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FOCUS ON THE IMPACT OF THE KNOWLEDGE ECONOMY ON ECONOMIC GROWTH IN THE MOROCCAN CONTEXT: EVIDENCE FROM THE NOVEL DYNAMIC ARDL SIMULATION (DYNARDL) AND KERNEL-BASED REGULARIZED LEAST SQUARES (KRLS)[4]

The question of the sustainability of growth has long been the subject of much debate among economists. However, since the emergence of endogenous growth theories, this confusion about sustainability seems to have been resolved, thanks to the integration of knowledge into economic models. Since then, the concept of the knowledge economy and its role in the sustainability of growth has been discussed. In this paper, we attempt to verify the sustainability of Moroccan economic growth by analyzing the determinants of the knowledge economy and their impact on growth in the short and long term. To this end, we adopt an empirical study based on the novel dynamic simulation ARDL approach and the KRLS method. The results obtained using both methods generally indicate positive effects of the knowledge economy on economic growth in the short term. In the long term, however, gross domestic product per capita stabilizes and the rate of economic growth tends to cancel out.
Keywords: Growth; knowledge; dynamic simulation ARDL; KRLS; Innovation
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1. Introduction

The knowledge economy is a recent discipline that has significantly expanded the scope of economic reflection and opened new horizons for economic theorists and analysts to study the mechanisms by which economic growth has become sustained, balanced, and durable

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through the dissemination and diffusion of knowledge within society. In this sense, contemporary growth theories (Aghion, Howitt, 1990; Barro, 1990; Domar, 1946; Harrod, 1955; Lucas, 1988a; Romer, 1990; Solow, 1988) began to emerge gradually just after World War II to confirm and develop Schumpeterian advances (Schumpeter, 1911) around the sustainability of economic growth through innovative activities and the accumulation of knowledge. Contrary to what was suggested by the old growth theories, notably the classical economy theory (Ricardo, 1821; Smith, 1776) and Keynesian theory (Keynes, 1936), these latter theories, based on narrow and static reflections, remained very limited by their assertions that sustainable and balanced growth is an impossible economic phenomenon.

In a turbulent global economy characterized by fierce competition, the intense use of knowledge by some countries has become a determining factor in achieving sustained and durable growth and improving their economic performance. In this context, this factor is gradually taking its place alongside physical capital in certain economies. Foray (2009) defines the knowledge-based economy as, for each country, a sector of production of goods and services based on knowledge-intensive activities. The knowledge economy primarily analyzes knowledge as an economic good and its economic properties. Gorz, in his work "The Immaterial" (2003), described the knowledge economy as an indispensable factor that fundamentally disrupted economic systems worldwide. Consequently, this economist confirms that knowledge today represents the main productive force. This transformation has turned the products of social labour activity from crystallized labour to crystallized knowledge.

Morocco, as a developing country, has long sought to become an emerging country through the path of the knowledge economy, knowing that the Moroccan economy is mainly based on natural resources such as phosphate exploitation and revenues from agricultural activities, which are somewhat insufficient resources to achieve the set objectives.

The objective of this paper is to try to analyze the effects of the knowledge economy on Moroccan economic growth, knowing that this economic paradigm relies on the importance of education and vocational training, technological innovation, and research and development infrastructures as drivers of growth. Our central question is then formulated as follows:

To what extent can the knowledge economy affect economic growth in Morocco?

To answer this question, we will use an empirical approach based on advanced econometric methods such as the new dynamic ARDL simulation (Autoregressive Distributed Lag) (Philips, 2018; Sarkodie, Owusu, 2020a) and the KRLS method (Kernel Regularized Least Squares) (Hainmueller, Hazlett, 2014). These approaches can capture the complex and dynamic relationships between the economic variables chosen for our modelling, considering the short- and long-term effects of exogenous variables on endogenous ones.

The choice of these methodological approaches aims to provide an in-depth analysis of how education, vocational training, technological innovation, and infrastructures can influence economic growth in the Moroccan context. We will, therefore, seek to highlight the political, economic, and strategic measures that are likely to accelerate the transition to a knowledge-based economy. Thus, this study will provide new perspectives for various policymakers and

economic actors by highlighting the potential positive economic consequences of such a transition for a developing country like Morocco.

2. Literature Review

Throughout history, the study of determinants that make economic growth sustainable and balanced has been one of the complex economic problems that have been the subject of significant debates among researchers, especially in the period after the 1929 crisis, which challenged the basic principles of classical theories that ruled the global economy since the industrial revolution. Capital and labour were considered the main factors of production. Economic growth, for its part, was seen as a finite economic phenomenon, i.e., not sustainable in the long term.

Just after World War II, contemporary growth theories began to appear, trying to address this problem. In this sense, the first attempts were made by Harrod and Domar (Domar, 1946; Harrod, 1955). These authors were relatively pessimistic about the possibility of sustainable and balanced growth in the long term. This Keynesian model was criticized by Solow, who developed a neoclassical growth model that stipulates that long-term sustainable economic growth is possible by integrating technical progress as an exogenous factor in the production process. The advent of endogenous growth theories solved this growth problem by considering that technical progress, resulting from the accumulation of knowledge, is a production factor characterized by its endogeneity in the productive process within the firm (Barro, 1990; Lucas, 1988a; Romer, 1990). These endogenous growth theories emphasize the role of knowledge, education, and innovation in economic growth.

Numerous empirical studies have focused on the dynamics of the knowledge economy and its impact on economic growth. For example, we can cite:

Lagzouli et al. (2024) studied the impact of the knowledge economy on economic growth in Morocco based on panel data concerning the MENA (Middle East and North Africa) region covering the period from 1990 to 2019. The results indicated that the chosen variables dependent on the knowledge economy do not have specific significant effects on economic growth in Morocco. Thus, the knowledge-based economy does not fully contribute to the economic growth of this country, which fails to capitalize on all the components of this economy.

Similarly, Essardi and Razzouk (2017) conducted research on the contribution of human capital to economic growth in Morocco. These authors attempted to evaluate the relationship between the components of human capital and growth during the period from 1965 to 2015. To do this, they used the Bayesian Model Averaging (BMA) method. The results indicated that in the specification of the determinants of GDP per worker growth, no human capital indicator significantly affects GDP per worker growth in Morocco.

Bennaghmouch and Bouoiyour (2002) focused on the importance of education as a determining factor in enhancing its contribution to economic growth in Morocco. These researchers dissected this explanatory variable into other sub-variables according to the level

of study. The initial modelling attempt based on a "Cobb-Douglas" production function revealed the positive impact of human capital and physical capital on economic growth, considering that the effect of human capital is weaker as the level of education increases. Thus, the most technical fields seem to be the most growth-determining.

In another context, Azfal et al. (2010) conducted an empirical study on the short- and long-term relationship between school education and economic growth in Pakistan. This empirical investigation is based on an ARDL modelling of the following temporal variables, from 1970 to 2009: real GDP, physical capital, inflation, and general school enrollments. The results of this modelling confirmed the existence of a cointegration between school education and economic growth. These results highlight the existence of a direct relationship between these variables in the short and long term in Pakistan. Macroeconomic instability due to inflation hinders economic growth both in the short and long term, while it only hampers school education in the long term. The statistically significant and inverse relationship between school education and economic growth is only observed in the short term in this country.

Rahman et al. (2023a) attempted to study the relationship between Bangladesh's economic growth on the one hand and technological innovation, foreign direct investment, trade, and human capital in this country on the other. Based on a nonlinear ARDL time series modelling covering the years 1990 to 2020, the authors sought to determine whether these factors have a symmetric or asymmetric effect on economic growth. The results showed that technological innovation and human capital have a long-term symmetric relationship with economic development in Bangladesh. Thus, a significant correlation was found between economic growth and all variables in the short term.

For the same country, Fan et al. (2018) studied the long- and short-term dynamics between technological innovation, infrastructure, and industrial development for the same country during the period from 1974 to 2016 according to an ARDL model on the one hand and causal relationships according to a VECM on the other. The results also highlighted the existence of a short- and long-term relationship and cointegration between the retained variables. Indeed, in the long term, infrastructure positively impacts industrial growth. In contrast, technological innovation has a negative impact on it. Moreover, both explanatory variables have a positive and significant effect on industrial growth in the short term. This negative effect of technological innovation can be explained, according to the authors, by the fact that a country like Bangladesh remains far behind global standards of technological progress and infrastructure.

Thus, Blanco et al. (2016) highlighted the impact of Research and Development (R&D) spending on the productivity of production factors in the USA. Their empirical analysis is based on panel data from 50 US states using the ARDL approach to confirm the significant positive effect of R&D spending on state production and total factor productivity in the long term.

On the other hand, Rahmane et al. (2023b) conducted a study whose main objective is to assess how technological innovation, foreign direct investment, trade, and human capital affect Bangladesh's economic development. To do this, the authors chose to use the new dynamic ARDL simulation approach to examine possible counterfactual changes in

variables. Thus, test cointegration, symmetric and asymmetric associations in the long and short term between these variables using the nonlinear ARDL approach. The results indicated that technological innovation and human capital have a long-term symmetric relationship with Bangladesh's economic development. A significant correlation was also found between economic growth and all the study variables in the short term.

3. Data and Methodology

3.1. Data and variables selection

The choice of variables is made based on a review of the literature on the relationship between economic growth and the determinants of the knowledge economy. Notably, Romer (1986) posits that sustainable and balanced growth in the long term is ensured through the dissemination of knowledge within the professional environment. Such knowledge is considered an input that increases marginal productivity, leading to endogenous radical technological changes and, consequently, increasing marginal returns. This explains the endogenous nature of economic growth.

Barro (1990) also proposes an endogenous growth model that incorporates both public spending on infrastructure, notably Information and Communication Technologies (ICT), and private capital into the firm's production function. The accumulation of public capital results from tax collection, which increases with the rise in private capital.

In another context, Lucas (1988a) emphasizes the importance of human capital in a country's economic development. This economist aims to explain disparities between countries in terms of realized wealth. He developed a simple model combining physical capital and human capital, illustrated by education and vocational training, to explain substantial income gaps between different countries over time.

Based on the above, the selection of variables used in our model is grounded in the principles of endogenous growth theories. Specifically, the key determinants of the knowledge economy are presented in alignment with these theories. These aspects are illustrated by Djeflat (2006) as the pillars of a knowledge-based economy. The four pillars are education, vocational training, innovation and research and development (R&D), and information and communication technologies (ICT). Our approach is to use a variable in the model that represents each of these four dimensions of the knowledge economy, adhering to the econometric and statistical requirements outlined by the empirical method chosen.

Our adopted variables are as follows:

- **SUP**: Gross enrollment rate in higher education. This is the total percentage of enrollments in tertiary education, regardless of age, from the total population five years after secondary school completion. This variable is chosen as it effectively represents the level of human capital development in a country. Higher enrollment rates reflect a more educated and skilled population, which can contribute more effectively to research, innovation, and tasks requiring technical and technological knowledge. Education,

especially higher education, enables the creation, use, and dissemination of knowledge in society, making it a catalyst for innovation in a knowledge-based economy. This is supported by Romer (1990), Lucas (1988a), Foray and Lundvall (1998), and others. Data for this variable comes from the World Bank database. This variable represents the "education" pillar, as higher education is considered a primary source of innovation in the literature.

- **AJST**: Number of articles published in scientific and technical journals. These publications refer to the number of scientific and engineering articles published in fields such as physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences. This reflects a country or region's ability to generate and disseminate new knowledge. The more articles published, the more a country is considered active in research and development. Scientific articles also share new knowledge with the international scientific community, allowing businesses and governments to integrate new technologies or methods into their production processes, enhancing productivity and economic growth. The number of published articles is often an indicator of the education and specialization level of human capital in a country, essential for a knowledge economy (Lucas, 1988b; Romer, 1987). Data for this variable also comes from the World Bank database. This variable represents the "innovation and R&D" pillar.

- **ABFIXP**: Fixed-line telephone subscriptions (per 100 inhabitants). This variable is selected due to the strong relationship between fixed-line telephony and internet use, particularly ADSL or fibre optic, which are widely integrated into ICT infrastructure. These technologies fully contribute to facilitating research and information communication between economic agents. Therefore, this variable can substitute for internet use, which only began in Morocco in the early 2000s (Barro, 1990). Data for this variable comes from the World Bank database. This represents the "ICT" pillar.

- **FP**: Number of graduates from vocational training centres. Data for this variable comes from the High Commission for Planning, Morocco's main official statistics producer. This variable represents the "vocational training" pillar.

- **PIBH**: GDP per capita is an indicator of economic activity. Data comes from the World Bank database. This variable is used to represent economic growth.

- **FBCF**: Gross fixed capital formation (data from the World Bank). This variable, representing physical capital, serves as a control variable to capture other information that could be included in the error term and reintroduced into the model.

All these variables are in the form of annual time series for Morocco, covering the period from 1990 to 2021, providing 32 observations for each variable.

To address our research problem, the new dynamic ARDL (Autoregressive Distributed Lag) simulation and the Kernel Regularized Least Squares (KRLS) method are the most suitable approaches for our research framework.

3.2. Model and methodology

This empirical study uses the new ARDL dynamic simulation approach to assess the moderating impact of the aforementioned knowledge economy determinants on economic growth. We will examine how economic growth in Morocco responds over time to an instantaneous change in one of the exogenous variables of our study.

The new ARDL dynamic simulation approach was developed by Jordan and Philips (2018) from the Bounds Test for cointegration developed by Pesaran et al. (2001). This approach simplifies the interpretation of long-term dynamics from an ARDL approach, which can be complex in model specification and increasingly difficult to interpret in the medium and long term.

This approach helps visualize the effect of a counterfactual change in a regressor at a given moment, keeping everything else constant, using stochastic simulation techniques. Dynamic simulation approaches are commonly used by researchers and are gaining popularity for their ability to substantiate results from dynamic models, whose coefficients often have non-intuitive or hidden interpretations.

The methodology followed is based on Sarkodie and Owusu (2020a) and includes the following steps:

- Check for Stationarity of Variables: Exogenous variables must be stationary at a level I(0) or at the first difference I(1). The endogenous variable must be strictly stationary at the first difference I(1).
- Determine the Optimal Number of Lags: Use the Akaike Information Criterion (AIC) to select the optimal number of lags for the ARDL modelling.
- Specify the Optimal ARDL Model.
- Test for Long-Term Relationship: Apply the Bounds Test for cointegration as proposed by Pesaran (2001).
- If a Long-Term Relationship is Confirmed: Proceed with the application of the ARDL dynamic simulation approach (Jordan & Philips, 2018).
- Simulate Counterfactual Stochastic Shocks: Generate appropriate graphs.

4. Results and Discussions

4.1. Stationarity analysis

To avoid spurious regression, it is crucial to check the stationarity levels of the variables and ensure that the results meet the necessary conditions for our modelling. The tests we will use are among those most commonly adopted by researchers due to their power to detect the presence of a unit root in our time series. Specifically, we refer to the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The results are presented in Table 1.

Table 1. Stationarity tests results

Variable	Level P.P	Δ. PP	Level .ADF	Δ. ADF	Decision
LPIBH	-2.669	-9.15***	-1.189	-9.878***	I(1)
LFP	-3.332	-9.093***	-0.306	-7.645***	I(1)
LAJST	-1.675	-4.878***	-1.216	-4.864***	I(1)
LSUP	-0.993	-4.370***	-0.943	-4.366***	I(1)
LABFIX	-1.926	-3.705**	-2.544	-3.698**	I(1)
LFBCF	-1.372	-3.231**	-1.486	-3.150**	I(1)

According to Table 1, the stationarity tests and the presence of a unit root in our series indicate that we do not have enough evidence to reject the null hypothesis (H0) of the existence of a unit root at level I(0) at a 5% significance level. However, at the same significance level, we can reject H0 and accept the alternative hypothesis (H1) at the first difference I(1) for all series. Therefore, all variables in the study, including the endogenous variable LPIBH, are stationary at the first difference I(1). These stationarity conditions allow us to apply the ARDL approach as per Pesaran (2001).

4.2. ARDL Model estimation

After satisfying the stationarity conditions required for the ARDL approach, we proceed to estimate the ARDL model.

The first step involves determining the optimal number of lags to use in estimating our ARDL model. Table 2 shows that a model with 4 lags appears to be optimal, as it minimizes certain information criteria such as the Akaike Information Criterion (AIC), the Hannan-Quinn Information Criterion (HQIC), the Schwarz Bayesian Information Criterion (SBIC), and others.

Table 2: Optimal lag selection

Lag	LL	LR	FPE	AIC	HQIC	SBIC
0	67.461		5.0e-^{10}	-4.39007	-4.3028	-4.1046
1	236.292	337.66	4.0e-^{14}	-13.878	-13.2671	-11.8797
2	274.671	76.759	5.1e-^{14}	-14.048	-12.9134	-10.3368
3	325.161	100.98	6.7e-^{14}	-15.0829	-13.4248	-9.65896
4	1942.66	**3235***	**6.7e-^{61}***	**-128.047***	**-125.865***	**-120.91***

The results of the ARDL model estimation are presented in Table 3. The ARDL model (3,1,2,1,0,0) with a constant is optimal given the chosen number of lags. Its equation is as follows:

$$\begin{aligned} \Delta LPIBHt = {} & \alpha + \lambda\,(LPIBH(t-1) - \beta 1\, LSUP(t-1) - \beta 2\, LAJST(t-1) \\ & - \beta 3\, LABFIX(t-1) - \beta 4\, LFP(t-1) - \beta 5\, LFBCF(t \\ & - 1)\,) + \gamma 1\, \Delta LPIBH(t-1) + \gamma 2\, \Delta LPIBH(t-1) \\ & + \delta 1\, \Delta LSUP(t-1) + \theta 1\, \Delta LAJST(t-1) + \theta 2\, \Delta LAJST(t \\ & - 2) + \varphi 1\, \Delta LABFIX\,(t-1) + \varepsilon t \end{aligned} \qquad (1)$$

Where:

- ΔLPIBHt is the change in LPIBH at period t.
- α is the constant of the model.
- λ is the adjustment coefficient.
- β1, β2, β3, β4 and β5 are the long-term coefficients for LSUP, LAJST, LABFIX, LFP and LFBCF, respectively.
- γi are the short-term coefficients for ΔLPIBH(t-i).
- δi are the short-term coefficients for ΔLSUP(t-i).
- θi are the short-term coefficients for ΔLAJST(t-i).
- φi are the short-term coefficients for ΔLABFIX(t-i).
- εt is the error term at period t.

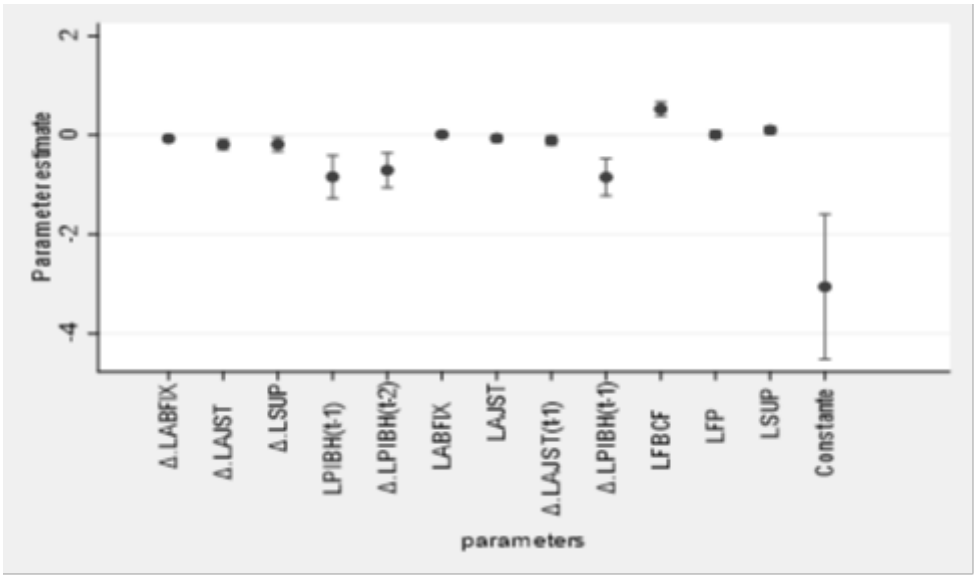
Table 3. ARDL Model results

EQN	Parameter	Estimate	Std. err.	t	P-value	[95% conf.	interval]
ECT	$LPIBH_{t-1}$	-0.8405933	0.2042952	-4.31	**0.001*****	-1.27368	-0.4075069
	LSUP	0.1006445	0.0339527	2.96	**0.009*****	0.0286679	0.1726211
	LAJST	-0.0636971	0.0284475	-2.24	**0.040****	-0.1240032	-0.003391
Long-Run	LABFIX	0.0128671	0.0229076	0.56	0.582	-0.0356948	0.0614289
	LFP	0.0073322	0.0341606	0.21	0.833	-0.065085	0.0797495
	LFBCF	0.5277386	0.0665416	7.93	**0.000*****	.3866767	.6688005
	$\Delta.LPIBH_{t-1}$	-0.8487724	0.1763423	-4.81	**0.000*****	-1.222601	-0.4749435
	$\Delta.LPIBH_{t-2}$	-0.7066778	0.1640787	-4.31	**0.001*****	-1.054509	-0.3588466
	Δ.LSUP	-0.1855883	0.0664721	-2.79	**0.013****	-0.3265029	-0.0446736
Short-Run	Δ.LAJST	-0.1891388	0.0476961	-3.97	**0.001*****	-0.29025	-0.0880276
	$\Delta.LAJST_{t-1}$	-0.1066596	0.0444652	-2.40	**0.029****	-0.2009216	-0.0123976
	Δ.LABFIX	-0.0686557	0.0251888	-2.73	**0.015****	-0.1220536	-0.0152577
	Constante	-3.057003	0.6911204	-4.42	**0.000*****	-4.522113	-1.591893
Model	ARDL(3,1,2,1,0,0)						
Obs	29						
R^2	0.8945						
Root MSE	0.0172						

The results obtained from the ARDL model estimation show that the error correction term (ECT = -0.8405933) has a negative sign and is statistically significant, with a p-value of 0.001, which is well below the 5% significance level. This indicates that 84.05% of the short-term errors are corrected in each period (1 year) to achieve long-term equilibrium. While these criteria are necessary to assert that cointegration between the variables exists, they are not sufficient. This cointegration must be confirmed by the cointegration bounds test as per Pesaran et al. (2001). The model will also undergo post-estimation validation tests, including

tests for autocorrelation of errors, normality of errors, heteroscedasticity, and model stability. The results of these tests are presented in Table 4.

Figure 1. Graph of Parameter Estimation from the ARDL Dynamic Simulation



4.3. Diagnostics of ARDL model

- Cointegration Bounds Test

The cointegration bounds test as per Pesaran (2001) evaluates the existence of a long-term relationship between the variables. For this purpose, we pay particular attention to the t-statistics (f-Bounds) and t-statistics (t-Bounds) values and their position relative to the lower and upper bounds. The results (Table 4) show that the f-bounds value of 10.651 is well above the upper bound I(1) (3.35) at the 5% significance level. Similarly, the absolute value of t-bounds (4.315) is also higher than the absolute value of the upper bound I(1) (3.86). These values confirm the existence of cointegration bounds and a balanced long-term relationship between the variables of this study.

- Autocorrelation Test

To test if the errors are autocorrelated, we use the Breusch–Godfrey test (Breusch & Godfrey, 1986). The p-value for this test is greater than 5% for all lags, indicating that we do not have enough evidence to reject the null hypothesis H0 of no autocorrelation of errors.

- Heteroscedasticity Test

To detect the possible presence of heteroscedasticity, we use Cameron & Trivedi's decomposition test. The p-value of this test is 0.6618, which is greater than 5%. This allows us to accept the null hypothesis H0 of homoscedasticity (Sarkodie & Owusu, 2020b).

- Normality Test of Errors

To check if the model errors follow a normal distribution, we use the "Skewness and Kurtosis" test (D'Agostino et al., 1990). The p-value obtained is 0.4863, which is also greater than 5%. This allows us to accept the null hypothesis H0 of normality of errors. The normality of the model residuals is confirmed by the results of the plots shown in Figures 2 and 3.

Table 4. Model diagnostic tests

Pesaran, Shin, and Smith Bounds testing							
K		10%		5%		1%	
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F	10.651	2.26	3.35	2.62	3.79	3.41	4.68
t	-4.315	-2.57	-3.86	-2.86	-4.19	-3.43	-4.79
Breusch–Godfrey LM test for autocorrelation							
lags(p)		F		df		Prob>F	
1		0.083		(1, 15)		0.7772	
2		0.220		(2, 14)		0.8053	
3		1.540		(3, 13)		0.2513	
Cameron & Trivedi's decomposition of IM-test							
Source		chi2		df		p	
Heteroskedasticity		29.00		28		0.4125	
Skewness		6.41		12		0.8941	
Kurtosis		1.30		1		0.2545	
Total		36.71		41		0.6618	
d. Skewness and kurtosis tests for normality							
Variable		Obs	Pr(skewness)	Pr(kurtosis)	Joint adj chi^2 (2)		Prob>chi2
Residuals		29	0.3183	0.5581	1.44		0.4863

Figure 2. Standardized Normal Probability Plot

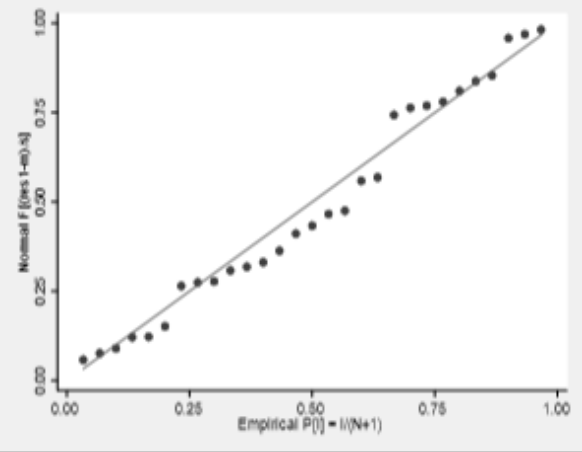
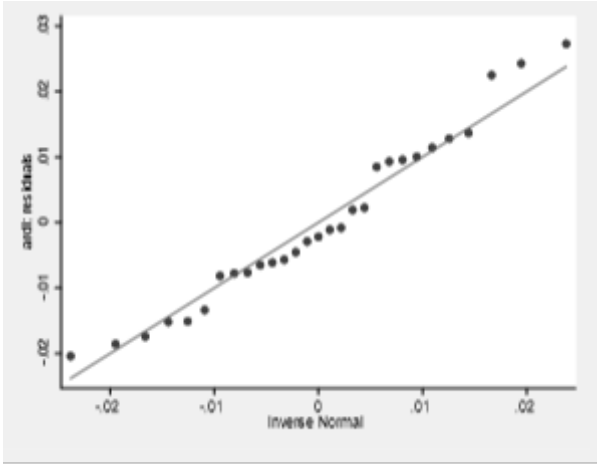


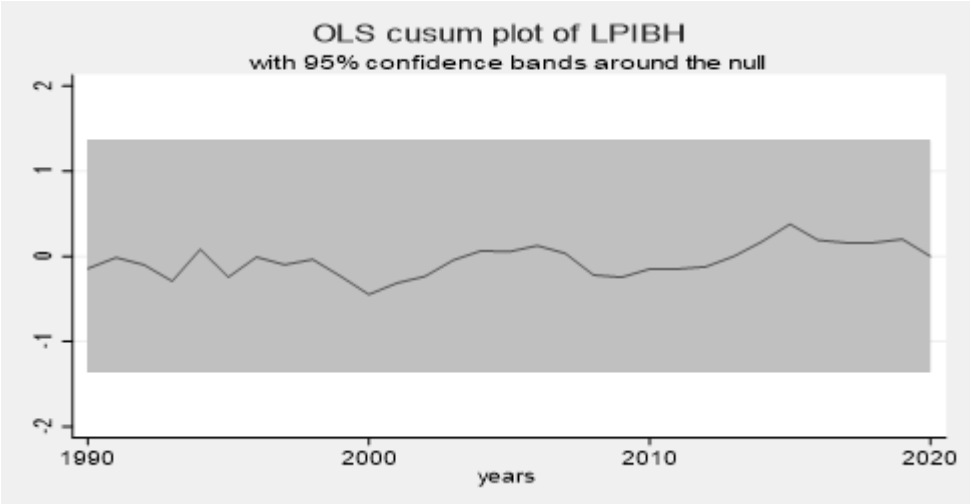
Figure 3. Quantiles of residuals versus quantiles of normal distribution



- Model Stability Test

To test the stability of the estimators, we use the Cusum tests (Figure 4) (Ploberger & Kramer, 1992). This figure represents the cumulative sum of the deviations of individual measures from the central line or the specification line instead of representing individual observations. This presentation technique allows us to effectively detect small deviations indicating the presence of structural breaks. For this test, the cumulative sums of deviations remain within the 5% significance confidence interval, indicating that the model remains stable over time.

Figure 4. Cumulative sum test using OLS CUSUM plot for parameter stability



Given the absence of hypothesis violations in the construction of the estimated ARDL model – namely, no autocorrelation of errors, normality of errors, homoscedasticity, and model stability as confirmed by the aforementioned tests – we have a robust ARDL model. The ARDL model indeed generates two types of equations:

Short-Term Effects: The estimators are statistically significant in principle, and all carry a negative sign. This suggests that the chosen variables exert a negative effect on economic growth in Morocco in the short term. Specifically, an increase of 1% in the Gross Enrollment Rate in Higher Education (Δ.LSUP) and the Number of Articles Published in Scientific and Technical Journals (Δ.LAJST) results in a decrease of approximately 17% in the Gross Domestic Product per Capita (LPIBH) in the short term. Additionally, for the same variable lagged by one period (Δ.LAJST(t-1)), its negative effect diminishes over time. Thus, a 1% increase in the lagged variable results in a 10% decrease in LPIBH instead of 18% for the current period. Similarly, the behaviour of the Number of Fixed-Line Subscribers (Δ.LABFIX) follows the same pattern as the other mentioned variables but with a less significant negative effect; each 1% increase in this variable results in a 6.86% decrease in GDP per Capita.

Long-Term Effects: Only the variables LSUP, LAJST, and LFBCF are statistically significant at the 5% risk level. The other variables are not significant at this threshold. Higher education positively impacts GDP per Capita. Specifically, a 1% increase in this variable results in a 10.06% increase in GDP per Capita. Likewise, a 1% increase in the number of articles published in scientific and technical journals leads to a 6.36% increase in GDP per Capita. Furthermore, a 1% increase in physical capital results in a substantial 52.77% increase in GDP per Capita.

The obtained results have been compared with those from other researchers. For instance, Khorasgani (2008) conducted an empirical study using the ARDL approach to analyze the impact of higher education on Iranian economic growth. The results showed that higher education has a positive and statistically significant impact on economic growth in Iran, both in the short and long term. Similarly, Gyimah-Brempong et al. (2006) analyzed the impact of higher education on economic growth using a panel of African countries from 1960 to 2000. Their empirical findings confirm the positive impact of higher education human capital on economic growth, though they did not distinguish between long-term and short-term effects. According to Toria Nipo et al. (2022), the number of fixed-line subscribers does not significantly influence economic growth in some Asian countries, which can be explained by the fact that fixed-line telephony remains expensive and less practical compared to other forms of ICT. The same result was found by Pradhan et al. (2022) in their analysis of a panel of 20 Asian countries. Additionally, Shala and Badivuku-Pantina (2023) studied and analyzed a panel of European Union countries to assess the impact of vocational training on economic growth. Their results confirmed the positive impact of non-tertiary vocational training on economic growth in Europe.

In summary, according to our ARDL model, we can conclude that in the short term, the determinants of the knowledge economy exert a negative effect on Moroccan economic growth. This negative effect diminishes over time until it becomes positive in the long term.

To further visualize and assess the effect of counterfactual changes in the exogenous variables, we applied the ARDL dynamic simulation approach (Jordan & Philips, 2018).

4.4. Dynamic ARDL Simulation

The new technique of dynamic ARDL simulation advanced by Jordan and Philips (2018) is gaining popularity, especially in social science research and studies related to climate change and renewable energy. This technique is used to capture potential future counterfactual shocks in socio-economic and climatic indicators to study the behaviour of the endogenous variable over time and its potential response to these shocks.

In this study, we will conduct an experiment using this technique to understand the variability of economic growth in Morocco that may result from a potential shock in one of the factors influencing the knowledge economy while keeping other estimators fixed. To do this, we will first estimate the dynamic simulation model based on our ARDL modelling and then generate easily interpretable graphs illustrating the responses of economic growth to counterfactual shocks in our exogenous variables (Sarkodie & Owusu, 2020a).

Table 5 and Figure 5 present the results of the estimation of the dynamic ARDL simulation coefficients. This dynamic ARDL simulation is based on a probabilistic contribution of about 1% over 30 years, covering the period from 2022 to 2052, for the variables LSUP, LFP, LAJST, LABFIX, and LFBCF, based on 5000 simulations.

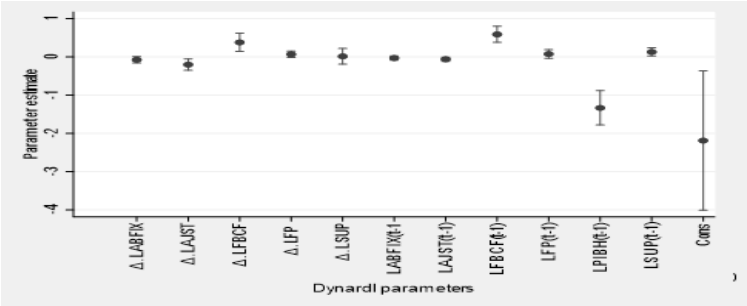
Table 5. Novel Dynamic Simulation ARDL analysis

Variables	Coefficient	Std. err.	t	P-value	[95% conf.interval]	
Constante	**-2.187412**	0.8700468	-2.51	**0.021****	-4.008441	-0.3663829
ECT	**-1.331808**	0.2138273	-6.23	**0.000*****	-1.779354	-0.8842627
Δ.LSUP	0.0139339	0.09819	0.14	0.889	-0.1915802	0.219448
Δ.LABFIX	**-0.075246**	0.0404102	-1.86	**0.078***	-0.1598255	0.0093336
Δ.LAJST	**-0.2019523**	0.0712291	-2.84	**0.011****	-0.3510365	-0.052868
Δ.LFP	0.0685099	0.040087	1.71	0.104	-0.0153931	0.1524129
Δ.LFBCF	**0.3794452**	0.1132749	3.35	**0.003*****	0.142358	0.6165323
LSUP $_{t-1}$	**0.1293507**	0.0517623	2.50	**0.022****	0.0210109	0.2376905
LABFIX $_{t-1}$	-0.0302328	0.025784	-1.17	0.255	-0.0841994	0.0237337
LAJST $_{t-1}$	**-0.0616007**	0.0268654	-2.29	**0.033****	-0.1178306	-0.0053707
LFP $_{t-1}$	0.07547	0.0543659	1.39	0.181	-0.0383192	0.1892592
LFBCF $_{t-1}$	**0.5887997**	0.1000133	5.89	**0.000*****	0.3794693	0.79813
N		31			**p-value**	0.0016***
R2		0.7313				
Adj_R2		0.5757			**Simulations**	5000

Table 6. Bounds Cointegration Test of the Dynamic ARDL Simulation

	F-test		t-test	
	I(0)	I(1)	I(0)	I(1)
10% critical value	2.508	3.763	-2.570	-3.860
5% critical value	3.037	4.443	-2.860	-4.190
1% critical value	4.257	6.040	-3.430	-4.790
	F-stat. = **6.897**		t-stat. = **-6.228**	

Figure 5. Graph of the Parameter Estimation of the Dynamic ARDL Simulation



According to Table 5, which represents the results of the ARDL dynamic simulation, the number of Fixed-Line Telephone Subscribers (LABFIX)5 and the Number of Articles in Scientific and Technical Journals Published (LAJST) have a negative effect in the short term. Consequently, a 1% increase in these variables results in a decrease in GDP per Capita (LPIBH) of 7% and 20%, respectively. In contrast, the Gross Fixed Capital Formation (LFBCF), representing physical capital, has a positive effect on economic growth. This variable increases LPIBH in the short term by about 37% for each 1% increase. Other variables, such as LFP and LSUP, are statistically insignificant at the 5% risk level.

In the long term, the Gross Enrollment Rate in Higher Education (LSUP) and LFBCF have a positive effect on LPIBH. Each 1% increase in these variables results in an increase in LPIBH of approximately 13% and 60%, respectively. However, the effect of LAJST, representing innovation activities, remains negative in the long term, though with reduced intensity. The negative effect of this variable is reduced to 6% in the long term compared to 20% in the short term for each 1% increase. Nevertheless, variables such as LFP and LABFIX are statistically insignificant at the 5% risk level in the long term.

These results are consistent with those found by Dangal (2022), who conducted a study on the relationship between higher education and economic growth in Nepal using the ARDL approach based on the existence of cointegration in the sense of Pesaran (2001). This study confirmed the existence of a positive effect of higher education on economic growth in Nepal in both the short and long term.

Similar results were found by Guo (2022), who studied the impact of higher education on regional economic growth in China using panel data from 290 cities. The results revealed that over the past 15 years in China, improving the level of higher education development can directly promote regional economic growth, particularly economic growth in China.

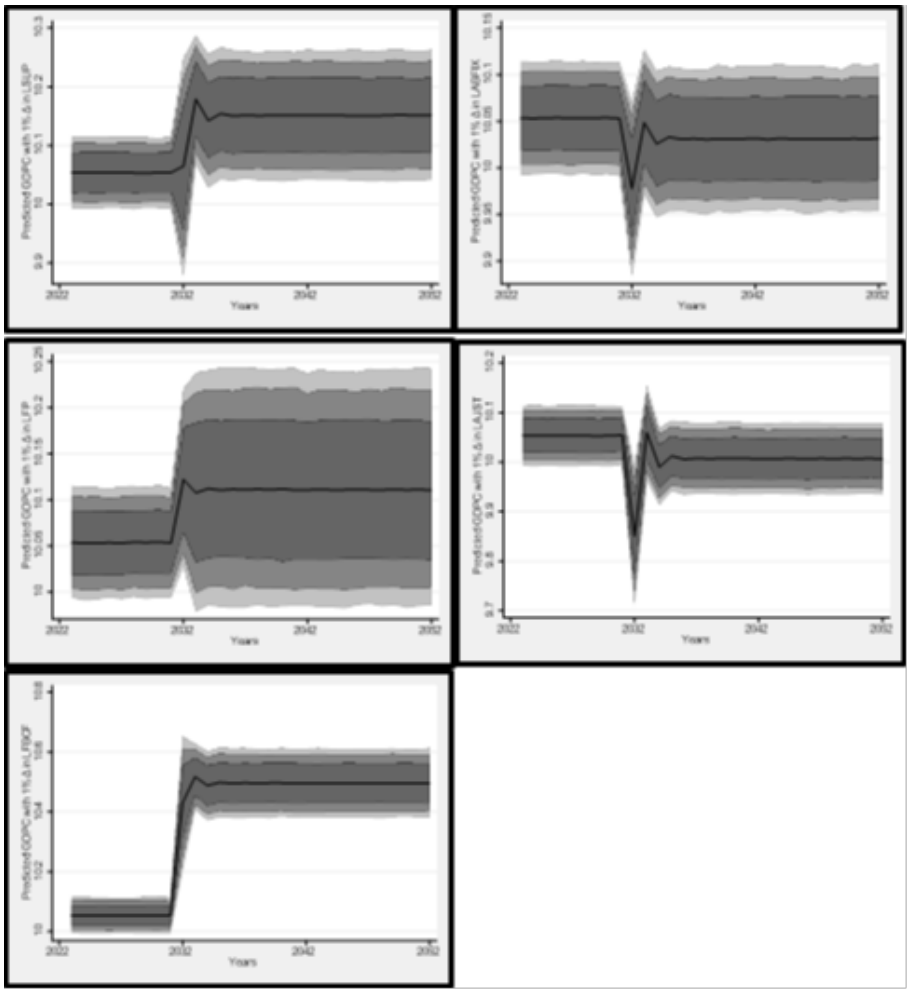
Toria Nipo et al. (2022), who conducted a study on the effects of ICT on economic growth in Asia based on a panel of 20 Asian countries, state that the number of fixed-line telephone subscribers does not have a significant influence on economic growth in some Asian

[5] The coefficient of this variable is significant at the 10% risk level.

countries. This may be explained by the fact that fixed-line telephony remains costly and less practical compared to other forms of ICT.

Regarding innovation activities, which are considered a source of economic growth, Dahani et al. (2020), through their empirical work using VECM modelling, confirm the positive effects of innovation on Moroccan productivity growth in both the short and long term.

Figure 6. Representations of the behaviour of economic growth following counterfactual shocks of (+1%) exerted on exogenous variables, generated from the ARDL dynamic simulation[6]



[6] The colors from dark blue to light blue represent confidence intervals at the 75%, 90% and 95% thresholds respectively.

To better assess the behaviour of economic growth over time following a counterfactual shock of (+1%) applied to one of the exogenous variables while keeping the other variables fixed, clear and easily interpretable graphical representations (Figure 6) of the dependent variable's response show that the effects of these shocks vary from one variable to another. Furthermore, following the (+1%) impulse applied to the variables LSUP, LFP, and LFBCF, the level of national production represented by GDP per Capita (LPIBH) experiences a significant increase in both the short term and the long term. Conversely, economic growth diminishes over time to a higher level of production.

However, the production level represented by the variable LPIBH responds negatively to the same (+1%) shock applied to the variables LABFIX and LAJST. In fact, LPIBH decreases slightly in both the short and long term, with this level stabilizing over time. This indicates that economic growth, according to our model, also diminishes in the long term to a slightly lower level. This suggests that economic growth in the case of Morocco will neither be sustainable nor maintained in the long term.

Considering the above and based on our modelling results, we can say that certain knowledge economy variables in Morocco may positively impact economic growth in the short term, but they cannot make it sustainable and maintained in the long term. However, beyond these pessimistic results, we can conclude that to achieve sustainable and maintained economic growth, relying on knowledge as a determining factor according to endogenous growth theories (Romer, 1986, 1987, 1990) is crucial. In this regard, economic growth must be continuously stimulated by shocks to be sustainable and maintained.

The results obtained can be seen as a mirror reflecting the economic reality in Morocco. Indeed, according to a report on unemployment prepared by the High Commissioner for Planning (2024), which analyzes the current unemployment situation in Morocco, the unemployment rate is higher among young graduates, at 19.7%. This proportion indicates that those representing a skilled workforce, coming from either higher education institutions or vocational training institutions, are affected by unemployment. This suggests that the labour market is unable to absorb the additional number of young graduates annually from these institutions. Even those who are not unemployed, a large proportion are employed in positions not aligned with their skills and expertise. Thus, in 2023, the "services" sector employs 48.3% of the employed population, followed by "agriculture, forestry, and fishing" with 27.8%. In contrast, the industrial sector employs only 12.2% of these workers. Analysis of these indicators reveals that the industrial sector, which is most concerned with deploying knowledge as a determining factor within its enterprises, does not effectively contribute to regulating the labour market and is unable to absorb the qualified unemployed workforce. This reflects that the industrial sector in Morocco remains focused on light consumer goods industries despite various reforms in industrial policies by the Moroccan government aimed at improving international industrial competitiveness and addressing a growing trade deficit. Additionally, Moroccan entrepreneurs' tendency to reduce their payroll expenses exacerbates this issue. These employers prefer unskilled labour over skilled labour in an attempt to reduce labour costs in a country characterized by cheap labour.

4.5. Application of Kernel Regularized Least Squares (KRLS) Method

The KRLS (Kernel Regularized Least Squares) method is a regression approach that uses both machine learning algorithms and regularization techniques to address specification problems arising from regression and classification without the need for strict assumptions about functional relationships between variables. Indeed, unlike generalized linear models (GLMs), which rely on assumptions of linearity and additivity, the KRLS method offers a certain degree of flexibility developed to capture non-linearities and complex interactions characteristic of the data (Hainmueller & Hazlett, 2014).

Table 7. Results of the KRLS method

LPIBH	Avg.	SE	t	P>|t|	P25	P50	P75
LSUP	0.053317	0.019673	2.710	0.012	0.011393	0.063758	0.097072
LABFIX	-0.009668	0.014936	-0.647	0.523	-0.038693	-0.007895	0.02769
LAJST	0.04935	0.008658	5.700	0.000	0.029455	0.051574	0.079988
LFP	0.062998	0.01558	4.043	0.000	0.013447	0.075361	0.110305
LFBCF	0.122117	0.0165	7.401	0.000	0.039194	0.067714	0.243741
Diagnostic							
Lambda	0.1213	**Sigma**	5	**R^2**	0.989		
Tolerance	0.032	**Eff. Df**	9.671	**Looloss**	0.1882		

Avg. Is the average marginal effect; SE is the standard error; P-25, P-50, and P-75 represent the 25th, 50th, and 75th percentile. Legend: PIBH represents Real GDP per capita; LSUP represents the Gross enrollment rate in higher education; LABFIX represents Fixed telephone subscriptions (per 100 inhabitants); LAJST represents the Number of articles in scientific and technical journals published; LFP represents the Number of graduates from vocational training centres; LFBCF represents Gross Fixed Capital Formation

KRLS provides point estimates of the partial derivatives for each explanatory variable at each data point. These marginal effects indicate the influence of a small change in each explanatory variable on the dependent variable. Thus, this method allows for an analysis of the distribution of these marginal effects to better understand their heterogeneity across the dataset.

KRLS also allows for the calculation of average marginal effects, which can be computed across all data points to obtain the average partial derivatives, similar to coefficients in a linear regression. The average marginal effect provides an overall idea of the average impact of an exogenous variable on the endogenous variable across all observations.

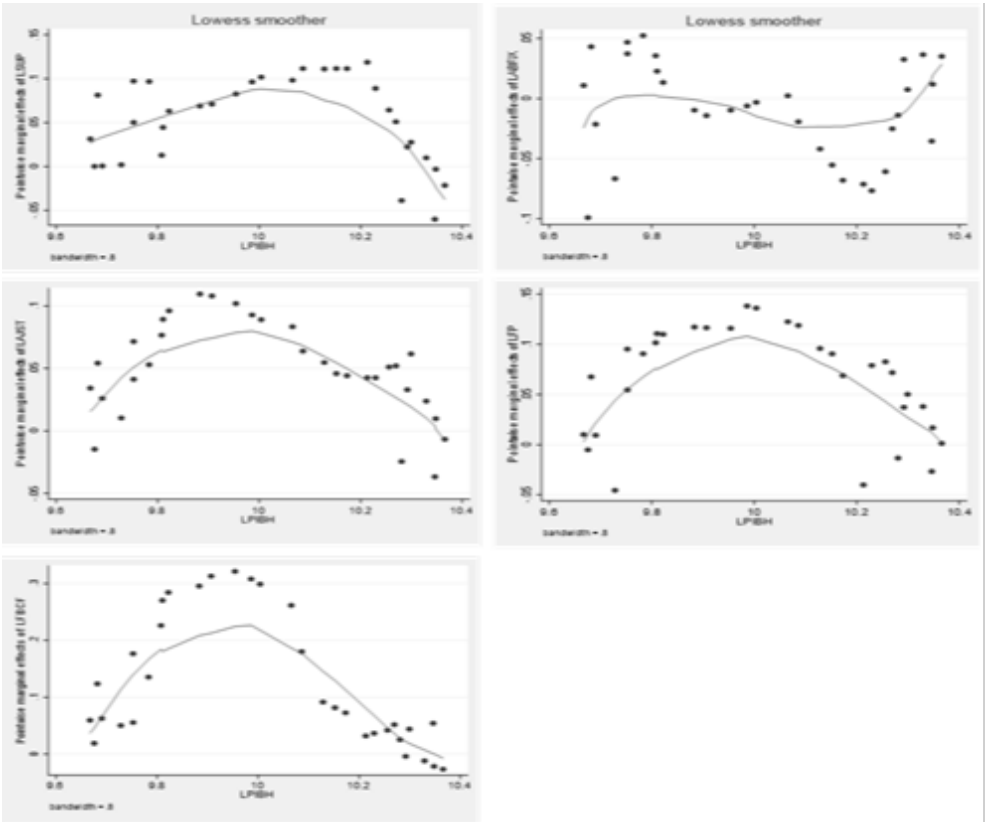
Table 7 presents the results of applying this method to our dataset, indicating that the model is statistically significant at the 5% risk level and is particularly robust with a predictive power of 98.9%. This means that the explanatory variables included in the model explain 98.9% of the variability in GDP per capita. Additionally, the cross-validation loss (Looloss), which provides an indication of the algorithm's convergence, decreases with each iteration to reach its minimum value of 0.1882, reflecting the good fit of the model.

The evaluation of average marginal effects using the derivatives of the explanatory variables is presented at the 25th, 50th, and 75th percentiles, showing that there is not enough evidence to confirm that the marginal effects are heterogeneous. Therefore, it can be said that the point estimates are robust. For example, the marginal effects of the Number of Graduates from

Vocational Training Centers (LFP) vary considerably among the observations, with the median indicating that the marginal effect is positive for the majority of observations.

Similarly, the average point marginal effects for the Gross Enrollment Rate in Higher Education (LSUP), the Number of Articles in Scientific and Technical Journals (LAJST), the Number of Graduates from Vocational Training Centers, and Gross Fixed Capital Formation (LFBCF) are 5.3%, 4.9%, 6.2%, and 12.2%, respectively. These coefficients are statistically significant, confirming the positive contribution of these variables to economic growth in Morocco. For example, an infinitesimal increase in the enrollment rate in higher education is associated with an average increase of 5.3% in GDP per capita. On the other hand, the average point marginal effect of the number of fixed-line telephone subscribers is not statistically significant at the 5% risk level, suggesting that its effect on GDP per capita is not identifiable in these data.

Figure 7. Graphical representations of the point marginal effects of explanatory variables on GDP per capita (LPIBH).



To better visualize and capture the relationships between the variables in our study and their nature, the KRLS method generates graphs (Figure 7) that illustrate these relationships simply. According to this figure, the relationships between GDP per capita and each exogenous variable are represented by curves with a nonlinear and concave shape. This suggests that in the short term, for each increase in one of the exogenous variables, economic growth increases in turn, and the point marginal effects in this phase are therefore increasing. However, beyond a certain threshold, the exogenous variables begin to decrease despite the increase in GDP per capita. Thus, the marginal returns of these variables become decreasing as economic growth increases in the long term. An exception is noted for the variable LABFIX, which is statistically non-significant in the model (Jordan & Phillips, 2018).

For example, initially, an increase in the variable LAJST raises GDP per capita to higher levels, showing increasing marginal returns in the short term. However, up to a certain threshold, economic growth increases with each decrease in the variable LAJST, reflecting decreasing marginal returns beyond this point. This decrease in LAJST can be explained by technological obsolescence affecting innovation production in Morocco.

5. Conclusions and Recommendations

The knowledge economy is currently considered a crucial and determinant factor for achieving sustainable economic development, as knowledge is a high-value, low-cost asset. However, for a developing country like Morocco, achieving the desired goals appears challenging, and numerous favourable factors need to be assembled to reach this objective. Our problem focuses on a deep empirical exploration of the short- and long-term effects of the knowledge economy on economic growth. To this end, we employed the new ARDL dynamic simulation approach, which is considered a novel method for better understanding the response of an endogenous variable to a small change in an exogenous variable while keeping other variables fixed. This approach confirmed the positive effects of human capital on economic growth in Morocco. Indeed, vocational training and higher education, which are considered the pillars of the knowledge economy according to theoretical literature (Djeflat, 2006), have a positive effect on economic growth in the short term. Consequently, GDP per capita responds positively to positive shocks from these two factors. However, in the long term, this endogenous variable stabilizes, and economic growth in this case is no longer sustainable.

Moreover, the response of GDP per capita to a small positive shock in innovation, represented by the number of publications in scientific and technical journals, is negative in the short term. The values of this indicator also stabilize but at a slightly lower level. Economic growth also declines in this case. The effect of the use of Information and Communication Technologies, represented by the number of fixed-line telephone subscribers, remains insignificant.

The results reveal that knowledge only partially contributes to Moroccan economic growth because some aspects, such as higher education and vocational training, positively impact growth only in the short term, and in the long term, this growth tends to be nullified.

Therefore, it is neither sustainable nor enduring. Results found by Lagzouli et al. (2024), who studied the same topic using panel data concerning Morocco, confirm these findings. These authors confirm the absence of specific effects of the knowledge economy on economic growth and that the four components of the knowledge economy do not fully contribute to stimulating economic growth.

On the other hand, we also examined the nature of the relationships between the four components of the knowledge economy and economic growth using the KRLS approach. The results indicate that in the short term, the relationships – though somewhat complex and nonlinear – between most variables and economic growth are positive. However, these relationships become negative in the long term, confirming the results from the new ARDL dynamic simulation of the unsustainability and non-endurance of Moroccan economic growth in the long term.

From the above, we can conclude that the Moroccan knowledge economy does not fully contribute to stimulating economic growth and making it sustainable and enduring. Therefore, economic growth in Morocco does not benefit fully from the advantages of this economy, according to contemporary growth theories, notably endogenous growth theories (Aghion & Howitt, 1990; Barro, 1990; Lucas, 1988b; Romer, 1990). This observed weak performance in the knowledge economy generally reflects the imbalance faced by sectors that generate and deploy knowledge as a reliable source of production growth. This imbalance is due to persistent structural problems, particularly affecting the Moroccan educational system, despite the efforts and strategies adopted by the government over the past two decades (e.g., the Strategic Vision for Education 2015-2030).

In this context, Morocco continues to rank among the lowest countries in the TIMSS (Trends in International Mathematics and Science Study) test results conducted by UNESCO. For instance, Morocco was ranked 5th from the bottom in TIMSS 2019 (UNESCO, 2020), just ahead of Kuwait, South Africa, Pakistan, and the Philippines. While there has been slight improvement compared to previous tests, it remains insufficient considering the significant efforts made.

To improve Morocco's economic performance, the Special Commission on the New Development Model (CSMD, 2021) paid particular attention to human capital development, considering it a key driver and potential source of economic growth. This report outlines a set of measures to give the Moroccan economy a boost by focusing on knowledge and innovation as pillars of economic development, aiming to overcome the current economic situation and make significant progress toward the prosperity of Moroccan economic agents. These measures include enhancing the quality of the educational and vocational training systems, encouraging investments in research and development to accelerate innovation in both the public and private sectors, and facilitating access to and upgrading Information and Communication Technologies, as these technologies represent an auxiliary factor that promotes and facilitates production and collabouration among various economic agents.

6. Limitations

Although this study provides interesting insights into the impact of the knowledge economy on economic growth in a developing country like Morocco, it is important to highlight certain limitations, particularly those related to the choice of variables. Due to the partial or complete unavailability of some relevant public data, we had to resort to less ideal alternative variables for certain dimensions of the knowledge economy to meet our statistical needs, such as the length of time series and data availability. For example, the variable used to measure innovation, 'Number of articles published in scientific and technical journals,' while partially reflecting scientific activity, does not fully capture the intensity of technological innovation. Similarly, the 'Gross enrollment rate in higher education' is only an approximation of human capital and does not account for the quality of education or the actual competence of workers, partly due to the lack of available data on indicators such as PISA scores or graduation rates in STEM fields.

References

Afzal, M., Begum, I., Quddus, M. A., Farooq, M. S., Ahmad, H. K. (2010). Relationship Between School Education And Economic Growth In Pakistan: ARDL Bounds Testing Approach to Cointegration.

Aghion, P., Howitt, P. (1990). A Model of Growth Through Creative Destruction (w3223; p. w3223). National Bureau of Economic Research. https://doi.org/10.3386/w3223.

Barro, R. J. (1990). Government Spending in a Simple Model of Endogeneous Growth. – Journal of Political Economy, 98(5, Part 2), S103-S125. https://doi.org/10.1086/261726.

Bennaghmouch, S., Bouoiyour, J. (2002). Capital humain et croissance économique au Maroc.

Blanco, L. R., Gu, J., Prieger, J. E. (2016). The Impact of Research and Development on Economic Growth and Productivity in the U.S. States: Impact of R&D on Growth & Productivity in U.S. – Southern Economic Journal, 82(3), pp. 914-934. https://doi.org/10.1002/soej.12107.

Breusch, T. S., Godfrey, L. G. (1986). Data Transformation Tests. – The Economic Journal, 96, p. 47. https://doi.org/10.2307/2232969.

CSMD. (2021). Le Nouveau Modèle de Développement. p. 170.

D'agostino, R. B., Belanger, A., D'agostino, R. B. (1990). A Suggestion for Using Powerful and Informative Tests of Normality. – The American Statistician, 44(4), pp. 316-321. https://doi.org/10.1080/00031305.1990.10475751.

Dahani, Z., Dehhaoui, M., Bousselhami, A. (2020). Analyse et Modélisation du Progrès Technique au Maroc: Les Enseignements d'un Modèle VECM. – Journal of Academic Finance, 11(2), pp. 209-225. https://doi.org/10.59051/joaf.v11i2.389.

Dangal, D. N. (2022). Tertiary Education and Economic Growth of Nepal: An ARDL-ECM Analysis. – Humanities and Social Sciences Journal, 13(2), pp. 15-27. https://doi.org/10.3126/hssj.v13i2.49799.

Djeflat, A. (2006). L'ECONOMIE FONDEE SUR LA CONNAISSANCE. 166.

Domar, E. D. (1946). Capital Expansion, Rate of Growth, and Employment. – Econometrica, 14(2), p. 137. https://doi.org/10.2307/1905364.

Essardi, O., Razzouk, R. (2017). Human Capital and Economic Growth in Morocco: Evidence from Bayesian Model Averaging. – International Business Research, 10(12), p. 167. https://doi.org/10.5539/ibr.v10n12p167.

Fadaee Khorasgani, M. (2008). Higher education development and economic growth in Iran. – Education, Business and Society: Contemporary Middle Eastern Issues, 1(3), pp. 162-174. https://doi.org/10.1108/17537980810909788.

Fan, H., Ismail, H. M., Reza, S. M. (2018). Technological Innovation, Infrastructure and Industrial Growth in Bangladesh : Empirical Evidence from ARDL and Granger Causality Approach. – Asian Economic and Financial Review, 8(7), pp. 964-985. https://doi.org/10.18488/journal.aefr.2018.87.964.985.

Foray, D. (2009). L'économie de la connaissance: La Découverte. https://doi.org/10.3917/dec.foray.2009.01.

Gorz, A. (2003). L'immatériel: Connaissance, valeur et capital. Galilée.

Guo, Y. (2022). Higher Education Development, Regional Economic Growth and Opening to the Outside World. – Asian Business Research, 7(1), 45. https://doi.org/10.20849/abr.v7i1.994.

Gyimah-Brempong, K., Paddison, O., Mitiku, W. (2006). Higher education and economic growth in Africa. – The Journal of Development Studies, 42(3), pp. 509-529. https://doi.org/10.1080/00220380600576490.

Hainmueller, J., Hazlett, C. (2014). Kernel Regularized Least Squares : Reducing Misspecification Bias with a Flexible and Interpretable Machine Learning Approach. – Political Analysis, 22(2), pp. 143-168. https://doi.org/10.1093/pan/mpt019.

Harrod, R. (1955). Les relations entre l'investissement et la population. – Revue économique, 6(3), p. 356. https://doi.org/10.2307/3497253.

Haut-Commissariat Au Plan. (2024). Note D'information Du Haut-Commissariat Au Plan Relative À La Situation Du Marché Du Travail En 2023 [Note D'information]. Haut-Commissariat Au Plan Maroc. https://www.hcp.ma/La-situation-du-marche-du-travail-en-2023_a3816.html.

Jordan, S., Philips, A. Q. (2018). Cointegration Testing and Dynamic Simulations of Autoregressive Distributed Lag Models. – The Stata Journal: Promoting Communications on Statistics and Stata, 18(4), pp. 902-923. https://doi.org/10.1177/1536867X1801800409.

Keynes, J. M. (1936). Théorie générale de l'emploi, de l'intérêt et de la monnaie. J.-M. Tremblay. https://doi.org/10.1522/cla.kej.the.

Lagzouli, A., Lagzouli, A., Lakhal, T. (2024). A Confirmatory Study of the Knowledge Economy in the Context of Moroccan Economic Growth : Analysis, Comparison and Solutions. – European Journal of Economics, 4(1), pp. 1-25. https://doi.org/10.33422/eje.v4i1.625.

Lucas, R. E. (1988a). On the mechanics of economic development. – Journal of Monetary Economics, 22(1), pp. 3-42. https://doi.org/10.1016/0304-3932(88)90168-7.

Lucas, R. E. (1988b). On the mechanics of economic development. – Journal of Monetary Economics, 22(1), pp. 3-42. https://doi.org/10.1016/0304-3932(88)90168-7.

Pesaran, M. H., Shin, Y., Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. – Journal of Applied Econometrics, 16(3), pp. 289-326. https://doi.org/10.1002/jae.616.

Philips, A. Q. (2018). Have Your Cake and Eat It Too? Cointegration and Dynamic Inference from Autoregressive Distributed Lag Models. – American Journal of Political Science, 62(1), pp. 230-244. https://doi.org/10.1111/ajps.12318.

Ploberger, W., Kramer, W. (1992). The Cusum Test with Ols Residuals. – Econometrica, 60(2), p. 271. https://doi.org/10.2307/2951597.

Pradhan, R. P., Sarangi, A. K., Maity, C., Behera, R. R. (2022). ICT Infrastructure and Economic Growth in G-20 Countries : New Insights form ARDL Modelling. – The Journal of Developing Areas, 56(1), pp. 47-58. https://doi.org/10.1353/jda.2022.0009.

Rahman, P., Zhang, Z., Musa, M. (2023a). Do technological innovation, foreign investment, trade and human capital have a symmetric effect on economic growth? Novel dynamic ARDL simulation study on Bangladesh. – Economic Change and Restructuring, 56(2), pp. 1327-1366. https://doi.org/10.1007/s10644-022-09478-1.

Rahman, P., Zhang, Z., Musa, M. (2023b). Do technological innovation, foreign investment, trade and human capital have a symmetric effect on economic growth? Novel dynamic ARDL simulation study on Bangladesh. – Economic Change and Restructuring, 56(2), pp. 1327-1366. https://doi.org/10.1007/s10644-022-09478-1.

Ricardo, D. (1821). Des principes de l'économie politique et de l'impôt. J.-M. Tremblay. https://doi.org/10.1522/cla.reo.rid.pri.

Romer, P. M. (1986). Increasing Returns and Long-Run Growth. – Journal of Political Economy, 94(5), pp. 1002-1037. https://doi.org/10.1086/261420.

Romer, P. M. (1987). Growth Based on Increasing Returns Due to Specialization. – The American Economic Review, 77(2), pp. 56-62.

Romer, P. M. (1990). Endogenous Technological Change. – Journal of Political Economy, 98(5,), S71-S102.

Sarkodie, S. A., Owusu, P. A. (2020a). How to apply the novel dynamic ARDL simulations (dynardl) and Kernel-based regularized least squares (krls). MethodsX, 7, 101160. https://doi.org/10.1016/j.mex.2020.101160.

Sarkodie, S. A., Owusu, P. A. (2020b). How to apply the novel dynamic ARDL simulations (dynardl) and Kernel-based regularized least squares (krls). MethodsX, 7, 101160. https://doi.org/10.1016/j.mex.2020.101160.

Schumpeter, J. A. (1911). Théorie de l'évolution économique: Recherches sur le profit, le c'édit, l'intérêt et le cycle de la conjoncture: Introduction (F. Perroux, Trad.). J.-M. Tremblay. https://doi.org/10.1522/cla.scj.the.

Shala, N., Badivuku-Pantina, M. (2023). The influence of vocational education parameters on economic growth in European Union member states. – International Journal of Applied Economics, Finance and Accounting, 17(1), pp. 39-50. https://doi.org/10.33094/ijaefa.v17i1.1007.

Smith, A. (1776). Richesse des nations.

Solow, R. M. (1988). La théorie de la croissance et son évolution. – Revue française d'économie, 3(2), pp. 3-27. https://doi.org/10.3406/rfeco.1988.1175.

Toria Nipo, D., Lily, J., Idris, S., Pinjaman, S., Bujang, I. (2022). Information and Communication Technology (ICT) on Economic Growth in Asia: A Panel Data Analysis. – International Journal of Business and Management, 17(12), p. 18. https://doi.org/10.5539/ijbm.v17n12p18.

UNESCO. (2020). Evaluer les objectifs d'éducation globaux: Le rôle de TIMSS (Document de programme et de réunion ED/PLS/EDP/2020/10/REV; p. 15).