Besides, this is only the basic model. In reality, the effect of innovations on productivity is influenced by many other factors and this impact is also different for a particular situation.

**** Knowledge production function (KPF)***

One of the first contributions to the literature on innovation input-output relationship is Griliches (1979) with the introduction of Knowledge Production Function (KPF). This is basically a function explaining the transformation process from innovative inputs (such as R&D investment,..) to innovative outputs (such as patents). In later studies, Raymond et al. (2015) develop this function through a dynamic approach as follow:

$$y^*_{1it} = \vartheta_{11} y_{1i,t-1} + \vartheta_{13} y_{3i,t-1} + \beta'_1 X_{1it} + \alpha_{1i} + \varepsilon_{1it}$$

In which, y^*_{1it} is the propensity to achieve product innovations at the time t in the firm i; $y_{1i,t-1}$ is the pass occurrence of product innovation; $y_{3i,t-1}$ is past labor productivity, x_{1it} is past R&D; α_{1i} unobserved firm heterogeneity; ϑ_{11} is the effect of past innovation occurrence; ϑ_{13} captures past productivity on the tendency of innovate; β'_1 explains the effects of the previous R&D, and ε_{1it} is the error term.

**** Crépon, Duguet and Mairesse (CDM) model***

The relationship between productivity, innovation and research investment are introduced by Crépon et al. (1998)[5]. They present a structural model that explains the relationships between R&D investment-innovation outputs-productivity as follow:

The Research Investment Equation:

$$g^*_i = x_{0i} b_0 + u_{0i}$$

$$k^*_i = x_{1i} b_1 + u_{1i}$$

The Innovation Equation:

$$lnn^*_i = lnE(n_i | k^*_i, x_2, u_2) = \alpha_K k^*_i + x_{2i} b_2 + u_{2i}$$

$$q_i = \alpha_I lnn^*_i + x_{3i} b_3 + u_{3i}$$

The Production Equation:

$$t^*_i = \alpha_K k^*_i + x_{2i} b_2 + u_{2i}$$

$$q_i = \alpha_I t^*_i + x_{3i} b_3 + u_{3i}$$

In which, x_i (x_{0i}, x_{1i},...) are the vectors of explanatory variables, b_i (b_1, b_2,...) are coefficient vectors, u_i (u_{0i}, u_{1i},...) are error terms, g^*_i is latent dependent variable for research occurrence, k^*_i is the dependent variable for a true intensity of research, n^*_i is an expectation conditional on research, lnn^*_i is expected patents per employee (or researcher), t^*_i is the latent innovative sales, q_i is the logarithm of labor productivity. α_K is the elasticity of the expected patent numbers, which is considered as the return to R&D on innovation outcomes, while α_I is the return to firm productivity on innovation outputs.

In these three methods, the CDM model can be considered an extension of the augmented production function by adding research inves
tment and innovation equations. This supplementation can address the endogenous problem in the production function and makes the model highly practical. In contrast, the knowledge production function reflects the transition from innovation inputs to innovation outputs and also provide more accurate estimations for production functions. Further, knowledge production function also allows dynamic approach.

Crépon et al. (1998)[5] also provide new data on French manufacturing firms with patents, innovation sales and related indicators. They find that research efforts, demand pull, and technology indicators raise innovation output. Their impacts may be directly or indirectly depending on the particular situation. Furthermore, the improvement of innovations significantly increases firm productivity. Similarly, using firm-level data of France, Germany, Spain, and the UK from Community Innovation Surveys (CIS3), Griffith et al. (2006)[9] explain the link between R&D spending, innovation output, and productivity. They find that, although there are differences and variations between countries, the policies and strategies driving innovation have significant positive impacts on productivity across these four countries. Accordingly, higher investment R&D will improve the innovation process and outputs; this enhancement raises firm productivity.

However, endogeneity is an economic problem, which did not mention in the traditional CDM model and could lead to bias in estimation. To deal with the problem, Mairesse et al. (2005)[20] provide instrument innovations and R&D, including both intensity variables and binary indicators.

Another problem in previous studies is that most of them based on static and cross-sectional data. To deal with the problem, Raymond et al. (2015)[27] extended traditional CDM model with dynamic linkages. Using unbalanced panels of Dutch and French manufacturing firms from Community Innovation Surveys, they examine the R&D-innovation-productivity relationship. They find that R&D activities have significant impacts on product innovations. Occurrence and the intensively of product innovations is the key factor to improve firm productivity. Accordingly, the relationship between innovation and productivity is nonlinear and a unidirectional causality respectively.

In addition, the relationship between innovations and productivity can be non-linear. Kancs and Siliverstovs (2016)[17] use data from 750 companies in the EU and 750 companies outside the EU to study the relationship between R&D expenditure and productivity growth. They conclude that this relationship follows the U-shaped curve. Accordingly, productivity growth decrease in the first stage, but increase significantly when knowledge accumulates to a certain threshold. Further, the impact of R&D investment on productivity growth also depends on sectors and R&D intensity.

3.2 Indirect effects of innovations on productivity

Besides the direct impact of R&D on the firm productivity itself, innovation also has spillover effects on industries and society. This effect can be explained through two types: Knowledge spillovers and capital investments (or also is called rent spillover or technology spillover). The primary difference between them is that knowledge spillover is transferred for free, while technology spillover is transmitted through commercial transactions (Nishimura and Okamuro, 2016)[23].

3.2.1 Knowledge spillover and productivity

Knowledge spillover occurs when knowledge generated from a firm's R&D project is beneficial to other firms within or outside the industry. At first, it must be noted that knowledge is a particular asset of the business and provide many advantages to the business. Hence, when a firm creates a piece of new knowledge through R&D, others want to steal or copy. The protection of the intellectual property is currently very weak, especially in developing countries, so it is difficult for them to keep secrets within the company for a long time. The knowledge, soon or later, will be stolen and spread to other companies without any payment (Hall et al., 2010). Of course, we need to distinguish between technology transfer (including royalty payments) and unexpected spillovers. Furthermore, there are some R&D projects done with the goal of providing knowledge to humanity or an industry. These projects often come from governments or global development organizations. In addition, some basic technology or old technology is also provided free for the general development of the community.

Hall et al. (2010)[13] distinguish between social and private rates of return. Accordingly, the private rate of return includes all the benefits of innovations to the firm after deducting the costs, including the cost of the failed innovations. In contrast, social benefits add to the private rate of return other benefits through knowledge spillover and are based on changes in consumer welfare, profits from imitators, benefits received through innovations of other companies and environmental charges. They also suggest that knowledge spillovers can come from four sources: (i) other firms in the same industry; (ii) other firms outside the sector; (iii) institutes, research institutes and public universities; (iv) other international organizations in other countries. In which, the first three sources reflect the social rate of return and the rest indicates the international spillover. However, social return also depends on each specific innovation project and particular sectors.

In agriculture, Griliches (1958)[10] estimates that investment in R&D would yield a net social return of 35-40% for hybrid corn. Griliches (1992)[12] find that each public investment in agriculture would help the country obtain a 13% social rate of return a year and bigger than private returns. In industrial innovations, Mansfield et al. (1977) study 17 innovations and conclude that the median social rate of return is 56% and twice that of the median private of return (25%). In which, they also included the costs of unsuccessful research and competitors. Similarly, Tewksbury et al. (1980)[29] study 20 innovations and find that innovation brings significant benefits to society (99% median social rate of return), but it is often not reported enough to innovators. The energy sector is also confirmed by Inglesi-Lotz (2017)[15] for the case of R&D investment on energy technology with G7 countries and in coal, petroleum and nuclear manufacturing for OECD countries (Corderi and Lin, 2011)[4]. In financial service, Bresnahan (1986)[1] evaluates social gain from price reduction due to the application of computers during 1958-1972, which refer to a kind of innovation. He concludes that the benefit would be five times the initial investment.

Medical research is also a field that offers a lot of social benefits because it has a tremendous inheritance. Innovations in a firm are very important to the rest of the sector. Weisbrod (1971)[32] finds that the social rate of return is 12% for poliomyelitis research. Similarly, Trajtenberg (1989)[30] estimates that the social benefits gained versus cost are 270% for computed tomography (CT) scanners.

3.2.2 Technology spillover and productivity

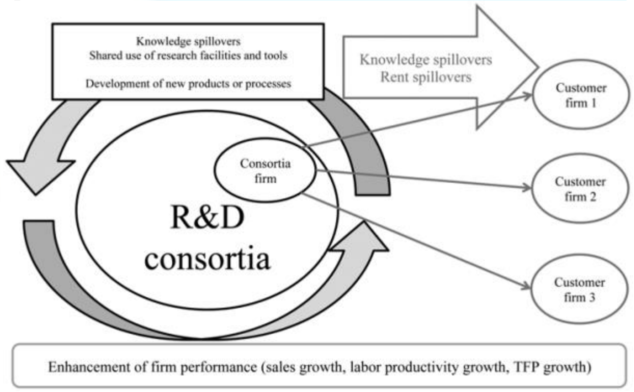
Technology spillover occurs when a business decides to purchase a part of the completed product or service of another firm, which is the result of the innovations process. However, the price of a purchased product or service does not reflect the value used by three reasons: (i) Imperfect price discrimination; (ii) imperfect appropriability and imitation; (iii) mismeasurement of the transaction value. Further, if the market is more competitive, investing in R&D is not profitable, so firms tend to buy (Hall et al. 2010).

In theory, it is possible to separate spillover knowledge and technology spillover. However, in practice, the two types of spillover are hard to dissociate because (i) an increase in TFP may include both knowledge and technology knowledge. These two effects usually happen simultaneously; (ii) The benefit of knowledge spillover also can be re-used to pursue economic rent (Hall et al., 2010)[13]. Of course, if the knowledge gained from innovations can be kept secretly, other firms in the industry can benefit from procurement to help lower costs, improve quality, and thus improve productivity. This is a typical case of technology spillover without any knowledge spillover (Nishimura and Okamuro, 2016)[23].Using data from American firms in 1987, Los (2000)[19] measures the effects of knowledge spillover and technological spillover on productivity separately. The result has shown that both knowledge and technology spillovers improve productivity. In overall, the impact of knowledge spillover is stronger than technology spillover, but the results vary depending on the industrial sector. Accordingly, in medium-technology industry (electrical products, chemicals, motor vehicles, other transport, machines and rubber and plastics) knowledge spillover is stronger. In high-technology industries (electronics, drugs, aerospace, instruments, computers) and low-technology sectors (other industries), technology spillover is higher.The impact of technology spillover depends on the characteristics of the enterprise and sector. Using data from 2000 innovations in the United Kingdom in 1945, Pavitt (1984)[26] introduces a taxonomy to explain sectoral patterns of technical change and provides reference information related to firm strategy: (i) purchase the innovation outputs, or (ii) invest in R&D and sell the innovations. He suggests four parts of taxonomy and could be categorized into two groups: (i) producer of innovations (specialized suppliers and science-based); (ii) buyers of innovation (supplier dominated and scale-intensive). Accordingly, innovative firms are usually in electronic and chemical sectors. They are big firms with lots of leading innovations within the industry, but fewer in other industries. In the sector of mechanics and equipment, the firms are relatively small and specialized; thus, they mostly have to buy innovation output from other large specialized companies such as metal and vehicles production. For the textile sector, innovations mainly come from suppliers.

One of the interesting phenomena related to the impact of information and communication technology (ICT) on productivity is the so-called "productivity paradox". While most studies and theories find that spillovers, in particular, application of ICT, improve productivity, Dewan and Kraemer (1998)[7], David (1990), reported a decline in the productivity of the US economy from 3% in 1960s to 1% in the 1990s when the ICT was invested and developed rapidly. This phenomenon raises a question on theories, and empirical evidence on the innovation process and lots of later studies tried to explain this issue. Brynjolfsson (1993) argues that there are four groups of reasons: (i) Mismeasurement, (ii) lags, (iii) redistribution issue; (iv) mismanagement. This result is also supported by Jones et al. (2012)[16], and another reason is added: poor usability. He concludes that the biggest problem here is the limitations of data and analytic methods. To deal with this problem, we need to change the way productivity is measured, which should reflect both quality and cost-benefit, ignore optimistic expectations, focusing on re-engineering and improve ICT usability measurement. Kijek and Kijek (2018)[18] solve the productivity paradox by adding a moderating effect. Using the data of 2960 Polish innovative manufacturing firms and the Generalized Structural Equation Model, they evaluate the impact of information and communication technology investments on firm productivity. ICTs directly enhance productivity and indirectly influence strongly through process innovation.

3.3 R&D Consortia and Productivity

R&D consortia are such collaborative R&D projects funded by not only private firms, but also universities, and public research institutes. It is created to foster creativity, development and transfer of R&D achievements. It also often supported by the government. It also often supported by the government. R&D consortia provide more ways firms can invest in innovations and also influence productivity not only consortia members but also the rest of the industry through knowledge spillovers and capital investment (technology spillovers).
Furthermore, R&D consortia also emphasize the support of governments in both creating control mechanisms, providing medium-term relationships and also financing the projects. Different from other approaches, the consortium allows effects to occur simultaneously with their transmission channels. This kind of platform is the current trend of leading enterprises because it can enhance cooperation, risk sharing and resource combinations (Nishimura and Okamuro, 2016), cost sharing (Veugelers and Casiman, 2005). This form allows the implementation of big FDI projects and promotes innovations. In addition, R&D consortia help solve market failures, allowing members to gain advanced scientific knowledge, reduce initial R&D costs for individual firms, and promote sharing experimental and research facilities - which usually require a lot of money to purchase (Nishimura and Okamuro, 2016). The impact of R&D consortia to productivity can be summarized in the following figure:
Figure 1. Summarizes our conceptual framework of spillover effects in the context of R&D consortia



(Sources: Nishimura and Okamuro, 2016)

An enterprise in the consortium can access the assets and research equipment of other organizations. The outputs of R&D project will be shared among participants through numerous channels. Member of the consortium is able to improve productivity based on direct knowledge spillover, while their business partners may benefit from indirect knowledge spillovers as well as capital investment. In details, information and knowledge will be exchanged directly through meetings, workshops and training. Know-how can be transferred through the movement of advanced skills workers through the exchange or support programs. This is a great advantage point of this interactive platform for operating innovations. The role of human beings is enormous in the development of the organization as well as in the economy.

Sharing of research equipment will improve the effectiveness of research. In general, the consortium will increase the efficiency of innovation, thereby increasing labor productivity and total factor productivity more than individual firms innovated (Nishimura and Okamuro, 2016)[23]. Although each R&D consortium has a different program and purpose, many projects are designed for the benefit of the community, and this is essential sources for small and medium enterprises.

Motohashi (2005) uses data from 786 university/industry collaborative (UIC) activities in Japan to assess the impact of UIC on productivity. He concludes that collaborative R&D projects between universities and industry would significantly increase productivity. In which, the rise of small firms is higher than that of large firms. They also confirm that collaborative projects play an important role in reducing Japan's dependence on the innovations of large corporations.

Using data from 1,550 firms participating in the 666 R&D consortia for four years (2004-2008), Nishimura and Okamuro (2016) evaluate the spillover effect of R&D consortia on productivity. They have confirmed that both direct and indirect knowledge spillovers have a positive influence on consortia participants and business partners of members, especially large enterprises.

4 CONCLUSION

Innovations play an increasing role as a strategic solution to improve firm productivity. This can be considered as an indispensable step of every firm. However, firstly, we need to have certain concepts and measurement methods for both innovations as well as firm productivity and suite with each specific case. Different indexes used can lead to dissimilar results. This paper has summarized the process of developing the concepts as well as analysis of the advantages and disadvantages of measurement methods.

Secondly, we need to distinguish the direct impact and indirect impact of R&D on productivity because the way they affect is non-identical. While direct effects through private rate of return reflect the investment efficiency of firms, the indirect impact through social rate of return reflects the overall impact of innovations on society and is interested in the governments. In this paper, the author also reviews three methods for modeling the direct effect of innovation on productivity as well as the link between them. Through theoretical literature and empirical evidence, the author finds that innovations have a direct and powerful effect on the productivity of the firm. However, the level of impact depends on the specific characteristics of the firms, R&D intensity, macroeconomic conditions as well as the industrial sector. Further, Innovations not only affects directly the productivity of the enterprise, but it also influences significantly the social rate of return through knowledge and technology spillover. In addition, the relationship between innovation and productivity is not always linear, but non-linear in certain cases. The results of these effect calculations will be the reference information to help firm leaders make the right decisions: (i) invest in R&D, apply and keep the innovation outputs for themselves only; (ii) invest in innovation for their own use and sell to other firms for profit, or (iii) buy innovations. This study also analyzes productivity paradox and provides possible explanations.

Thirdly, the paper emphasizes the importance of R&D consortia, one of the most popular and important platforms nowadays. This is also the leading trend for firms and governments. R&D consortia bring tremendous benefits for not their members through direct effect but also to the rest of the industry through indirect impacts. R&D consortia overcome the difficulties in innovations, provide more opportunity to create advanced knowledge, foster long-term cooperative relationships, share risks and costs, promote entrepreneurship. The governments should provide exceptional support for this form.

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