The Cointegration Relationship between Patent, Domestic Investment and Economic Growth in United States of America

Othmani, Abdelhafidh and Ben Yedder, Nadia and Bakari, Sayef

PS2D, Faculty of Economics Sciences and Management of Tunis, University of Tunis El Manar, Tunisia., Graduate College of Commerce of Tunis (ESCT). University of Manouba Tunisia., Faculty of Law, Economics and Management of Jendouba, University of Jendouba, Tunisia, LIEI, Faculty of Economics Sciences and Management of Tunis, University of Tunis El Manar, Tunisia.

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Abdelhafidh Othmani

PS2D, Faculty of Economics Sciences and Management of Tunis, University of Tunis El Manar, Tunisia.

Email: hafedh.othmani@yahoo.fr

Nadia Ben Yedder

Graduate College of Commerce of Tunis (ESCT). University of Manouba Tunisia.

Email: Ben.yedder.nadia.90@gmail.com

Sayef Bakari

Faculty of Law, Economics and Management of Jendouba, University of Jendouba, Tunisia

LIEI, Faculty of Economics Sciences and Management of Tunis, University of Tunis El Manar, Tunisia.

Email: bakari.sayef@yahoo.fr

Abstract

This empirical paper searched the three way-linkage between patent, domestic investment, and economic growth in the case of USA during the period 1980 – 2020. By using cointegration analysis and VECM Model, we found that there is no causal relationship between the three variables in the long run. However, we found that domestic investment and economic growth cause patent in the short run. which explains why patents are not a source of economic growth and domestic investment in America and that there are other determinants that have stimulated American economic activity.

Key Words: Cointegration, Patent, Domestic Investment, Economic Growth, United States of America.

JEL Classification : D23 ; E22 ; G31 ; H54 ; I28 ; O16 ; O31 ; O32 ; O47 ; O51.

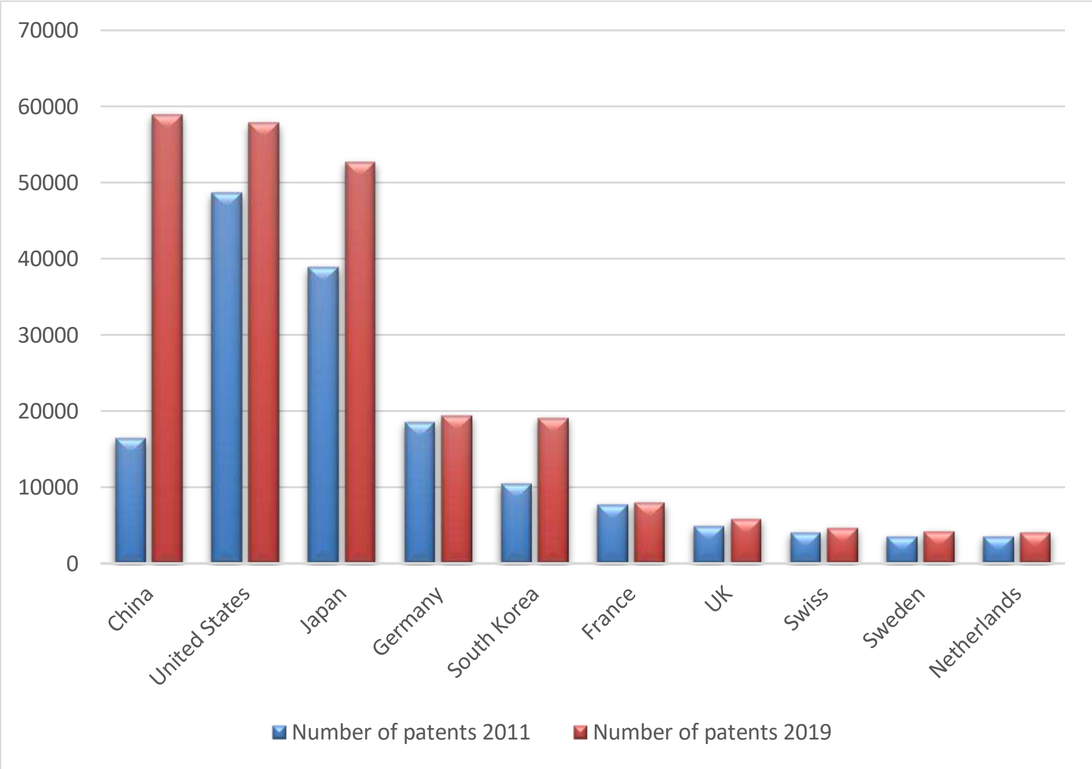
1. Introduction

The relationship between patents and economic growth still presents a very valuable and complex framework. In fact, previous events and experiences have proven that patents are presented as a key factor for the economic development of many countries through its impact on productivity. Domestic investment, patents and economic growth are all closely intertwined. Domestic investment is important in driving economic growth, as investment in new capital and infrastructure can stimulate the economy by providing new jobs and new businesses with more resources. Patents are important for driving economic growth through innovation and technological progress. Innovation and technological progress can lead to increased productivity and economic growth. It is also important for protecting companies from competition and giving businesses a competitive edge in the marketplace. Ultimately, domestic investment, patents and economic growth are all linked, and work together to create a prosperous and healthy economy. Patents play a critical role in the economy of the United States by encouraging research and development, stimulating investment, and creating economic growth. Patents encourage innovators to continue to create and improve new products and services, which attracts more valuable investments than may have been possible without the patent. In the United States, companies in industries ranging from software and pharmaceuticals to electronics and biotechnology rely on patents to protect their investments and to secure the returns those investments generate. By giving innovators the assurance that their inventions will be protected and their investments secure, patents create an incentive for sustained investment in the development of new technologies, products, and services. This innovation contributes to the competitiveness of American businesses, enhances our quality of life, and expands our economic progress. Also, Domestic investments in the United States are extremely important to the country's economy. They are essential for development and economic growth. Domestic investment creates jobs and stimulates consumer demand, allowing businesses to grow and increase their profits. Domestic investments also allow companies to increase their productivity and their competitiveness on the international market. In addition, domestic investments support infrastructure and public services, which improve the quality of life of citizens and contribute to macroeconomic stability. Finally, domestic investments encourage innovation and research and development, which can bring new products and services to market.

According to figure n°1 and compared to 2010, patent filings increased by 10.7% in 2011. China, the United States of America, and Japan accounted for 82% of total growth; the Chinese company ZTE (Zhongxing Telecommunication Equipment) is the largest applicant, totaling

2,826 published applications, followed by the Japanese Panasonic (2,463 applications) then the Chinese Huawei (1,831 applications) {See: Carpentier and Côté (2005)}. In 2019, the ranking shows a shift in patent applications to Asia (more than half of applications) according to figure n°1.

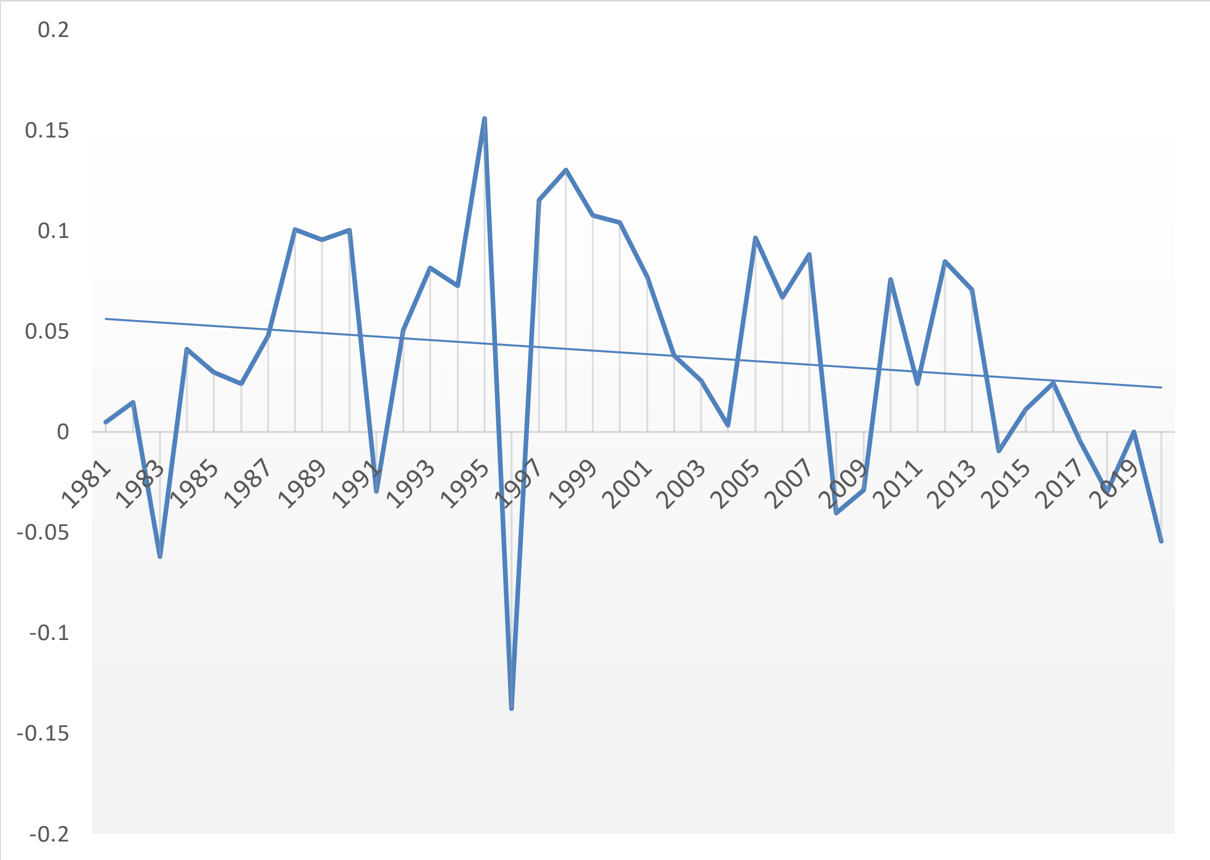
Figure n°1: International patent filings



***Source: World Intellectual Property Organization* (*WIPO*)**

In 2019, China becomes the main depositor, overtaking the United States for the first time. Chinese telecommunications giant Huawei Technologies is the top filer for the third consecutive year, with 4,411 applications. The following two filing companies are also Asian: Mitsubishi Electric Corporation (2,661) in Japan and Samsung Electronics (2,334) in Korea. In total, among the top ten applicants, there are four Chinese companies, two Korean and one in Germany, Japan, Sweden, and the United States {See: Dou and Sebastião (2022); Prud'homme and Zhang (2019); Motta et al (2015)}. Figure 2 shows that the growth rate of invention patents is characterized by a downward trend during the period 1981 – 2020.

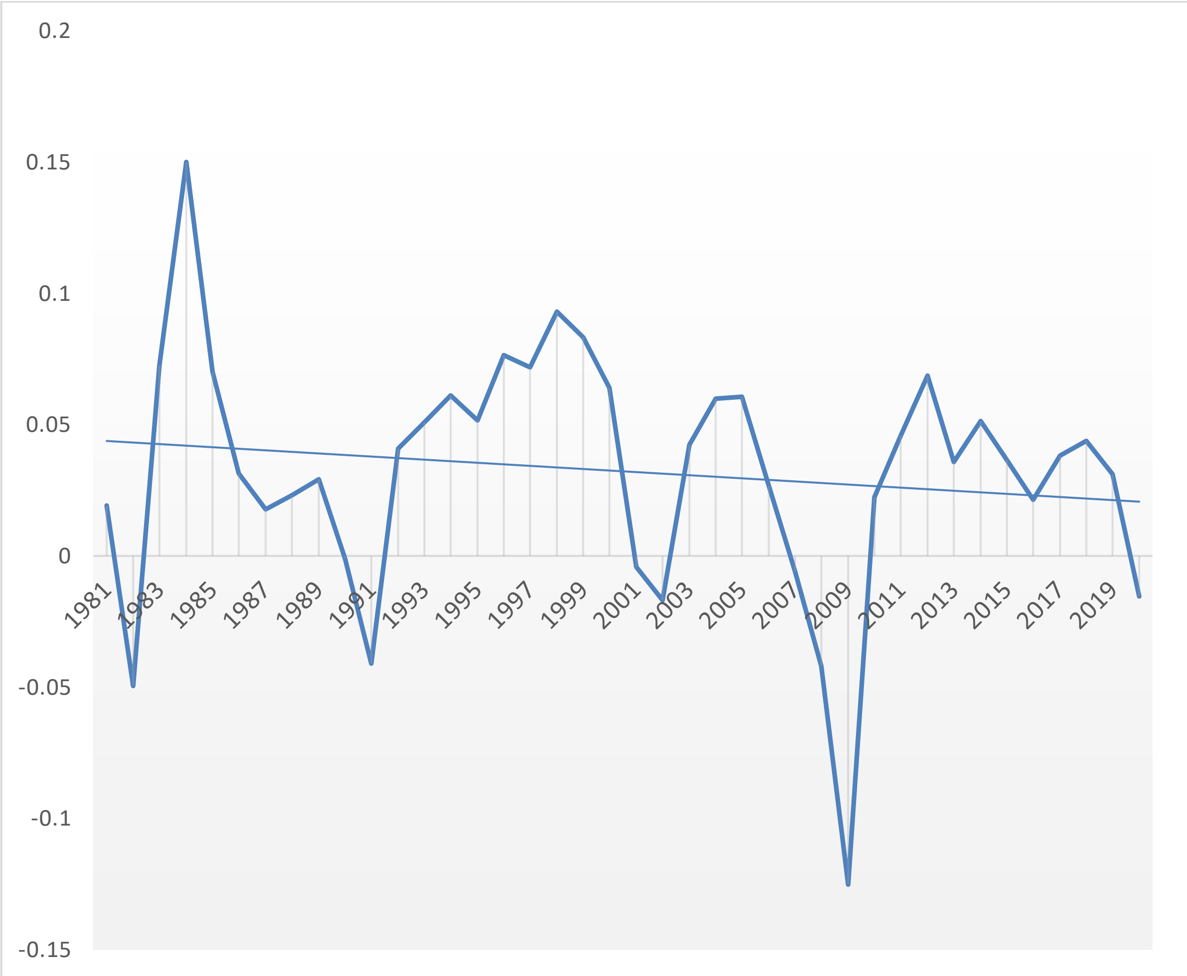
Figure n°2: Growth rate of invention patents



Source: Author's calculations using World Bank Annual Reports.

The economy of the United States is the world's largest by nominal GDP and total wealth and is the second largest by purchasing power parity. In 2021, the US economy had the 5th largest nominal GDP per capita and the 7th largest GDP on a per capita power purchasing basis. The United States has the most powerful and innovative economy in the world over the world, and the strength of the economy is evident in the areas of artificial intelligence, computers, medicine, medicine, space, and military technology. The US dollar is the most used currency in international trade and the main currency in the reserve currencies held by banks and countries, supported by the US economy and armed forces, recycling of Petro glares, dollars in dollars outside US banks and US treasure. The United States is the largest producer of oil and natural gas. The United States was, in 2016, the country with the most business transactions in the world, and ranked third in terms of industry, so that American industries account for a fifth of global industrial production. Not only does the United States have the largest domestic goods market, but it also dominates trade in services. The value of business transactions in the United States was $5.6 billion in 2018. Also, figure n°3 shows that the growth rate of domestic investments is characterized by a downward trend during the period 1981 – 2020.

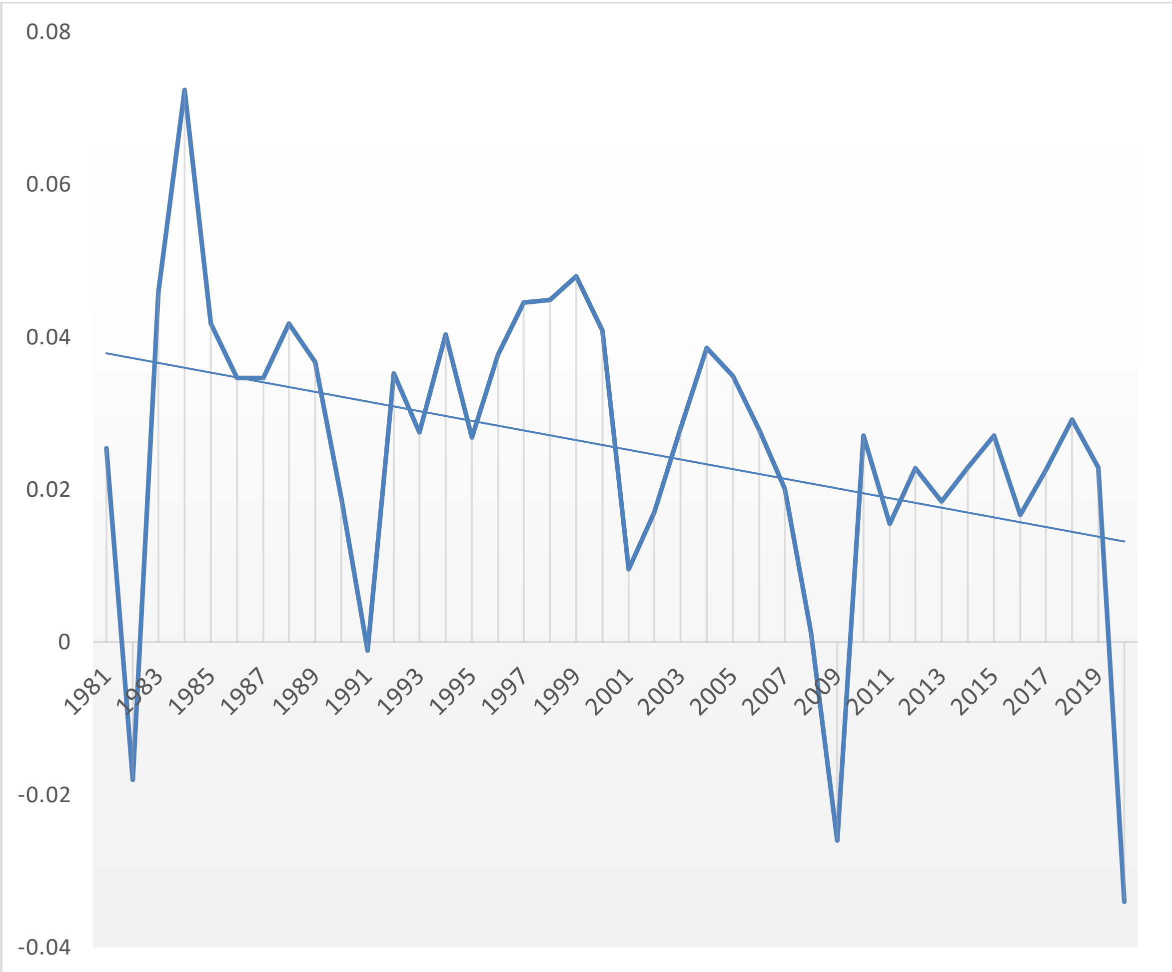
Figure n°3: Growth rate of domestic investments



Source: Author's calculations using World Bank Annual Reports.

The US economy ranks first in the world in terms of investment capital and global research and development funding. Consumer spending accounted for 68% of the US economy in 2018 and the share of employee income was 43% in 2017. The US has the largest consumer market in the world. The national labor market has attracted immigrants from all over the world, and the net immigration rate to the United States is the highest in the world. The US economy experienced a critical contraction during the 2008 recession, which began from December 2007 to June 2009. However, real GDP recovered to its pre-crisis level (late 2007) in 2011, and net household income recovered to its level before in the second quarter of 2012, non-farm wages returned to their previous level in May 2014, while the unemployment rate returned to its level in September 2015. These changing values persisted in the post-recession record, and the time of recovery was the US economy ranked second in the world in April 2018. During the first two quarters of 2020, the US economy entered a recession due to the spread of the COVID-19 virus. The economic recession caused by the Covid-19 pandemic caused the most severe downturn in the global economy since the Great Depression, and its impact was far worse than the "2008 recession". The United States ranked 41st on the list of countries with the highest economic inequality, out of 156 countries, in 2017, and the wealth gap in the United States was higher than in the rest of the Western world {See: Heyer and Hubert (2016); Sampognaro (2023); MacFeely and van de Ven (2023)}. Figure n°4 shows that the growth rate of gross domestic product is characterized by a downward trend during the period 1981 – 2020.

Figure n°4: Gross domestic product growth rate



Source: Author's calculations using World Bank Annual Reports.

The originality of this paper is that it not only demonstrates the relationship between domestic investment, patent, and economic growth, but also adduces gainful knowledge for policy makers to elaborate strategic plans attempted at fostering the development patent, domestic investment, and economic growth in USA. The rest of this task is as follow: Section 2 recaps a view of the literature survey. Section 3 shows empirical methodology. Section 4 gives back empirical results. Concluding the paper is putted in Section 5.

2. Literature Survey

As we mentioned before, we will examine the relationship between patents, investments and economic growth in the USA. To achieve this goal, it is very important to exploit recent works which have dealt with the different links between these three variables. for this reason, this section carries a review that describes firstly the link between patents and economic growth, secondly the link between domestic investments and economic growth and thirdly the link between patents and investments.

2.1.Patent and economic growth

Economic growth allows companies to develop their products and conquer new markets. Invention patents provide them with the protection they need to protect their innovations. Companies that file patents have a significant competitive advantage over companies that do not file patents. Economic growth stimulates demand for innovative products and services, and patents help protect these innovations. The link between patents and economic growth is an important element in the field of innovation and economic development. Patents are intellectual property rights that grant inventors a temporary monopoly over the use, manufacture and marketing of their inventions. Patents provide legal protection to inventors by granting them exclusive rights to their creations. This creates incentives for innovation, as individuals and businesses are more likely to devote time and resources to researching and developing innovative ideas when they know they will benefit from the fruits of their labor through patents {See: Heller and Eisenberg (1998), Moser (2016), Moser (2013), Sampat (2018), Mansfield (1986), Pavitt (1982)}. Research and development (R&D) are essential to generate new ideas and technologies. Patents provide a way to recoup R&D investments by allowing companies to market their inventions exclusively for a set period of time. This encourages companies to invest more in research and innovation {See: Hall et al (2007), Arora et al (2008), Maskus et al (2019)}. Patents prevent other companies or individuals from copying or reproducing an invention without permission. This protects inventors from unfair competition and allows them to profit from their development efforts {See: Zlinkoff (1943), Yankwich (1956), Drexl and Lee (2013), Maresch et al (2016), Nie et al (2023)}. In sum, patents play an essential role in the innovation process, encouraging investment in research and development, stimulating the creation of new technologies and generating economic benefits. They are an important tool for fostering economic growth by allowing businesses and individuals to capitalize on their innovative ideas. Mabrouki (2022) examined the impact of patent on economic growth in the case of Scandinavian countries over the period 1990 - 2019 by using panel cointegration analysis and panel CS-ARDL. Empirical results confirmed that patent has a positive effect on economic growth in the long run. Nihal et al (2023) examined the nexus between patent and economic growth in the case of G8 countries over the period 1996 - 2020. By using cointegration analysis, Panel VAR and the Granger causality tests, they found that there is a positive relationship between patent and economic growth in G8 countries. Nguyen and Doytch (2022) conducted a study to examine how inventions, quantified by the count of new patents, influenced economic expansion across 43 economies between 1998 and 2016. Employing a two-stage Generalized Method of Moments (GMM) approach to address potential data endogeneity, their findings revealed that the relationship between overall patent counts and economic growth was reciprocal, but no significant correlation was detected between total patents and the growth of the manufacturing sector. Simultaneously, their analysis indicated a noteworthy positive influence of ICT (Information and Communication Technology) patents on economic growth, whereas the broader spectrum of total patents did not exhibit a similar impact. Ben Yedder et al (2023) searched the impact of patents on economic growth in the case of MENA countries during the period 1998 - 2022. By using panel data analysis, they found that patents don't have any effect on economic growth. Mabrouki (2019) examined the impact of patent on economic growth in the case of Sweden during the period 1970 - 2017. By using cointegration analysis and ARDL model, he found that patent has a positive effect on economic growth in the long run. Bakari (2022a) searched the nexus between patent and economic growth in the case of Romania during the period 1990 – 2020. By using cointegration analysis and ARDL model, he found that patent has a positive impact on growth in the long run. Bakari (2022b) examined the impact of patent on economic growth in the case of 52 African Countries during the period 1996 – 2021. Results of the random effect model and the fixed effect model indicated that patents don't have any effect on economic growth. Bakari et al (2022a) look for the nexus between patent and economic growth in the case of Tunisia. For the period 1985 – 2018 and using the ARDL model, they found that patent has a negative impact on economic growth in the long run. In another study treated by Bakari (2019), patent has a positive effect on economic growth in the long run during the period 1995 – 2016 for the case of 76 developed and developing countries. Using panel cointegration techniques, Blind et al (2022) studied the effects of formal standards and patents on economic growth in a panel of eleven European Union countries between 1981 and 2014. The empirical results showed shown that patents have no significant effect on long-term economic growth. Mtar and Belazreg (2021) examined the relationship between patents, financial development, and economic growth for 27 OECD countries over the period 2001-2016. Using an estimate based on the VAR model, they found that patents cause economic growth and financial development causes patents. For the case of 30 Chinese provinces, Li and Wei (2021) found that innovation is represented as an engine of economic growth during the period 1987 - 2017. Using the VAR model and Granger causality tests, Mabrouki (2018) found that invention patents were behind economic growth in Tunisia during the period 1970 – 2015. In the case of Taiwan, Yang (2006) found that invention patents had a positive impact on long-term and short-term economic growth during the period 1951 - 2001. In his work, he used cointegration analysis and the model VECM. In the case of 13 developed countries, Galindo and Mendez (2014) sought the link between patents and economic growth during the period 2002 - 2007. By applying an estimate based on the fixed effects model, they found that patents are a source of economic growth. In the case of Malaysia, Sohag et al (2015) studied the link between technological patents and economic growth during the period 1985-2012. Using an estimate based on cointegration analysis and the ARDL model, they found that an increase in technology patents leads to an increase in economic growth in the long and short term.

2.2.Domestic investment and economic growth

Investment allows companies to develop their products and conquer new markets. Companies that invest have a significant competitive advantage over companies that don't spend money on innovation. Economic growth stimulates demand for innovative products and services and investment contributes to fulfilling this demand. The link between domestic investment and economic growth is deeply interconnected and crucial for the development of an economy. Domestic investment refers to capital expenditures made within a country to improve infrastructure, equipment, technology, businesses and other aspects of the economy. Domestic investments contribute to the creation of physical capital (infrastructure, equipment, facilities) and human capital (training, education). These forms of capital are essential for increasing productivity, which in turn stimulates economic growth {See: Srinivasu and Rao (2013), Laroche et al (1999)}. Investments in more advanced technologies, more efficient production processes and better training of the workforce can improve the overall productivity of the economy. Greater productivity means that each unit of labor or resource generates more output, which can lead to faster economic growth {See: Black and Lynch (1996), Galenson and Leibenstein (1955), Power (1998), Aschauer (1989)}. Domestic investments can lead to the creation of new businesses, the expansion of existing businesses and the creation of jobs. This increases the disposable income of individuals, stimulating aggregate demand and thus contributing to economic growth {See: Adelino et al (2017), Willis (1985), Ianchovichina et al (2013), Rendon (2004)}. When a country has a strong domestic investment base, it can become more attractive to foreign investors. Foreign investment can bring new technologies, skills and additional capital, which also contributes to economic growth {See: Agosin and Machado (2005), Shi et al (2019), Moses et al (2013), Ha et al (2022), Lautier and Moreaub (2012), Titarenko (2005)}. By using annual data for the period 1970 – 2020, Bakari (2022c) searched the impact of domestic investment on economic growth in the case of Greece. By using cointegration analysis and vector error correction model, he found that there is no relation between domestic investment and economic growth in the short term and in the long term. Bakari and El Weriemmi (2022) investigated the nexus between domestic investment and economic growth in Arab Countries for the period 1990 – 2020. By applying vector error correction model, they found that there is no relation between domestic investment and economic growth in the long run. However, they found that there is a bidirectional causality between the investment and growth in the short run. Bakari (2021a) searched the nexus between domestic investment and economic growth in the case of Spain during the period 1970 – 2017. He found that domestic investment has a positive effect on economic growth in the long run using error correction model. Bakari et al (2019) examined the impact of domestic investment and economic growth in the case of Uruguay during the period 1960 – 2017. Empirical analysis indicated that there is no relationship between domestic investment and economic growth in the long run and in the short term. Amade et al (2022) examined the link between domestic investments and economic growth in the case of Nigeria during the period 1981 – 2018. Using estimation based on cointegration analysis and ARDL model, they found that domestic investment drives economic growth, and they recommended that policy makers optimize local investment options and normalize the exchange rate and trade transactions. Ogunjinmi (2022) studied the link between domestic investment and economic growth in Nigeria during the period 1981 - 2019. Applying estimation based on cointegration analysis and ARDL model, he found that domestic investment affects negatively to long-term economic growth. In the case of South Africa, Meyer and Sanusi (2019) used quarterly data from the first quarter of 1995 to the fourth quarter of 2016 as part of Johansen's cointegration and vector error correction models to detect the link between domestic investment and economic growth. They found that the causality runs from economic growth to investment and not vice versa. For the case of Germany, Bakari et al (2020) found that there is no cointegration relationship between domestic investment, taxation, and economic growth in the long run during the period 1972 – 2016. Also, for the case of France, Bakari (2019) searched the cointegration relationship between domestic investment, economic growth, and taxation during the period 1972 – 2016. By using cointegration analysis and vector error correction model, he found that domestic investment and taxation have a negative impact on economic growth in the long term. Bakari and Tiba (2019) searched the determinants of economic growth in the case of USA during the period 1970 - 2016. By using cointegration analysis and vector error correction model, they found that domestic investment cause economic growth in the long run. Fakraoui and Bakari (2019) examined the relationship between exports, domestic investment, and economic growth in the case of India during the period 1960 – 2017. In their analysis, they used cointegration analysis and vector error correction model. They found that there is no relationship between domestic investment, exports, and economic growth in the long run. Bakari (2020) searched the nexus between domestic investment and economic growth in the case of Tunisia during the period 1965 – 2016. By applying cointegration analysis and vector error correction model, they found that a negative bidirectional causality between domestic investment and economic growth in the long run {Same results found by Bakari (2017a), Bakari (2017b), Bakari et al (2018) and Bakari et al (2021)}. For the case of Canada, Bakari (2016) found that there is no relationship between domestic investment and economic growth in the long run using cointegration analysis and vector error correction model. Bakari et al (2022b) examined the impact of digitalization and trade openness on the economic growth of the ten richest Asian countries using domestic investment as a control variable during the period 1990 - 2020. Using an estimation based on the Static Gravity Model and the Generalized Method of Moments Model, they found that domestic investment, digitalization, and trade openness have a significant positive effect on economic growth. Bakari (2021b) examined the effect of the Internet on the relationship between domestic investment and economic growth in the case of G7 countries over the period 1991-2018 using estimates linked to panel data analysis. Empirical analysis proves that domestic investment has a positive effect on economic growth, but the effect of domestic investment on economic growth is found to be unaffected by the Internet.

2.3. Domestic investment and patent

Patents are a form of intellectual property that protects inventions. Invention patents stimulate economic growth by allowing companies to capture part of the benefits of innovation. Companies that hold invention patents have a significant competitive advantage over companies that do not hold patents. Economic growth stimulates demand for innovative products and services, and patents help fulfill this demand. The link between innovation and domestic investment is close and complex. Innovation refers to the creation and adoption of new ideas, products, processes or technologies that bring significant improvements to the economy and society. Domestic investment, on the other hand, encompasses financial expenditure aimed at improving and developing resources and activities within a country. Innovation can stimulate domestic investment by creating new business opportunities and opening up new markets. Companies invest in research and development (R&D) to design innovative new products and technologies, which in turn may require investment in capital, equipment, and labor to bring these ideas to fruition {See: Lehmann et al (2022), Oh et al (2020), Sarni and Pechet (2013)}. Domestic investments, particularly in R&D and innovation, contribute to increasing the competitiveness of companies on national and international markets. Companies that invest in innovations can create lasting competitive advantages, which can result in stronger economic growth and increased investment in various sectors {See: Erdal and Göçer (2015), Deng (2007), Tassey (2004), Miozzo and Dewick (2002)}. Innovation can trigger an investment cycle in which companies invest in new technologies, new production methods and new products. These investments in turn encourage further innovation, thus creating a virtuous circle where innovation fuels investment, and vice versa {See: Nanda and Rhodes-Kropf (2013), Courvisanos (2014), Domnina et al (2016), Shahzad et al (2022)}. Domestic investments in innovative technologies and processes can improve business productivity, which can lead to increased economic growth. Businesses that adopt advanced technologies can accomplish more with fewer resources, boosting their profitability and ability to invest more {See: Mohnen and Hall (2013), Hall (2011), Mohnen (2019), Geroski (1989), Rao et al (2001)}. In the case of 27 developed countries, Seyoum (1996) found that there is no relationship between patent and investment. Lee and Mansfield (1996) examined the privilege between patents and investments in the case of countries where intellectual property rights are weak. They found that there is a positive relationship between invention patents and investments. In the context of developing countries, Maskus (1998) finds that investments make positive use of invention patents. In the case of the 75 developed and developing countries, Law et al (2018) examined the link between investments and inventions patents during the period 1996 - 2010. Using an estimate based on the GMM model, they found that investments have a negative effect on inventive patents. For MENA countries, Nuruzzaman et al., (2018) have found that the presence of competition within investments promotes innovation. Cheung and Lin (2004) examined the link between investments and invention patents in China during the period 2004 - 2012. By applying an estimation based on the fixed effect model and the random effect model, they found that Investments have a positive effect on inventive patents. For the case of Estonia, Vahter (2011) examined the impact of foreign direct investment on product innovation of domestic investment using panel data estimates. He found that foreign direct investment has a significant positive impact on domestic business innovation. Based on European data covering several countries, Sandu and Cioconel (2014) find that foreign direct investment has a positive effect on innovation. Similarly, Crescenzi et al. (2015) explored the impact of foreign direct investment on the innovation activities of national firms in the case of the United Kingdom. The results show that foreign investments considerably improve the innovation profitability of national companies. Malik (2019) analyzed various institutional and macroeconomic variables that influence the level of innovation for a set of 15 Asian countries during the period 2008 - 201. Using the Generalized Method of Moments (GMM) technique, he found foreign direct investment has a negative impact on the level of innovation. For the case of a panel of 21 OECD countries, Fu and Yang (2009) examined the link between patents and foreign direct investment during the period 1990-2002. They found that foreign direct investment encourages local producers to strengthen their R&D efforts and leads to more knowledge flows, thus leading to innovation. In fact, these are the same results found by Wang and Kafouros (2009) in the context of industrial enterprises in China. On the other hand, in the case of 50 countries, Sharma et al (2022) found that investments negatively affect invention patents during the period 1998 - 2017 using an unconditional quantile regression analysis to interrogate the effects of institutional quality on innovation results. Governments can play a crucial role in encouraging domestic investment in innovation through policies and incentives. Measures such as R&D tax credits, grants for start-ups and innovation support programs can encourage companies to invest in innovative activities {See: Hoekman et al (2005), Archibugi and Iammarino (1999), Fu and Mu (2014), Hong et al (2016)}. In short, innovation and domestic investment are closely linked in a dynamic cycle where innovation stimulates investment and investment in turn supports innovation. This relationship is essential for economic growth, competitiveness and the long-term development of a national economy.

3. Empirical methodology

To search the link between domestic investment, patent, and economic growth in the case of USA, the empirical investigation in this work consists in studying the order of integration of the variables using the two stationary tests ADF and PP. If the variables are stationary in level, we will apply an estimate based on the simple linear regression model. In fact, if the variables are stationary in level and in first differences, we will apply an estimate based on the ARDL model. On the other hand, if all the variables are stationary in first difference, we will apply an estimate based on the model of Sims (1980).

The augmented production function, including domestic investment, invention patents, and economic growth, manifests as follows:

$$\mathbf{Y = F(DI, P)} \quad \textbf{(1)}$$

'Y' denotes economic growth which is expressed by gross domestic product at constant price; DI' designates domestic investments which are expressed by gross fixed capital formation; and, P' denotes invention patents which are expressed by the number of invention patents of residents.

The augmented production function implicating each of these variables is emitted as:

$$\mathbf{Y = A\ DI^{\alpha_1} P^{\alpha_2}} \quad \textbf{(2)}$$

'A' confirm the standard of technology implicated in the country which is assumed to be constant. The returns to scale are attached with domestic investment and patent which are manifested by 'α_1' and 'α_2' respectively.

To translate the linear model and avoid problems of heteroscedasticity, all the variables are converted into logarithms.

$$\mathbf{LogY_t = \alpha_0 + \alpha_1 LogDI_t + \alpha_2 LogP_t + \varepsilon_t} \quad \textbf{(3)}$$

We will bind a time series database that will smolder the interval 1980 - 2020 and possessed from annual statistical reports of the World Bank. The squabby exposition of variables is proclaimed as below in Table 1.

Table 1: Characterization of variables

Variables	Descriptions	Source
Y	Gross Domestic Product (Constant US$)	The World Bank
DI	Domestic Investment (Constant US$)	The World Bank
P	Patent applications, residents	The World Bank

Source: Constructed by the author

After having the recognition of our empirical methodology, the next section keeps an empirical authentication that investigates into the relationship between domestic investment, patent, and economic growth in USA.

4. Empirical results

This section is an empirical detection on the relationship between domestic investment, patent and economic growth in USA. To acquire on our target, we part this section into five phases. In the first phase, we will determine the order of integration of all variables. Then, in the second phase, we will define the number of optimal lags that is suitable to our estimate. Next, in the third phase, we will test the entity of cointegration between all variables. The fourth phase exhibits the Sims model estimate. And lastly, the last phase takes part diagnostic tests to verify the quality of our estimate.

To locate the classification of integration of all variables (the stationarity of all variables), we will stratify the most compatibles tests which are the ADF test (Dickey Fuller Augmented test) and the PP test (Phillips Perron test). Results are presented in table 2.

Table 2: Results of Unit Root Tests

Tests		**PP Test**			**ADF Test**		
At Level							
Variables		***LOG(Y)***	***LOG(P)***	***LOG(DI)***	***LOG(Y)***	***LOG(P)***	***LOG(DI)***
With Constant	**t-Statistic**	-2.4991	-1.0876	-1.1353	-2.4147	-1.0876	-1.3430
	Prob.	0.1232	0.7114	0.6923	0.1442	0.7114	0.5998
With Constant & Trend	**t-Statistic**	-0.0397	-0.5656	-1.7021	-0.1678	-0.4893	-2.4550
	Prob.	0.9942	0.9757	0.7318	0.9917	0.9800	0.3474
Without Constant & Trend	**t-Statistic**	7.0482	3.7279	3.4805	2.7464	3.8111	1.9870
	Prob.	1.0000	0.9999	0.9997	0.9980	0.9999	0.9873
At First Difference							
Variables		***d(LOG(Y))***	***d(LOG(P))***	***d(LOG(DI))***	***d(LOG(Y))***	***d(LOG(P))***	***d(LOG(DI))***
With Constant	**t-Statistic**	-3.5465	-5.6810	-3.3272	-3.6494	-5.6810	-3.6953
	Prob.	0.0118	0.0000	0.0203	0.0090	0.0000	0.0080
With Constant & Trend	**t-Statistic**	-3.5109	-5.7889	-3.2933	-4.2211	-5.7977	-3.7351
	Prob.	0.0521	0.0001	0.0824	0.0098	0.0001	0.0316
Without Constant & Trend	**t-Statistic**	-2.0023	-4.4548	-2.8873	-2.2131	-4.3439	-2.9859
	Prob.	0.0446	0.0000	0.0050	0.0276	0.0001	0.0038
Notes: (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant							
**MacKinnon (1996) one-sided p-values.*							

Source: Authors' calculations using EViews 12 software.

The table overhead points out that all variables (Log (Y), Log (K) and Log (P) are stationary. They are all integrated in First difference, which means that cointegration analysis and Sims Model will be held. To assay the cointegration between domestic investment, patent, and economic growth, it is needful to go over two stages. First, it is necessary to appoint the number of optimal lags which must be suitable for our model. Therewith, we will employ Johanson's test to assign the cointegrating relationships between all the variables.

Table 3: Lag order selection criteria

VAR Lag Order Selection Criteria						
Endogenous variables: DLOG(Y) DLOG(P) DLOG(DI)						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	236.0245	NA	6.80e-10	-12.59592	-12.46530*	-12.54987
1	247.5814	20.61500*	5.93e-10	-12.73413	-12.21167	-12.54994*
2	257.2205	15.63104	5.80e-10*	-12.76868*	-11.85437	-12.44634
3	262.8957	8.282803	7.13e-10	-12.58896	-11.28281	-12.12848
** Indicates lag order selected by the criterion*						
LR: sequential modified LR test statistic (each test at 5% level)						
FPE: Final prediction error						
AIC: Akaike information criterion						
SC: Schwarz information criterion						
HQ : Hannan-Quinn information criterion						

Source: Authors' calculations using EViews 12 software.

The selection of the lag number has a very significant role in the design of a VAR model. It is believed that most VAR models involve symmetric lags, the same lag length is exerted for all variables in all model equations. This lag length is often chosen using an explicit statistical criterion such as HQ, FPE, AIC or SIC. The results of Table 3 show us that the number of delays was equal to 2 since the criteria FPE and AIC select that the number of delays is equal to 2. As soon as the optimal number of lags is fixed, we proceed directly to the cointegration analysis.

Table n°4: Johansen Test Results

Series: DLOG(Y) DLOG(P) DLOG(DI)				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.444759	36.63604	29.79707	0.0070
At most 1	0.319056	14.86695	15.49471	0.0620
At most 2	0.017382	0.648776	3.841466	0.4205
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
** Denotes rejection of the hypothesis at the 0.05 level*				
***MacKinnon-Haug-Michelis (1999) p-values*				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.444759	21.76909	21.13162	0.0406
At most 1	0.319056	14.21818	14.26460	0.0508
At most 2	0.017382	0.648776	3.841466	0.4205
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				
** Denotes rejection of the hypothesis at the 0.05 level*				
***MacKinnon-Haug-Michelis (1999) p-values*				

Source : Authors' calculations using EViews 12 software.

The results of Johansen's test are shown in Table 4. There is a cointegrating relationship between the variables included in our model. In this case, the vector error correction model will be applied. In the next step, we will exploit results of our estimation. The main objective of the vector error correction model is to determine the long-term and short-term relationships between domestic investments, invention patents and economic growth. The estimation results indicate that our vector error correction model will have the following 3 equations form:

$$\mathrm{D(DLOG(Y))} = \mathrm{C(1)} * (\mathrm{DLOG(Y(-1))} - 1.04394546458 * \mathrm{DLOG(DI(-1))} - 0.482805308004 * \mathrm{DLOG(P(-1))} + 0.027848331379) + \mathrm{C(2)} * \mathrm{D(DLOG(Y(-1)))} + \mathrm{C(3)} * \mathrm{D(DLOG(Y(-2)))} + \mathrm{C(4)} * \mathrm{D(DLOG(DI(-1)))} + \mathrm{C(5)} * \mathrm{D(DLOG(DI(-2)))} + \mathrm{C(6)} * \mathrm{D(DLOG(P(-1)))} + \mathrm{C(7)} * \mathrm{D(DLOG(P(-2)))} + \mathrm{C(8)} \quad \textbf{(4)}$$

$$\mathrm{D(DLOG(DI))} = \mathrm{C(9)} * (\mathrm{DLOG(Y(-1))} - 1.04394546458 * \mathrm{DLOG(DI(-1))} - 0.482805308004 * \mathrm{DLOG(P(-1))} + 0.027848331379) + \mathrm{C(10)} * \mathrm{D(DLOG(Y(-1)))} + \mathrm{C(11)} * \mathrm{D(DLOG(Y(-2)))} + \mathrm{C(12)} * \mathrm{D(DLOG(DI(-1)))} + \mathrm{C(13)} * \mathrm{D(DLOG(DI(-2)))} + \mathrm{C(14)} * \mathrm{D(DLOG(P(-1)))} + \mathrm{C(15)} * \mathrm{D(DLOG(P(-2)))} + \mathrm{C(16)} \quad \textbf{(5)}$$

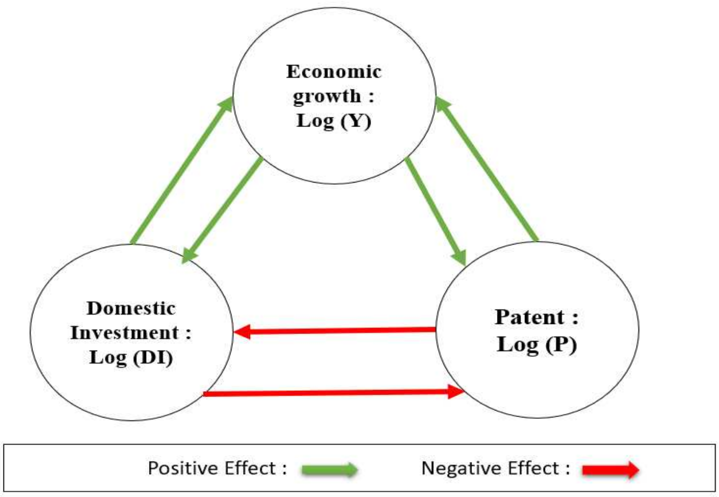
$$\mathrm{D(DLOG(P))} = \mathrm{C(17)} * (\mathrm{DLOG(Y(-1))} - 1.04394546458 * \mathrm{DLOG(DI(-1))} - 0.482805308004 * \mathrm{DLOG(P(-1))} + 0.027848331379) + \mathrm{C(18)} * \mathrm{D(DLOG(Y(-1)))} + \mathrm{C(19)} * \mathrm{D(DLOG(Y(-2)))} + \mathrm{C(20)} * \mathrm{D(DLOG(DI(-1)))} + \mathrm{C(21)} * \mathrm{D(DLOG(DI(-2)))} + \mathrm{C(22)} * \mathrm{D(DLOG(P(-1)))} + \mathrm{C(23)} * \mathrm{D(DLOG(P(-2)))} + \mathrm{C(24)} \quad \textbf{(6)}$$

In fact, Equation 4 explains the impact of patents and domestic investment on economic growth. Similarly, equation 5 explains the impact of economic growth and patents on domestic investment. In addition, Equation 6 presents the impact of economic growth and domestic investment on patents. Also, the equation of long-run equilibrium is presented as follows:

$$\mathbf{LOG(Y) = 0.027 + 1.04 * LOG(DI) + 0.48 * LOG(P)} \quad \textbf{(7)}$$

using the long-term equilibrium equation (Equation n°7), we can present the causal links between domestic investments, patents, and long-term economic growth. In fact, the long-term causal links are shown in Figure 1. We find that there is a positive bidirectional relationship between domestic investment and economic growth. Similarly, we find a positive bidirectional relationship between patents and economic growth. On the other hand, the long-term equilibrium equation indicates that there is a negative two-way relationship between domestic investment and patents.

Figure n°5: Summary of three-way linkage between domestic investment, patent, and economic growth in the long run



Source: Constructed by the author using the long-term equilibrium equation

To ascertain the currency and the credibility of the long-run equilibrium equation, we will pull out the equations of the vector error correction model (Equations 4, 5 and 6) and we estimate them using the Gauss-Newton method to establish the signification of the long-term relationships. The econometric rule of the significance of the long-term equilibrium equation requires that the coefficient of the error correction term be negative and have a probability less than 5%. Results are presented in table 5.

For the equation (4), the coefficient of the error correction term is positive (0.170565) and has a non-significant probability (C1 = 0.1125). So, we can confirm that patent and domestic investment have not any effect on economic growth in the long run. For the equation (5), the coefficient of the error correction term is positive (0.694789) and has a significant probability (0.0023). In that case, we can confirm that economic growth and patent have not any effect on domestic investment in the long run. For the equation (6), the coefficient of the error correction term is positive (0.770038) and has a significant probability (0.0290). So, we can confirm that economic growth and domestic investment have not any effect on patent in the long run. We conclude in the long run that there is no relationship between domestic investment, patent, and economic growth in USA.

Table 5. Vector Error Correction Model (VECM) Estimation in the long run

Estimation Method: Least Squares				
	Coefficient	***Std. Error***	***t-Statistic***	***Prob.***
C(1) : ECT	0.170565	0.106389	1.603223	0.1125
C(2)	-0.307669	0.550184	-0.559210	0.5775
C(3)	-0.680631	0.470983	-1.445128	0.1520
C(4)	0.113651	0.210686	0.539433	0.5910
C(5)	0.229097	0.178886	1.280684	0.2037
C(6)	0.042637	0.063651	0.669862	0.5047
C(7)	0.027377	0.055337	0.494727	0.6220
C(8)	-0.002096	0.003097	-0.676673	0.5004
C(9) : ECT	0.694789	0.221388	3.138334	0.0023
C(10)	-0.207106	1.144897	-0.180895	0.8569
C(11)	-1.731247	0.980084	-1.766427	0.0808
C(12)	0.228652	0.438423	0.521533	0.6033
C(13)	0.620694	0.372250	1.667411	0.0990
C(14)	0.283293	0.132453	2.138825	0.0353
C(15)	0.106874	0.115153	0.928109	0.3559
C(16)	-0.002607	0.006445	-0.404459	0.6869
C(17) : ECT	0.770038	0.346752	2.220717	0.0290
C(18)	3.821108	1.793213	2.130872	0.0359
C(19)	-1.122778	1.535072	-0.731417	0.4665
C(20)	-0.857662	0.686687	-1.248986	0.2150
C(21)	1.120074	0.583043	1.921084	0.0580
C(22)	-0.367829	0.207456	-1.773045	0.0797
C(23)	-0.026670	0.180360	-0.147873	0.8828
C(24)	-0.002886	0.010095	-0.285869	0.7757

Source: Authors' calculations using EViews 12 software.

As soon as the examination of the causal links between the variables has been determined in the long term, we will examine them in the short-term using the WALD test. The latter's econometric rule denotes that if there is a probability less than 5% then there is a causal relationship between variables. However, if there is a probability greater than 5% then there is not a causal relationship between variables. The results of the short-term causal relationships are presented in Table 6.

Table 6. Vector Error Correction Model (VECM) Estimation in the short run

VEC Granger Causality/Block Exogeneity Wald Tests			
Dependent variable: D(DLOG(Y))			
Excluded	Chi-sq	df	Prob.
D(DLOG(DI))	1.692505	2	0.4290
D(DLOG(P))	0.452403	2	0.7976
All	1.873047	4	0.7591
Dependent variable: D(DLOG(DI))			
Excluded	Chi-sq	df	Prob.
D(DLOG(Y))	3.555477	2	0.1690
fD(DLOG(P))	5.044052	2	0.0803
All	6.546185	4	0.1619
Dependent variable: D(DLOG(P))			
Excluded	Chi-sq	df	Prob.
D(DLOG(Y))	7.971398	2	0.0186
D(DLOG(DI))	6.863894	2	0.0323
All	15.36578	4	0.0040

Source: Authors' calculations using EViews 12 software.

It is very clear for us that economic growth and domestic investment cause patent in the short term. Also, we found that patent causes domestic investment in the short term. However, we found that domestic investment and patent don't cause economic growth in the short term.

5. Conclusions and discussions

The aim of this paper is to search the three way-linkage between patent, domestic investment, and economic growth in the case of USA during the period 1980 – 2020. To attempt our goal, we used cointegration analysis and VECM Model, we found that there is no causal relationship between the three variables in the long run. However, we found that domestic investment and economic growth cause patent in the short run. which explains why patents are not a source of economic growth and domestic investment in America and that there are other determinants that have stimulated American economic activity.

There is no definitive answer, but one possibility is that the innovation gap between the United States and other countries is larger than the innovation gap between different sectors within the United States. For example, the United States has a strong technology sector, but other countries have more significant sectors such as pharma and automobiles. Thus, it may take more than just a great deal of innovation to have a significant impact on economic growth. There is no clear relationship between domestic investment and patent in the case of the USA. This is because the two are not necessarily related. For example, research and development spending may be directed towards developing new products or technologies, which may not involve the acquisition of patents. In addition, the number of patents granted may not necessarily be indicative of the level of domestic investment in the economy. If a country wants to spur a larger economic growth, then it must invest more in domestic businesses. The main goal of domestic investments is to create or increase demand within a country, which will in turn help businesses to flourish. For example, if a company is investing in machinery to boost production, then this will spur demand for the company's products and services, which in turn will encourage more businesses to invest and grow in line with the new demand. However, as we have seen in the case of the United States, there is no clear relationship between domestic investment and economic growth. This is mainly due to several factors, including a lack of available capital, weak demand from consumers, and several other challenges that businesses face. Consequently, investing in domestic businesses is not always the most effective way to spur economic growth.

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