THE ROLE OF SCIENCE, TECHNOLOGY AND INNOVATION IN ECONOMIC GROWTH: A THEORETICAL AND EMPIRICAL REVIEW AND IMPLICATIONS FOR VIETNAM

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Abstract:

The paper conducts theoretical and empirical reviews on the role of science, technology and innovation (STI) in economic growth. In general, economic growth theories and practical experience around the world all show that STI has long-term effects on economic growth. However, the later economic growth theories show that, depending on particular national innovation systems, the impact of STI on economic growth differs from country to country. Practical experience from successful countries shows that, in order to sustain long-term economic growth, each country needs to build a national innovation system tailored to its conditions and circumstances, where the private sector should play a central role. The system must ensure to generate a workforce of high quality and meet market needs.

Keywords: *Economics; Economic growth; Science, Technology and Innovation.*

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1. Introduction

Searches of driving forces for economic growth get attentions from economists since appearance of economics as academic discipline. Classic economists, namely Adam Smith, David Ricardo, Thomas Malthus and Karl Marx showed out fundamental factors causing impacts to economic growth of a country, namely capital accumulation, trade, workforce and technical progress. However, the interests of classic economists for economic growth really come back since the 1929-1933 great economic depression, especially after the appearance of the neo-classic growth model by *Robert Solow* in 1956.

From view of modern economic growth models, science-technology-innovation (STI) is seen as a factor leading to technical change[2]. The role of

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[2] In this paper, the STI factor in economy is understood as including components of the economic system for realization of innovations. This means the components are interlinked by flows of knowledge and resources circulating between them for creation of science and technology knowledge and ways to use them for making new products/procedures of commercial nature or considerable improvement of these products/procedures (*Hall & Jaffe, 2018*). In this sense, STI activities create a unified structure to produce new knowledge for economy.

STI varies from model to model but, globally, STI is the key factor for economic growth in long-term vision.

In Vietnam after long years of economic development based on attraction of investment capitals and shift of labours from agricultural sector, the role of STI for economic development gets increasing attentions[3]. Numerous studies give warnings that Vietnam may face middle income traps if not doing strong improvements for productivity *(Ohno, 2009; Tran Van Tho, 2013).*

This paper targets to provide a theoretical and empirical overview on the role of STI for economic growth. Some lessons are made to suggest the policy orientation to push up STI-based economic growth for Vietnam in the next development stage.

2. Theoretical overview

Economist *Joseph Schumpeter,* for the first time, provides a detail analysis, on basis of innovation concepts, of the role of STI for economic growth *(Schumpeter, 1934 [1912]).* He indicated the role of innovation in micro-scale where, accordingly, business start-ups are driving forces for innovation and, then, for growth. Later, he emphasizes the role of business start-ups within enterprises and large corporations. The Schumpeter-like approaches make focus for analysis with description of interactions between factors for creation of driving forces for economic growth without presenting them in form of mathematical models. For this reason, the analysis made by Schumpeter almost falls forgotten in community of contemporary economists.

Robert Solow is the first economist to introduce innovation factors to the neo-classic growth model *(Solow, 1956)*. The model by Solow, in fact, is an extension of the model developed by *Roy Harrod and Evsey Domar* during 1940s. In the Harrod-Domar growth model, the capital accumulation and labour extension are two factors providing main contributions for economic growth while technological progress being assumed unchanged. In the Solow model, the technological progress is seen as getting improved with time. However, the capital accumulation is assumed to be an endogenous variable while the technological progress is seen as exogenous one. By this interpretation, technology (or technological knowledge, for more exact view) is a type of public goods free accessible by people. Solow does not make

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Innovation cannot separate from science and technology and, most crucially, science-technology needs orient to innovation.

[3] Facing challenges from transformation of growth models, the Party Central Committee Session XII issued Resolution No. 05-NQ/TW on 01st November 2016 *Some large policies and guiding lines to keep on renovation of growth models, enhancement of growth quality, labor productivity and competitiveness of economy* with the statement: "Renovation of growth models is to be conducted with higher attention and focus for the factors which accelerate labor productivity, effective use of resources and, especially, mobilization of patriotism, national pride, Vietnamese creativity and S&T achievements of human kind, potentials and advantages of sectors, fields, localities and the whole nation".

discussions of this meaning for some countries. But studies made later on basis of neo-classic concepts pretend that, in global view, the technology and knowledge are also free once they are free in the US. The following remark was made by *Denison,* leading empirical researcher in this field, namely: "Since knowledge is international goods I would expect that the contributions from knowledge progress (…) are the same in all the nations *(Denison, 1967, p. 282)*. With this assumption, the neo-classic growth model makes a guess that, in long term vision, GDP growth per capita of all the countries converge to the same level thanks to the role of global technological progress as exogenous variable.

The only remaining factor of this model capable to interpret the difference in average growth per capita between countries is "the difference in transforming process", that means, due to initial conditions different from country to country, they can experience growth processes with different rates in a long term process to balance state. Poor countries are capable of making a growth rate faster than rich countries do because these countries experience capital shortage over labour (which means a lower rate of capital distribution over a labour). This would lead to higher rates of returns, capital accumulation and average growth per capita. With eventual international circulation of capitals and their expected flows to the countries with highest interest potentials, this trend would keep on occurring. Then, the gap in income levels between rich and poor countries would get narrowing (which is called "income convergence").

Many empirical evidences, however, show the technological progress depends much on deliberate decisions of each country but is not an exogenous variable. This leads to attentions for searching different ways for interpretation of the role of technological progress for growth. It is the starting point of the new growth theory which is called also as endogenous growth theory.

The endogenous growth theory sees the knowledge capitals as factor to decide the technological progress speed, the knowledge capitals being defined as knowledge spillover *(Romer, 1986)*, human capitals *(Lucas, 1988)* and R&D activities *(Romer, 1990)*. In these models, they try to explore the interaction between knowledge capitals and technological progress for interpretation of the way their combination leads to economic growth. Differently from the Solow model, the endogenous growth theory puts innovation to center position of economic process.

Paul Romer and *Robert Lucas* are seen as the most remarkable scholars in this field. Their models are based on a study by *Arrow (1962)* for learning-by-doing *(Barro and Sala-i-Martin, 1995; Aghion and Howitt, 1998)*. The Romer model (1986) explains technological progress-based economic growth as capital accumulations where the increase of capital sources of a company would lead to increase of knowledge because the technological progress is defined by knowledge spillover. Knowledge spillover has non-rival nature and, then, it is possible to create scale-based increasing profits when more people can use knowledge. The combination of technological progress and increasing profits based on scale of knowledge use would create the learning-by-doing effects which help economy to maintain long-run growth speed. It is the fact the Solow model cannot explain because, in this model, the steady equilibrium would not change except appearance of effects from exogenous technological progress *(Aghion and Howitt, 1998)*.

Lucas (1988) develops a model similar to the one by *Romer (1986)*, except one argument by Lucas which pretends that technological progress is due to human capital spillovers but not material capitals as proposed by Romer. Lucas gives a definition of human capitals as skills bound to individuals and used by individuals for creation of products or for accumulation of knowledge through education activities. Accordingly, it is the share of time between production activities and education activities to decide economic growth *(Barro and Sala-i-Martin, 1995; Kurz, 2012)*. Also, the Lucas model introduces the scale-based increasing profits with reference to Arrow's concept of learning-by-doing.

By 1990, Romer improves his model in some aspects. *First,* the Romer model (1990) allows imperfect competition. *Second,* the main factor to push up innovation is R&D investments but not investments in general. *Third,* differently from *Lucas (1988)*, knowledge accumulation is not necessarily made by individuals; and, apart from that, knowledge is a non-rival factor when used while the human capital is a rival factor. With these new assumptions, the Romer model (1990) pretends the knowledge spillover is free and does not require any costs.

In the Romer model, 3 sectors are separated, namely: final output sector, intermediate sector and R&D sector. The R&D sector contains human resources for creation of new ideas and designs of new products. The R&D sector sells new ideas and designs of new products for intermediate sector. This sector can get innovative patents and get monopolistic royalties because of being the unique producer of new goods thanks to implementation of new ideas and designs in their producing lines. Then, intermediate sector outputs get sold and provide the final output sector with extreme profits. With this approach, the R&D sector is the source to make sustainable growth *(Ulku, 2002; Aghion and Howitt, 1998)*.

Some other researchers, namely *Grosman and Helpman (1991)* and *Aghion and Howitt* (1992, 1998), develop additionally some modified models on basis of the Romer theory (1990) in taking R&D activities as representative factor for innovation, and, then, they are called as R&D-based endogenous growth models. These models, however, get strongly criticized because of making implications to increase investment sources for R&D then leading to increasing growth rate. Namely, *Jones (1995a, 1995b)* considers carefully empirical evidences and shows well that the continuous increase of R&D workforces and R&D expenditures have no links to increasing growth rate.

In global view, the endogenous growth theory excludes the 3 central assumptions of the neo-classic theory. *First,* the technology is assumed to be endogenous instead of being exogenous which shows importance of interventions by the Government with impacts to economic development in long term vision. *Second,* technologies may be different from country to country instead of being unchanged (which means that the profit generating rate may be different between countries instead of being assumed as unchanging). This would lead to implications that the countries with lower capital reserves do not necessarily have growth rates faster than the countries with higher capital reserves can do (because the rule of reduction of profit rates in relation with capital factor scale gets adjusted in various levels in dependence on technological factor between countries) *(Ulku, 2002)*. *Third*, the endogenous growth models do not assume the reducing profits thanks to possibility to use knowledge factors without causing rivalry. In this sense, the endogenous growth models can explain the reason the growth rate remains positive in long term vision *(Barro and Sala-i-Martin, 1995)*. More than that, it is necessary to note that the endogenous growth model emphasizes the role of technological spillovers in growth process because it is the diffusing way as indicated actually in these models.

The objective of endogenous growth model is to make analysis and clarify endogenous mechanism for creation of economic growth. This helps explain the fact that some countries make great take-offs and get rich while some other countries cannot do that and get perished. Here, some lessons can be made to suggest the ways leading the economy to long lasting, stable and sustainable development. According to this theory, the growth basically comes from innovation efforts in production activities where innovation is of endogenous nature. The endogenous growth theory is basically still based on the framework of neo-classic theory because it sees that one of important channels to impact economic growth is investment capitals. Even, the endogenous growth theory gives the most important role for growth to producing capitals which is the basic factor for creation and accumulation of technical and technological progress as growth source.

The endogenous growth theory allows to interpret differences in economic growth rates of economies depending on innovation efforts instead of investment capital reserves. Even with this, the theory cannot explain different ways of development of economies in practice. There exist economies developing with strong shift of vocational structures as described by economists *Clark (1944)* and *Kuznets (1971)*, but there are also economies exhibiting almost growth halting trends as noted by *(Bliss, 1975)*, or there are economies where the sectors develop with the same pace *(Pasinetti, 1993;*

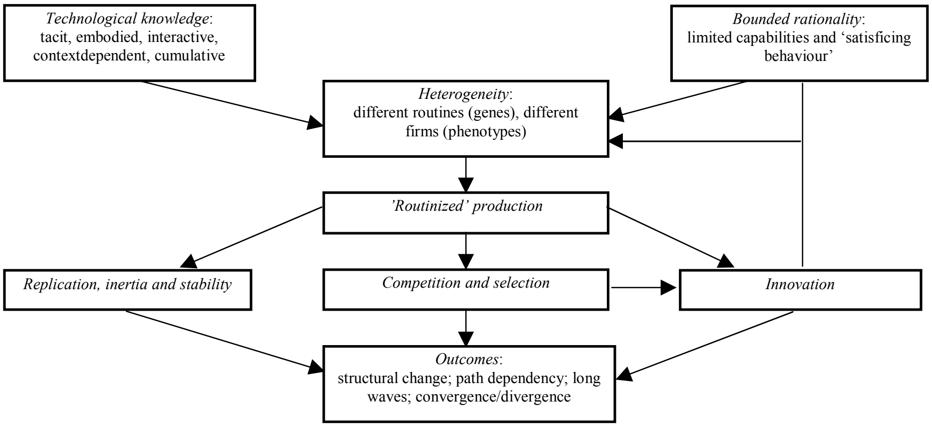
Metcalfe and Foster, 2009). The different ways of development of countries are the source inspiring the appearance of the evolutionary growth theory with main contributions by *Iwai (1984), Silverberg and Lehnert (1994)* (about long-run waves of growth generated from destructive changes of technologies), *Abramovitz (1986 and 1994), Fagerberg (1987, 1988 and 1994) and Verspagen (1991 and 1993)* (about catching up capacities of economies with gaps in technology level), and *Nelson and Winter (1982), Silverberg and Verspagen (1994a; 1994b; 1995; 1996), Foster and Metcalfe (2010)* (about modelization of dynamic interactions between different factors of capacities, strategies and innovation outcomes at macro level.

Among the above noted studies, the ones by *Nelson and Winter (1982)* were considered by scholars as breakthrough move for modelization of development process by evolutionary approaches which establish fundamental background for further extension of models. In these models, producing capacities in sector of enterprises play center roles which guide the evolutionary road of an economy. The producing capacities of an enterprise are defined as a set of cycles, similarly to genetic structures of living organisms. Enterprises would search or imitate new solutions for higher profits. Successful searching would lead to development and the situation would get inversely if otherwise. With this simulation, enterprises, event with great efforts for searching optimal solutions for maximal profits, are not wholly sure of successful outcomes, this being different from assumptions by growth models in neo-classic economic theories. Whatever are outcomes of efforts by enterprises, their producing capacities would eject old knowledge and keep on getting new knowledge for creation of new capacities. This makes the entire development of the successive stage depend on the previous stage, the process being irreversible.

Later, the studies following the approaches by *Nelson and Winter (1982)*, basically, have 3 directions of extension, namely: (i) Simulating the evolutionary process of enterprises, consumers and organizations in close links with studies on epistemology; (ii) Simulating the evolutionary process and development inside a sector and changes of structures between sectors; and (iii) Building formal evolutionary processes on economic growth *(Fulvio, 2006)*. Whatever is the direction of extension, the later studies all see the evolutionary process as result of interaction between processes of differentiation, selection and innovation (Fig. 1). Evolutionary models of economic growth share among themselves the following specific features of development/growth of economies:

- Changes of structures are accompanied with creative destruction;
- Growth process has its own evolution path;
- Growth may pass fluctuations or mutations but not periodicity;
- Specialization in some vocational sectors has endogenous structure;

- Convergence trends exist (where low developed economies have economic growth trends faster than developed economies do which help convergence and divergence in economic growth between economies at macro level).



Source: Fulvio (2006)

Figure 1. Main relationships in Nelson and Winter-like evolutionary economics

Arguments of evolutionary growth models open development roads for studies on National Innovation System (NIS) *(Nelson, 1993; Lundvall, 1992)*. NIS is the system which describes components at both micro and macro levels. At micro level, R&D and learning activities taking place in enterprises and public organizations are the main driving forces to create innovations. At macro level, the components are: education and training system (including activities inside enterprises), system of industrial and innovation policies by the Government, macro economic conditions (Government purchases, international trade policies, budget policies, monetary policies) and consumption trends/capacities. In fact, they are features of structural nature of NIS which decide implementation level and effectiveness of national innovation activities.

Shortly, economic growth models show out the important role of STI for economic development in long term vision. In the neo-classic model, STI are exogenous factors giving hopeful expectations for developing countries to catch up developed countries while the endogenous model shows different results subject to investment rates and effective activities of the STI system. Also, the evolutionary growth model indicates that the long-run economic growth depends on convergence of numerous factors where the NIS of the country plays considerable roles.

3. Impacts of STI to economic growth

According to growth theories, the both endogenous and exogenous growth models consider STI as necessary conditions for economic growth. In general, almost all empirical studies on endogenous growth models usually relate to tests of impacts from R&D variables to economic growth while a few other studies check relations between patents and economic growth *(Hasan and Tucci, 2010; Wang, 2013).*

While viewing documents which use patents as a STI indicator, *Schmookler (1966)* gives a reasoning that there exist long and positive relations between patents and economic growth but, in short term, they may have negative relations. Inversely, *Devinney (1994)* shows positive relations in short term between patents and economic growth by checking changes between these two factors while doing evaluations of a group of countries. However, *Crosby (2000)* finds out evidences which support conclusions by Schmooklers and, according to that, his findings show that the relations between patents and labour productivity/economic growth are positive in long term but negative in short term.

Yang (2006) in his study uses a similar model for analysis of data of patents of Taiwan and finds our positive impacts of STI to economic growth in both short term and long term. Also, a most recent study by *Hasan and Tucci (2010)* investigates relations between STI and economic growth by using patents as STI indicator and R&D indicator is one of control variables. They note that countries having higher quality patents and the increasing number of patents have higher economic growth rates. These results are based on samples collected from 58 countries in 1980-2003 period and use one quantitative measurement and two qualitative measurements of patents. The first measurement is the number of USPTO granted patents and the second measurement is represented by the ratio of USPTO granted patents (which is defined as the ratio of patents granted by certain country in certain year) to the residual from R&D intensity taken by regression from the total number of patents.

Regarding studies using R&D as STI indicator, *Coe and Helpman (1995)* find out empirical evidences for spillover effects of R&D. They use data collected from 22 countries of 1971-1990 period for analysis of accumulated impacts of R&D to TFP. In addition, they note that foreign R&D activities produce positive impacts to domestic productivity and get higher with open economies. More than that, they discover the profits gained from investments for R&D activities take high shares in domestic products which intensify international spillover effects. *Ulku (2004)* checks the Romer theory in relations to innovations activities in R&D sector and thinks that these activities allow sustainable economic growth as long as they have unchanging profits from investments for R&D sector. *Ulku* uses data collected from 20 OECD countries and 10 non-OECD countries of 1981-1997 period and use patents and R&D as STI indicator. His study shows a positive relation between STI and GDP per capita in the two groups of countries. However, he does not find out evidences for unchanging profit generating rates from R&D which implies that innovations do not lead to permanent economic growth. However, he makes a conclusion that his finding does not exclude absolutely the Romer theory because both patents and R&D data do not reflect fully the scope of innovation and R&D activities *(Ulku, 2004).*

However, an increasing number of economists still does not remain too optimist on the role of pushing-up forces by innovations for economic growth. A recent study by *Wang (2013)* uses statistic data of patents for checking relations between innovations and economic growth and shows that innovations may not have positive roles in pushing-up effects for economic growth. Remarkably, this study uses data samples from US, UK, Germany, Japan, France and Australia. The US is a particular case because, here, innovations cause negative impacts to economic growth while no similar evidences are found in the UK and Germany. However, positive effects are still observed in some countries including Japan, France and Australia *(Wang, 2013)*.

Briefly, the studies using R&D activities and patents as innovation indicator always find long-run positive impacts from innovations for economic growth and produce different conclusions on impacts of patents in short term. However, the study by *Verspagen (1997)* shows spillover effects between countries which lead to positive impacts from R&D and patents to growth rates.

4. Experiences of STI-based economic growth of some countries

In this section, the team of authors reviews practical experiences in STI development policies with economic growth in some countries considered as successful in maintaining long-run continuous economic growth. The US, Germany and Japan are taken as developed countries for consideration; Korea and Taiwan are taken as successful followers, and China and some ASEAN countries are taken as successful developing countries.

The United States of America: Owning early high STI capacities, the US is one of the countries which have the strong STI-based growth model which is reflected by numerous aspects. The system of private enterprises is dynamic and advancing in numerous new technologies in competitive environment *(Atkinson and Audretsch, 2011; Atkinson, 2014).* This dynamism and competition get raised in business environment with advantageous policies to make private enterprises become the success deciding factors of NIS. The early system of support funds and venture investments help to incubate ideas and audacious projects. In addition, the system of universities with great training and researching capacities and large links with industrial sectors is also important platform for development of the US NIS *(Atkinson, 2014)*. Finally, the policy system, from federal level to state and local level, uses different tools such as defence spending and supports for fundamental research *(Mowery, 1994)* accelerates innovation link chains *(Baily and Montalbano, 2017)* to facilitate the sector of private enterprises and universities to promote their own innovation capacities and interlinks which allows the US to maintain the leading position in

S&T fields. The most remarkable policies which get maintained always are to ensure competitiveness and protect IP rights *(David, 1993).*

Germany: As shown by experiences of Germany, this country has a very long history of development of STI capacities which actually serve as platform for its outstanding economic strength. The deciding factor for successes of the Germany NIS is excellent capacities for effective organization of a system of research institutes, universities and public research facilities well linked from state level to federal level to support fundamental research activities, create excellent researching and training centers and supply high quality human resources for private sector *(Keck, 1993; Hommes, Mattes, and Triebe, 2011)*. In addition, the sector of enterprises develops cooperation with universities, colleges and vocational training schools for supply of human resources. The official and non-official institutions play key roles in maintaining a healthy environment for competition and cooperation between enterprises in development of new technologies *(Bromely, 2004).*

In the STI policy system of Germany, the Federal Government and State Governments have certain degree of independence in roles and they are officially defined by laws. Accordingly, the states have agencies with specially assigned duties and own policies of focused supports for development of local innovation chains *(Dohse, 2007).* From its position, the Federal Government, in addition to supports for large technological projects and research institutes, provides supports for extension and cooperation between innovation chains through various policy tools. Clearly, the success of Germany during recent decades comes from policy tools which help create driving forces for development and effective R&D activities in both sectors of enterprises and research institutes *(Keck, 1993).*

Japan: The efforts of catching up of this country in S&T field started by serious and global reforms led by the Government, especially the Meiji Restoration Reforms *(Odagiri and Goto, 1993)*. Cultural factors and management modes in the system of Japanese enterprises are the factor to decide the success of the Japan NIS in the post-WWII time. Then, the Japan Government used skilfully policies as tools for protection of young domestic industries while kept on import of advanced technologies from external sources *(Chang, 2002).* With formed-in-advance capacities in absorbing and mastering import technologies, Japanese enterprises early made overpassing moves and started competition with leading companies from the US and Germany in certain important sectors of industries such as automobile manufacturing and electronic products *(Odagiri and Goto, 1993; Chang, 2002)*. Actually, Japan possibly is the only developed country still maintaining 5-year development plans with increasing focus for the role of STI, especially development of digital platforms, in economic development of the country *(Carraz and Harayama, 2016).*

Korea: Among the countries called as followers, Korea possibly is the only case successfully combining specific features from the US NIS and the Japan NIS for successful creation of its own NIS *(Kim, 1993; Kalinowski and Cho, 2009)*. In initial stages, the Korea Government made efforts for import of mature technologies while protecting domestic export-oriented sectors of industries by applying restrictions of foreign investments in these sectors. A group of chaebols were supported by the Government and then, through screening, gets incentives for development of technologies with next extension to international markets *(Kim, 1993)*. After the 1997 Asian financial crisis, the pushed-up trend of liberalization and the shift to market driven economy stopped the direct interventions by the Korea Government in the system of Korean enterprises and, then, the role of private sector in R&D activities arises highly *(Kalinowski and Cho, 2009; Klingler-Vidra and Pardo, 2019).*

Taiwan: Differently from Korean "self-governance" policies, the Taiwanese Government follows the approach based on development of links between FDI enterprises and domestic SMEs for absorption of import technologies *(Hu and Schive, 1998)*. Upstream links get formed and the network of local enterprises play roles of suppliers of original technologies for gradual development of multi-national companies. These links form channels for transfer of important technologies and techniques for Taiwanese SMEs *(Aw, 2003)*. More importantly, Government supported research institutes provide the sector of enterprises with effective supports through adequate modes of technological spillover. Many large companies in sector of electronic technology of Taiwan get formed and develop thanks to technological supports from these research institutes *(Hou and Gee, 1993)*.

China: Despite being one of the world's largest economies, China is one of late-comers in technological development. In general, the framework of STI policies of China permanently is under process of completion through combination of historical lessons, tests at grass-root levels, tests of designs, top-down amendment of policies in "trials and error" modes, learning and application of innovation policies from developed countries with necessary adjustments for China's context *(Liu, et al., 2017; Zhou and Liu, 2016)*. China's innovation policies still show signs of impacts from the Soviet central planning concepts where every 5-year plan draws out the main S&T development orientations. S&T activities conducting organizations are to carry out tasks assigned by higher level authorities with budgets officially allocated as needed resources, the sector of State owned enterprises (SOE), especially the ones in high tech fields, get priorities from the Government for R&D activities *(Lin et al., 2020)*. Institutional entities taking part in innovation activities never bear the full losses in case of failures and, the, they have no chances to get the whole profits from successful outcomes of works. However, the bottom-up trends in innovation activities gradually arise together with the higher roles of the sector of private enterprises in the China NIS *(Băzăvan, 2019).*

ASEAN countries: Despite starting later than the above noted countries, ASEAN countries are making great efforts to build up their NISs tailored to the context and development level of each country. Singapore is the first country in the region to start it and then have the most developed STI platforms. Experiences by Singapore show that its Government was able to use inherent advantages at best with strong commitments to implement FDI attracting policies, develop link chains and cooperation activities and, by this way, enhance national STI capacities *(Wong, 2001)*. Abundant sources of external workforces, especially the high quality ones, in combination with local human resources trained at international level help Singapore settle the problem of shortage of labours enough qualified to absorb high quality FDI, as it is observed in case of Malaysia and Thailand *(Rasiah, 2018).*

So, as shown by experiences of the above noted countries, both developed countries and developing ones all have made considerable efforts for strong promotion of STI activities. Also, experiences of successful outcomes show the main trends to put the private sector to center position of innovation activities. But, depending on actual context, political institutional structure and cultural features, the interactions between the public sector and the private one appear different.

5. Conclusion and implications for Vietnam

The paper provides an overview of growth theories and practical realization of STI roles in economic growth. Globally, theories and practical realization show well the key roles of STI for long-run economic growth of all the countries. However, the extent of impacts from STI activities remains depending on NIS operations of every country.

As shown by experiences of successful countries, since the development process of every country takes its own evolution path, Vietnam should not impose identically the way which was conducted by any country. Vietnam should have deliberate considerations of real factors of its specific political, cultural and social contexts and international trends for building up adequately its own innovation policies to offer the highest driving forces for innovations by the private sector in the whole framework of NIS.

In practical context of developing countries, the lack of high quality human resources does not mean only a shortage of researchers and scientists but also skilful engineers and workers. It is the problem every developing country has to face while building up its own STI platforms. Especially, for maximal attraction and use of high quality FDI sources, the developing countries, where Vietnam is a case, should turn investment attentions for high grade education systems including vocational training system. They have to be well linked to needs of business communities, attract investment sources form and develop cooperation with the private sector.

In developing countries, the novelty in innovations is of relative nature. In the system many entities do not appear or develop yet, many market or non-market institutions are still lacking, economic components still depend on external factors and capacities of domestic organizations and institutions remain limited. Therefore, the State organizations and authorities need to remove barriers and stimulate the private sector to create the missing entities and linkage. In 4.0 Industry context, the audacious measures should be taken to set up pilot institutional frameworks for trial (sand box) of new technologies and new business models by domestic and foreign businesses. STI policies should take considerations for social and sustainability aspects in order to meet supports by population for practical implementation of new technologies (*Schot and Steinmueller 2018; Bach Tan Sinh, 2020*). It is, in fact, the spirit of the NIS approach under formation where Vietnam needs to learn for building up its own NIS in vision to support the long-run and sustainable economic growth./.

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