# Autoregressive Distributed Lag (ARDL) Analysis of the Relationship Between Public Health Expenditure and Economic Growth in Benin

**Abstract**

The objective of this research is to examine the impact of public health expenditure on economic growth in Benin over the period from 1977 to 2017 using the Autoregressive Distributed Lag (ARDL) model analysis approach. The cointegration test (Bound test) indicated that the variables are linked in the long run. The associated balance correction was also negative and significant for each model, confirming the existence of long-term relationships. The results of the study also reveal that public health expenditure has a negative long-term and positive short-term impact on economic growth in Benin. Moreover, life expectancy at birth, in turn, has a positive effect both in the short and long term on economic growth, which corresponds to the results of Aghion et al. (2008). Furthermore, Benin's policy of openness to the outside world and the inflation rate has a negative impact in the short and long term on economic growth. This can be explained by the fact that Benin is a potential importer of goods and services from abroad, which leads to a trade balance deficit. In short, this study highlights the importance of public health expenditure and life expectancy on Benin's economic growth, as well as the negative impact of the open policy and the inflation rate on growth. These results can contribute to political and economic decisions for sustainable and balanced economic growth.

*Keywords:* Autoregressive Distributed Lag, Public expenditure, Health, Economic growth

## 1 Introduction

Following the conclusion of the Second World War, industrialized countries experienced the "golden age of growth." During this era, the health and well-being of the populations in these countries continued to improve. This improvement in health status was largely attributed to significant investments in the healthcare sector by the governments. These

investments led to the eradication of major diseases such as sleeping sickness, plague, and smallpox, and also contributed to a substantial reduction in other health conditions. Following the "golden age of growth," specifically around the late 1950s and early 1960s, the theory of human capital emerged, with significant contributions from Mincer (1958) [1] and Becker, Philipson, and Soares (2001)[2]. This theory suggests that enhancing worker productivity is the primary way human resources can drive economic growth. Investing in the health sector to enhance workers' health, qualifications, and dexterity fosters favorable conditions for the production process. During this period, economists like Schultz (1961)[3] and Harbison (1962)[4] asserted that human capital holds greater significance than material capital.

However, public health expenditure significantly influenced Gross Domestic Product (GDP) in accordance with Solow's perspective, which posits that GDP is the result of combining labor and capital. According to the World Health Organization (WHO), high levels of morbidity in certain low-income regions, particularly in sub-Saharan Africa, have posed a substantial barrier to economic growth[5, 6]. Moreover, the emergence of the HIV/AIDS epidemic presented an urgent and intense challenge. This epidemic alone posed a significant threat to the development of Africa, potentially compromising an entire generation's progress[7].

Furthermore, a key link between public health expenditure and the economy is that investments in public health improve the overall health of the population. This, in turn, enhances the economy by increasing both the quality and quantity of the labor force, thereby boosting productivity across various economic sectors[8]. Additionally, a healthy workforce maximizes the utilization of existing capital, such as land, machinery, and infrastructure. Since health is a crucial aspect of human capital, healthier individuals can achieve higher levels of productivity[9]. There is a strong and significant relationship between economic growth and public health expenditures. Consequently, it is essential to incorporate these connections into the development policies of countries like Benin, where economic development cannot rely heavily on natural resources due to their limited presence. Adopting this approach would enable the country to emulate the development models of nations such as South Korea, Japan, Switzerland, and Denmark, which have thrived despite limited natural resources by leveraging their high-quality human resources as a result of effective education and health systems.

To explore the relationship between public health spending and economic growth in Benin, it is crucial to address the following key questions: What is the influence of public health spending on economic growth in Benin? What is the impact of life expectancy on economic growth in Benin? What is the optimal level of public health spending in Benin?

# 2 Theoretical and empirical literature

## 2.1 Theoretical literature

### 2.1.1 Traditional human capital theory

The traditional theory of human capital is founded on two key hypotheses: the causality between education, productivity, and earnings, as well as the positive correlation between productivity and earnings. Contributions from Mincer (1958-1974)[1], Becker (1964-1975)[2], and Schultz (1961)[3] established the core assumption of human capital theory, which posits that education is an investment both for individuals and society. This investment boosts the productivity of those who receive it, subsequently leading to an increase in their earnings. The

causal relationship between education and productivity is grounded in the idea that training, whether general or specific to a particular task or company, enhances individuals' productivity by improving their overall skills and knowledge. It also equips them with qualifications that can be directly and effectively applied to the production process (Becker, 1964). In this context, human capital naturally influences economic growth.

The positive link between productivity gains and earnings emerges from the neoclassical analysis framework. In competitive goods and labor markets, firms achieve equilibrium and maximize profits by compensating production factors according to their marginal productivity. This analysis leads to three key observations: workers with identical marginal productivity receive the same pay rate; the most productive workers earn the highest wages; and the best-educated workers tend to be the best paid. All else being equal, the most productive workers should be those who have received a higher level or quality of education, as their productive performance stems from these differences. These assumptions lead to at least two significant implications: an increased demand for education and variations in income distribution. The demand for education within the human capital theory is primarily viewed as an investment. Individuals will pursue education or training when they find it economically beneficial. They aim to maximize the return on their investment in education, opting for additional education when the expected internal rate of return on an extra unit of training time surpasses other investment opportunities with comparable costs.

### 2.1.2 Theoretical review on health and economic growth

Health economics focuses on achieving, disseminating, and utilizing health within a population through prevention, care, and changes in behavior. Its application to the healthcare field has evolved since the 1960s, beginning with the work of economist and 1992 Nobel Prize laureate Kenneth Arrow. In his 1978 publication "Uncertainty and the Welfare Economics of Medical Care"[10] in the American Economic Review, Arrow emphasized the dual uncertainties in healthcare: uncertainty surrounding illness and the effectiveness of treatments. He argued that the market alone cannot meet all health needs and that health insurance, though essential for enhancing individual well-being, cannot cover everyone. Thus, state intervention is necessary to boost collective well-being. Arrow also examined the double asymmetry of information: one between patients and doctors and another between doctors and health insurers. The 1970s were characterized by the dominance of the neoclassical approach in health economics, which saw the development of analysis focusing on the behavior of key stakeholders. Much of this work, grounded in the neoclassical perspective, centered on the analysis of healthcare services rather than health itself. Canadian economist Robert G. Evans contributed to this field in 1974 by introducing the concept of "Supplier-induced demand,"[11] suggesting that doctors could influence patients' demand for care to boost their income. Subsequently, English economist Alan Williams (University of York) conducted influential work in 1975 on the concept of need and indicators of healthcare effectiveness. His research aimed to evaluate the impact of healthcare procedures on quality of life.

The 1980s saw the emergence of new paradigms in health economics, introducing radically different conceptual approaches that incorporated theories of agency, bureaucracy, conventions, and non-market contracts. Research during this period also delved into the causes of inflation in medical expenses. In the United States, economist Alain Enthoven[12] (California) proposed a model where health insurance providers compete with one another in an effort to balance universal coverage with efficiency. The 1990s were characterized by an interna-

tional perspective in health economics, focusing on the evaluation and comparison of health systems across different countries. Researchers analyzed the reforms implemented in most countries, their theoretical underpinnings, the array of regulatory tools available, and the effectiveness of the measures adopted. Prominent figures in the field included Brian Abel-Smith[13], Jean-Pierre Poullier[14], and Denis-Clair Lambert[15], among others. Initially, research centered on healthcare expenditures, but over time, the emphasis shifted toward the quality of care. Consequently, the concept of growth has continuously evolved to address the emerging concerns and priorities of development policymakers.

### 2.2 Empirical review on the contribution of health to economic growth

Improved health contributes to economic growth in several ways. First, it reduces production losses due to morbidity-related workforce absences. It also enables the exploitation of natural resources in areas previously plagued by disease-carrying vectors, making them more accessible for economic activities. Additionally, better health boosts school attendance rates and enhances children's ability to absorb their education. Lastly, it frees up resources that would otherwise be spent on treating illness, allowing them to be allocated to other productive purposes. The most apparent benefits of improved health on the working population include a reduction in the number of days lost to illness, higher productivity, better opportunities for securing higher-paying jobs, and an extended working lifespan.

### 2.3 Expenses of health and growth economic

Empirical research examining the impact of health on economic growth through public health expenditure can be broadly categorized into studies focused on developing countries and those centered on developed countries. According to Kocoglu and Rodrigo De Albuquerque David (2009) [16] in their work "Contributions of the Health Sector to Economic Growth in Developed Countries: A Review of the Literature," there is a positive relationship between health status and growth in developing countries. However, this relationship is less clear-cut or even challenged in developed countries. The impact of health on growth diminishes marginally, reaching zero beyond a certain level of health status[17]. There may be a threshold beyond which the benefits of further health improvements no longer outweigh the costs, resulting in negative marginal returns. Acemoglu and Johnson (2008)[18] attribute these negative returns to the adverse effects of population growth on economic growth. In line with neoclassical growth theory, improvements in health can have two negative effects on per capita income: the "Solow effect" (capital stock dilution) and the "Malthus effect" (reduction in land per worker), both of which lead to decreased capital/labor and land/labor ratios. Therefore, it can be concluded that there is a threshold for public health spending, beyond which there is little to no significant impact on economic growth.

## 3 Methodology

This research utilizes data from the World Bank's World Development Indicators (WDI) database, covering the period from 1977 to 2017. The main variables include the growth rate of GDP per worker (TPIB), the growth rate of capital per worker (TCAPI), average gross enrollment rate (TBSM), public health expenditure (DEPS) for the entire population, public

health expenditure focused on the working population (DEPSA), life expectancy at birth (ESPE), the policy of openness to the outside world (DOU), and the inflation rate (TINFL).

The study adopts the human capital production function from Romer (1990) as a base model, which is modified to account for factors influencing the total productivity of the factors, following Romon's (1998) approach. The production function is given by:

$$Y = V_a K^{\alpha} H^{\beta} (AL)^{1-\alpha-\beta-a} \tag{1}$$

$\alpha > 0$,$\beta > 0$, $\alpha + \beta < 1$ and $a$ is arbitrary. $Y$ is the total output obtained from physical capital ($K$), human capital ($H$), and effective labor ($AL$); V is the vector of variables that influence total factor productivity ($TFP$) outside of human capital.

Before testing the model, we conducted unit root tests on each variable to assess their stationarity. We examined the short- and long-term relationships between GDP and other model components. The cointegration testing approach was effective as it allowed us to handle variables that are either stationary (I(0)) or integrated of order one (I(1)). We used the logarithmic transformation of the data to identify elasticities and performed quantile regression to establish the level of growth that optimizes public health spending. Thus, we obtain the following ARDL model:

$$\begin{aligned}
\Delta \log(\text{TPIB}_t) =& C_0 + C_1 \log(\text{TPIB}_{t-i}) + C_2 \log(\text{TCAPI}_{t-i}) + C_3 \log(\text{DEPS}_{t-i}) + C_4 \log(\text{ESPE}_{t-i}) \\
&+ C_5 \log(\text{TBSM}_{t-i}) + C_6 \log(\text{DOU}_{t-i}) + C_7 \log(\text{TINFL}_{t-i}) + C_8 \log(\text{DEPSA}_{t-i} \\
&+ C_9 \Delta \log(\text{TPIB}_{t-i}) + C_{10} \Delta \log(\text{TCAPI}_{t-i}) + C_{11} \Delta \log(\text{DEPS}_{t-i}) \\
&+ C_{12} \Delta \log(\text{ESPE}_{t-i}) + C_{13} \Delta \log(\text{TBSM}_{t-i}) + C_{14} \Delta \log(\text{DOU}_{t-i}) \\
&+ C_{15} \Delta \log(\text{TINFL}_{t-i}) + C_{16} \Delta \log(\text{DEPSA}_{t-i}) + \epsilon_t.
\end{aligned} \tag{2}$$

In this study, a sensitivity analysis was conducted by initially including the variable of public health expenditure allocated to the working population in the model and then excluding it in a subsequent step of the estimates. This approach allowed for a comparison of how the presence or absence of this specific variable affected the model's outcomes and provided insights into the impact of targeted public health expenditure on the active population.

# 4 Results and Discussion

The empirical results of the ARDL model, deemed essential for the discussion, are presented in Tables 1, 2, and 3. After examining stationarity through the unit root test (Dickey-Fuller), we assessed the presence of long-term relationships using the Bounds test. Subsequently, we estimated the ARDL model, selecting the optimal lag length based on the Akaike information criterion. Lastly, we estimated the long-term and short-term relationships using the cointegration test, extracting the long-term and short-term coefficients to shape the model.

## 4.1 Unit root test

Table 1 below presents the results of the Dickey-Fuller unit root test for each of the variables.

**Table 1.** Results of the ADF level test on the model variables

| Variables | Test Value (ADF) | Critical Value at 5% | Decision |
|---|---|---|---|
| log TPIBt | -6.273 | -2.945 | Stationary |
| log TCAPIt | -3.386 | -2.936 | Stationary |
| log DEPSt | -1.953 | -3.526 | Non-stationary |
| log ESPEt | -1.795 | -3.529 | Non-stationary |
| log TBSMt | -1.916 | -3.526 | Non-stationary |
| log DOUt | -3.469 | -3.526 | Non-stationary |
| log TINFLt | -4.684 | -3.562 | Stationary |
| log DEPSAt | -1.618 | -3.544 | Non-stationary |

The analysis of stationarity of level variables, as presented in the table, reveals the presence of unit roots. For the variables log DEPSt, log ESPEt, log TBSMt, log DOUt, and log DEPSAt, the ADF statistic is higher than Mackinnon's critical value at the 5% threshold, indicating that these variables are non-stationary at level. Since not all variables are stationary at level and some are integrated of order 1, there is a presumption of cointegration.

## 4.2 Cointegration test or Bounds test

Three models were specified and subjected to cointegration testing. For each of the three models, the Fisher statistic F was found to be greater than the upper limit of the critical value interval (I(0)) at a 5% error level, indicating the presence of cointegration in each of the models. This suggests a long-term relationship between the variables in all three models.

**Table 2.** Results of the cointegration test for the three models

| Models | F-Statistic | Cointegration | Type of estimate |
|---|---|---|---|
| M1 | F1 = 8.305; t1 = -6.831 | Yes | ECM (Error Correction Model) |
| M2 | F2 = 8.357; t2 = -6.864 | Yes | ECM (Error Correction Model) |
| M3 | F3 = 15.303; t3 = -6.658 | Yes | ECM (Error Correction Model) |

According to the results of this test, it is therefore necessary to write an error correction model for each of the models.

## 4.3 Long and short-term relationship estimations

Table 3 below summarizes the results of the long and short-term model estimation for the models.

**Table 3.** Summary table of the estimation of the long and short-term relationship for the models

| **Models** | **Model 1** | **Model 2** | **Model 3** |
|---|---|---|---|
| **Long-term model** | | | |
| Variables | Coefficients | Coefficients | Coefficients |
| Adjustment | -1.399516 (-6.83)*** | -1.406777 (-6.86)*** | -1.243714 (-4.01)*** |
| Log TCAPIt | 0.4468806 (2.03)* | 0.4404855 (2.03)* | 0.5382241 (1.94)* |
| Log DEPSt | -0.2991403 (-2.60)** | | 0.51253 (-1.44) |
| Log ESPEt | 0.89544 (-2.73)** | 0.955003 (-2.78)** | 0.188515 (-1.61) |
| Log TBSMt | 0.975175 (3.48)*** | 0.984936 (3.52)*** | 0.5897633 (0.83) |
| Log DOUt | -0.1712247 (-0.25) | -0.1688284 (-0.25) | 0.973131 (2.27)* |
| Log TINFLt | -0.938298 (-2.19)* | -0.0946524 (-2.22)** | -0.6680635 (-2.47)** |
| Log DEPSAt | | -0.2965107 (-2.63)** | 0.97429 (1.43) |
| **Short-term model** | | | |
| C | 18.01768 (1.91)* | 18.12884 (1.92)* | 18.28229 (1.10) |
| Log TCAPIt | -0.0339368 (-0.13) | -0.0320602 (-0.12) | -0.1438251 (-0.48) |
| Log DEPSt | 0.6282089 (1.97)* | | 0.10592 (0.92) |
| Log ESPEt | 0.95405 (3.70)*** | 0.07812 (3.73)*** | 0.63827 (3.47)*** |
| Log TBSMt | -0.7637452 (-1.21) | -0.7846343 (-1.24) | 0.3598554 (1.58)* |
| Log DOUt | -0.015404 (-0.02) | -0.0004417 (-0.00) | 0.997676 (-2.53)** |
| Log DEPSAt | | 0.6255623 (1.97)* | -0.81264 (-0.90) |
| **Model Features** | R2 = 0.9405; R2 adjusted = 0.8430; Prob(F-statistic) = 0.000; DW = 2.042413 | R2 = 0.9406; R2 adjusted = 0.8435; Prob(F-statistic) = 0.000; DW = 2.036911 | R2 = 0.9694; R2 adjusted = 0.8820; Prob(F-statistic) = 0.005; DW = 2.69366 |

*NB: ***, **, and * correspond respectively to the statistical significance of 1%, 5% and 10% and in parentheses the value of t-student.*

The adjusted $R^2$ values of 0.8430, 0.8435, and 0.8820 for models 1, 2, and 3, respectively, indicate that the ARDL models are well-calibrated. These values suggest that the explanatory variables in models 1, 2, and 3 account for 84.30%, 84.35%, and 88.20% of the variation in Benin's GDP growth rate. The probabilities associated with the Fisher statistic are all less than 1%, confirming the overall significance of the three models. Additionally, the Durbin-Watson statistics for all three models exceed 2, indicating an absence of first-order autocorrelation in the residuals. Moreover, the negative coefficient of the residuals is statistically significant at the 1% level, confirming the presence of an error correction mechanism across all three models.

The expected signs for all variables in both the short and long term are confirmed across all models. The error correction coefficient is statistically significant and exhibits the expected negative sign for all models, indicating that restoring forces toward long-term equilibrium are significantly negative and different from zero. Thus, the error correction models are validated.

In the estimation of the first model, short-term results show that public health expenditure and life expectancy at birth are significant, while the other variables are not. In the long term, all variables are significant with the exception of the political variable related to openness to the outside world. This suggests that while public health expenditure and life expectancy at

birth play a notable role in the short term, most variables contribute to long-term outcomes, except for political openness.

A 100% increase in the growth rate of capital per worker leads to a 3.39% decrease in GDP growth rate in the short term but a 44.68% increase in the long term. Additionally, a 100% increase in public health spending results in a 62.82% increase in GDP growth rate in the short term and a 29.91% decrease in the long term. The short-term boost in economic growth due to health investments is attributed to the elimination of critical diseases affecting the population. In contrast, in the long term, the population's awareness of the importance of health encourages them to maintain their health independently.

This temporal variation in the relationship between health spending and economic growth indicates that there is an optimal economic growth rate that maximizes health spending in Benin. According to the quantile regression, the 25th percentile quantile is where public health expenditure is maximized, with a coefficient of 0.081, which is the highest coefficient across all quantiles in the results. Therefore, when the GDP growth rate surpasses 0.25, public health expenditures reach their maximum level.

A 100% increase in life expectancy at birth results in a 95.40% increase in GDP growth rate in the short term and an 89.54% increase in the long term. This occurs because an increase in life expectancy at birth enlarges the active workforce, which supports short-term economic growth. However, this may contribute to a reduction in the long-term growth rate.

Similarly, a 100% increase in the average gross enrollment rate boosts GDP growth rate by 76.37% in the short term and 97.51% in the long term. This highlights the positive impact of education on economic growth. Conversely, a 100% increase in imports and exports leads to a decrease in GDP growth rate by 1.54% in the short term and 17.12% in the long term. This may be due to external trade imbalances that can impact domestic economic performance. Finally, a 100% increase in the inflation rate leads to a significant 93.82% long-term decrease in GDP growth rate. This result is explained by the reduction in purchasing power for consumers due to higher inflation, which discourages exports and encourages imports. This situation may result in a trade balance deficit and a subsequent decline in the GDP growth rate.

The estimation of the second model validates the relationship between public health expenditure and economic growth in Benin, demonstrating similar elasticities. Specifically, a 100% increase in public health spending allocated to the working population results in a 62.55% increase in GDP growth rate in the short term and a 29.65% decrease in the long term. The other variables maintain consistent signs with economic growth in Benin.

When examining the relationship between the two types of expenses, we find that a 100% increase in public health spending leads to a 10.59% increase in GDP growth rate in the short term and a 51.25% decrease in the long term. In contrast, a 100% increase in public health expenditure allocated to the working population results in an 81.26% decrease in GDP growth rate in the short term and a 97.42% increase in the long term. The other variables maintain consistent signs with respect to the economic growth rate of GDP in Benin.

# 5 Conclusion

This empirical study aims to demonstrate how individuals' health, specifically through public health expenditure, significantly impacts economic growth in Benin. By examining Benin's economic and social conditions, we observed several notable aspects, such as a

low economic growth rate and the underperformance of the Beninese health system. After conducting a critical review of the literature, we proceeded to empirical analysis using the appropriate methodology. To establish the relationship between health spending and economic performance in Benin, we employed ARDL model techniques. The Bounds test indicated long-term relationships among the variables. Moreover, the associated error correction terms were negative and significant in each model, further confirming the presence of these long-term relationships. The results of the selected model indicate that public health spending has a positive impact on economic growth in Benin in the short term, while its effect is negative in the long term. In the short term, investments in the health sector help to eliminate critical diseases affecting the population, while in the long term, the population, having recognized the importance of health, maintains its health independently. Life expectancy at birth has a positive effect on economic growth in both the short and long term, which aligns with the findings of Aghion et al. (2008). Additionally, Benin's policy of openness to the outside world and inflation exert negative impacts on economic growth in both the short and long term, confirming that Benin is a potential importer of goods and services with a trade balance deficit. Lastly, the study successfully estimated the long-term effects of the components of public health expenditure on economic growth in Benin. These findings provide important insights into the complex relationship between public health spending and economic performance, highlighting areas where targeted investments could potentially drive sustainable growth.

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We affirm that this paper is original and is not currently under consideration by any other publication.

**Data availability:** The data can be obtained from the corresponding author (on request).

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