International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

The impact of patent application on economic growth in Africa

George Duodu Kissi [1] and Samuel Gyedu [2,*]

[1] *University of Economics and Law "KROK" Kyiv, Ukraine.*
[2] *School of Intellectual Property, Jiangsu University, 301 Xuefu Rd, Jingkou Qu, Zhenjiang, Jiangsu Province, China.*

International Journal of Science and Research Archive, 2023, 10(02), 798–805

Publication history: Received on 01 November 2023; revised on 10 December 2023; accepted on 12 December 2023

Article DOI: https://doi.org/10.30574/ijsra.2023.10.2.1037

Abstract

This study investigates the impact of the application of patents on economic growth for 9 selected African countries between the period 2000 and 2017. We use the least squares ordinal econometric framework to test linear relationships and varying effects on patents application and economic growth. The findings showed that conditioning on other growth determinants, the impact of patent applications on economic growth was positive among African countries. Although patent applications affect economic growth, it is weak in magnitude. The results showed that a 1% increase in patent application will increase GDP per capita by 0.43% for all countries sampled. Patent applications have a significant impact on economic growth among the African countries for the period 2000-2008 and 2009-2017. The results show that conditioning other growth determinants, 1% increase in patent application in years that vary less than 2009 will contribute to an increase of 0.395% in GDP growth, while the percentage increase in patents application in years that vary greater than 2008 will contribute to a high increase of 0.437% in GDP growth. In other words the impact of patents on GDP growth has continued to increase from 2000 -2017. The results also show that African countries can increase their economic growth from increasing patent applications.

Keywords: Economic Growth; Patent Application; GDP Per Capita; Ordinary Least Square.

1. Introduction

Generally, investment in patent has been regarded as one of the key strategies to secure technological potential, and thereby innovation and economic growth. Patent includes creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications for rapid economic growth. The innovation and research sector relation was first focused upon at the beginning of the 90s (Silverberg, & Yildizoglu, 2002). They built an endogenous growth model with simulations. Since the creation of the first mechanism to protect inventions in 15th century, the patent system has evolved with a view to promote innovation and encouraging economic development. By offering exclusive rights for a limited period, an inventor may recover R&D costs and investments. It also promotes investment to commercialize and market new inventions so that the general public can enjoy the fruit of the innovation. Further, the system is designed to disseminate knowledge and information to the public through publication of patent applications and granted patents. Many countries, in particular Africa countries, have only begun to address the challenges of setting up an appropriate patent system in place to reap economic and social benefits. The development of Africa countries' resources and infrastructure and their capacity to benefit from the rapid growth of innovation as a valuable economic asset in the world economy remain an urgent concern (WIPO, 2015).

A patent is not a monopoly but gives the inventor the right of 20 years from the day the patent application was first filed to stop another person from using, making and selling the invention without the person's permission. Patents provide huge power to companies that are driven by technology around the world and also help in creating wealth for economic

* Corresponding author Samuel Gyedu.

growth for countries. While patent applications are important component of the patent system, their effects on economic growth have not been fully studied to date, mainly because the lack of available data for measuring patent applications (Papageorgiadis et al., 2016). Also, most studies on the impact of applying patents on economic growth vary in specific countries and periods. For example, Saini, A. K., & Jain, S. (2011) fined mixed results on the relationship between patent applications and GDP growth among Asian countries for 10 years (2000-2009). While Atta Ur Rehman, A., et al, (2015) also set mixed results on the impact of population and patents on economic growth, for middle and low income countries for the 1993-2012 period. In contrast Pece, A. M., et al. (2015) found a positive relationship between patent applications and economic growth in CEE countries from the period 2000-2013. This shows that the results of whether patent applications affect economic growth or not vary according to the geographical location of the country.

Global challenges such as brain drain, poverty and epidemics are still affecting African continent, though these could be handled by adopting appropriate innovation technologies (OECD, 2012). In addition, the most African countries are still depending on the export of low value-added products causing problems in their catching-up process. According to the World Economic Forum (WEF, 2017), economic growth and productivity development are sure to be achieved if there is an improvement in innovation, information and technological competence of these countries. Interestingly, adoption of appropriate foreign technology, improvement in innovation research and technological advancement such as patent application has been at the forefront of governance in Africa (Ács & Szerb, 2012) yet due to financial constraints, the chances of these countries have been extremely limited. (Udvari, & Ampah, (2018). Also, a study on brain drain in developing countries got to the conclusion that the highest average brain drain rates were observed in Sub-Saharan Africa (13%) and the Middle East and North Africa (10%). This is due to poor working conditions, low salaries, low level of development, high political instability, religious/ethnic fractionalization and strong colonial links. This is of course an issue that requires reflection and attention when discussing innovation activities which lead to economic growth in African countries (Docquier et al. 2007; de Pinho, 2013).

34 Out of the 49 countries considered to be "least developed" by the United Nations (UN) are in Africa (Africa Progress Report 2013). Although Africa is a rich continent. Many of its 54 countries are rich in mineral resources, including oil, metals and precious stones. It was estimated by The Economist (2013a) that this wealth in commodities has led to one-third of Africa's more recent GDP (Gross Domestic Product) growth, not counting indirect benefits (Albuquerque, E. M. 2004). However, in the recent African Progress Report (2013), Kofi Annan stresses that in many African countries "natural resources revenues are widening the gap between rich and poor. The continent has made several bold efforts to turn around its development fortunes through treaties that include the adoption of Africa's Science and Technology Consolidated Plan of Action by the African Union in January 2007 (UNESCO, 2010). Despite these attempts, Africa remains the poorest and most economically marginalized

Although, it is known that African has relative distinct knowledge on innovation. Africa's share of world science started to rise since 2004. Patent has contributed significantly in the economic growth of some African countries like South Africa, Egypt, Algeria and Tunisia. (de Pinho, 2013). Also there had been technological improvement in the global markets, majority of developing countries like Africa lags behind the innovation level of the developed countries. Considering the total factor economic growth as a measure of innovation level – as the World Bank (2008) recommends, African countries accomplish only 5.2 percent of the US performance, while the upper-developed countries achieve 23.7 percent (Udvari, B., & Ampah, I. K, 2018). Paradoxically, innovation in Africa has existed despite a prevailing developmental environment plagued by deficits in skills, technologies or infrastructure. Likely, African innovation stems from the extreme need to find immediate, sustainable solutions for critical problems the continent has been facing, and which threatens to hinder its growth and development, if not addressed properly. This could be as a result of paying little or no attention to innovation activities in most African countries and most of them do not even reap back the investment made in innovation which has been a social canker in Africa which needs immediate attention (de Pinho, 2013).

The objective of this study is to examine whether patent application has an impact on economic growth in African countries.

Our study differs from previous research in several ways. First, this extends the literature by given empirical evidence whether patent applications affect economic growth by employing reliable measures of the variables of interest over the period 2000-2017. Such an approach minimizes the possibility of endogeneity problems resulting from measurement errors found in previous studies (Bayarcelik, E. B., & Taşel, F. 2012; Pece, A. M. et al., 2015). In addition, we determine the impact of patents appreciation on economic growth among African countries Also, we use least squares method approach to explore linear relations between variables while conditioning other growth determinants. Finally, we explore how the impact of patent applications on economic growth varies over a period of time among the African countries.

The rest of the study is as follows: section two (2) looks at the literature review of the research, section three (3) deals with methodology. This includes variables, data, econometric modelling, and endogeneity. Section four (4) looks at results and discussion. Finally, section five (5) gives the conclusions and policy recommendations.

2. Literature review

Schumpeter was the first to state innovation in a scientific form. He defines innovation as an introduction of new goods, methods, procedures, market and structure of an organization, which means a new combination of fundamental resources. He sought to realize the factors influencing on the economic growth of countries when he found the crucial role and importance of innovation in the growth of countries (Schumpeter 1934). Peter Drucker (1985), the father of management science, introduced innovations as a special tool of entrepreneurship through which one can use change as an opportunity to offer service and considered innovation as a learnable and applicable capability in organizations. Schumpeter also added that innovation is a source of economic change. In addition he argued that economic development is driven by innovation through a dynamic process in which new technologies replace the old, a process he label In this context, he specified that innovation consists of the following five circumstances: (1) introduction of a new good; (2) introduction of a new method of production; (3) opening of a new market; (4) conquest of a new source of supply of raw materials or semi-manufactured goods; and (5) implementation of a new form of organization. Innovation can be defined as the process of using a new idea or concept for a product, service, business model or process that will create or add value, and which will make the customer pay for it (Foroudi, 2016).

Nisula and Kianto (2013) share the view that innovation is not restricted to the procedure of developing a new product, but it can also apply to the development of new processes and strategies, as well as coming up with new business ideas. They also state that innovation activities are not only a result of research centers but can occur anywhere within an organization. Much of the innovation literature has viewed innovation as the process of using new technology to develop new products. However, innovation is broader than this definition, since it may mean successfully applying a new idea in an organization, no matter where it occurs within the organization.

Many studies have investigated the extent of the contribution that innovation continues to have upon competitiveness and the growth of firms, industries, and national economies. As such, this concept has become an attractive research area for scholars. Many of the early models treated technological progress as an exogenous process driven only by time, as in the work of Robert Solow. He defined growth as the increase in GDP per hour of labour per unit time. He also treated technological progress as exogenous, and focused on the role played by capital accumulation in driving economic growth (Bayarcelik, E. B., & Taşel, F. 2012). On the other hand, new models in which growth is driven by technological change are called endogenous growth models that arises from intentional investment decisions made by profit-maximizing agents (Bayarcelik, E. B., & Taşel, F. 2012).

Westmore, (2013) investigated the determinants of R&D expenditures and patents and the link between innovation and economic growth, by using a panel model, based on a sample of 19 OECD countries, during the period 1980-2008. The empirical results provide evidence that tax incentives and public support for research and development and for patent rights encourage innovation activities in private sector. Moreover, the results have not identified a direct effect of these policies on aggregate productivity growth. Also, the policies that support competition are important for the transmission of knowledge from both sources, both domestic and external.

Czarnitzki and Toivanen, (2013) analysed the link between economic growth and research and development investments in the case of Germany and Belgium. The results indicated that public investments in research and development stimulate private investments and the effects vary based on experience in corporate innovation activity and the level of labor productivity from the past.

Minniti, Venturini, (2013) conducted research on indicator for innovation which he used the number of patents granted annually for each industry analysed, by using micro-level data for nineteen US manufacturing industries over the period 1975 to 2000. The results obtained showed that the impact of tax incentives for research and development activity is lengthy. The subsidies awarded to for research activities increase the research and development efforts and the economic growth rate, but only for short term. For a long time horizon, this research and development policy does not have a significant effect, in the best case it is noted that subsidies for research and development activities have a temporary effects on growth.

Pece, A. M., Simona, O. E. O., & Salisteanu, F. (2015) analyze if the long term economic growth is influenced by the innovation potential of an economy. Our analysis was performed by using multiple regression models estimated for the following CEE countries, namely Poland, Czech Republic and Hungary. In order to quantify the innovation we have used

various variables, such as number of patents, number of trademarks, R&D expenditures. The results provide evidence of a positive relationship between e

Bayarcelik, E. B., & Taşel, F. (2012 examine the relationship between innovation and economic growth in Turkey by using endogenous economic growth theory. Recent developments in theory support the view that the key driver for economic growth in global economies is innovation. According to this conceptual framework, a model is developed to examine the relation between researchers employed in R&D departments, R&D expenditures, patents as innovation indicators, and Gross Domestic Product (GDP) as economic growth. A panel regression model is used to investigate these relations for chemical firms listed on the Istanbul Stock Exchange (ISE) between 1998 and 2010. The data for this study has been obtained from the Turkish Statistical Institute and the Turkish Patent Institute. The results of analysis indicated a positive and significant relation between R&D expenditure and the number of R&D employees in influencing economic growth.

From a different point of view, Lerner reviewed significant changes in patent law in more than 70 countries over 150 years and correlated them with the number of patents granted in these countries. He found that strengthening patent rights generated an increase in patent filing and allow patentees longer to put patents into effect (Pouris and Pouris, 2011).

3. Materials and Methods

3.1. Variables

The variables of interest are patent applications as independent variables and economic growth as the dependent variable. We proxy patent applications and GDP per capital (gdppc) to meet theoretical arguments around economic growth. We also controlled for some variables that are identified as other economic growth determinants to control for their impacts in our model. Through the literature, variables- the initial level of inflation rate, initial level of government final expenditure, initial level of trade openness and foreign direct investment have been established and used as determinants of economic growth, which need to be controlled in the model specifications (Pece, AM et al., 2015).

3.2. Data

Our sample comprises annual data from all African countries. We employed panel data from nine (9) African countries from 2000-2017. The number of countries excluded were as a result of lack of available data. We retrieved our data from the World Development Indicators database (World Bank 2019). We used natural log transformations for all the variables. This is a common practice in econometric analysis to improve the linearity of data. Tables 1 and 2 present the summary descriptive statistics of the data.

Table 1 Mean and Standard Deviations

Variable	Obs	Mean	Std. Dev.	Min	Max
lngdppc	162	8.346	0.954	6.098	9.635
lnpatent	162	5.686	1.919	0.000	9.026
lnfdi	160	0.754	1.214	-3.219	5.130
lntinf	160	1.627	0.868	-1.081	3.660
lntradeo	162	3.864	0.402	2.422	4.585
lngfe	162	2.690	0.323	1.522	3.344

The results in Table 1 show that GDP per capita has (M=8.346; SD=0.954). However, patent applications has (M=5.686; SD=1.919). The correlation matrix shows intercorrelations among the variables. The matrix revealed that no multicollinearity involve in the explanatory variables (see Table 2).

Table 2 Correlational Matrix

	lngdppc	**lnpatent**	**lnfdi**	**lntinf**	**Lntradeo**	**lngfe**
lngdppc	1					
lnpatent	0.86	1				
lnfdi	-0.2793	-0.2447	1			
lntinf	-0.0754	-0.0622	0.0365	1		
lntradeo	0.0925	0.0612	0.238	-0.4546	1	
lngfe	0.1298	0.202	0.0033	-0.5559	0.6901	1

3.3. Econometric Modelling

The benchmark model for this study proposes that economic growth is a function of patent application. This general function is represented as: general equation is hypothesized to reflect the level of objective for the study:

$$y = f(x) \qquad (1)$$

Where *y* is the dependent variable - economic growth and *x* is the independent variable – patent application. In a classical linear regression, the benchmark model can be written as:

$$y_{i,t} = \beta_j x_{i,t} + v_{i,t} \qquad for\ i = 1, 2, \ldots, N \ and \ \ t = 1, 2, \ldots, T \qquad (2)$$

Where y_{it} represents economic growth for the *ith* unit and *tth* time period; α_0 is the intercept; β_i represents the coefficients of the independent variables ($\beta_i \neq 0$); x_{it} represents the vector of independent variables for the *ith* unit and *tth* time period, and v_{it} is the error for the *ith* unit and the *tth* time period. Thus, v_{it} satisfies the assumptions of the classical model. Eq. 2 does not encompass other factors that influence economic growth. Since it is unrealistic that these other factors are uncorrelated with patent application (see Table 2 for correlation matrix), excluding these variables in the model leads to inconsistent empirical estimates and model uncertainty. The common problem encountered here is omitted variable (z). The standard formula for omitted variable bias is given by:

$$bias = E\left[\delta_{OLS} - \delta\right] = \frac{\mathrm{cov}\left[x, z\right]}{\mathrm{cov}\left[x\right]}\beta \qquad (3)$$

Where δ and β are parameters of x and z (control variables). However, the bias can increase over time (Arcand et al., 2012). To avoid this problem, the study modified the benchmark model to reflect true model for this study given as:

$$y_{i,t} = \beta_j x_{i,t} + \delta_j z_{i,t-1} + \zeta_j w_{i,t} + v_{i,t} \qquad (4)$$

Where $z_{i,t-1}$ represents initial values of a controlling variable set and $w_{i,t}$ represents time (year) dummy variables. Other variables were defined. Thus, Eq. 4 represents a linear relationship between economic growth and patent application controlling for other variables such as initial level of inflation rate, initial level of government final expenditure, initial level of trade openness and foreign direct investment and time. The modified equation (Eq. 4) follow the recent methodologies of (Pece, A. M. et al., 2015; Atta Ur Rehman, A., et al, 2015; Abid Bashir, H., & Akhtar, A, 2016). However, unlike earlier studies, this study modified their economic model by using patent application in African countries to find out its true impacts on economic growth nexus.

3.4. Endogeneity Tests

The main problem that must be faced in the study of economic growth happens to be the problem of endogeneity. To overcome this, several tests were run to identify potential endogeneity problems. First, correlation analysis does not

detect one of the highly correlated regressors. Second, Sargan and Basman's test of identifying restrictions that are too strict for instrument quality does not reveal potential endogenous variables. Thus, both tests affirm the credibility and validity of the instrument set for our model. Thus, the inclusion of potential growth determinants increases the credibility and validity of the instrument which minimizes the existence of endogeneity resulting from the omitted variables in the model.

4. Results and Discussion

This part of the work focuses on presenting the results of empirical research. Table 3 and 4 presents the findings of the study. We present results based on research objectives. The objective of the study aims to examine the impact of patent application on economic growth. First, we estimated the influence of using all sample periods. Second, we estimate some of the impacts on dividing the sample periods into two. The main reason for conducting partial regression is to (1) take into account heterogeneity between datasets and (2) provide a true picture of how impacts exist for the countries. The results are presented in Table 3.

Table 3 The impacts of patent application on economic growth.

lngdppc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnpatent	0.430***	0.021	20.76	0.000	0.388713	0.470499
lnfdi	-0.085**	0.034	-2.53	0.012	-0.15217	-0.0188
lntinf	-0.050	0.052	-0.95	0.341	-0.15361	0.053541
lntradeo	0.421***	0.135	3.11	0.002	0.153503	0.688028
lngfe	-0.542***	0.179	-3.02	0.003	-0.89627	-0.18764
F-Test	100.46***					
Obs	158					
R2	0.7677					

***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

According to Table 3, the influence of patent applications on economic growth varies. The findings showed that conditioning on other growth determinants, the impact of patent applications on economic growth was positive among African countries. Although patent applications affect economic growth, it is weak in magnitude. For example, the results show that conditioning other growth determinants, 1% increase in patent application will increase GDP per capita by 0.43% for all countries sampled. These results validate the results (Ata Ur Rehman, et al., 2015). These results seem to confirm the logical argument that patents involve sunk costs in terms of various costs including filing fees, agency fees and translation fees making it expensive in the initial years. Therefore, the relationship between economic growth and patent is weak in the current year unless anticipated to be strong in subsequent years (Crosby, 2000; Takalo and Kanniainen, 2000; Ata Ur Rehman, et al., 2015).

After establishing the relationship between patent applications and economic growth for African countries, it is prudent to explore how this relationship varies over time. As such, our second objective focuses on exploring how the relationship between patent applications and economic growth for different periods among the African countries. However, we believe that exploring this variation among the African countries can provide a basis for which conclusions from the results can be used to assess. To achieve this, we explore the variations for linear models. Tables 4 present the findings of the relationship between patent applications and economic growth over different sample periods for each linear relationship. Because we had estimated the impact over the full sample period, we concentrated on variations during the years less than 2009 and the years greater than 2008 of our dataset. As such, we broke our sample into two periods of 8 non-overlapping years to explore the impact of patent application over the periods.

Table 4 Varying Effects of Patent Application on Economic Growth – Linear Relationship

lngdppc	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
lnpatent	0.395***	0.028	0.437***	0.036
lnfdi	0.037	0.050	-0.178***	0.051
lntinf	0.153**	0.072	0.111	0.080
lntradeo	0.518***	0.186	0.527**	0.219
lngfe	0.579**	0.270	-0.440	0.266
F-Test	46.04***		61.34***	
Obs	79		79	
R2	0.7592		0.8077	
Period 2000-2008			2009-2017	

***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

According to Table 4, patent applications have a significant impact on economic growth among the African countries for the period 2000-2008 and 2009-2017. The results show that conditioning other growth determinants, 1% increase in patent application in years that vary less than 2009 will contribute to an increase of 0.395% in GDP growth, while the percentage increase in patents application in years that vary greater than 2008 will contribute to a high increase of 0.437% in GDP growth. In other words the impact of patents on GDP growth has continued to increase from 2000 -2017. These results are similar to (Iwaisako and Futagami 2013; Ur Rehman, et al., 2015), which shows that patents contribute significantly to economic growth. Stronger patents uphold economic and industrial growth through technological advancement. This result is not surprising in the sense that it seems to suggest that there is continuous increase in patent filling among the African countries (de Pinho, 2013).

5. Conclusion

This study investigated the impact of patent application on economic growth. We explored the impact of patent application on GDP per capita for the period 2000-2017. We also explored how this impact varies different time periods in the African countries.

Based on the results, we concluded that conditioning other growth determinants, patents application positively impacts on economic growth among the African countries. Even though patent applications influence economic growth, it is weak in magnitude. The marginal impact of patent application is positive and statistically significant at PCmin. Thus, African countries will gain from increasing their patent application. Finally, patent applications have significant impacts on economic growth African countries for the period less than 2009 and greater than 2008.

In terms of policy recommendations, we advocate that African countries should consider incorporating patent applications in their economic growth forecast. This can be done by restructuring patent laws and its application process to increase its impacts on the economy.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Atkinson, A., & Messy, F. A. (2012). Measuring financial literacy: Results of the OECD/International Network on Financial Education (INFE) pilot study.

[2] Autio, E., Cleevely, M., Hart, M., Levie, J., Acs, Z. J., & Szerb, L. (2012). Entrepreneurial Profile of the UK in the Light of the Global Entrepreneurship and Development Index. *Available at SSRN 2070320*.

[3] Bayarcelik, E. B., & Taşel, F. (2012). Research and development: Source of economic growth. *Procedia-Social and Behavioral Sciences*, *58*, 744-753.

[4] Crosby, R. H. J. (2000). AMEE Guide No 20: The good teacher is more than a lecturer-the twelve roles of the teacher. *Medical teacher*, *22*(4), 334-347.

[5] Czarnitzki, D., & Toivanen, O. (2013). *Innovation policy and economic growth* (No. 482). Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.

[6] de Pinho, J. M. B. (2013). *As casas da Misericórdia: confrarias da Misericórdia e a arquitectura quinhentista portuguesa* (Doctoral dissertation, Universidade de Lisboa (Portugal)).

[7] Docquier, F., Lohest, O., & Marfouk, A. (2007). Brain drain in developing countries. *The World Bank Economic Review*, *21*(2), 193-218.

[8] Hafeez, K., Foroudi, P., Dinnie, K., Nguyen, B., & Parahoo, S. K. (2016). The role of place branding and image in the development of sectoral clusters: The case of Dubai. *Journal of Brand Management*, *23*, 383-402.

[9] ITU, O., UNCTAD, U., UNFCCC, U., & WIPO, W. (2015). Science, technology and innovation for sustainable development in the global partnership for development beyond 2015.

[10] Iwaisako, T., & Futagami, K. (2013). Patent protection, capital accumulation, and economic growth. *Economic Theory*, *52*, 631-668.

[11] Minniti, A., & Venturini, F. (2013). *R&D Policy and Schumpeterian Growth: Theory and Evidence, University of Bologna*. Working Paper 945, 1-43.

[12] Papageorgiadis, Nikolaos, and Abhijit Sharma. "Intellectual property rights and innovation: A panel analysis." *Economics Letters* 141 (2016): 70-72.

[13] Pece, A. M., Simona, O. E. O., & Salisteanu, F. (2015). Innovation and economic growth: An empirical analysis for CEE countries. *Procedia Economics and Finance*, *26*, 461-467.

[14] Saini, A. K., & Jain, S. (2011). The impact of patent applications filed on sustainable development of selected Asian countries. *International Journal of Information Technology*, *3*(2), 358-364.

[15] Schumpeter, J. A., & Nichol, A. J. (1934). Robinson's economics of imperfect competition. *Journal of political economy*, *42*(2), 249-259.

[16] Silverberg, G. P., & Yildizoglu, M. (2002). An evolutionary interpretation of the Aghion & Howitt (1992) model.

[17] Takalo, T., & Kanniainen, V. (2000). Do patents slow down technological progress?: Real options in research, patenting, and market introduction. *International Journal of Industrial Organization*, *18*(7), 1105-1127.

[18] Udvari, B., & Ampah, I. K. (2018). Impacts of aid for innovation on economic growth in the sub-saharan african countries. *Mediterranean Journal of Social Sciences*, *9*(4), 99.

[19] Ur-Rehman, A., Naqvi, S. M., Mihaylova, L., & Chambers, J. A. (2015). Multi-target tracking and occlusion handling with learned variational Bayesian clusters and a social force model. *IEEE Transactions on Signal Processing*, *64*(5), 1320-1335.

[20] Westmore, B. (2013). Innovation and growth: Considerations for public policy. *Review of Economics and Institutions*, *4*(3), 50.