

# Innovation in SMEs as a Driver of Sustainable Economic Growth in Algeria: An Econometric Study for the Period 1999-2022

Hadjeris Souhila <sup>a</sup>  , Djellaba Ali <sup>b</sup> 

## ABSTRACT

**Purpose** – Innovation has become a pivotal concern for small and medium-sized enterprises (SMEs) as it plays a fundamental role in ensuring their survival and supporting their sustainable growth. This study aims to examine the impact of promoting and supporting innovation within SMEs on economic growth in Algeria during the period from 1999 to 2022. The overarching goal is to contribute to enhancing the added value of national economic output.

**Design/methodology/approach** – To achieve the study's objectives, the autoregressive distributed lag (ARDL) model was employed as the main methodology. This econometric model was selected because it analyzes the dynamic relationship between innovation and SME development over time, utilizing a standard time-series data set covering key economic indicators related to innovation and enterprise growth.

**Findings** – The empirical findings of the study revealed a statistically significant and positive long-term relationship between the innovation index and the growth of SMEs. The analysis confirmed that supporting innovation positively influences the development of SMEs and enhances their contribution to economic performance.

**Originality/value** – This study provides original empirical evidence on the strategic importance of innovation for SMEs in a developing economy context. Unlike previous studies, it focuses specifically on Algeria over a substantial time frame and highlights the necessity of adopting innovation as a strategic priority to foster sustainable economic growth and long-term value creation.

**Keywords:** Innovation, SMEs, Economic Growth, ARDL model, Algeria

## Cezayir'de Sürdürülebilir Ekonomik Büyümenin Sürücüsü Olarak KOBİ'lerde İnovasyon: 1999-2022 Dönemi İçin Ekonometrik Bir Çalışma

### ÖZET

**Amaç** – İnovasyon, küçük ve orta ölçekli işletmelerin (KOBİ) hayatta kalmalarını ve sürdürülebilir büyümelerini desteklemelerinde temel bir rol oynadığı için onlar için temel bir ilgi alanı haline gelmiştir. Bu çalışma, 1999-2022 döneminde Cezayir'de KOBİ'lerde inovasyonun teşvik edilmesi ve desteklenmesinin ekonomik büyüme üzerindeki etkisini incelemeyi amaçlamaktadır. Genel amaç, ulusal ekonomik çıktının katma değerinin artırılmasına katkıda bulunmaktır.

**Tasarım/veri/metodoloji** – Çalışmanın hedeflerine ulaşmak için, ana metodolojik yaklaşım olarak otoregresif dağıtılmış gecikmeli model (ARDL) kullanılmıştır. Bu ekonometrik model, inovasyon ve KOBİ'lerin zaman içindeki gelişimi arasındaki dinamik ilişkiyi analiz etmek için seçilmiştir. Bu model, inovasyon ve işletme büyümesiyle ilgili temel ekonomik göstergeleri kapsayan standart bir zaman serisi veri seti kullanmıştır.

**Bulgular** – Çalışmanın ampirik bulguları, inovasyon endeksi ile KOBİ'lerin büyümesi arasında istatistiksel olarak anlamlı ve pozitif bir uzun vadeli ilişki olduğunu ortaya koymuştur. Analiz, inovasyonu desteklemenin KOBİ'lerin gelişimini olumlu yönde etkilediğini ve ekonomik performansa katkılarını artırdığını doğrulamıştır.

**Özgünlük/değer** – Bu çalışma, gelişmekte olan bir ekonomi bağlamında KOBİ'ler için inovasyonun stratejik önemine dair orijinal ampirik kanıtlar sunmaktadır. Önceki çalışmalardan farklı olarak, uzun bir zaman diliminde Cezayir'e odaklanmakta ve sürdürülebilir ekonomik büyümeyi ve uzun vadeli değer yaratımını teşvik etmek için inovasyonu stratejik bir öncelik olarak benimsemenin gerekliliğini vurgulamaktadır.

**Anahtar Kelimeler:** İnovasyon, KOBİ'ler, Ekonomik Büyüme, ARDL modeli, Cezayir

Received: 23.08.2025

Accepted: 15.12.2025

<sup>a</sup> Chadli Bendjedid University, Department of Economic Sciences, s.hadjeris@univ-eltarf.dz, El Tarf, Algeria;

<sup>b</sup> Chadli Bendjedid University, Department of Financial Sciences and Accounting, djellaba.ali@univ-eltarf.dz, El Tarf, Algeria;

**Corresponding Author:** Hadjeris Souhila, s.hadjeris@univ-eltarf.dz



## 1. Introduction

Knowledge economics is based on the optimal and effective exploitation of human intellectual capital in creativity and innovation. Throughout the stages of economic development, developed economies have achieved successive and escalating increases in added value. This value is generated by converting inputs or resources into goods or services. The highest of these increases was seen in information technology and then knowledge economics, respectively. This knowledge, which emerges from human skills to fuel innovation, represents the capabilities used to design and develop products capable of competing, and to develop effective production methods. Furthermore, innovation is a way to reduce costs, improve quality, and achieve excellence, making it one of the most important competitive strategies for ensuring the continuity of institutions.

Small and Medium-sized Enterprises (SMEs) are globally recognized as the backbone of economic activity, contributing significantly to employment and Gross Domestic Product (GDP). However, their survival and growth are critically dependent on their ability to innovate. Innovation is particularly crucial for SMEs as it allows them to overcome size-related disadvantages, adapt swiftly to market changes, enter new markets, and maintain a competitive edge against larger corporations. Without a proactive stance on innovation—whether in product, process, marketing, or organizational structure—SMEs face stagnation and decline, underscoring its role not just as a strategy for growth, but often as a requisite for their very continuity.

In parallel, understanding the relationship between SMEs and economic growth has attracted the interest of many researchers and many attempts have been made to establish statistical relationships between SMEs and the GDP rate. Some authors confirm the essential role of these small businesses as the engine of job creation and economic growth. Applied studies across various economies have provided mixed evidence on the direct impact of innovation on SME performance and subsequent macroeconomic growth. For instance, empirical work in OECD countries consistently supports a positive correlation between R&D investment (a proxy for innovation) in SMEs and productivity growth. Conversely, studies focusing on developing or transition economies often point to structural and institutional challenges—such as access to finance, weak intellectual property rights, and bureaucratic hurdles—that can dampen the expected positive effect of innovation. This heterogeneity in findings highlights the crucial need for context-specific research.

Algeria, like other developing countries, has paid great attention to small and medium-sized enterprises in recent years, and this has emerged through the introduction of legal frameworks, national bodies and organizations to develop them, the development of strategies to support them, attention to research and development activities, and the creation of regulatory conditions conducive to creativity and innovation to achieve growth for such institutions, which in turn will affect economic growth and achieve

development goals in Algeria. Despite this recognized policy focus and the global literature, there remains a significant gap concerning the rigorous empirical assessment of how innovation within Algerian SMEs specifically translates into sustainable economic growth. Previous studies on Algeria often rely on descriptive data or qualitative analyses with limited focus on the long-term, dynamic relationship.

This study aims to fill this critical gap. The original contribution of this manuscript lies in its application of an econometric framework to rigorously investigate the impact of SME innovation proxies on sustainable economic growth indicators in Algeria. By covering the specific time frame from 1999 to 2022, our analysis provides up-to-date and contextually relevant evidence for policymakers, offering a more precise and quantitative understanding of innovation's role in driving Algeria's economic development goals.

## **2. Theoretical Framework and Literature Review**

### **2.1. Theoretical Framework**

In this section, the theoretical framework is presented under the following four headings.

#### **2.1.1. Defining Innovation**

According to the English dictionary, Merriam-Webster, innovation is 'the introduction of something new,' which can be a new idea, method, or device. Innovation, in general, can be applied to all fields. Specifically, in the business field, it is the process of translating an idea or invention into a good or service that creates added value or that customers are willing to pay for (Webster). Joseph Schumpeter defines innovation as an activity that leads to a new production function (Schumpeter, 2021). This activity is divided into several steps as follows:

- Introduce a new product: The entrepreneur must introduce a new product that can be sold and is not currently available on the market.
- Introducing a new way of producing: Innovation should provide a new blueprint for production that, through existing inputs, can lead to increased output and lower costs.
- Opening a new market: Innovations can increase sales in new regions and increase the number of customers.
- Searching for appropriate sources of raw materials (primary resources).

Schumpeter describes these steps as the entry of the entrepreneur into a temporary monopoly market, or creating conditions that enable the entrepreneur to take a monopoly position. Innovation often results when ideas are applied by the company or organization in order to meet customer needs and expectations.

In summary, the term innovation, the term innovation is often associated with the concept of "new" and is defined as a process of adopting new ideas and methods

(Abdilahi, Hassan, & Muhumed, 2017). Furthermore, innovation is emphasized as creating new wealth or changing prevailing resources to generate wealth (Kuratko & Hodgetts, 2004).

### 2.1.2. Open Innovation

It is one of the common theories of innovation that states that in order to adopt an innovative strategy and promote their own technology; companies must use both internal and external innovation ideas, as well as internal and external market channels (Chesbrough, 2006). The theory confirms that companies should not be limited to internal ideas and market channels, but must consider external ideas that can be equally important for adopting innovation. SMEs face a number of obstacles, including the absence of innovation resources, methods, and administrative capabilities. However, this type of institution shows strong capabilities to continuously improve innovation.

Above all, open innovation provides an opportunity for SMEs as they can exploit external innovation resources on a large scale as well as scientific innovation ideas and administrative means (Chesbrough, 2006).

### 2.1.3. Importance of Innovation in SMEs

Innovation is essential for most institutions to solve problems and develop production processes. By addressing consumer desires and boosting growth and productivity, innovation helps institutions achieve their strategic objectives. The importance of innovation can be summarized by several key points (Mustafa, 2006):

- Employment generation;
- Reducing expenses by providing faster services (costing less labor) and more accurate processes (reducing the costs associated with damage and rework);
- Increasing market shares, thereby maximizing the organization's position in the market;
- Strengthening knowledge and practical capacities through knowledge and expertise on technical innovation and development processes;
- Maintaining survival and continuity;
- Achieving consumer satisfaction through new products.

### 2.1.4. The elements of innovation in SMEs

Determining the elements of innovation is difficult, especially in light of a fertile investment climate characterized by intense competition, rapid technological change, and contemporary scientific momentum. These elements result from the positive interaction between the variables of the environment in which the institution is active, harmoniously balancing the effectiveness of research and development, the efficiency of the organizational structure, and the prevailing organizational culture. The various elements listed in the table below can also be considered:

**Table 1.** Elements of Innovation in SMEs

Element	Description
<b>R &amp; D</b>	<p>The research and development (R&amp;D) process is the most effective way through which institutions can obtain modern methods in the field of modern production. It must be carried out in a planned and organized manner according to recognized approaches. Therefore, R&amp;D is indispensable for institutions in our world where technology has become the basic capital. The more modern technology is available to the institution thanks to research and development, the more this enables it to control its costs and thus enter the markets at competitive prices.</p>
<b>The climate and culture of the SMEs</b>	<p>The organizational climate is considered a key characteristic of the small and medium-sized enterprise (SME) in Algeria, defined by the mixture of attitudes, feelings, and behaviors that characterize the firm, which often arise independent of the formal structure or members' stated perceptions. Therefore, Algerian SMEs must seek to provide an innovation-supportive climate, characterized by openness to change, risk-taking, and promoting open discussion.</p> <p>Regarding organizational culture: Each institution possesses a distinct culture; there is no single, unifying culture to which all employees belong. Therefore, Algerian SMEs must seek to foster harmony among their members under a comprehensive culture to facilitate innovation. Leaders must be familiar with the subcultures of the individuals working in their firm and, when necessary, impose a certain culture based on the circumstances of the surrounding environment.</p>
<b>Organizational structure</b>	<p>The organizational structure of Algerian SMEs must be linked to the environment in which the institution operates to act as a catalyst for innovation. If the environment is stable, a mechanistic structure is appropriate. Conversely, if the organizational environment is characterized by change and unpredictability, an organic structure is required.</p>

**Source:** (Boukemoum & Ghiat, 2009)

## 2.2. Literature Review

The role of innovation within Small and Medium-sized Enterprises (SMEs) has been extensively investigated across various geographical and economic contexts, yielding consistent empirical evidence that underscores its significance as a crucial driver of both enterprise performance and broader economic growth. Studies conducted within emerging and Asian market economies particularly highlight the strong positive correlation between innovative activities and superior firm outcomes. For instance, in an analysis of 6,930 firms in Hargeisa, Somaliland, Abdilahi et al. (2017) demonstrated that both product innovation and process innovation significantly improved SME performance. This finding provides strong empirical support for the positive and catalytic role of innovation in supporting the growth trajectories of enterprises operating in developing and emerging economic landscapes.

Further reinforcing this perspective, research focusing on the Chinese context has refined the understanding of the conditions under which innovation thrives within SMEs. Cui and Song (2022) argued that the successful impact of entrepreneurship on innovation performance in Chinese SMEs is critically dependent on the presence of dynamic capabilities within the firm and a supportive external innovation environment. When these prerequisites are met, the resulting innovation performance is substantially enhanced, leading to higher contributions to the national Gross Domestic Product (GDP). More recently, Li and Abdullah (2024) explored the intersection of innovation and strategic risk-taking. Their work concluded that combining innovation with judicious, calculated risk-taking—especially when supported by a favorable cultural and institutional environment—significantly fosters sustained SME growth and long-term business sustainability. Collectively, this body of research firmly establishes that innovation in SMEs, supported by robust institutional, financial, and organizational frameworks, is an essential mechanism for enhancing individual firm performance, which in turn aggregates into meaningful contributions to national economic development and growth.

Despite the compelling global evidence, a notable geographical gap exists in the existing literature. As highlighted by the studies above, the majority of current empirical research focuses heavily on contexts within Asia or general emerging markets. Consequently, there is a scarcity of econometric analyses specifically dedicated to examining this relationship within the Maghreb or North-African region, and virtually none that focus on Algeria using advanced time-series methods. This omission is critical, as the institutional, financial, and regulatory environments of North African economies often differ significantly from those in East Asia or other emerging regions. These unique structural and environmental characteristics may mediate the established innovation-growth nexus, warranting a dedicated empirical investigation.

This study addresses the identified gap by focusing explicitly on the Algerian context for the period 1999–2022. By applying the Autoregressive Distributed Lag (ARDL) approach, this research aims to assess the long-term cointegrating relationship and the short-run dynamics of innovation on economic growth in Algeria. This methodological choice is particularly robust for establishing long-run linkages in time-series data and provides a novel contribution by offering the first such comprehensive econometric assessment for this strategically important North-African economy.

### **3. Research Methodology**

#### **3.1. Sample and Data**

The study sample comprises the State of Algeria. The study period from 1999 to 2022 was determined based on the comprehensive availability and consistency of annual data for all variables under investigation. The necessary time series data were systematically

procured from three principal sources: the World Bank's World Development Indicators (WDI) database, the National Office of Statistics (ONS) of Algeria, and the official statistical bulletins published by the Ministry of Industry and Pharmaceutical Production (formerly the Ministry of Industry and Mines).

### 3.2. Model description and study variables

The selection of variables impacting sustainable economic growth was guided primarily by established economic theory and secondarily by the findings of relevant empirical literature on innovation, entrepreneurship, and growth. To rigorously examine the impact of innovation in Algerian SMEs on economic growth, the study employed an Autoregressive Distributed Lag (ARDL) approach. This modeling technique was selected due to its capacity to provide robust, efficient long-run estimates when variables exhibit mixed orders of integration (I(0) and I(1)) and its superior performance in small sample sizes (T=24) inherent to this study's time frame. The econometric analysis is based on the following functional relationship:

$$LPIB = C(1) * LPIB (-1) + C(2)* LPME + C(3) * LPA + C(4)* LCHO + C(5)* LAR01 + C(6)$$

Whereas:

#### ➤ Dependent Variable:

***Lpib***: Expresses the logarithm of the average GDP per capita measured in constant local currency prices. *Lpib* is chosen as the standard proxy for sustainable economic growth. This choice aligns with established Endogenous Growth Theory, which emphasizes that long-run growth is driven by internal factors like human capital, innovation, and R&D. Furthermore, using GDP per capita (PIB) rather than aggregate GDP provides a better measure of the standard of living and the sustainability of growth, consistent with the manuscript's focus.

#### ➤ Independent variables:

***LPME***: The number of SME development in Algeria, obtained from the statistical reports and bulletins of the Ministry of Industry and Pharmaceutical Production for the period (1999-2022). This is the primary variable of interest, reflecting the structural component of innovation capacity through the number of Small and Medium Enterprises. SMEs are widely recognized as key drivers of innovation and competition (Schumpeterian view), making their number a crucial indicator in the Algerian context.

***LCHO***: Log of Unemployment Rate is included as a control variable to capture macroeconomic stability and labor market conditions. High unemployment typically indicates underutilization of resources, potentially hindering sustainable growth and innovation efforts.

***LAR***: Represents knowledge creation and research and development efforts. Published articles are a proxy for the knowledge stock and human capital dedicated to innovation, a key factor in endogenous growth models.

**LPA:** Expressed by the algorithm of innovation, where it was expressed by the total number of patent applicants for residents and non-residents. Patents are a common metric for measuring the knowledge output of an economy, directly linking innovation to the growth model (Romer, 1990).

## 4. Results

### 4.1. Unit Root and Joint Integration Testing

As an initial stage, we studied the stability of the time series under investigation by using the Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979) and the Phillips-Perron (PP) test to determine their order of integration. We found that all time series were non-stationary at the level (I(0)). We then repeated the tests on the first difference, which confirmed that they are stationary, meaning they are integrated of order one (I(1)) (See Table 2). This result allowed us to move on to conducting a cointegration test using the ARDL Bounds Test approach. After determining the optimal lag order for the model, Table 2 shows that the F-statistic value is equal to 6.002 and is greater than the critical value of the upper bound at the 1% significance level. Therefore, there is a long-term equilibrium relationship between the study variables.

**Table 2.** Unit Root and PP Test Results for Study Variables

Variables	At the level			At the first differences			Decision	
	Steady	Constant and general trend	No constant and no general trend	Steady	Constant and general trend	No constant and no general trend		
LPA	t-Statistic	5895	2	3	8	-8	4	1=I
	PROB	0.9861	1612	999.	0.0000 ***	0.0000 ***	0.0000 ***	
LPME	t-Statistic	8	4830	5	1911	10	2.	1=I
	PROB	0.0000	9767	1.0000	0.0039 ***	0.0000 *****	0.443 **	
LPIB	t-Statistic	069	2572	2	3	3	3	I(1).
	PROB	2577	0.8731	0.9884	0.0097 ***	0.0313 ***	0.0019 ***	
LCHO	t-Statistic	t-Statistic	1312	.7547	1	3079	5	I (1)
	PROB	PROB	2351	0.9557	0.0635	0.0030 ***	0.0004 ***	
LAR01	t-Statistic	t-Statistic	3135	1	0443	4	4	I(1).
	PROB	PROB	6054	5943	1.0000	0.0013 ***	0.0076 ***	

**Notes:** \*\*\* Moral at the level of significance 1%, \*\* Moral at the level of significance 5%, \* Moral at the level of significance 10.

**Source:** Data processed (2025)

**Table 3.** Joint integration testing using the bounds test methodology

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif	(0)	(1)
			Asymptotic: n=1000	
F-statistic	6.003370	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37
Actual Sample Size	23		Finite Sample: n=35	
		10%	2.46	3.46
		5%	2.947	4.088
		1%	4.093	5.532
			Finite Sample: n=30	
		10%	2.525	3.56
	5%	3.058	4.223	
	1%	4.28	5.84	

Source: Data processed (2025)

#### 4.2. Estimate the long-term co-integration relationship

Since the existence of a long-term equilibrium relationship of the model has been confirmed, the results of estimating the long-term relationship between the study variables are shown in the following table:

**Table 4.** Results of a long-term relationship test

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std.Error	t-Statistic	Prob.
LPME	-0.512826	0.572531	-0.895718	0.3829
LPA	0.350298	0.247228	1.416905	0.1746
LCHO	-1.195092	0.235379	-5.077315	0.0001
LAR01	0.130683	0.443529	0.294644	0.7718
C	33.00508	5.075189	6.503221	0.0000

Source: Data processed (2025)

The long-term estimation results of the ARDL model indicate that the variables LPME (development of SMEs) and LAR01 (research and development) have probability values greater than 0.10, meaning their estimated coefficients are not statistically significant at conventional levels and therefore cannot be considered as having a definitive effect on GDP per capita. Although the positive signs of these coefficients suggest potential positive relationships, their actual impact on economic growth may require longer time periods or additional data to fully capture their effect in the Algerian context. In contrast, the variable LCHO (unemployment) shows a negative and statistically significant effect on GDP per capita, indicating that higher unemployment hinders economic growth; therefore, policies aimed at reducing unemployment are likely to effectively support economic development. The results also suggest that the non-significant variables reflect potential trends but do not show a clear effect in the short term, and their inclusion in the

analysis remains theoretically justified based on prior studies, as it may help capture long-term or indirect effects. Furthermore, the error correction model confirms the existence of a long-term equilibrium relationship among the variables, with the CointEq (-1) coefficient being negative and significant, reflecting the model's ability to correct deviations from equilibrium at a rate of approximately 1.8% per year.

Additionally, diagnostic tests indicate no serial correlation in the residuals, normality of the residual distribution, homoscedasticity, correct functional form, and overall model stability over time, providing confidence in the reliability of the ARDL estimates and emphasizing the importance of examining the relationship between innovation, SME development, and economic growth from a comprehensive perspective of macroeconomic policies and extended time horizons, rather than solely through short-term analysis, to ensure a complete assessment of potential impacts.

### 4.3. Estimating the short-term equation

The short-term relationship is represented by the estimated Error Correction Model (ECM), which includes the variables used in the study model expressed as first differences, in addition to the Error Correction Term (ECT). The latter measures the speed of adjustment of the disequilibrium in the short term to the long-term equilibrium. If the error correction parameter is negative and statistically significant, this confirms a long-term relationship between the variables. The results are presented in the following table:

**Table 5.** Results of estimating the relationship in the short term

ECM Regression				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob
D (LPA)	0.028218	0.059684	0.472797	0.6531
D (LCHO)	0.490230	0.166878	2.937651	0.0260
D (LCHO (-1))	1.191602	0.230816	5.162554	0.0021
D (LCHO (-2))	0.573571	0.165728	3.460915	0.0135
D (LAR01)	0.813951	0.130472	6.238485	0.0008
D (LAR01 (-1))	1.645925	0.267499	6.153012	0.0008
D (LAR01 (-2))	1.458743	0.215357	6.773594	0.0005
D (LPME)	-0.702846	0.228107	-3.081215	0.0216
D (LPME (-1))	-0.937103	0.210555	-4.450623	0.0043
CointEq (-1)*	-0.862634	0.111781	-7.717190	0.0002

Source: Data processed (2025)

The error correction model (ECM) results indicate that the CointEq(-1) coefficient is negative and significant at -0.862634, confirming the existence of a long-term equilibrium relationship among the studied variables. This value reflects the model's strong ability to correct deviations from equilibrium in each period, indicating that approximately 86.26% of the disequilibrium from the long-run path is corrected annually (or per period).

#### 4.4. Study the validity of the ARDL model

To determine the validity of the model, we must conduct tests that allow us to ensure that the study model is free from the problem of serial correlation, the problem of heterogeneity of variation, and the normal distribution of residues.

##### 4.4. Serial correlation test for errors (Breusch – Godfrey Test)

Among the tests devoted to the serial correlation problem is the Lagrange Multiplier *LM test*, which is based on the Lagrange Multiplier principle. The standard test used is the *Breusch – Godfre* (BG) test. The results are as follows:

**Table 6.** Serial correlation test results of errors (*Breusch – Godfrey Test*)

<b>Breusch-Godfrey Serial Correlation LM Test:</b>			
<b>Null hypothesis: No serial correlation at up to 2 lags</b>			
F- statistic	1.770310	Prob. F(2.15)	0.2041
Obs*R-squared	4.392208	Prob. Chi-Square(2)	0.1112

Source: Data processed (2025)

Since the test statistic  $LM = 1.77$ , and the corresponding p-value (0.20) is greater than the significance level ( $\alpha=0.05$ ), the null hypothesis  $H_0$ : 'There is no serial correlation of the residuals,' is accepted.

##### 4.5. Fault variation heterogeneity test Breusch – pagan

The problem of unsteadiness of variance is represented in the variation of the random term variance with the change in the values of the explained variable, and it may be the relationship between them is written or non-linear through the following table:

**Table 7.** Heterogeneity test of error variation *Breusch – pagan*

<b>Heteroskedasticity Test Breusch-Pagan-Godfrey</b>			
<b>Null hypothesis: Homoskedasticity</b>			
F-statistic	1.021751	Prob. F (5.17)	0.4357
Obs*R-squared	5.314697	Prob. Chi-Square (5)	0.3787
Scaled explained SS	2.760277	Prob. Chi-Square (5)	0.7369

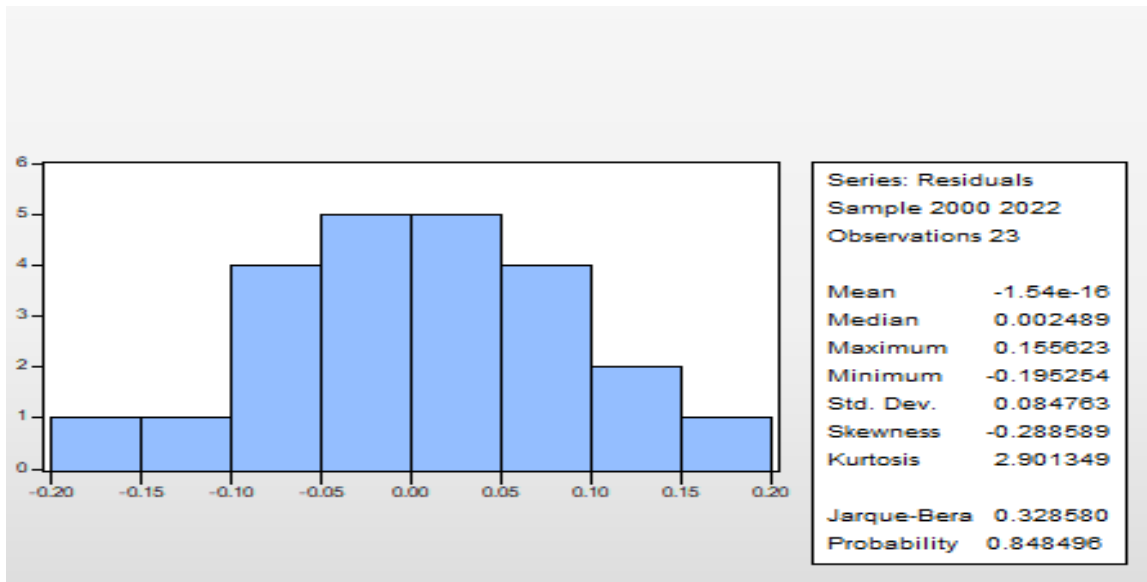
Source: Data processed (2025)

Since the test statistic  $BP = 1.02$ , and the corresponding p-value (0.43) is greater than the significance level ( $\alpha=0.05$ ), the null hypothesis  $H_0$ : 'There is no problem of heteroscedasticity in the model,' is accepted."

##### 4.6. Testing the normal distribution of the remnants (Jarque – Bera)

Figure 1 shows the test results for the normal distribution of residues. Through the figure, the normal distribution of the remainders is tested (Jarque – Bera) (Jarque & Bera, 1987) according to the following:

**Figure 1.** Testing the normal distribution of the remnants



Source: Data processed (2025)

That  $JB = 0.32$ , and the probability of facilities for this statistic (0.84) is equal to and greater than the significance level of 5%, and therefore the null hypothesis is accepted  $H_0$ , which says that the series of remnants follows the normal distribution.

**4.7. Testing the deltoid shape of the model Ramsey test**

Through a table that contains a test of the deltoid shape of the model Ramesy test (Ramsey, 1969) according to the following:

**Table 8.** Testing the deltoid shape of the model Ramsey test

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LP1B (-1)	-8.734203	4.850631	-1.800632	0.0906
LPME	4.840296	2.703617	1.790304	0.0923
LPA	-3.282222	1.827535	-1.795983	0.0914
LCHO	11.03243	6.140604	1.796636	0.0913
LAR01	-1.250487	0.728318	-1.716952	0.1053
C	-65.52550	43.84541	-1.494466	0.1545
FITTED^2	0.374465	0.197146	1.899426	0.0757

Source: Data processed (2025)

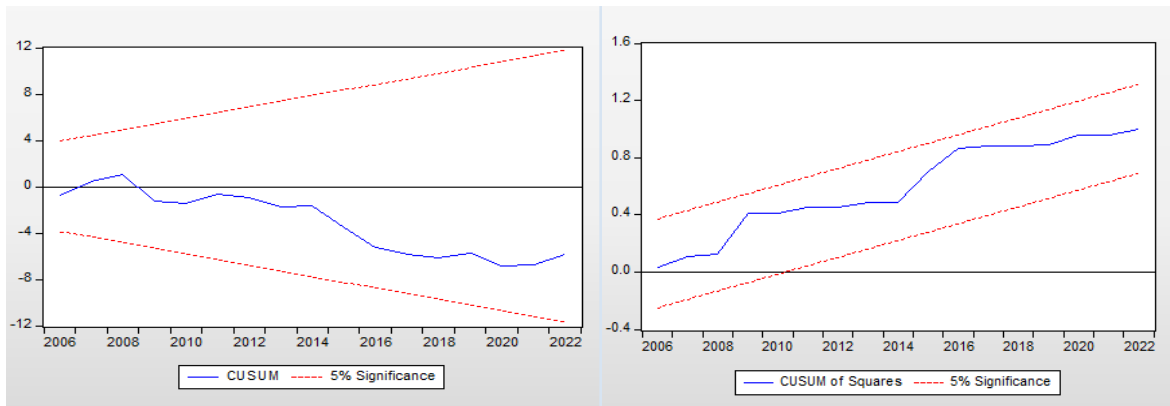
Whereas  $RESET = 0.37$ , the probability of facilities for this statistic is equal to (0.07), which is greater than the significance level of 5%, and therefore the null hypothesis is accepted, which states that the functional form is suitable for estimation.

**4.8. Stability Test**

To verify that there are no structural changes in the model—that is, to confirm the stability of the estimated parameters—we use the CUSUM test. The structural stability of the estimated parameters of the ARDL model is assessed using both the CUSUM and CUSUM of Squares tests. Stability is confirmed if the plotted line falls within the critical 5% significance boundaries. As shown in Figure 2, where both the CUSUM test and the

CUSUM of Squares test plotted lines are located within the critical area, indicating the stability of the model at the 5% level of significance. These two tests confirm the stability of the model, indicating consistency between the long-term and short-term results.

**Figure 2.** Stability Test Results



Source: Data processed (2025)

## 5. Discussion

The results of the ARDL model indicate that innovation in small and medium-sized enterprises plays a fundamental role in supporting economic growth in Algeria during the period 1999–2022. A positive and statistically significant long-run effect was identified, while the short-run impact appeared limited or insignificant. This can be explained by the fact that innovation requires knowledge and technological accumulation, as well as longer cycles before innovative activities translate into tangible productivity outcomes. This finding aligns with international literature, which considers innovation a key driver of growth when accompanied by supportive regulatory and financial frameworks.

These results are consistent with the study of Mohamed Hussein et al. (2017), which confirmed a positive relationship between innovation in SMEs and economic growth in developing countries. They also converge with findings from studies conducted in China and Turkey, which demonstrated that expanding investment in technology and research and development enhances the contribution of SMEs to GDP. Conversely, the findings of this study differ from research conducted in contexts where the impact of innovation on growth was insignificant—often due to weak technological infrastructure or limited adoption of innovation—highlighting the particularities of the Algerian experience during the study period.

Furthermore, the positive long-run relationship may be attributed to government efforts to strengthen innovation and entrepreneurship, particularly through business incubators and support programs for SMEs. However, the limited short-run effect may be associated with several constraints, such as insufficient funding for research and development, weak integration between productive firms and universities, and

bureaucratic barriers that slow the transformation of innovative ideas into marketable products and services.

## 6. Conclusion and Recommendations

In this study, the impact of innovation on the growth of SMEs in Algeria is analyzed using time-series data from 1999 to 2022. By building a standard model for our study we found that the ARDL model (3.2.2.2) is optimal.

The results indicate a positive and significant impact of the innovation index (measured by the number of patents for residents and non-residents) on the growth of SMEs. Specifically, an increase in the number of patents leads to a positive increase in SME growth. This positive effect influences economic growth through the creation of new firms/jobs, though this relationship may not be strong enough to appear significant in short-term economic analyses, requiring a comprehensive view of macroeconomic policies over longer time periods.

Our analysis also found a negative effect between unemployment rates and enterprise growth; a one-unit increase in the unemployment rate leads to a 4% lower growth rate. This confirms the critical role of SME growth in increasing job opportunities and reducing unemployment. Furthermore, there is a positive and significant effect between investment in Research and Development (R&D) and the growth rate of SMEs, confirming that R&D investment is essential for SMEs to cope with competition, reduce costs, and ensure survival and growth.

### 5.1. Implications of the Study

The findings of this econometric study provide several crucial insights for policymakers and entrepreneurs in Algeria:

- **Policy Validation:** The significant positive effect of innovation (patents) and R&D on SME growth provides strong empirical evidence supporting policies that directly invest in and incentivize innovative activity within the SME sector;
- **SME-Driven Employment:** The strong negative correlation between SME growth and unemployment highlights SMEs not just as drivers of economic output, but as primary engines for job creation. Therefore, supporting SME growth is a direct and efficient strategy for mitigating Algeria's unemployment challenge;
- **Strategic Imperative:** The results underscore that innovation is not merely an option but a strategic necessity for Algerian SMEs to remain competitive in a globalized economy. The study highlights the urgency for businesses to proactively activate innovation behavior.

## 5.2. Limitations of the Research

Despite robust findings, this study is subject to certain limitations:

- **Innovation Measurement:** The use of patent registration as a proxy for the innovation index provides a quantifiable measure but may not fully capture all forms of innovation (e.g., organizational, marketing, or non-registered process innovations) occurring within Algerian SMEs.
- **Short-Term Focus:** While the ARDL model provides both short-run and long-run dynamics, the overall macroeconomic context is assessed over a limited time frame (1999–2022). A deeper understanding of the full long-term relationship between innovation, SMEs, and economic growth would benefit from an extended dataset.
- **Macro-Level Data:** The analysis relies on aggregate national data. It does not account for sectoral heterogeneity or regional differences, which may influence how innovation impacts SME growth across different industries or provinces in Algeria.

## 5.3. Suggestions for Future Research

Based on the limitations and findings, we suggest the following avenues for future research:

- **Disaggregated Analysis:** Future studies should explore the innovation-SME growth nexus using sector-specific data (e.g., manufacturing vs. services) to identify which sectors yield the highest returns on innovation investment.
- **Alternative Innovation Metrics:** Researchers could employ alternative or composite indices for innovation, such as those including R&D personnel, collaboration networks, or firm-level surveys, to provide a more nuanced understanding of innovative activity.
- **Impact of Specific Policies:** Further research could focus on empirically evaluating the effectiveness of specific government support programs.

### Conflict of interest

The authors declare that there are no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Ethical approval

This study does not require ethical approval.

### Funding

No funding was provided for writing this manuscript.

### ORCID

<sup>a</sup> Hadjeris Souhila, <https://orcid.org/0009-0007-7713-7952>

<sup>b</sup> Djellaba Ali, <https://orcid.org/0000-0003-0591-5907>

## REFERENCES

- Abdilahi, M. H., Hassan, A. A., & Muhumed, M. M. (2017). The Impact of Innovation on Small and Medium Enterprises Performance: Empirical Evidence from Hargeisa, Somaliland. *International Journal of Academic Research in Business and Social Sciences* , 7 (8), 14-28. <http://dx.doi.org/10.6007/IJARBS/v7-i8/3202>
- Boukemoum, M., & Ghiat, C. (2009). Technology business incubators and their role in developing creativity and innovation in small and medium enterprises - the case of Algeria. *Managerial economic research* , 3 (2), 42-66. <https://asjp.cerist.dz/en/article/62824>
- Budianto, R., Praptapa, A., Herwiyanti, E., Puji, P., Suyono, E., & Rusmana, O. (2022). Technological innovation in Small and Medium Enterprises: A bibliometric analysis. *Journal of Sustainable Tourism and Entrepreneurship (JoSTE)* , 4 (1), 55-69. <https://doi.org/10.35912/joste.v4i1.1707>
- Chesbrough, H. W. (2006). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business Press.
- Cui, F., & Song, J.-h. (2022). Impact of Entrepreneurship on Innovation Performance of Chinese SMEs: Focusing on the Mediating Effect of Enterprise Dynamic Capability and Organizational Innovation Environment. *Sustainability* , 14, 1-17. <https://doi.org/10.3390/su141912063>
- Dickey, D. A., & Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series With a Unit Root. *Journal of the American Statistical Association*, 74 (366), 427-431. <https://doi.org/10.2307/2286348>
- Jarque, C. M., & Bera, A. K. (1987). A Test for Normality of Observations and Regression Residuals. *International Statistical Review* , 55 (2), 163-172. <https://doi.org/10.2307/1403192>
- Kuratko, D. F., & Hodgetts, R. M. (2004). *Entrepreneurship : theory, process, practice*. Ohio: Thomson South Western.
- Li, N., & Abdullah, M. Y. (2024). Innovation and Risk-Taking in Small and Medium Enterprises (SMEs): How Cultural and Environmental Factors Influence Business Growth in China. *Uniglobal Journal of Social Sciences and Humanities* , 3 (2), 376-386. <https://doi.org/10.53797/ujssh.v3i2.40.2024>
- Mustafa, B. (2006). Knowledge and technological innovation and their role in stimulating economic growth. *Economic studies* , 6 (1), 65-79. <https://asjp.cerist.dz/en/article/135264>
- Ramsey, J. B. (1969). Tests for Specification Errors in Classical Linear Least-Squares Regression Analysis. *Journal of the Royal Statistical Society* , 31 (2), 350-371. <https://www.jstor.org/stable/2984219>
- Romer, P. M. (1990). Human capital and growth: Theory and evidence. *Carnegie-Rochester Conference Series on Public Policy* , 32, 251-286. [https://doi.org/10.1016/0167-2231\(90\)90028-J](https://doi.org/10.1016/0167-2231(90)90028-J)
- Schumpeter, J. A. (2021). *The Theory of Economic Development* (1st Edition ed.). London: Routledge.
- Webster, M. (n.d.). *innovation definition & meaning*. Retrieved July 25, 2025, from Merriam Webster: <https://www.merriam-webster.com/dictionary/innovation>