WHAT DETERMINE THE EFFECT OF INNOVATION ON ECONOMIC GROWTH? A DESCRIPTIVE INVESTIGATION FOR HIGH AND MIDDLE INCOME COUNTRIES

QU'EST-CE QUI DÉTERMINE L'EFFET DE L'INNOVATION SUR LA CROISSANCE ÉCONOMIQUE? ANALYSE DESCRIPTIVE POUR LES PAYS À REVENU ÉLEVÉ ET INTERMEDIAIRE

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ABSTRACT:
This study aims to analyze the effect of R&D expenditures and innovation on economic growth. Also, we put emphasis on the role of other determinants that may have a higher influence than R&D, patent on economic growth. In this study, 28 countries were included during the period 2000-2014. The results

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provide evidence that R&D spending contributes to economic growth in both high- and middle-income countries, as the theory suggests. Furthermore, the innovation seems impact indirectly through some other factors as: political institutions, or the inflows of foreign direct Investments. Policy makers wanting to stimulate innovation may want to look at the level of the quality of institutions and the level of trade openness as a precondition innovation policy.
Key Words: Innovation, Economic growth, High income countries, Middle income countries.

Résumé:
Cette étude vise à analyser l'effet des dépenses de R&D et de l'innovation sur croissance économique. En outre, nous mettons l'accent sur le rôle des autres déterminants qui peuvent avoir une influence plus importante que les dépenses de R&D, brevets sur la croissance économique. Dans cette étude,28 pays ont été inclus au cours de la période 2000-2014. Les résultats apportent la preuve que les dépenses de R&D contribuent à la croissance économique, comme le suggère la théorie. En outre, l'innovation semble avoir un impact indirect par le biais d'autres facteurs tels que: les institutions politiques, ou les investissements directs étrangers. Les décideurs politiques qui souhaitent stimuler l'innovation peuvent vouloir considérer le niveau de qualité des institutions et le niveau d'ouverture commerciale comme une politique d'innovation préalable.
Mots clés : Innovation, Croissance économique, Pays à revenu élevé, Pays à revenu intermédiaire.

1- INTRODUCTION:

Technical progress is an important factor of economic growth (Solow 1957, Romer 1986 and Romer 1990). The new theories of growth have emerged in order to endogenize technical progress. According to Solow (1956), technical progress is exogenous to the model, that is to say that it does not explain it but considers it as given, it is a "residual factor".

How does innovation define? The term "innovation" has existed since 1934, Joseph Schumpeter was the only economist of the time to have the factors influencing innovation and its impact on economic growth. Today, the Oslo Manual, implemented by the OECD and the European Commission defines innovation as the implementation of a new or

significantly improved product (good or service) or process, a new method of marketing, or a new organizational method in the company's practices. Organization of the workplace or external relations ".

The question of the measure of innovation was for a long time at the center of economic and political debate. For many researchers, it is difficult to measure and study the performance of innovation as it heavily depends on the economic situation, governance, education and infrastructure and other factors. However, the most developed, reliable, and most applied innovation indicators are R&D activities (R&D intensity) and patent (applied or granted) data, which can be defined as respectively input and output innovation indicators (khan and Ur Rehman, 2014; Wang, 2013 and Green halgh & Rogers 2010 pp 59-60). "*Research and development is an indicator of investment in technology and future capabilities, and therefore plays a critical role in the innovation process and the creation of new products, processes and services*" (Harris, 2018). While R&D measures contribute to innovation, IPR statistics provide measures of innovation output (Wang 2013: pp 3). In the economic analysis of innovation, several important types of IPRs have considered especially patent statistics have been very widely analyzed as a proxy for innovation “output". In contrast, trademarks have not enjoyed broad coverage in the economic literature as innovation measures. For this fact, it is interesting to take into account the measure of R&D expenditure, and patents (application). Trademarks will be added as another measure of innovation.

Since 2000s, the studies of the relationship between research and development activities, innovation and economic growth are on the rise. Furthermore, the issue on the effects of technology on economic growth has become a subject of intense interest and discussion among researchers worldwide at this time. Hence, the news shows that innovation and R&D expenditure are important factors for economic growth. Besides, innovation has led to a profound improvement in the standard of living in many countries (Wang 2013: pp1). For example, in

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the world economic forum report published on February 07, 2018, Harris shows that "China is already well on its way to becoming a superpower in the key areas of science and innovation". In terms of R&D activities, China is the second-largest spender on research and development (R&D) after the US. Furthermore, China's new generation of scientists is also venturing into more demanding and high-tech areas.

Existing studies show that the direction of effect of innovation on growth economic differ across countries (Inekwe 2015: p728; Brenner2014: pp 9-10 and Hasan and Tucci 2010: pp1265) and between periods (Sandu and Ciocanel 2014: pp84 and Wang 2013: pp 14). Hence, the level of development plays essential in the determination of this relation. The literature on the advanced countries is extensive, especially around the topics of innovation. Unlike on the developing countries, given the lack of information on innovation and its nature (Cirera and Maloney 2017: pp16), studies on this type of country are becoming few comparing to developed countries.

Theoretical and empirical work suggests that innovation (research and development investment) has a positive effect on productivity and economic growth in developed countries (Türedi 2016 and Huňady and Orviská 2014). On the other hand, in developing countries, this relationship is still not positive or there is no direct effect on economic growth (Gumus and Celikay 2015; Akcali and Sismanoglu 2015; Ulku, 2004; Coe, Helpman and Hoffmaister 2009 and Coe and Helpman 1995) because of the lack of resources allocated to R&D activities in these countries (Tuna, Kayacan and Bektaş 2015; Şahin 2015; Inekwe 2015; Khan and Ur Rehma 2014 and Samimi and Alerasoul 2009).

In this study, 28 countries (18 from the high income countries and 10 from the middle income countries) were included during the period 2000-2014. Our objective is to analyze the effect of R&D expenditures and innovation on economic growth. And we shed light on the role of other determinants that may have a higher influence than R&D, patent and economic growth. We also explore the indirect relations between

innovation and economic growth and look forward the factors through which these indirect channels are made.

These results provide evidence that R&D spending contributes to economic growth in both high- and middle-income countries, as the theory suggests. However, the innovation seems impact indirectly through some other factors as: political institutions, or the inflows of foreign direct Investments. Policy makers wanting to stimulate
Innovation may want to look at the level of institutional environment and the level of trade openness as a precondition innovation policy.
The structure of this paper is organized as follows. First section proceeds to literature review obtained from the relationships of the R&D intensity, IPS (patent application and trademarks) and other macroeconomic indicators. Section two proceed to descriptive analysis of the relationships between measure of innovation and other macroeconomic indicators. The last section provides conclusion.

2- LITERAURE REVIEW:

Empirical relationship between innovation and economic performance are divided according to the level of development of countries, the level of innovation, the foreign direct investment, the development of export performance and the level of institutional environment. Furthermore, we are three type of relationships: First, R&D expenditures and economic Growth. Second innovation and economic Growth. And finally R&D expenditures, patent, and economic Growth.
"*Research and development is an indicator of investment in technology and future capabilities, and therefore plays a critical role in the innovation process and the creation of new products, processes and services*" (Harris, 2018). From the recent work, R&D acts have been most frequently used to measure innovation (Wang 2013: pp2).

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However, these studies are motivated by the ideas that to realize a sustainable economic growth it is very important to give more role to the R&D activities (Şahin 2015: pp14). Besides, it's not surprising to observe the significant increase of the studies of relationship between economic growth and research and development R&D activities, especially R&D expenditures, since 2000.

The contribution from innovation to economic growth varies greatly across countries and among macroeconomic factors. Nevertheless, the level of development of countries is an important factor in determining this relationship. Then, "*R&D expenditures have a strong impact on the level of development of a country*" (Şahin 2015: pp4). Furthermore, the experience of developed countries has shown that R&D spending positively affects economic growth (Türedi 2016; Freimane & Bāliņa 2016; Van Elk 2015; Gumus and Celikay 2015; Akcali and Sismanoglu 2015; Şahin 2015; Pece 2015; Huňady and Orviská 2014; Coe, Helpman and Hoffmaister 2009 and Coe and Helpman 1995).

Thus of information on innovation and its nature in developing countries are becoming rare (Cirera and Maloney 2017: pp16), and the relationship between R&D expenditure and economic growth is still not positive or there is no direct effect on economic growth (Gumus and Celikay 2015; Akcali and Sismanoglu 2015; Tuna, Kayacan and Bektaş 2015; Bozkurt 2015; Inekwe 2015; Khan and Ur Rehma 2014 and Samimi and Alerasoul 2009). However, the conclusion drawn from these studies is that for developing countries to achieve a high and sustainable rate of economic growth and reduce the development gap with developed countries, they must allocate a greater share of national income to R&D (Freimane and Bāliņa 2016; Gocer 2016; Türedi 2016; Tuna, Kayacan and Bektaş 2015; Inekwe 2015, Bozkurt 2015; Gumus and Celikay 2015; Şahin 2015; Khan and Ur Rehma 2014 and Samimi and Alerasoul 2009).

Patent data is another important proxy for innovation. According to the level of development of the countries, the studies show that R&D expenditures impact on economic growth or total factor. However, the

evidence of this relationship is not always the same when the effect of innovation (patent or trademark) is concerned. The recent empirical findings about this causal link show positive, negative or mixed correlation. First, the impact of patent on economic growth is positive and statistically significant (Akoum 2016; Gocer 2016; Pece 2015; Türedi 2016; Josheski and Koteski 2011 and Sinha 2008). Second, on the contrary, the impact of patent on economic growth is negative (Vuckovic 2016; Vetsikas and Markatou 2015 and Sinha 2008). For example Vuckovic (2016) found that innovation (the number of patent per million citizens) and economic growth (GDP growth rate) are not statistically significant in the emerging markets. Finally, there is mixed correlation between patent on economic growth (Wang 2013; Saini and Jain 2011). For Wang (2013) used patent and trademark statistics as proxies for innovation and examines the long-term effect of innovation on economic growth in six countries with the largest number of rights system statistics of Intellectual Property (IPR): United States, Japan, Germany, United Kingdom, France and Australia. The results of the study show that the contribution from innovation to economic growth varies greatly across countries, and over time. For United States, United Kingdom and Germany, the effect of innovation no longer be positively driving the economy growth in trademarks statistic. But for Japan, France and Australia, the results showed that innovation has maintained a positive role and had a significant effect on economic growth, especially in the post-World War II era.

However, for countries aiming to achieve a sustainable and high rate of economic growth, it is necessary to establish a new development policy where innovation (patent system) must play a central role in this process (Türedi 2016: pp46; Gocer 2016: pp162 and Vetsikas and Markatou 2015).

Other literature has claimed that R&D investments are driving technological change and technological change is driving economic growth. In fact, the authors find that R&D spending leads to innovation

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success in the form of patents which, in turn, leads to economic growth and productivity. In these studies, the authors estimate two relationships: first, the estimation of the innovation model. Second, the estimation of the economic growth model (the relationship between innovation (as input) and economic growth) (Verba 2015; Adak 2015; Meo and Usmani 2014; Guloglu and Tekin 2012; Wu 2010; Prodan 2005; Bilbao-Osorio and Rodriguez-Pose 2004 and Ulku 2004).

Whatever the method of estimation, the level of development of countries, there are significant effect of R&D activities, patent application and economic growth (Meo and Usmani 2014; Guloglu and Tekin 2012; Wu 2010; Prodan 2005, Bilbao-Osorio and Rodriguez-Pose 2004 and Ulku 2004). For Guloglu and Tekin (2012) investigated the causal link between R&D spending, innovation and economic growth in 13 high-income OECD countries: Australia, Canada, Finland, France, Germany, Italy, Japan, Korea, Netherlands, Portugal, Spain, United Kingdom and United States for the period 1991-2007. Using *Panel Granger-Causality Test* (GMM and Panel VAR methods), the results of the Granger table causality test provide important insights into the causal relationships between R&D, innovation, and economic growth.

Moreover, and with technology import, another proxy of innovation input, Adak (2015) analyzed the relationship between technological progress (technology import), innovation (total number of patent applications) and economic growth in Turkey. The results show a significant effect of technology import and the total number of patent applications on economic growth.

The level of development of countries is not always considered as a key determinant of the relationship between innovation and economic growth. Akcali and Sismanoglu (2015), show, taking as a single measure of economic development GDP growth, a relatively higher impact of R&D spending on all countries (some developing and developped countries) for a period from 1990 to 2013: Developped countries spend more than developing countries, but the effect on economic growth in this case does not depend on the level of development. That is, regardless

of the level of development of countries, the effect of R&D on economic growth is the same. Hence, other factors, other than the level of development of countries, can be taken into account to determine the relationship between innovation and economic growth (Hasan and Tucci 2010 and Aristizabal-Ramirez 2015). "If a country wants to benefit from the spillovers and externalities associated with innovation, it is necessary for them to make efforts and increase their innovation levels" (Aristizabal-Ramirez 2015: pp 1475).

Also, the level of innovation is an important determinant in a study of the relationship between innovation and economic growth, it is for this reason that, Aristizabal-Ramirez (2015) examined the existence of a threshold in the relationship between innovation (the number of patents per capita as a proxy of the intensity of the innovation) and economic growth for 147 countries taken from 2006 to 2012. His results suggest the existence of a threshold effect in the relationship between innovation and economic growth. In other words, lower levels of innovation do not generate economic growth, while higher levels of innovation have a positive impact and a significant effect on output.

The financial opening is, then, an important determinant for economic growth. It was found out that very few studies were conducted about the relationship between R&D investment spending and foreign direct investment. Foreign Direct Investments (FDI), which is defined "as a form of inter-firm cooperation that involves a significant equity stake in or effective management control of foreign enterprise" (Erdal and Göçer 2015: pp 750). Besides that, knowing that R&D expenditure is essentially very expensive, especially for developing countries increasing R&D spending is a task that is not always easy. Therefore, it is important to promote foreign direct investment to reduce the weight of investment in R&D activities for the developing countries (Can, Doğan and Değer 2017: pp66). In other words, when multinationals invest in R&D, they accelerate both their high-tech development and the R&D stock in the host country. According to Erdal and Göçer (2015), the countries who

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suffer from capital deficiency and technology gap problems should attract more FDI to increase capital accumulation and economic growth. In the recent studies, the authors found that foreign direct investments have a major impact on economic growth through knowledge transfer and improvement of technological processes. Therefore, they found that R&D spending, innovation, foreign direct investment, and economic growth have a long-term relationship (Can, Doğan and Değer 2017; Erdal and Göçer 2015; Sandu and Ciocanel 2014; Brenner 2014 and Guloglu, Tekin and Saridogan 2012). However on the contrary, other work shows that foreign direct investment has negative effects on innovation activities (the number of patent applications) (Vuckovic 2016). The author shows that FDI decreases the total number of patents per million citizens in emerging economies in the period from 1991 to 2013, while increasing R&D expenditures has stimulating effects on patent application.

Moreover, the creation of technologies by the national companies to cross the technological frontier is an advanced stage of development despite those FDI inflows represent the most important factors for South Korea, China, Malaysia and Singapore (Cherif and Hasanov 2015). The author examined Malaysia's economic performance relative to other economies such as Korea, Taiwan Province of China, Thailand and Chile during the period 1970-2010. The study reveals that Malaysia has reached the same export sophistication level as those of the other Asian countries, but its total factor productivity remains low. In addition, the lack of domestic technological upgrading is the main reason why Malaysia remains stuck in the middle income room unlike the Taiwan Province in China and Korea. In other words the creation of technologies by the national companies push to cross the technological frontier at an early stage of development.

More recently, the focus has turned to high-technology trade; other works stress the importance of the innovation in the development of export performance. The analysis of exports growth and its overall economic effects has been a significant topic in the economic literature

over the last decades (Tebaldi 2011: pp344). However, as researchers endeavor to understand the links among innovation, high-tech international trade and overall economic performance (Meo and Usmani 2014; Sandu and Ciocanel 2014 and Guloglu, Tekin, Saridogan 2012). Economic recovery and the resumption of sustainable economic growth in some countries are largely supported by export stimulation and, especially, high-tech exports (Sandu and Ciocanel 2014). This finding seems consistent with the theoretical arguments that intensity of R&D has a positive impact on the intensity of high tech export especially in developed countries: the greater the level of R&D investment in high income countries, the higher will be its high technology exports.

The institutional development is another determinant that stimulate the relationship between innovation and economic growth (Oluwatobi and EFOBI 2015; D'Agostino and Scarlato 2012; Barbosa and Faria 2011 and Coe, Helpman, and Hoffmaister 1997). For Oluwatobi and EFOBI (2015) examined the link between institutions and innovation in Africa. A sample of 40 African countries during the period 1996-2012 was used. Drawing on the work of Tebaldi and Elmslie (2008a), they found that the control of corruption, the effectiveness of government and the quality of regulation positively affect the rate of innovation (articles in scientific and technical journals) in Africa. Furthermore, D'Agostino and Scarlato (2012) explored the relationship between inclusive institutions, innovation and economic growth for 15 European countries based on two different periods (1960-2010 and 1996-2010). The results suggest the existence of a positive relationship between inclusive institutions and innovation and economic growth.

We can conclude from these works the most contributing factors towards a knowledge economy and adapt it according to our objective as follows. Figure 1 represent the relationship between innovation measures and economic growth can be conditioned by other factors such as: the level of institutional environment, FDI, level of development or innovation.

Figure 1: Innovation cycle and others macroeconomics indicators.

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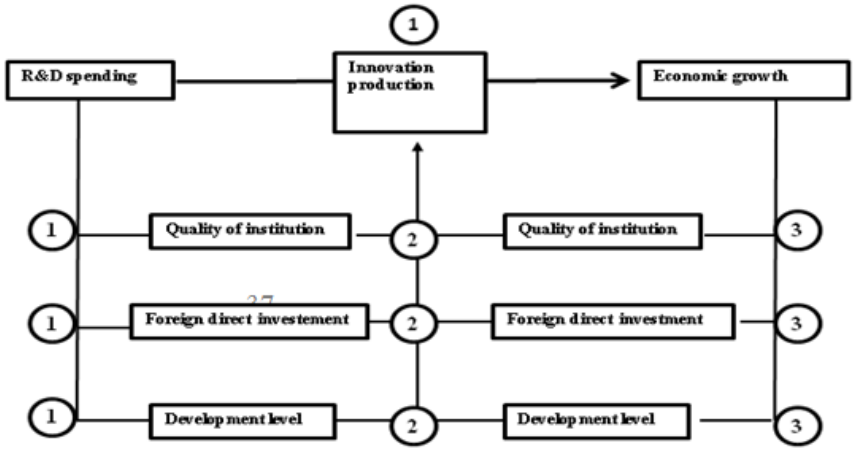


Source: Own inspiration.

The number 1: represent the effect of R&D spending on economic growth conditioned by innovation, quality of institutions, Foreign direct investment, and level of development respectively. The number 2: represent the effect of R&D expenditures on the innovation production conditioned by quality of institutions, Foreign direct investment, and level of development respectively. And finally the number 3: represent the effect the innovation on the economic growth conditioned by quality of the institutions, Foreign direct investment, and level of development respectively.

3- DESCRIPTION ANALYSIS:

3-1. Methodology and Data Set:

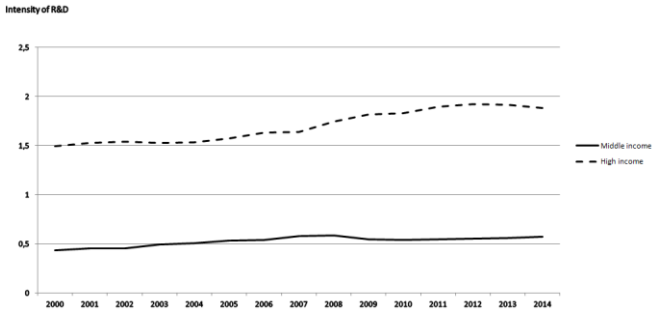
We use the Averages of a sample of individual data covering the period from 2000 to 2014 for 28 countries (18 from the high income countries and 10 from the middle income countries). We perform a correlation analysis between measures of innovation and other macroeconomics indicators. Hence, mesures of innovation represented by intensity of R&D and Innovation performance (patent and trademark), and macroeconomics indicators represented by : Economic growth (GDP per capita and Total factor productivity), opening the

economy (The intensity of high tech exports and Foreign direct investment) and institutional intensity (Kaufmann indicators).

3-2. the correlation between measures of innovation other macroeconomics indicators:

"Research and experimental development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge"[1].

Figure 2: Average R&D intensity (2000-2014) by level of income.



Source: World Development Indicators 2014

R&D data (R&D expenditure or R&D-related employment), have been most frequently used to measure innovation. But Research and development spending is one of the most used measures for innovation inputs, as it is used to describe investment in innovation activities[2]. For Verba (2015), R&D expenditures are more favored than R&D personnel because it gives an indication of the potential for innovation. In addition, R&D expenditures is one of the very few inputs that offer a consistent

[1] The definition of R & D is established by the Frascati Manual (OECD, 6th edition, 2002) which is the methodological reference for the collection and exploitation of R & D statistics. It contains the definitions of the basic concepts and guidelines for data collection and the classifications to be used for the compilation of statistics:

[2] See Greenhalgh and Rogers (2010)

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measure for firms and countries[3]. Figure 2 represents data for Research and Development expenditures as a percentage of GDP for 2000-2014, and indicates that, in recent years, intensity of R&D has gradually increased. In high income countries, R&D presents a larger share of GDP (1.7%) than in the middle income countries (0.53%). This result confirm the idea that: "Poor countries invest far less in R&D than rich countries"[4]. Between 2000 and 2014, the results show an increase of 26% in high income countries, then, for middle income countries, the results show an increase of 31%. Developing countries are spending less than developed countries. For this observation, Cirera and Maloney use the term of "The innovation paradox" and asking for the next question: why do poor countries not invest far more than they do?

Indeed, several studies affirm this last result (as for Tuna and al 2015; Inekwe 2015; Khan and Ur Rehma 2014 and Samimi and Alerasoul 2009). In fact, developed countries seem to spend more in R&D than developing countries, and the question that concerns us here is whether the effect of R&D on economic performance depend also on the level of development.

Intellectual property statistics, particularly patents, have drawn attention in the economics literature as an alternative innovation proxy data. While R&D measures contribute to innovation, IPR statistics provide measures of innovation output (Wang, 2013). "Patents is a policy instrument that is designed to encourage firms to invest in research in order to increase innovation by ensuring a time-limiting monopoly rent that provide the inventors the opportunity of profiting from their inventions, before they get copied by competitors"[5] Several researchers use patent statistics as proxies for innovation in studies related to the innovation economy. In addition, the use of a patent application is more popular than patents granted because it takes a few years for a patent to be issued (Prodan 2005: pp9).

[3] See Cirera and Maloney (2017)
[4] See Cirera and Maloney (2017)
[5] See Svenningsen (2015)

The observation of intensity of innovation data (*Data on the intensity of innovation patent are represented by patent applications (resident + non-resident) on average for the year 2000-2014*), patent have steadily risen in the past two decades. It can be seen that in middle-income countries the increase in patent applications during this period is spectacular **(89%).** Unlike high-income countries, and despite a high investment in R&D, during this period, the patent applications decreased by **15%**. Developed countries seem to produce less patent than developing countries after 2005, and the question that concerns us here is whether the effect patent on economic performance depend also on the level of development.

The third measure of innovation is trademark. The trademarks have not enjoyed broad coverage in the economic literature as innovation measures.

The trademark data shows (*Data on the intensity of innovation are represented also by trademark applications (resident + non-resident) on average for the year 2000-2014*) that trademark applications have steadily risen in the past two decades, particulary in middle income countries. It can be seen that in middle-income countries the increase in trademark applications during this period is spectacular **(89%).** Unlike in high-income countries, and despite a high investment in R&D during this period, trademark decreased by **14%.** Developing countries seem to produce more trademark than developped countries, and the question that concerns us here is whether the effect trademark on economic performance depend also on the level of development.

3-2-1. The correlation between mesure of innovation and economic growth:

We test the relationship that greater level of R&D investment, patent and trademark is likely associated with higher economic growth.

a-GDP per capita:

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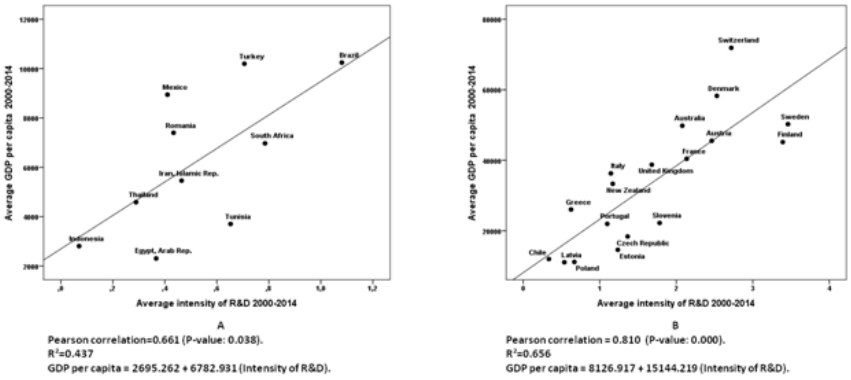
First, for the intensity of R&D;

Figure 3: Correlation coefficient between the intensity of R&D and GDP per capita among middle income and high income countries (2000-2014).



Source: World Development Indicators 2014

The relation between GDP per capita and intensity of R&D for middle income and high income countries is shown in figure3a and figure3b respectively. The results of the Pearson's correlation analysis show that there is a statistically high significant positive relationship between GDP per capita and R&D expenditures in middle and high income countries. According to the two-sided t-test, correlation coefficients indicating the direction and strength of the relationship are 0.66 and 0.81, respectively. Then, by running a simple linear regression: the results show a reasonable explanatory power (R2= 0.437) for middle income countries and (R2= 0.656) for high income countries. Furthermore, this finding is more in line with theoretical finding that R&D expenditures have a positive impact of economic development: the greater the level of R&D investment in middle and high income countries , the higher will be it GDP per capita. Research related to the OECD countries, Türedi (2016) showed that there is a positive two-way causality relationship between economic growth and R&D spending. Şahin (2015) concluded that an

increase in R&D expenditure of 1% results in an average increase of 0.61% in economic growth.

In another study covering the developing and developped countries, Gumus and Celikay (2015) have found that R&D spending has a positive and significant effect on economic growth for all countries (52 countries) in the long term, but for developing countries, the effect is small in the short run but strong in the long run. In studies on Turkey, Bozkurt (2015) suggest that there is a unidirectional causal relationship ranging from economic growth to R&D and not vice versa. Furthermore, in long run, the growth rate of GDP will increase 0, 263 % if R&D shares in the GDP increases 1%. In another study covering the developing countries, Inekwe (2015) examined the role of R&D spending on economic growth in seventy-six developing countries grouped as lower middle-income and upper middle-income between 2000 and 2009. In the survey, the author concludes that R&D spending has a significant impact on economic growth in developing countries and the effect of R&D spending on growth is positive for upper middle income and insignificant in lower-income economies. In addition, the beneficial effects of R&D spending in developing countries could come from the positive effects of R&D in upper-middle-income economies.

Second, the intensity of innovation (patent) shows a positive linear relationship with GDP per capita in middle income countries (Pearson coefficient ($r = 0.573$)). This finding is more in line with theoretical arguments that innovation activity has a positive impact of economic development. Unlike in high income countries, the correlation is lower ($r = 0.269$). A popular study Ulku (2004) examined the relationship between innovation, created in the R&D sectors, and economic growth for 20 OECD and 10 non-OECD countries for the period 1981-1997. He found a strong positive relationship between innovation (Patent) and GDP per capita and TFP in both OECD and non-OECD countries.

Although high-income countries spend more on R&D than middle-income countries, the innovation production in term of patent is lower.

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For Savrul (2015), the innovation rank and R&D intensity data evaluated in this study shows that innovation performance and R&D intensity ranks deviate. "Some countries such as Israel may have a much worse innovation performance score than expected in return of its R&D intensity in contrast some other countries may have much better innovation performance with lesser investment". The author concluded that positive environmental factors have great impact on a country in transforming its innovation investments to innovation performance.

Third, the results for the relation between GDP per capita and intensity of innovation (trademark) show that, for middle income, there is a reasonable explanatory power (R2= 0.529) and a positive coefficient with significance (p = 0.017). For high income countries , the results show a positive coefficient but not significant. Wang (2013) considered that trademarks have drawn attention in the economics literature as an alternative innovation proxy data.

b- Total Factor Productivity:

Now, we compare the impact of R&D expenditures, patent, and trademark on Total Factor Productivity represented.

First, according to the correlation coefficient between the intensity of R&D and TFP, the results show that in high income countries there is a reasonable explanatory power (R2= 0.504) and a positive coefficient with *high* significance (p = 0.001). Unlike, in middle income countries, there is a positive coefficient but not significant correlation. This finding is more in line with theoretical results (Ulku 2004; Coe, Helpman and Hoffmaister 1997 and Coe and Helpman 1995) arguing that R&D expenditure is an important determinant of TFP growth.

Second, for the correlation coefficient between the patent and TFP, the results show a positive coefficient (r = 0.443) for high income countries. Then, for middle income countries, the results show a negative coefficient (r = -0.254).

Bilbao-Osorio and Arjona (2018) in Science, research and Innovation Performance of the EU (SRIP) report show that despite the rise of several

new technologies with the potential to bring large gains in productivity, such as the Internet of Things or artificial intelligence (AI), productivity growth has been sluggish owing to the slow diffusion of innovations.
Third, the relation between TFP and intensity of innovation (trademark) for middle income is negative and for high income countries is positive.

3-2-2. The correlation between mesure of innovation :

A higher level of expenditure on R&D necessarily does imply a strong production of innovation (patent)?
The correlation between patent and R&D expenditure, the results show a positive correlation between intensity of R&D and patent application in middle income countries (r=0.484) with linear relationship. For high income countries, the correlation is lower (r=0.092). This result confirms that although R&D spending is higher, innovation output in terms of patents is not necessarily higher. According to Wu (2010) examined the impact of R&D efforts on innovation (patent application) and hence economic growth in 31 Chinese regions during the period 1998-2007. The results found that innovation affects China's economic growth positively while R&D intensity has a positive impact on regional innovation.
We test the relationship that greater level of R&D is likely associated with trademark. The results provide a positive correlation between intensity of innovation (trademark) and R&D intensity for middle income countries. But for high income countries, there is no correlation. Is there a relationship between patent applications and trademark applications? The results provide a positive correlation between the two indicators of intensity of innovation for middle and high income countries (r=857) and (r=767) respectively. Indeed, there are a reasonable explanatory power (R2= 0.735) to (R2=0.589) respectively. These finding show that patent application have a positive impact on trademark application.

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3-2-3. The correlation between mesure of innovation and opening the economy:

The financial opening is an important determinant for us to indicate the direction of the relationship R&D expenditure and economic growth; in the following we will first analyze the correlation between foreign direct investment- measure of innovation then measure of innovation -high tech export.

a-Foreign direct investment:

From the correlation between foreign direct investments (stock) inflow and the intensity of R&D, despite there are low positive correlation between the spending on R&D and FDI, it is slightly higher in the middle income countries. This result confirms previous work, especially for developing countries, increasing R&D spending is not always easy, knowing that R&D expenditure is essentially very expensive. Therefore, it is important to promote foreign direct investment in these countries (Can, Doğan, and Değer 2017: pp66). According for Erdal and Göçer (2015) found that a one percent increase in FDI inflows is associated with a 0.83% increase in R&D spending and a 0.42% increase in patent application in 10 developing Asian countries; China, South Korea, India, Iran, Pakistan, Malaysia, Singapore, Thailand, Saudi Arabia and Turkey for the period between 1996 and 2013. This means that there are FDI effects on R&D spending and innovation activities in host countries. Brenner (2014) tested the impact of FDI on economic growth, capital and labor inputs and innovation activities (patent invention and application activities) using a sample of 112 countries from 1974-2009. The data are divided into two periods, namely 1974-1991 and 1992-2009, and in three groups of countries: the less, medium and more developed countries. The results are confirmed the effects of FDI on innovation activities are observed for medium-developed countries in the latter time period.

For patent, there are a negative correlation between the intensity of innovation (patent) and FDI in middle and high income countries (r=-0.299) and (r=-0.198) respectively.

Then for trademark, The correlation between FDI and intensity of innovation (trademark) for middle income and high income countries is negative but not significant. In middle income countries, the correlation is higher (r=-0.402).

b-Concerning export sophistication:

The relationship between intensity of R&D and intensity of High-Tech exports, the Pearson's correlation analysis and simple linear regression show that there is a statistically high significant positive relationship (r=0.649) and a reasonable explanatory power (R2= 0.422) in high income countries between high –tech exports and R&D expenditures. In middle income countries, the Pearson's correlation analysis show that negative correlation. This finding seems consistent with the theoretical arguments that intensity of R&D has a positive impact on the intensity of high tech export especially in developed countries. Sandu and Ciocanel (2014) also show that, for the private sector an increasing R&D expenditure leads to growth of the medium and high-tech products export in Romania and other EU countries employing quantitative and qualitative methods.

The relationship between patent and intensity of High-Tech exports, the results show a positive coefficient but not significative in both high and middle income countries. Nowadays, when every country is seeking viable solutions for relaunching sustainable economic growth, the issue of high-tech production is highly relevant and timely (Sandu and Ciocanel 2014: pp 81).

A positive association between patents and high technology exports was also observed, Meo and Usmani (2014) compared the impact of Research & Development (R&D) expenditures on research publications, patents and high-tech exports among 47 European countries during the period 1996-2011. They concluded that, expenditure on R&D, scientific

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indexed journals and research publications are the most significant contributing factors towards a knowledge economy which in turn give a boost to patent applications, high technology exports and ultimately GDP.

For trademark, the results show a positive coefficient but not significative in middle and high income countries (r=373) and (r=355) respectively. Hence, the greater the level of production of innovation (trademark), the higher will be its high technology exports.

It is interesting to see also the relationship between foreign direct investment and high technology exports. So, we test the relationship that greater level of foreign direct investment is likely associated with high technology exports. The results show that there is a positive correlation in the middle and high income countries but it is weak. Moreover, the correlation in the high income countries is slightly higher (r=165).

Turen and Gökmen (2013) examined the relationship between high technology exports and FDI including human development level and economic freedom level for EU-15 countries covering the period 1995-2010. They found a positive relationship between high technology exports and FDI. According to Tebaldi (2011), FDI inflows have a positive and statistically significant and imply that a one percent increase in net FDI inflows is associated with an increase of about 0.17% on high-tech exports per worker for the period 1980-2008. This result corroborates the view that opening the economy to both FDI and international trade will create an environment conducive for high-tech exports growth.

3-2-4.The correlation between mesure of innovation and quality of institutions:

"The term "institutions" has been used in the literature to represent different aspects of economic, legal, political, and social activity, making it difficult to arrive at a single definition" (Barbosa and Faria 2011: pp 1158).

Our statistical representation provides a positive correlation between intensity of R&D and the WGI elements for middle and high income countries. Institution intensity between R&D intensity is tested below.

The Worldwide Governance Indicators (WGI) project reports aggregate and individual governance indicators , for six dimensions of governance by Daniel Kaufmann

We will now test the correlation between intensity of R&D and institutional intensity in middle and high income countries. Knowing that there are six measures of institutional quality, the results indicate: For high income countries, we show a positive coefficient with *high* significance (p=0.000 to p=0.007) and a reasonable explanatory power (R2= 0.376 to R2=0.671). Government Effectiveness, rule of law and Voice and Accountability are the three indicators that have a strong correlation on R&D spending in the high income countries. For middle income countries, Control of Corruption, Political Stability and Absence of Violence are the thwo indicators that have a strong correlation on R & D spending, especially Control of Corruption, a positive coefficient with *high* significance (p=0.005) and a reasonable explanatory power (R2=648). In fact, for high income countries the impact of the institution's measures on R&D intensity is higher when Government effectiveness and Voice and Accountability are improved in relation to the improvement of control corruption, rule of law etc . This implies that high income countries should focus on improving their Government effectiveness and Voice and Accountability to stimulate a higher of R&D intensity. However, these last two measures are essential in high income countries to improve innovation. Then, in middle income countries, the impact of the institution's measures on R&D intensity is higher when Control of Corruption, Political Stability and Absence of Violence are improved in relation to the improvement of Government effectiveness and Voice and Accountability etc. This implies that middle income countries should focus on improving their Control of Corruption,

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Political Stability and Absence of Violence to stimulate a higher of R&D intensity.

For the intensity of innovation (patent), the pattern is less clear. The results provide a low correlation between patent and WGI for middle and high income countries. The higher correlation, in middle income countries, is for the variable voice and accountability (r=0.392). Then, for high income countries, the higher correlation is for the variable regulatory quality (r=0.310).

For trademark, the results obtained are not clear, the correlation is very weak in middle and high income countries for all measures of quality of institution. In middle income countries, there are positive coefficient for the variable of the voice and accountability (r= 490). In high income countries, the correlation vary between r=0.316 to r= 0.256. Another industry-level study was conducted by Barbosa and Faria (2011). The authors examined the relationship between the institutional environment and innovation in European Union (EU) countries at the industry level. The results highlight the importance of institutions in explaining the intensity of innovation. Coe, Helpman, and Hoffmaister (2009) addressed the issue of heterogeneity of parameters to examine institutional sources of heterogeneity and came to the conclusion that institutional factors are important determinants of total factor productivity. In other words, institutions can affect economic growth.

4- CONCLUSION:

Our study aims to analyze the effect of R&D and innovation on economic growth by taking into consideration the level of development of countries and other macroeconomic factors. In this study, 28 countries (18 from the high income countries and 10 from the middle income countries) were included during the period 2000-2014. According to the findings obtained from previous work, R&D investment is driving technological change, and technological change is driving economic growth. But this relationship is not always obvious and it can depend on several elements: The level of development, the changes in the time, type

of R&D spending, lagged R&D (R&D accumulation), type of IPR, the level of innovation, The market size, the economic goals of the countries, type of models/ function, type of sector/ region and type of method of analysis. The conclusion suggests that, for the developing countries should concentrate on R&D to achieve the sustained economic growth. According to the findings obtained from our analysis, these results provide evidence that R&D spending contributes to economic growth in both high- and middle-income countries, as the prediction of the endogenous growth model suggests. Furthermore, innovation is important for economic growth across political institutions, or the inflow of foreign direct investments. However, the innovation seems impact indirectly through this two factors. It is recommended that the countries who suffer from capital deficiency and technology gap problems should attract more FDI to increase capital accumulation and economic growth. In the other word, technology ownership can be gained through technology transfer by the way of inward foreign direct investments (FDI). For quality of institutional, in high income countries should focus on improving their Government effectiveness and Voice and Accountability to stimulate a higher innovation. For middle income countries should focus on improving their Control of Corruption, Political Stability and Absence of Violence to stimulate a higher of innovation. Policy makers wanting to stimulate innovation may want to look at the level of institutional environment and the level of trade openness as a precondition innovation policy.

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