Politická ekonomie 2025

Volume 73 (4)
https://doi.org/10.18267/j.polek.1464
Open Access

VŠE / PRAGUE UNIVERSITY OF ECONOMICS AND BUSINESS

Interactive Impacts of Remittance Inflows on Economic Growth in Algeria: Is the N-shaped Hypothesis Valid?

Hicham Ayad, Amina Bendahmane, Mohamed Driouche Dahmani

Hicham Ayad (corresponding author, email: a_hichem210@hotmail.fr, h.ayad@cu-maghnia.dz), University Centre of Maghnia, LEPPESE laboratory, Algeria; Research Centre for Applied Economics for Development – CREAD, Algiers, Algeria

Amina Bendahmane (email: a.bendahmane@cread.dz, aminabendahmane46@gmail.com), Research Centre for Applied Economics for Development – CREAD, Algiers, Algeria

Mohamed Driouche Dahmani (email: mohammed.dahmani@univ-sba.dz), Djillali Liabes University, Sidi Bel Abbes, Algeria; Research Centre for Applied Economics for Development – CREAD in Algiers, Algeria

Abstract

This investigation explores the influence of remittances on economic growth in Algeria during the period 1970–2022 using the Fourier autoregressive distributed lags (FARDL) model. This study provides new insights by suggesting an N-shaped association between remittances and economic growth. The findings reveal a nonlinear relationship between remittances and growth in Algeria. Initially, the impact of remittances on income is positive, then becomes negative when they exceed a threshold of 1.2% of GDP, and later becomes positive again when remittances surpass a second threshold estimated at 1.894% of GDP. These results highlight the importance of increasing remittance inflows to promote development in Algeria and urge decision-makers to create conditions that encourage the inflow of these funds through official channels.

Keywords: Remittances, economic growth, N-shape association, Algeria, FARDL model

JEL Classification: C22, F22, F24

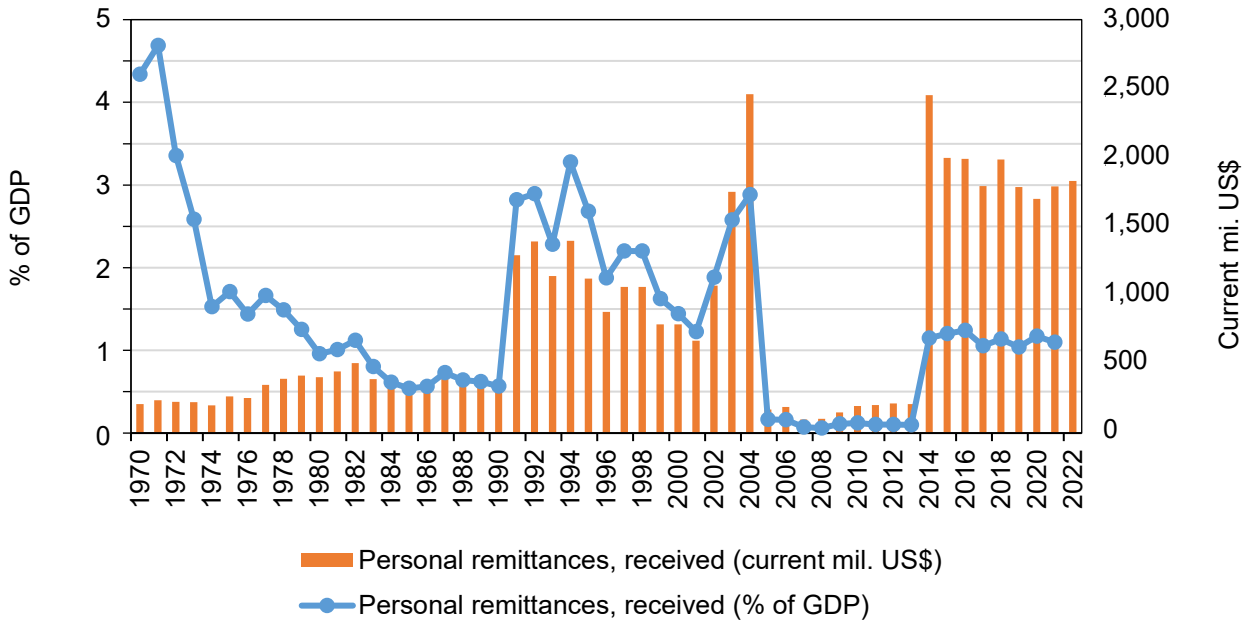
Citation: Ayad, H., Bendahmane, A., Driouche Dahmani, M.: Interactive Impacts of Remittance Inflows on Economic Growth in Algeria: Is the N-shaped Hypothesis Valid? *Politická ekonomie*, 2025, 73 (4), 584–614, https://doi.org/10.18267/j.polek.1464

1. Introduction

Algeria currently faces challenges of low domestic savings and substantial government expenditure (Hicham, 2018; Ayad *et al*., 2020). Recurring negative oil shocks have exposed the unsustainability of the rentier-based development model, necessitating a serious exploration of more effective and stable financing alternatives. The rentier mentality has led Algeria to overlook other potential funding sources. However, remittances could serve as a significant financing alternative to address the fiscal deficit. Notably, remittances are particularly valuable during crises (Sharma, 2010). Since 2014, Algeria has experienced a sharp decline in foreign trade income due to plummeting global oil prices. This has plunged the country into economic turmoil, exacerbated by austerity measures implemented from 2015 onwards, resulting in significant decreases in income and economic activity. Hence, this study aims to assess the role of remittances in mitigating the impact of the oil crisis and to determine the extent to which remittances can stimulate economic growth. However, it also acknowledges potential negative effects of these financial flows. To this end, the study proposes an N-shaped relationship between remittances and economic growth.

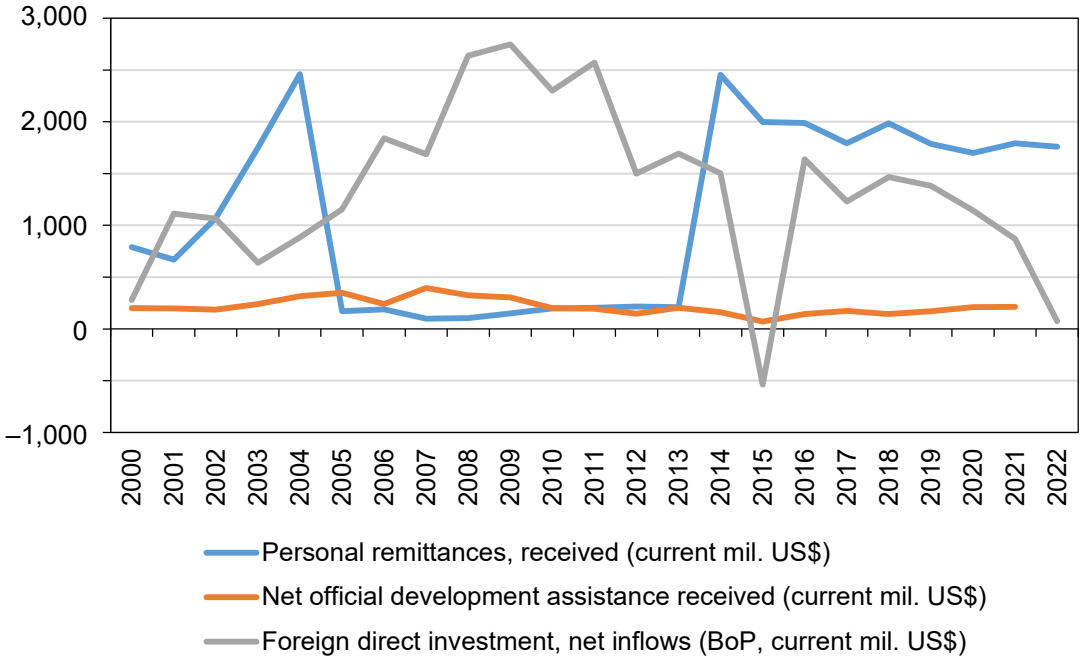
More precisely, remittances from abroad represent a critical stream of external funding for Algeria, exceeding official aid. Furthermore, remittances in Algeria exceeded FDI during the period 2014–2022 (Figure 2). In 2021, remittances in Algeria amounted to $1,792,159, which was more than double the amount of foreign direct investment, totalling $869,151 million (WB, 2023**)**. Moreover, for many years, the value of remittances has surpassed that of non-hydrocarbon exports, making them an important source of foreign exchange. Notably, 85% of these remittances come from the European Union (EU27), with France hosting the largest percentage of Algerian expatriates. Remittances from France alone represent more than 80% of the total remittances. Additionally, the remaining 20% originate from countries such as Spain, Belgium and the Arab Gulf countries, particularly Saudi Arabia and the United Arab Emirates (Kalantaryan and McMahon, 2021). Yet, a significant amount of remittances occur through informal channels, with estimates suggesting that formal remittances are two to three times lower than informal remittances in Algeria (Margolis *et al*., 2015).

Figure 1: Remittances in Algeria



Source: WB (2023)

Figure 2: Remittances, FDI and ODA received by Algeria, 2000–2022



Source: WB (2023)

Subsequently, this scrutiny emphasizes the influence of remittances on income in Algeria, a rentier state that has relied for many years on oil revenues to finance development. Hydrocarbon exports are considered the primary source of foreign exchange in Algeria. At the beginning of the third millennium, the boom in fuel prices on global markets helped Algeria implement many development plans and make numerous investments. In early 2009, as shown in Figure 1, fuel revenues declined because of the 2008 financial crisis and the global economic slowdown. Subsequently, there was a notable plunge in oil prices in 2014, dropping to less than $55. According to the United Nations Economic Commission for Africa (UNECA), this downturn in oil prices led to a reduction in revenues, resulting in a budget deficit of −15.3%, −13.2% and −8.8% in 2015, 2016 and 2017, respectively (UNECA, 2020). Concurrently, there was a substantial depletion of foreign exchange reserves, compelling Algeria to turn to unconventional financing in 2017 to fund its investments (Ayad, Ben-Salha, Ouafi, 2023). Considering all the shocks and structural changes throughout the study period, the FARDL methodology will be adopted to ensure results that closely reflect reality. This approach is ideal for handling unknown outliers in the data and structural breaks. It effectively allows the verification of the N-shape hypothesis regarding the relationship between the two study variables, without being affected by the numerous structural changes that characterized the study period.

Globally, remittances have witnessed a significant increase, from $1,929 billion to $766,848 billion over the period 1970–2022 (WB, 2023). Remittances belong among the most substantial external capital flows. Starting from 1979, remittance flows worldwide exceeded official development assistance (WB, 2023) and surpassed foreign direct investment (FDI) in many developing countries (Eggoh *et al*., 2019). During 2021, remittances in the world amounted to $739,456 billion, compared to $202,112 billion in official development assistance and up to $2,198,458 billion in foreign direct investment (WB, 2023).

Moreover, remittances are acknowledged as the most stable (Ratha, 2003; Feeny *et al*., 2014) and economically efficient external financial streams. This positions them as a crucial reservoir of foreign exchange (Qutb, 2021) vital for financial development, effectively circumventing credit constraints (Cazachevici *et al*., 2020). Consequently, remittances play a pivotal role in addressing the domestic financial disparity, particularly in developing countries grappling with insufficient domestic savings and the inability to bridge the divide between savings and investments. As a result, remittances prove crucial during economic crises, as they provide a stable income source and potentially serve as an optimal strategy to mitigate the reduction in foreign financial inflows, such as diminished export revenues.

Regarding their importance, researchers have tried to scrutinize the economic and social impacts of remittances. Despite their importance in facilitating the lives of families that receive

them, remittances act as an insurance mechanism for families that lack income or are exposed to income shocks by facilitating and stabilizing their consumption (Combes and Ebeke, 2011), enhancing their access to education and healthcare (Zhunio *et al*., 2012; Ngoma and Ismail, 2013; Azizi, 2018; Amega, 2018), reducing poverty and improving well-being (Taghizadeh-Hesary *et al*., 2021; Imai *et al*., 2014). However, their impact on overall economic growth is still under study and the fluctuating results remain the subject of controversy and debate. While some papers have provided evidence of a positive influence of remittances on GDP (Pradhan *et al*., 2008; Kumar, 2013; Odugbesan *et al*., 2021), others have found that remittances can have a negative impact due to the consumption of remittances or their investment in non-productive sectors, the negative incentives they create for recipients who may refrain from working in their home country (Sutradhar, 2020; Chowdhury *et al*., 2023), or by causing the Dutch disease (Rao and Hassan, 2012).

Alternatively, another line of research has arisen in recent years that emphasizes the non-linear relationship between remittances and income, influenced by economic and institutional conditions. Zghidi *et al*. (2018) demonstrated that economic freedom complements remittances, resulting in a greater positive impact on growth. Kadozi (2019) also attributed the significance of the institutional environment in enhancing the effect of remittances on GDP. However, other studies have linked the influence of remittances on economic development to the degree of financial advancement (Sobiech, 2019; Bangake and Eggoh, 2020). Hassan *et al*. (2016) stated that there is a U-shaped connection between the two variables, wherein the influence of remittances on growth is initially negative but becomes positive after a specific threshold. The researchers explained this fluctuation by stating that families initially spend remittances on consumption and in paying off the debt resulting from the individual's migration, while later, after completing the repayment of the debt, they can invest the remittances in productive projects.

This paper aims to propose a novel framework by suggesting an N-shaped relationship between remittances and economic growth. The influence of remittances on growth is initially positive, turning negative when remittances exceed a certain threshold and then returning to positive when they exceed a second threshold. Initially, remittance inflows positively influence families' consumption, education and healthcare spending. However, once remittances surpass a certain threshold, they can become a substitute for domestic employment, negatively affecting local economic growth. Subsequently, when remittances exceed a second threshold, they can be large enough to be invested in productive projects, thereby positively contributing to economic development.

The rest of this paper is organized as follows. Section 2 focuses on the theoretical background explaining the possibility of an N-shaped relationship. Section 3 reviews previous studies

on the relationship between remittances and GDP. Section 4 details the data and methodology employed in this study, followed by an analysis of the estimation findings in Section 5. Finally, Section 6 discusses the findings and concludes the paper.

2. Theoretical Background

In the era of globalization, the importance of workers' remittances for developing countries cannot be ignored. Remittances are an effective solution to reducing poverty rates and inequality among citizens (Khan, 2023). Furthermore, as demonstrated by Ratha and Mohapatra (2007), remittances are a more stable and less volatile source of hard currencies compared to foreign direct investment (FDI) and official development assistance (ODA). Consequently, in developing countries, remittances play a crucial role as a source of external finance and foreign exchange. However, Adams and Page (2005) identified that remittances can have dual impacts on developing countries, with both beneficial and detrimental economic effects. For instance, at the macroeconomic level, remittances help these countries strengthen their balance of payments with stable inflows of foreign exchange. On the other hand, these remittances could worsen the trade balance by increasing imports and causing appreciation of the local currency. Remittances could also disrupt social balance and create economic dependency, contributing to reduced labour demand (Abdulai, 2023; Dastidar, 2017).

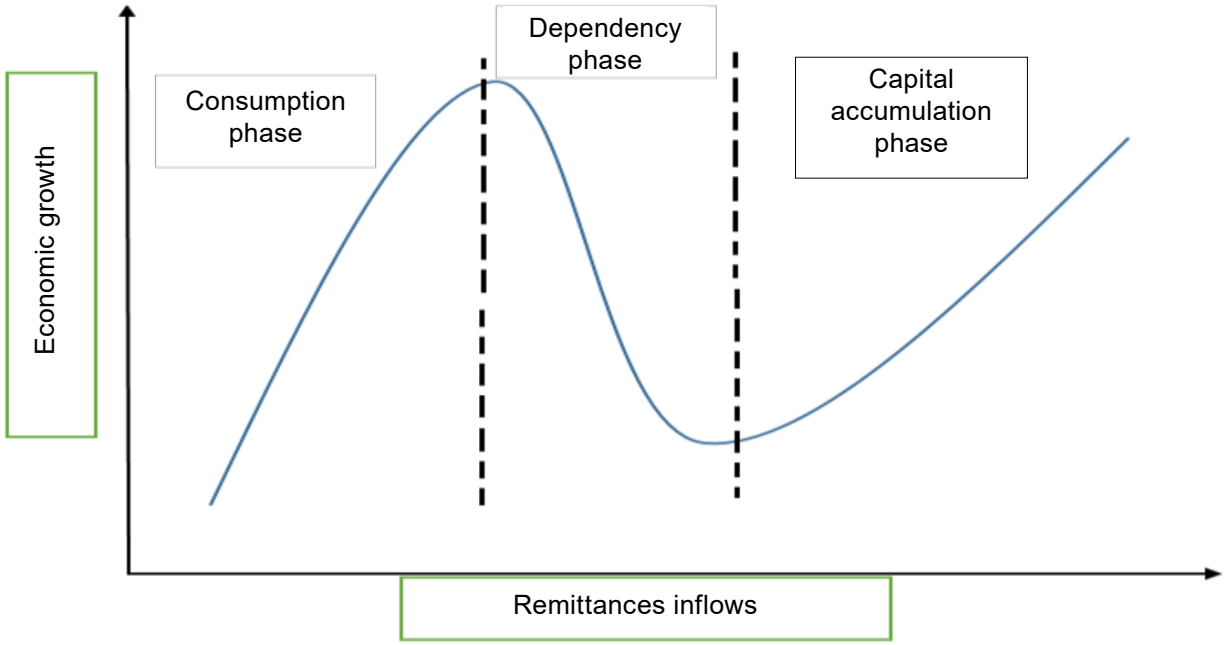
At the microeconomic level, remittances assist individuals in meeting their needs (healthcare and education) and provide social security. However, these remittances can also encourage leisure activities and potentially reduce labour participation in sectors such as agriculture and industry in the long term.

In this vein, Barajas *et al*. (2009) identified three different channels that describe the effects of remittances on GDP. The first is the capital accumulation channel. Steady remittance flows help families and individuals accumulate significant capital, especially amid declining local currency values, thereby facilitating investment projects that provide goods and services and reduce unemployment rates by increasing labour demand. The next channel is that of labour force growth. Beneficiary families may perceive transferred funds as relieving them from job searches, leading to increased leisure activities. Consequently, they may reduce their labour force participation, limit job searches and decrease labour efforts. The last channel is the total productivity channel. In this scenario, remittances influence the economy akin to Dutch disease effects. Significant remittance flows can mimic the effects of natural resource booms, resulting in local currency appreciation and a shift from tradable to non-tradable goods production (Eggoh *et al*., 2019).

Therefore, this paper proposes an N-shaped relationship between remittance inflows and income, as depicted in Figure 3. At low levels, remittances provide income that enables families

and individuals to meet basic needs, stimulating demand for goods and services through the consumption channel, thus fostering economic growth (consumption phase). However, as remittance inflows increase, societies may become dependent on these flows. Decreased labour demand and increased demand for non-tradable goods such as land and housing can lead to inflationary pressures (dependency phase). Yet, at very high levels, remittances can promote capital accumulation. Increased fixed capital formation drives private investment, expands production, reduces unemployment and moderates consumption, thereby stimulating economic growth once more (capital accumulation phase). The proposed N-shaped relationship reflects these stages of low, intermediate and high remittance flows respectively.

Figure 3: N-shaped relation between remittances and economic development



Source: Authors' own elaboration

Literature Review

During the last two decades, migrant remittances have garnered the attention of researchers, authorities and governments due to their critical role amid financial constraints. This growing interest in analysing increasing remittance inflows into developing countries has spurred experts to investigate their impact on income. Research indicates that remittances serve as a significant incentive, enhancing the purchasing power of families (Adjei *et al*., 2000).

Empirically, recent research has primarily focused on examining the relationship between migrant remittances and income. While numerous empirical studies have recognized a positive associ-

ation between remittance inflows and income, contradictions exist in the literature. These variations stem from differences in methodologies, including empirical approaches, diversity in the countries studied and measures of financial development. In this section, we will review literature that examines and analyses these studies to gain a comprehensive understanding of this topic.

In this vein, Hassan and Shakur (2017) utilized annual time-series data from Bangladesh spanning from 1976 to 2012 to investigate the impact of inward remittances on GDP per capita growth. They employed OLS, instrumental variable-two stage least square (IV-2SLS) and IV-GMM estimators. Their findings revealed a nonlinear relationship where the effect of remittances on growth is initially negative and later becomes positive. This suggests that initially, the financial transfers received by families were used unproductively, but over time, improved social and economic conditions led to a more productive use of these resources in later periods. Moreover, their results demonstrate the emergence of a U-shaped association between remittance inflows and GDP per capita progress. Similarly, Das *et al*. (2019) examined the relationship between remittances and GDP in Jamaica from 1976 to 2014 using the ARDL model to fill gaps in existing studies. Their main findings indicate a complementary relationship where GDP and remittances reinforce each other positively. They also highlight the beneficial role of control variables such as gross capital formation, total factor productivity and the population aged 15–64 in contributing to GDP in Jamaica.

Cao and Kang (2020) used balanced panel data across multiple countries to analyse the nexus between remittances and income using dynamic panel system GMM estimation for 29 economic transition countries from 2000 to 2015. In this context, the authors affirmed that remittances promote economic growth. They also emphasized the interaction between remittances and the level of financial development, noting their varying impacts across countries with underdeveloped financial systems versus those with medium to high levels of financial development.

Furthermore, El Hamma (2017) examined the relationship between remittances, institutional variables and income across 11 countries in the southern Mediterranean region from 1984 to 2014. He used the generalized method of moments (GMM) procedure to estimate his model. His study revealed three key findings. Firstly, institutional quality positively influences income, underscoring the importance of a strong institutional environment in fostering economic growth. Secondly, there is an indirect link between remittances and income, suggesting that remittances do not directly affect economic growth rates. Thirdly, remittances and institutional quality can complement each other in promoting economic growth, highlighting the need for a balanced approach between remittance inflows and institutional frameworks to support economic growth in the region. These findings align with Zghidi *et al*. (2018), who investigated causality among remittances, economic freedom and GDP in Algeria, Egypt, Morocco and Tunisia from 1980 to 2012 using GMM.

Their results indicate that remittances positively and significantly influence economic progress, economic freedom complements remittances and remittance effects are stronger under conditions of economic freedom. Similarly, Issahaku *et al*. (2018) studied the effects of remittance inflows on economic growth, reconsidering the role of institutions across 106 developing countries from 1996 to 2013. Their findings suggest that remittance inflows promote economic growth in all the sampled countries, particularly in low-income and middle-income countries, while they do not stimulate growth in upper-middle-income and high-income countries.

However, other studies have argued that migrant remittance inflows could negatively affect economic growth. Qutb (2021) found no beneficial influence of remittances on economic expansion in Egypt using annual data from 1980 to 2017. He employed the Johnson cointegration test to establish long-term and short-term relationships between variables and the vector error correction model (VECM). His significant findings reveal a negative impact of workers' remittance inflows on GDP per capita growth, attributed to a large proportion of these inflows being used for consumption rather than investment. Granger causality tests further indicate causal links from remittances to both imports and inflation, reinforcing their detrimental effect on growth. Similarly, Ayenew (2022) found that remittances alone negatively affect income across 26 sub-Saharan African countries from 2010 to 2019. However, when interacting with financial sector growth, institutional quality and economic freedom, remittances generate a positive impact on economic growth. Several additional studies are mentioned in Table 1.

3. Originality and value

Considering the review of existing research presented above, it clearly emerges that many of the studies did not fully deliver a clear answer about the specific impact of remittance inflows on income in many developing countries (Abdulai, 2023) . In addition, it must be noted that the impacts of these remittances vary from one country to another, and therefore, it is insufficient to rely on the results of these studies in addressing this relationship in a country such as Algeria. Therefore, it is necessary to conduct an econometric study using fairly modern econometric models to understand the effect of remittances on income more accurately and specifically. Thus, most of the studies in the field are limited to cross-country data.

The present paper seeks to fill this gap using empirical analysis in one country with the aim of making a comparative study. While most previous studies have focused on using linear models, our study will focus on nonlinear models and use modern econometric approaches. Therefore, we will address the fact of the presence of a nonlinear, U-shaped association between remittances and income and the possibility of the emergence of a nonlinear, N-shaped relationship.

Table 1: Recent investigation on remittance-income link

Authors	Period and country	Variables employed	Method	Findings
Review of empirical studies: Single-country analyses				
Junaid et al. (2011)	1976–2009 Pakistan	*GDP*, *REM*, *M2*, *EXP*	ARDL	Positive impacts of remittances on growth in the long and short run
Kumar (2013)	1982–2010 Guyana	*Y*, *K*, *REM*, *AID*, *FIN*	Augmented Solow framework, ARDL	Significant and linear positive influence of remittances on income
Hassan et al. (2016)	1976–2012 Bangladesh	*REM*, *FDI*, *AID*, *TRO*, *GOV*, *POP*	E-G cointegration, P-O cointegration	Significant nonlinear negative and positive (U-shaped) effect of remittances on income
Nyasha and Odhiambo (2020)	1970–2017 South Africa	*Y*, *REM*, *FSD*, *SAV*, *TRO*	Multivariate Granger-causality and ARDL	No causality between remittances and GDP
Yadeta and Hunegnaw (2022)	1980–2015 Ethiopia	*GDP*, *REM*, *GFCF*, *HC*, *GOV*, *LF*, *M2*	ARDL and Granger causality	Significant linear positive impact of remittances on income
Golder et al. (2023)	1988–2020 Bangladesh	*GDPPC*, *FP*, *REM*, *TRO*	NARDL	Positive and negative variations in financial advancement and remittances promote income
Review of empirical studies: Panel studies				
Fayissa and Nsiah (2010)	1980–2004 36 African countries	*GDPPC*, *REM*, *ENR*, *GFCF*, *AID*, *OOF*, *FDI*, *TOT*, *EFI*, *TFP*, *INY*	Random-effects and quasi-fixed-effects models	Positive linear impact of remittances on income
Bettin and Zazzaro (2012)	1970–2005 66 developing countries	*GDPPC*, *REM*, *M2*, *POP*, *I*, *INF*, *GOV*, *TRO*, *BINEF*, *LOAN*, *M2*, *CRE*, *DEP* and 6 controls, institutional quality	OLS SGMM	Remittances enhance income exclusively in countries with effectively functioning banking systems
Imai (2014)	1980–2009 24 Asia and Pacific countries	Δ*Y*, *REM*, *GDPPC*, *INF*, *FSD*, *CW*, *RA*, *CAO*, *I*	PVAR	Remittances promote income
Odugbesan et al. (2021)	1980–2019 Mexico, Indonesia, Nigeria, Turkey	*GDP*, *REM*, *FDI*	ARDL NARDL	Effect of financial development and remittance inflows on economic growth is characterized by both linear and nonlinear positive impacts
Islam (2022)	1986–2019 Selected South Asian economies	*GDP*, *REM*, *FDI*, *TRO*	Panel GLS, panel FMOLS and D–H panel causality tests	Positive impact of remittance on economic growth; unidirectional causality from remittances to economic growth
Dutta and Saikia (2022)	1993–2017 17 Asian countries	*GDPPC*, *REM*, *HC*, *FSD*, *GOV*, *EXP*	Kao cointegration test, Pedroni's cointegration test (FMOLS)	In these countries, remittance inflows enhance economic growth

Notes: *GDPPC*: Per capita GDP; *FP*: Financial progress; *REM*: Remittances as percentage of GDP; M2: As percentage of GDP; *EXP*: Exports of goods and services as percentage of GDP; *Y*: The growth rate of real GDP; *TRO*: Trade openness proxied by the sum of imports and exports as ratio of GDP; *FSD:* financial development; *SAV*: domestic savings; *FDI*: The foreign direct investment to GDP ratio; *AID*: The foreign aid to GDP ratio; *GOV*: Stands for government consumption expenditure to GDP ratio; *POP*: Population growth rate; k: Capital per worker dollars deflated; *FIN*: Financial deepening; *GFCF*: Gross fixed capital formation as a percentage of GDP; *HC*: Human capital (tertiary school enrolment as a percentage of gross enrolment); *LF*: Total amount of labour force; ENR: Gross enrolment rate secondary and tertiary (% of gross); *OFI*: Other Official Flows; *TOT*: Net barter terms of trade; *EFI*: Economic Freedom Index; *CW*: Civil war; *RA*: Resource abundance; *CAO*: Capital account openness; I: investment; *CRE*: the ratio of domestic credit provided by the banking sector to GDP; *DEP*: The ratio of bank deposits to GDP; *LOAN*: The ratio of claims on the private sector to GDP; *TFP*: Total factor productivity, measured as the log of GDP divided by the product of labor force and gross capital formation; *INY:* Initial Per Capita Income (GDPPC 1980) measured in constant U.S. dollars; *BINEF*: Bank Inefficiency

Source: Authors' own compilation

4. Data and Methods

5. Model and variables

This investigation examines the relationship between remittances and economic growth in Algeria over the period 1970–2022. To achieve our objective, we utilize the personal remittances received growth variable provided by the WB, which comprises both personal transfers and compensation of employees. Hence, these remittances consist of all cash or in-kind transfers that reach resident or non-resident households, in addition to the income of border and seasonal workers. It is important to note that the method of calculating transfers was changed by the WB in 2009. At the beginning of that year, the WB began to rely on the sixth edition of the IMF's Balance of Payments Manual (BPM6), which essentially aims to unify the method of calculating balance of payments (BOP) statistics and international investment position (IIP) among countries to ensure uniformity among countries in addition to the transparency and accountability guaranteed by the methodology. In accordance with the WB's definition of remittances, data are compiled from national reports submitted by individual countries. Furthermore, to address gaps in the dataset, missing values are imputed using two statistical methods: last observation carried forward (LOCF) and next observation carried backward (NOCB). These techniques guarantee continuity in the time series data. This indicator has been used in several papers such as Qamruzzaman (2023), Ojeyinka and Ibukun (2024) and Dilanchiev *et al*. (2024).

Furthermore, the dependent variable, as stated earlier, is GDP per capita growth obtained from the WB Indicators database. Moreover, we include several control variables in the model. Firstly, we introduce financial development and trade openness as proxies for the financial and trade situations, respectively. Including these two variables is crucial. Regarding financial development, it will clarify the extent to which remittances can reach investment projects through banks and loans, contributing to spreading these flows across all aspects of economic life. As for trade openness, it will contribute to understanding the movement of capital with the outside world and its effect on income. Accordingly, the inclusion of these two variables will help clarify the impact of remittances on economic growth, especially given the significant role that financial development and trade openness play in supporting economic activities and overall economic growth.

In econometric studies using time series or panel data analysis, it is crucial to include the most pertinent variables in the model to control for them. The Algerian economy heavily relies on oil trade, as it is an oil-exporting country with 97% of its exports being oil products (Haouas *et al*., 2024). On the other hand, financial development is a vital link in the relationship between remittances and economic growth. Under the supply-leading hypothesis, financial

development leads to economic growth and acts as an important catalyst for economic activities, mainly private investments (Wu *et al*., 2020). This is highly significant in determining the possibility of remittance flows reaching various economic activities through financial channels.

Secondly, we employ the inflation rate as an economic instability variable due to its significance in the nexus between remittances and GDP. In this context, the inclusion of the inflation rate aims to control for its effect on the association between the two variables. In other words, high inflation rates will contribute to eroding the purchasing power of families receiving remittances and vice versa. This would limit the impact of remittances on stimulating consumption and investment, thereby inhibiting economic growth. On the other hand, the inflation rate can be influenced by the exchange rate channel, especially due to foreign trade. As Algeria is an oil-dependent country that relies on its income from petroleum trade, this renders it vulnerable to major shocks in the exchange rate, which will escalate inflation rates through the phenomenon known as the Dutch disease. For this purpose, we aim at estimating the effect of remittances on economic growth in the presence of foreign trade and inflation rate as control variables.

Thirdly, we incorporate gross fixed capital formation as the variable for private investment. Additionally, we enhance our model by including the squared and cubic forms of the remittance variable to examine both the inverted U and N-shaped relationships. Consequently, we develop three models. Model 1, represented by Equation (1), aims to investigate the impact of remittances and all explanatory variables on GDP. Model 2, depicted in Equation (2), focuses on the U-shaped relationship between the variables by including the squared form of remittances. Meanwhile, Model 3, as formulated in Equation (3), aims to explore the potential existence of an N-shaped relationship by incorporating the cubic form of remittances.

$$GDP_t = \beta_1 + \beta_2 REM_t + \beta_3 GFCF_t + \beta_4 FIN_t + \beta_5 INF_t + \beta_6 TRA_t + u_t \quad (1)$$

$$GDP_t = \beta_1 + \beta_2 REM_t + \beta_3 REM_t^2 + \beta_4 GFCF_t + \beta_5 FIN_t + \beta_6 INF_t + \beta_7 TRA_t + u_t \quad (2)$$

$$GDP_t = \beta_1 + \beta_2 REM_t + \beta_3 REM_t^2 + \beta_4 REM_t^3 + \beta_5 GFCF_t + \beta_6 FIN_t + \beta_7 INF_t + \beta_8 TRA_t + u_t \quad (3)$$

Table 2: Data description

Variable	Acronym	Definition	Source	Expected sign
Economic growth	*GDP*	Per capita GDP growth (annual %)	WB	–
Remittances	*REM*	Personal remittances, received (% of GDP) (personal transfers and compensation of employees)	WB	Positive
Remittances squared	*REM2*	Squared form of remittances	Our calculations	Negative
Cubic remittances	*REM3*	Cubic form of remittances	Our calculations	Positive
Financial development	*FIN*	Domestic credit to private sector (% of GDP)	WB	Positive
Trade openness	*TRA*	Imports + exports / GDP	WB	Positive
Inflation rate	*INF*	Inflation, consumer prices (annual %)	WB	Negative
Private investment	*GFCF*	Gross capital formation (% of GDP)	WB	Positive

Source: Authors' own compilation

6. Methodology

Equations (1), (2) and (3) are tested using the auto regressive distributed lags (ARDL) bounds testing approach presented by Pesaran *et al*. (2001). This procedure is very powerful for estimating both long-run and short-run terms simultaneously (Ayad, Lefilef, Ben-Salha, 2023). For this purpose, these equations can be reformulated according to this approach as follows:

$$\Delta GDP_t = c + \gamma_1 GDP_{t-1} + \gamma_2 REM_{t-1} + \gamma_3 GFCF_{t-1} + \gamma_4 FIN_{t-1} + \gamma_5 INF_{t-1} + \gamma_6 TRA_{t-1} +$$
$$+ \sum_{i=1}^{b} \theta_1 \Delta GDP_{t-i} + \sum_{i=0}^{j} \theta_2 \Delta REM_{t-i} + \sum_{i=0}^{k} \theta_3 \Delta GFCF_{t-i} + \sum_{i=0}^{s} \theta_4 FIN_{t-i} + \quad (4)$$
$$+ \sum_{i=0}^{u} \theta_5 \Delta INF_{t-i} + \sum_{i=0}^{m} \theta_6 \Delta TRA_{t-i} + e_t$$

$$\Delta GDP_t = c + \gamma_1 GDP_{t-1} + \gamma_2 REM_{t-1} + \gamma_3 REM^2_{t-1} + \gamma_4 GFCF_{t-1} + \gamma_5 FIN_{t-1} + \\ + \gamma_6 INF_{t-1} + \gamma_7 TRA_{t-1} + \sum_{i=1}^{b} \theta_1 \Delta GDP_{t-i} + \sum_{i=0}^{j} \theta_2 \Delta REM_{t-i} + \sum_{i=0}^{j} \theta_3 \Delta REM^2_{t-i} + \\ \sum_{i=0}^{k} \theta_4 \Delta GFCF_{t-i} + \sum_{i=0}^{s} \theta_5 FIN_{t-i} + \sum_{i=0}^{u} \theta_6 \Delta INF_{t-i} + \sum_{i=0}^{m} \theta_7 \Delta TRA_{t-i} + e_t \quad (5)$$

$$\Delta GDP_t = c + \gamma_1 GDP_{t-1} + \gamma_2 REM_{t-1} + \gamma_3 REM^2_{t-1} + \gamma_4 GFCF_{t-1} + \gamma_5 FIN_{t-1} + \\ + \gamma_6 INF_{t-1} + \gamma_7 TRA_{t-1} + \sum_{i=1}^{b} \theta_1 \Delta GDP_{t-i} + \sum_{i=0}^{j} \theta_2 \Delta REM_{t-i} + \sum_{i=0}^{j} \theta_3 \Delta REM^2_{t-i} + \\ \sum_{i=0}^{k} \theta_4 \Delta GFCF_{t-i} + \sum_{i=0}^{s} \theta_5 FIN_{t-i} + \sum_{i=0}^{u} \theta_6 \Delta INF_{t-i} + \sum_{i=0}^{m} \theta_7 \Delta TRA_{t-i} + e_t \quad (6)$$

The optimal lag length is chosen using the Akaike information criterion (AIC), which is highly suitable for exploring the optimal lags by minimizing the error terms. Pesaran *et al*. (2001) established the co-integration association depending on the *F*-test and the *t*-test to test the significance of the estimation coefficients in Equations (3), (4) and (5), as follows:

$$H_{0A}: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = 0 \qquad \text{or } H_{0B}: \gamma_1 = 0 \quad (7)$$

$$H_{0A}: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = 0 \qquad \text{or } H_{0B}: \gamma_1 = 0 \quad (8)$$

$$H_{0A}: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = \gamma_8 = 0 \qquad \text{or } H_{0B}: \gamma_1 = 0 \quad (9)$$

Previous studies have used many traditional econometric techniques that require some preconditions. A case in point is the ARDL bounds testing approach, which was presented by Pesaran *et al*. (2001). In this perspective, a bootstrap ARDL bounds testing methodology was proposed by McNoon *et al*. (2018) to overcome the barriers of the traditional ARDL technique regarding its limited strength and the size problem that could occur in the case of small samples and a lot of explanatory variables (Aydin, 2022). According to the conventional ARDL bound testing methodology, if the results of the co-integration test lie between the upper and lower boundary regions (Critical values CV), no judgement can be made. To overcome this situation, preliminary bootstrap critical values are used in this method (Yilanci *et al*., 2020). McNown *et al*. (2018) pointed out the importance of using the bootstrap simulation method to obtain critical values for solving the problem of not being able to make a test result decision in the area between the two limits. They considered that the CV achieved in this way had superiority in comparison to the normal CV in the ARDL bounds test.

Correspondingly, McNown et al. (2018) added another Fisher test (F2) complementary to the tests proposed by Pesaran et al. (2001), namely the Fisher (F) test and the existing Student's t-test, for cointegration to examine the null hypothesis below and to the current examinations performed by Pesaran et al. (2001):

$$H_{0C}: \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = 0 \tag{10}$$

$$H_{0C}: \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = 0 \tag{11}$$

The approach presented by McNown *et al*. (2018) yields more robust results than the conventional ARDL approach. However, it is worth noting that McNown *et al*. (2018) did not take into account the integration orders (stationarity) of the variables, but this methodology shows greater empirical strength compared to conventional ARDL (Kirikkaleli *et al*., 2023; Ayad, Lefilef, Ben-Salha, 2023b).

Moreover, overlooking structural breaks in estimation models can lead to weak and incorrect inferences, as can be revealed from the ARDL model that does not cover structural breaks (Enders and Lee, 2012). The models described in Equations (4), (5) and (6) above can also be extended to include dummy variables for detecting structural breaks. This extended model can be conceptualized as a bootstrap ARDL with evident structural break identification (Li *et al*., 2022).

Given the insights from Gallant (1981) and Gallant and Souza (1991), which indicate that a minor amount of low-frequency components (indicating slow-moving trends) from the Fourier approximation could effectively detect an unspecified number of gradual and sharp structural breaks, we opt for the following Fourier function as a replacement for the conventional dummy variable approach (Wu *et al*., 2021). Building upon the work of Yilanci *et al*. (2020), we employ the Fourier function to capture the subtle ups and downs in the data as depicted below:

$$d(t) = \sum_{k=1}^{n} a_k \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^{n} b_k \cos\left(\frac{2\pi kt}{T}\right) \tag{13}$$

Notably, n is the count of frequencies included in the approximation, k designates a particular frequency selected for the approximation, t denotes the trend and T is the number of observations. By following the methodology of Ludlow and Enders (2000) and Yilanci *et al*. (2020), we only consider one frequency, as shown below:

$$d(t) = \lambda_1 \sin\left(\frac{2\pi kt}{T}\right) + \lambda_2 \cos\left(\frac{2\pi kt}{T}\right) \tag{14}$$

We include the Fourier expansion in Equations (4), (5) and (6) and derive the subsequent equations:

$$\Delta GDP_t = c + \lambda_1 \sin\left(\frac{2\pi kt}{T}\right) + \lambda_2 \cos\left(\frac{2\pi kt}{T}\right) + \gamma_1 GDP_{t-1} + \gamma_2 REM_{t-1} + \gamma_3 GFCF_{t-1} + \gamma_4 FIN_{t-1} + \gamma_5 INF_{t-1} + \gamma_6 TRA_{t-1} + \sum_{i=1}^{b}\theta_1 \Delta GDP_{t-i} + \sum_{i=0}^{j}\theta_2 \Delta REM_{t-i} + \sum_{i=0}^{k}\theta_3 \Delta GFCF_{t-i} + \sum_{i=0}^{s}\theta_4 FIN_{t-i} + \sum_{i=0}^{u}\theta_5 \Delta INF_{t-i} + \sum_{i=0}^{m}\theta_6 \Delta TRA_{t-i} + e_t \quad (15)$$

$$\Delta GDP_t = c + \lambda_1 \sin\left(\frac{2\pi kt}{T}\right) + \lambda_2 \cos\left(\frac{2\pi kt}{T}\right) + \gamma_1 GDP_{t-1} + \gamma_2 REM_{t-1} + \gamma_3 REM_{t-1}^2 + \gamma_4 GFCF_{t-1} + \gamma_5 FIN_{t-1} + \gamma_6 INF_{t-1} + \gamma_7 TRA_{t-1} + \sum_{i=1}^{b}\theta_1 \Delta GDP_{t-i} + \sum_{i=0}^{j}\theta_2 \Delta REM_{t-i} + \sum_{i=0}^{j}\theta_3 \Delta REM_{t-i}^2 + \sum_{i=0}^{k}\theta_4 \Delta GFCF_{t-i} + \sum_{i=0}^{s}\theta_5 FIN_{t-i} + \sum_{i=0}^{u}\theta_6 \Delta INF_{t-i} + \sum_{i=0}^{m}\theta_7 \Delta TRA_{t-i} + e_t \quad (16)$$

$$\Delta GDP_t = c + \lambda_1 \sin\left(\frac{2\pi kt}{T}\right) + \lambda_2 \cos\left(\frac{2\pi kt}{T}\right) + \gamma_1 GDP_{t-1} + \gamma_2 REM_{t-1} + \gamma_3 REM_{t-1}^2 + \gamma_4 REM_{t-1}^3 + \gamma_5 GFCF_{t-1} + \gamma_6 FIN_{t-1} + \gamma_7 INF_{t-1} + \gamma_8 TRA_{t-1} + \sum_{i=1}^{b}\theta_1 \Delta GDP_{t-i} + \sum_{i=0}^{j}\theta_2 \Delta REM_{t-i} + \sum_{i=0}^{j}\theta_3 \Delta REM_{t-i}^2 + \sum_{i=0}^{j}\theta_4 \Delta REM_{t-i}^3 + \sum_{i=0}^{k}\theta_5 \Delta GFCF_{t-i} + \sum_{i=0}^{s}\theta_6 FIN_{t-i} + \sum_{i=0}^{u}\theta_7 \Delta INF_{t-i} + \sum_{i=0}^{m}\theta_8 \Delta TRA_{t-i} + e_t \quad (17)$$

where:

Equation (15) H_{0d}: $\gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = 0$

Equation (16) H_{0d}: $\gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = 0$

Equation (17) H_{0d}: $\gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = \gamma_8 = 0$

Following the approach outlined by Christopoulos and Leon-Ledesma (2011), we estimate the Fourier ARDL equation for various values of k within the interval k = [0.1; …; 5], with increments of 0.1. We select the value of k that yields the minimum sum of squared residuals, as suggested by Christopoulos and Leon-Ledesma (2011), where integer frequencies indicate temporary breaks and fractional frequencies imply permanent breaks. The CV are calculated using bootstrap simulations (Kathuria and Kumar, 2022).

5. Findings and Discussion

5.1 Descriptive statistics

Before embarking on the econometric analysis, it is crucial to delve into the descriptive statistics of our variables. Table 3 provides an overview of these statistics. Firstly, it is evident that GDP growth exhibits an average of 1.212, fluctuating between −13.307 and 24.516, with a standard deviation (SD) of 4.666. These findings underscore the considerable volatility in Algeria's economic growth, primarily attributed to various shocks, many of which are linked to fluctuations in oil prices. This volatility arises from the country's heavy reliance on oil revenues.

Shifting the attention to remittances, it has been observed that the average share of remittances as a percentage of GDP is 1.416, ranging from 0.060 to 4.687, with an estimated SD of 1.087. These figures clearly highlight the relatively modest contribution of remittances to Algeria's GDP. Additionally, the average financial development indicator throughout the study period stands at 30.741% of GDP, with a notable peak of 69.311% in 2010. This surge coincided with a period of significant economic recovery, driven by soaring oil prices, emphasizing the country's vulnerability to oil price fluctuations.

In juxtaposition, the gross fixed capital formation (*GFCF*) metric displays an average of 36.413, with fluctuations spanning from 22.446 to 52.219. Furthermore, the inflation rate demonstrates an average of 8.599 and an SD of 7.433. These results elucidate the pronounced monetary instability within the country, especially in recent years following the global oil price collapse.

Lastly, the average trade openness index is 57.747, with maximum and minimum values of 76.684 and 32.684. Respectively, the zenith of trade openness in Algeria occurred between 2008 and 2014, aligning with the surge in global oil prices during this period. This phenomenon underscores the Algerian government's heavy reliance on oil revenues, rendering it susceptible to price fluctuations, as witnessed in recent years, particularly in the wake of the 2014 oil price crash. This situation has contributed to the economic crisis, leading to austerity measures and reduced imports since 2015.

Table 3: Descriptive statistics

Variables	*GDP*	*REM*	*FIN*	*GFCF*	*INF*	*TRA*
Mean	1.212	1.416	30.741	36.413	8.599	57.748
Median	1.410	1.166	24.402	35.281	5.967	57.093
Maximum	24.516	4.687	69.311	52.219	31.669	76.684
Minimum	–13.307	0.060	3.907	22.446	0.339	32.684
Std. dev.	4.666	1.087	22.039	7.598	7.433	10.485
JB	322.399	9.704	5.439	2.139	36.395	0.882
JB-prob	0.000	0.007	0.065	0.343	0.000	0.643

Source: Authors' own calculations

5.2 Unit root tests

The first phase in this investigation should be the unit root analysis to detect the integration order of all the series. This procedure allows us to determine the appropriate estimation techniques in the following stages in order to avoid spurious findings. Hence, we use the NG-Perron (2001) test, which suggests four tests to produce robust outcomes. The findings seen in Table 4 reveal clearly the nonstationary behaviour in the level series in all the variables, indicating the existence of unit roots. However, these unit roots disappear in the first difference series in all the variables at the 1% significance level (SL). The results indicate that all the series are of the form I(1), which reveals the possibility of a co-integration relationship between them and a long-run relationship. This will be addressed in the next stage using the bounds test according to the FADRL methodology.

Table 4: Integration order analysis

Variables	*MZa*	*MZt*	*MSB*	*MPT*
GDP	–1.179	–0.733	0.621	71.734
D*(GDP)*	–24.757***	–3.511***	0.141***	3.721***
REM	–8.004	–1.978	0.247	11.445
D*(REM)*	–25.390***	–3.562***	0.140***	3.594***
REM2	–6.821	–1.821	0.266	13.381
D*(REM2)*	–17.540**	–2.961**	0.168**	5.195**
REM3	–6.855	–1.819	0.265	13.323
D*(REM3)*	–24.385***	–3.490***	0.143***	3.746***
GFCF	–5.483	–1.644	0.299	16.586
D(GFCF)	–25.369***	–3.534***	0.139***	3.755***
INF	–9.062	–2.122	0.234	10.077
D*(INF)*	–25.128***	–3.543***	0.141***	3.634***
FIN	–6.214	–1.754	0.282	14.659
D*(FIN)*	–22.868***	–3.378***	0.147***	4.000***
TRA	–6.653	–1.806	0.271	13.706
D*(TRA)*	–23.440***	–3.423***	0.146***	3.887***
5% CV	–17.300	–2.910	0.168	5.480

Notes: ***, ** and * denote significance at the 1%, 5% and 10% level. D denotes the differences operator. CV denotes critical values.

Source: Authors' own calculations

5.3 Bounds test

As mentioned previously, this paper employs the FARDL procedure with bootstrap techniques to mitigate the issue of endogeneity, particularly its impact on the size and power features of the bounds test. Furthermore, the Fourier approximation proves to be a robust method for identifying an unknown number of breaks in the long-term relationship, using low-frequency components. This approach surpasses traditional methods that rely on dummy variables to account for structural breaks (Li *et al*., 2022). Notably, the outcomes shown in Table 5 unequivocally demon-

strate the acceptance of the cointegration hypothesis across all cases, as evidenced by the three tests applied in the three models under study. Consequently, these findings affirm the occurrence of a long-term association between *GDP* and the independent variables, indicating that their behaviour remains consistent and unchanged over the long run.

Table 5: Bounds test outcomes

Tests	Models	OF	t-statistic	10% CV	5% CV	1% CV
Fa	Model 1	3.910	7.236***	3.264	3.781	4.981
	Model 2	0.740	5.848***	3.220	3.708	4.880
	Model 3	2.52	5.101***	3.181	3.650	4.730
T	Model 1	3.910	–5.328***	–2.325	–3.325	–3.982
	Model 2	0.740	–4.328***	–2.135	–2.898	–3.328
	Model 3	2.52	–3.325**	–2.328	–3.125	–3.987
Fb	Model 1	3.910	8.328***	2.328	2.658	2.989
	Model 2	0.740	6.328***	2.659	2.897	3.3179
	Model 3	2.52	6.112***	2.569	2.932	3.658

Note: ***, ** and * denote significance at the 1%, 5% and 10% significance level.
Source: Authors' own calculations

5.4 FARDL estimation

After confirming the long-run relationship among our variables, the next step in this analysis is to estimate the long-run effects of explanatory variables on the dependent variable. The results are summarized in Table 6. In Model 1, remittances show a positive impact on *GDP*: a 1% increase in remittances leads to a 1.61% increase in *GDP* in the long run. This relationship arises because remittances boost individual and familial incomes in Algeria, stimulating demand for goods and services and thereby logically increasing *GDP* per capita. Remittances also contribute significantly to reducing poverty and improving economic inequality, thereby fostering human capital development, which enhances economic growth. Moreover, remittances stimulate private investments, given the local currency depreciation against foreign currencies upon receipt, injecting substantial liquidity into the country, which helps create new jobs and spur production. Additionally, these inflows bolster the balance of payments, providing supplementary funds

that can maintain a more favourable current account balance and logically promote long-term economic growth.

Secondly, the findings indicate a positive impact of *GFCF*, *FIN* and *TRA* on *GDP* per capita. These variables collectively contribute to raising income levels in Algeria. *FIN* facilitates substantial capital infusion, enabling job creation and income generation for citizens, thereby boosting consumption and demand for goods and services, stimulating economic activity. *TRA* stimulates domestic investments by supplying raw materials and advanced production methods and increases state revenue through exports, particularly oil exports, thereby bolstering foreign reserves and enhancing national competitiveness. *GFCF*, on the other hand, enhances the private sector's capacity to establish investments, creating new jobs and revitalizing the economy.

Conversely, *INF* plays an essential role in hindering economic growth in Algeria. This is mainly due to the decline in the consumers' purchasing power due to rising prices, which leads to a decline in demand for goods and services, including a deterioration in *GDP*. Inflation also leads to an intensification in interest rates by the central bank; thus, bank transactions decrease, the amount of loans shrinks and the gross domestic product declines.

Considering Model 2, the outcomes reveal positive and negative signs for *REM* and *REM2* with significance at the 5% SL. This analysis implies the incidence of an inverted U-shaped association between remittances and *GDP* per capita in Algeria in the long run. In other words, the positive and stimulating effect of remittances on economic growth is not sustainable and may turn into a negative effect when remittances reach the threshold of 1.70% as a percentage of *GDP*, after which the relationship turns to the opposite. This is due to several reasons that can be summarized as follows. Firstly, the Algerian economy is predominantly non-productive, heavily dependent on oil revenues for generating hard currency. Remittance inflows are not effectively complemented by domestic production. Consequently, this dependence contributes to the devaluation of the national currency and exchange rates, thereby elevating the costs of imported goods. This phenomenon is exacerbated by the significant surge in Algerian imports from foreign markets over the past two decades. As a result, the inflation rates escalate and the purchasing power diminishes, inevitably leading to a reduction in *GDP* per capita as a natural outcome.

Moreover, a substantial portion of the remittances flowing into Algeria is allocated to purchasing non-tradable goods, particularly housing and food. This trend is exacerbated by the stagnant state of Algeria's investment sector and persistently high poverty rates. Consequently, it exerts an upward pressure on the prices of these essential commodities, contributing to economic inequality. This, in turn, adversely affects the overall economy by dampening demand for goods and services, resulting in a decline in *GDP*. Additionally, the consistent and substantial influx of remittances to households often reduces their incentive to actively participate in the workforce

or initiate investment ventures, primarily due to the dependency that can develop on these remittance flows. This dependency may also lead to reduced productivity in various sectors, including agriculture, where financial incentives are lacking. Consequently, this discouragement of economic initiatives slows economic growth and leads to a long-term decrease in *GDP* per capita. In essence, this finding supports the Dutch disease phenomenon, as proposed by Acosta *et al*. (2009), who suggested that large remittance inflows can appreciate the domestic exchange rate, reducing external competitiveness and thereby decreasing the production of tradable goods.

Moving to Model 3, the outcomes using the cubic form of *REM* reveal the existence of an N-shaped association between *REM* and *GDP* due to the occurrence of positive, negative and positive effects for *REM*, *REM2* and *REM3* correspondingly at the 5% SL. This indicates that the positive effect of *REM* will return after reaching a second turning point. In this case, the turning points are estimated at 1.200 and 1.894%, respectively (the two points were extracted by adopting *REM* as a variable in the equation in order to derive it to the first degree, then setting the obtained derivative equal to zero and calculating the two roots). This can be explained by the high flows of *REM* that lead to the accumulation of capital by families and individuals who have large amounts of liquidity, seeking to open investment projects to provide new products and services that contribute to creating jobs, reducing the import basket and increasing tax collections for the government, which stimulates economic growth. Also, the large flows of *REM* will lead to the availability of hard currencies on the currency market, which will raise the value of the Algerian dinar due to the demand for it to convert these incoming currencies; this leads to decreasing import costs and decreasing unemployment rates, thus increasing the *GDP* per capita.

Additionally, Panel B indicates the presence of adjustment behaviour in the three models due to the significance ECT coefficient at the 1% SL. This result implies that the dependent variable and the explanatory variables behave similarly and do not deviate from each other in the long run, and in the event of a shock or imbalance, the system corrects by 17.9%, 14.6% and 37% of its imbalances each year in the three models, respectively, to return to equilibrium again. Furthermore, the adjusted *R*-squared coefficient showed relatively high values and improved with the addition of *REM2* and *REM3*, implying a better fit in the second and third models, respectively. Besides, the three estimates are free from various statistical problems as they are characterized by a normal distribution (Jarque–Berra *p*-value higher than 0.05), no autocorrelation of errors (Breusch–Godfrey *p*-value higher than 0.05) and stability of error variance over time (ARCH *p*-value higher than 0.05). Finally, the estimators are stable over time (both CUSUM and CUSUMSQ graphs are stable).

Table 6: FARDL estimation outcomes

Variables	M1		M2		M3	
	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
Panel A: Long-run estimations and error correct term (ECT)						
REM	1.609***	0.000	1.951**	0.013	6.933**	0.021
REM2	–	–	−0.576**	0.023	−4.717**	0.013
REM3	–	–	–	–	1.016**	0.017
GFCF	0.072***	0.002	0.142***	0.007	0.159***	0.004
FIN	0.025***	0.002	0.031***	0.003	−0.008	0.505
INF	−0.112***	0.000	−0.131***	0.002	−0.015	0.750
TRA	0.205***	0.000	0.207***	0.000	0.277***	0.000
Constant	−10.182***	0.000	−6.471***	0.000	−12.161***	0.000
ECT	−0.179***	0.000	−0.146***	0.000	−0.370***	0.000
Panel B: Diagnostic statistics						
Adjusted *R*-squared	0.725		0.782		0.836	
α_1	−1.434***	0.001	−0.852**	0.028	−1.991***	0.000
α_2	0.632**	0.047	−0.063	0.843	−0.089	0.765
Jarque–Berra	7.325	0.123	5.609*	0.060	6.325	0.102
Breusch–Godfrey	4.325	0.103	3.479*	0.054	6.103	0.211
ARCH	0.305	0.738	0.650	0.526	0.465	0.636
CUSUM	S		S		S	
CUSUMSQ	S		S		S	

Note: M1, M2 and M3 represent the models of study.
Source: Authors' own calculations

As outlined in the introduction, this study aimed to determine the role of remittances in enhancing economic growth in Algeria through an N-shaped association. The results revealed three distinct stages in the impact of remittances on economic growth.

Initially, remittances have a positive influence on economic growth by stimulating household and individual consumption, driving the economy into what we refer to as the "consumption phase". As the remittance flows increase, however, this positive effect can become negative, hindering economic growth due to reduced labour demand, marking the onset of a "dependency phase". During this phase, economic activity declines as individuals become reliant on financial inflows, potentially decreasing their participation in the workforce and increasing unproductive economic activities, such as luxury consumption. Once the remittance flows exceed a threshold of 1.9% of *GDP*, a "capital accumulation phase" begins. This phase facilitates significant capital provision, enhancing economic investment either directly through family or individual business ventures, or indirectly through bank deposits that boost funding for investment projects.

These findings were obtained while controlling for crucial variables affecting economic growth, such as *GFCF* (gross fixed capital formation), *FIN* (financial sector development) and *TRA* (trade openness), which demonstrated positive impacts. Conversely, inflation (*INF*) was found to hinder long-term economic growth in Algeria.

6. Conclusion

In this study, we suggested a new framework in order to scrutinize the association between remittances and economic growth. This paper is the first attempt to examine the N-shaped association between *GDP* and remittances. In this vein, we conducted an econometric study in the context of Algeria over the period 1970-2022 using the Fourier ARDL procedure. To reach the objective of the study, we estimated three models to examine the influence of remittances on *GDP*, to explore the inverted U-shaped link between the two variables and to investigate the N-shaped link, respectively. Furthermore, we proposed four control variables in our models to examine the effect of economic openness (financial and trade), instability (inflation rate) and the gross fixed capital formation on *GDP* per capita.

The main results of the paper can be summarized as follows: Model 1 found a constructive effect of remittances on *GDP* per capita. Model 2 revealed an inverted U-shaped affiliation between the two variables, indicating that the effect of remittances on *GDP* per capita eventually becomes negative as remittances increase. Model 3 showed an N-shaped association between the two variables, suggesting that the negative impact of remittances on *GDP* per capita reverses again at high levels of remittances. Additionally, the results indicated positive effects of financial development, trade openness and *GFCF* on *GDP* per capita, while inflation had a negative effect. Overall, these findings reveal that the impact of remittances on *GDP* per capita goes through three stages: initially positive as the remittances increase *GDP*, then negative as the remittances reach a threshold, and finally positive again after the remittances surpass a second turning point.

In light of these findings, we can offer the following policy implications. Firstly, The Algerian government needs greater incentives for residents abroad to increase their economic transfers to their families in order to increase the proportion of these transfers in *GDP* to ensure crossing the second threshold in the N shape, especially in light of its decline in recent years. Among the possible solutions here, there is an utmost necessity to enhance the ability of expatriates and their families to access banking services, which is weak in Algeria. Banking services in Algeria are characterized by great slowness and a large number of obstacles and laws that hinder the free movement of money, which makes it difficult for many families to receive their money in the right way and at the right time. Furthermore, Algeria is characterized by imposing large fees on the movement of funds, which represents additional costs for the recipient families or emigrants who send money. Thus, these fees must be re-examined and the transfer and entry of funds must be facilitated with nominal fees to encourage these flows in the long term and encourage their sending through official channels. Alternatively, there is an urgent need to curb the informal economy, which has grown into a large proportion of the national economy. This is because the informal economy represents a real escape for remitters in order to avoid the slowness of the official processes as well as the high fees by using hawala networks or hand campaigns by friends or family. In this context, there is a need to strengthen digital government, for example, to control the movement of money at home and reduce informal transactions. Besides, simplifying tax regulations and policies would facilitate the transition of informal enterprises into the formal economy as complex bureaucracy discourages formalization.

Secondly, it is necessary for the Algerian government to stimulate internal investment in order to ensure that these remittances reach productive projects that guarantee the creation of investment opportunities that enhance economic growth. For example, it is important to improve access to finance for SMEs by developing capital markets, stimulating lending by state banks and reducing collateral requirements. This will facilitate obtaining financing for investment projects. In addition, bureaucratic processes must be streamlined to ensure ease of starting a business. In addition, it is important to create clusters, special economic zones and industrial parks with superior infrastructure and services to attract investments and motivate citizens to access them. All in all, the development of financial instruments such as expatriate bonds, deposits linked to remittances and securitization tools to facilitate remittance investments may be considered an ideal solution to ensure the optimal use of these remittances. Finally, it is also important to strengthen public-private partnerships for commercially viable infrastructure projects to open up opportunities for remittance investments.

Acknowledgement

Funding: The authors gratefully acknowledge the financial support provided by the Applied Economics for Development Research Centre (CREAD) under Research Project No (03/CS 05/2022).

Conflicts of interest: The authors hereby declare that this article was not submitted no published elsewhere.

References

Abdulai, A. M. (2023). The impact of remittances on economic growth in Ghana: An ARDL bound test approach. *Cogent Economics & Finance*, 11(2), 2243189. https://doi.org/10.1080/23322039.2023.2243189

Acosta, P. A., Lartey, E. K., Mandelman, F. S. (2009). Remittances and the Dutch disease. *Journal of International Economics*, 79(1), 102–116. https://doi.org/10.1016/j.jinteco.2009.06.007

Adams Jr., R. H., Page, J. (2005). Do international migration and remittances reduce poverty in developing countries? *World Development*, 33(10), 1645–1669. https://doi.org/10.1016/j.worlddev.2005.05.004

Adjei, M., Bo, Y., Nketiah, E., et al. (2020). The effects of remittances on economic growth in West Africa. *Journal of Human Resource and Sustainability Studies*, 8(3), 312–329. https://doi.org/10.4236/jhrss.2020.83018

Amega, K. (2023). Harnessing the Benefits of Remittances via a Health Account. *Journal of Developing Societies*, 39(3), 397–404. https://doi.org/10.1177/09734082231182309

Ayad, H., Ben-Salha, O., Ouafi, M. (2023). Do oil prices predict the exchange rate in Algeria? Time, frequency and time-varying Granger causality analysis. *Economic Change and Restructuring*, 56, 3545–3566. https://doi.org/10.1007/s10644-023-09545-1

Ayad, H., Lefilef, A., Ben-Salha, O. (2023). A revisit of the EKC hypothesis in top polluted African countries via combining the ARMEY curve into the Kuznets curve: A Fourier ARDL approach. *Environmental Science and Pollution Research*, 30, 81151–81163. https://doi.org/10.1007/s11356-023-27980-5

Ayad, H., Sari Hassoun, S. E., Mostefa, B. (2020). causality between government expenditure and economic growth in Algeria: explosive behavior tests and frequency domain spectral causality. *Economic Computation & Economic Cybernetics Studies & Research*, 54(2). https://doi.org/10.24818/18423264/54.2.20.19

Aydin, M. (2022). The impacts of political stability, renewable energy consumption and economic growth on tourism in Turkey: New evidence from Fourier Bootstrap ARDL approach. *Renewable Energy*, 190, 467–473. https://doi.org/10.1016/j.renene.2022.03.144

Ayenew, B. B. (2022). Can remittance inflow foster economic growth? What matters? Evidence from sub-Saharan African countries. *Journal of East-West Business*, 28(2), 150–163. https://doi.org/10.1080/10669868.2022.2077505

Azizi, S. (2018). The impacts of workers' remittances on human capital and labor supply in developing countries. *Economic Modelling*, 75, 377–396. https://doi.org/10.1016/j.econmod.2018.07.011

Bangake, C., Eggoh, J. (2020). Financial development thresholds and the remittances-growth Nexus. *Journal of Quantitative Economics*, 18(2), 425–445. https://doi.org/10.1007/s40953-019-00188-6

Barajas, A., Chami, R.. Fullenkamp, C., et al. (2009). *Do Workers' Remittances Promote Economic Growth?* IMF Working Paper No. 09/153.

Bettin, G., Zazzaro, A. (2012). Remittances and financial development: substitutes or complements in economic growth? *Bulletin of Economic Research*, 64(4), 509–536. https://doi.org/10.1111/j.1467-8586.2011.00398.x

Cao, S., Kang, S. J. (2020). Personal remittances and financial development for economic growth in economic transition countries. *International Economic Journal*, 34(3), 472–492. https://doi.org/10.1080/10168737.2020.1765187

Cazachevici, A., Havranek, T., Horvath, R. (2020). Remittances and economic growth: A meta-analysis. *World Development*, 134, 105021. https://doi.org/10.1016/j.worlddev.2020.105021

Chowdhury, E. K., Dhar, B. K., Gazi, M. A. I. (2023). Impact of remittance on economic progress: evidence from low-income Asian Frontier countries. *Journal of the Knowledge Economy*, 14(1), 382–407. https://doi.org/10.1007/s13132-022-00898-y

Christopoulos, D. K., Leon-Ledesma, M. A. (2011). International output convergence, breaks and asymmetric adjustment. *Studies in Nonlinear Dynamics & Econometrics*, 15(3). https://doi.org/10.2202/1558-3708.1823

Chuc, A. T., Li, W., Phi, N. T. M., et al. (2022). The necessity of financial inclusion for enhancing the economic impacts of remittances. *Borsa Istanbul Review*, 22(1), 47–56. https://doi.org/10.1016/j.bir.2020.12.007

Combes, J. L., Ebeke, C. (2011). Remittances and household consumption instability in developing countries. *World Development*, 39(7), 1076–1089. https://doi.org/10.1016/j.worlddev.2010.10.006

Das, A., McFarlane, A., Jung, Y. C. (2019). Remittances and GDP in Jamaica: An ARDL bounds testing approach to cointegration. *International Economic Journal*, 33(2), 365–381. https://doi.org/10.1080/10168737.2019.1597144

Dastidar, S. G. (2017). Impact of remittances on economic growth in developing countries: The role of openness. *Global Economy Journal*, 17(2), 20160066. https://doi.org/10.1515/gej-2016-0066

Dilanchiev, A., Sharif, A., Ayad, H., et al. (2024). The interaction between remittance, FDI, renewable energy and environmental quality: a panel data analysis for the top remittance-receiving countries. *Environmental Science and Pollution Research*, 31, 14912–14926. https://doi.org/10.1007/s11356-024-32150-2

Dutta, U. P., Saikia, B. (2022). Remittances and economic growth: empirical analysis from a panel of selected Asian nations. *Millennial Asia*, 15(1), 5–23. https://doi.org/10.1177/09763996221086745

Eggoh, J., Bangake, C., Semedo, G. (2019). Do remittances spur economic growth? Evidence from developing countries. *The Journal of International Trade & Economic Development*, 28(4), 391–418. https://doi.org/10.1080/09638199.2019.1568522

El Hamma, I. (2017). Do political institutions improve the effect of remittances on economic growth? Evidence from South-Mediterranean countries. *Economics Bulletin*, 37(3), 2133–2148.

Enders, W., Lee, J. (2012). A unit root test using a Fourier series to approximate smooth breaks. *Oxford Bulletin of Economics and Statistics*, 74(4), 574–599. https://doi.org/10.1111/j.1468-0084.2011.00662.x

Fayissa, B., Nsiah, C. (2010). The impact of remittances on economic growth and development in Africa. *The American Economist*, 55(2), 92–103. https://doi.org/10.1177/056943451005500210

Feeny, S., Iamsiraroj, S., McGillivray, M. (2014). Remittances and economic growth: larger impacts in smaller countries? *The Journal of Development Studies*, 50(8), 1055–1066. https://doi.org/10.1080/00220388.2014.895815

Gallant, A. R. (1981). On the bias in flexible functional forms and an essentially unbiased form: the Fourier flexible form. *Journal of Econometrics*, 15(2), 211–245. https://doi.org/10.1016/0304-4076(81)90115-9

Gallant, A. R., Souza, G. (1991). On the asymptotic normality of Fourier flexible form estimates. *Journal of Econometrics*, 50(3), 329–353. https://doi.org/10.1016/0304-4076(91)90024-8

Golder, U., Rumaly, N., Hossain, M. K., et al. (2023). Financial progress, inward remittances and economic growth in Bangladesh: Is the nexus asymmetric? *Heliyon*, 9(3). https://doi.org/10.1016/j.heliyon.2023.e14454

Haouas, A., Ochi, A., Labidi, M. A. (2024). Sources of Algeria's economic growth, 1979–2019: Augmented growth accounting framework and growth regression method. *Regional Science Policy & Practice*, 16(3), 12448. https://doi.org/10.1111/rsp3.12448

Hassan, G. M., Shakur, S. (2017). Nonlinear effects of remittances on per capita GDP growth in Bangladesh. *Economies*, 5(3), 25. https://doi.org/10.3390/economies5030025

Hassan, G. M., Chowdhury, M., Bhuyan, M. (2016). Growth effects of remittances in Bangladesh: Is there a U-shaped relationship? *International Migration*, 54(5), 105–121. https://doi.org/10.1111/imig.12242

Hicham, A. (2018). Poverty reduction, financial development and economic growth in Algeria: A Gregory Hansen co-integration regime shift analysis. *Economic Research Guardian*, 8(2), 40–52.

Imai, K. S., Gaiha, R., Ali, A., et al. (2014). Remittances, growth and poverty: New evidence from Asian countries. *Journal of Policy Modeling*, 36(3), 524–538. https://doi.org/10.1016/j.jpolmod.2014.01.009

Islam, M. S. (2022). Do personal remittances influence economic growth in South Asia? A panel analysis. *Review of Development Economics*, 26(1), 242–258. https://doi.org/10.1111/rode.12842

Issahaku, H., Abor, J. Y., Amidu, M. (2018). The effects of remittances on economic growth: reexamining the role of institutions. *The Journal of Developing Areas*, 52(4), 29–46.

Junaid, A., Khalid, Z., Iqtidar, A. S. (2011). An empirical analysis of remittances-growth nexus in Pakistan using bounds testing approach. *Journal of Economics and International Finance*, 3(3), 176–186. https://doi.org/10.5897/JEIF.9000008

Kadozi, E. (2019). Remittance inflows and economic growth in Rwanda. *Research in Globalization*, 1, 100005. https://doi.org/10.1016/j.resglo.2019.100005

Kalantaryan, S., McMahon, S. (2021). *Remittances in North Africa: sources, scale and significance*. Luxembourg: Publications Office of the European Union. ISBN 978-92-76-29685-0.

Kathuria, K., Kumar, N. (2022). Are exports and imports of India's trading partners cointegrated? Evidence from Fourier bootstrap ARDL procedure. *Empirical Economics*, 62(3), 1177–1191. https://doi.org/10.1007/s00181-021-02061-z

Khan, I. (2023), Analyzing the impact of positive and negative remittance inflow shocks on economic growth of India. *Journal of Economic Studies*, 51(2), 338–356. https://doi.org/10.1108/JES-02-2023-0089

Kirikkaleli, D., Sofuoğlu, E., Ojekemi, O. (2023). Does patents on environmental technologies matter for the ecological footprint in the USA? Evidence from the novel Fourier ARDL approach. *Geoscience Frontiers*, 14(4), 101564. https://doi.org/10.1016/j.gsf.2023.101564

Kumar, R. R. (2013). Remittances and economic growth: A study of Guyana. *Economic Systems*, 37(3), 462–472. https://doi.org/10.1016/j.ecosys.2013.01.001

Li, F., Chang, T., Wang, M. C., et al. (2022). The relationship between health expenditure, CO2 emissions and economic growth in the BRICS countries – Based on the Fourier ARDL model. *Environmental Science and Pollution Research*, 29, 10908–10927. https://doi.org/10.1007/s11356-021-17900-w

Ludlow, J., Enders, W. (2000). Estimating non-linear ARMA models using Fourier coefficients. *International Journal of Forecasting*, 16(3), 333–347. https://doi.org/10.1016/S0169-2070(00)00048-0

Margolis, D. N., Miotti, L., Mouhoud, E. M., et al. (2015). "To Have and Have Not": International Migration, Poverty and Inequality in Algeria. *The Scandinavian Journal of Economics*, 117(2), 650–685. https://doi.org/10.1111/sjoe.12103

McNown, R., Sam, C. Y., Goh, S. K. (2018). Bootstrapping the autoregressive distributed lag test for cointegration. *Applied Economics*, 50(13), 1509–1521. https://doi.org/10.1080/00036846.2017.1366643

Ng, S., Perron, P. (2001). Lag length selection and the construction of unit root tests with good size and power. *Econometrica*, 69(6), 1519–1554. https://doi.org/10.1111/1468-0262.00256

Ngoma, A. L., Ismail, N. W. (2013). Do migrant remittances promote human capital formation? Evidence from 89 developing countries. *Migration and Development*, 2(1), 106–116. https://doi.org/10.1080/21632324.2013.786883

Nyasha, S., Odhiambo, N. M. (2020). Does remittance inflow Granger-cause economic growth in South Africa? A dynamic multivariate causality test. *The Review of Black Political Economy*, 47(1), 86–103. https://doi.org/10.1177/0034644619885348

Odugbesan, J. A., Sunday, T. A., Olowu, G. (2021). Asymmetric effect of financial development and remittance on economic growth in MINT economies: an application of panel NARDL. *Future Business Journal*, 7(1), 39. https://doi.org/10.1186/s43093-021-00085-6

Ojeyinka, T. A., Ibukun, C. O. (2024). Do remittances mitigate poverty? Evidence from selected countries in Africa, Asia and Latin America. *Economic Change and Restructuring*, 57(3), 93. https://doi.org/10.1007/s10644-024-09666-1

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

Pradhan, G., Upadhyay, M., Upadhyaya, K. (2008). Remittances and economic growth in developing countries. *The European Journal of Development Research*, 20, 497–506. https://doi.org/10.1080/09578810802246285

Qamruzzaman, M. (2023). Does economic policy uncertainty influences personal remittances: Evidence from AARDL and NARDL. *World Journal of Advanced Research and Reviews*, 18(1), 14–34. https://doi.org/10.30574/wjarr.2023.18.1.0535

Qutb, R. (2021). Migrants' remittances and economic growth in Egypt: an empirical analysis from 1980 to 2017. *Review of Economics and Political Science*, 7(3), 154–176. https://doi.org/10.1108/REPS-10-2018-0011

Rao, B. B., Hassan, G. M. (2012). Are the direct and indirect growth effects of remittances significant? *The World Economy*, 35(3), 351–372. https://doi.org/10.1111/j.1467-9701.2011.01399.x

Ratha, D. (2003). Workers' remittances: an important and stable source of external development finance. In: WB. *Global development finance 2003*.

Sharma, K. (2010). The impact of remittances on economic insecurity. *Journal of Human Development and Capabilities*, 11(4), 555–577. https://doi.org/10.1080/19452829.2010.520923

Sobiech, I. (2019). Remittances, finance and growth: Does financial development foster the impact of remittances on economic growth? *World Development*, 113, 44–59. https://doi.org/10.1016/j.worlddev.2018.08.016

Sutradhar, S. R. (2020). The impact of remittances on economic growth in Bangladesh, India, Pakistan and Sri Lanka. *International Journal of Economic Policy Studies*, 14(1), 275–295. https://doi.org/10.1007/s42495-020-00034-1

Taghizadeh-Hesary, F., Yoshino, N., Otsuka, M. (2021). Role of international remittances as an economic instrument for poverty eradication in line with sustainable development goals. In: Quah, E., Schubert, R. *Sustainability and Environmental Decision Making*, 441–466. Singapore: Springer. https://doi.org/10.1007/978-981-15-9287-4_7

UNECA (2020). *STEPS Algeria 2019 Structural transformation, employment, production and society*. Addis Ababa: Economic Commission for Africa.

WB (2023). *World Bank Indicatos*. [Retrieved 2024-05-13] Available at: https://data.worldbank.org/indicator/BX.TRF.PWKR.DT.GD.ZS?locations=DZ

Wu, C. F., Huang, S. C., Chang, T., et al. (2020). The nexus of financial development and economic growth across major Asian economies: Evidence from bootstrap ARDL testing and machine learning approach. *Journal of Computational and Applied Mathematics*, 372, 112660. https://doi.org/10.1016/j.cam.2019.112660

Wu, C. F., Huang, S. C., Chiou, C. C., et al. (2021). The relationship between economic growth and electricity consumption: Bootstrap ARDL Test with a Fourier Function and Machine Learning Approach. *Computational Economics*, 60, 1197–1220. https://doi.org/10.1007/s10614-021-10097-7

Yadeta, D. B., Hunegnaw, F. B. (2022). Effect of international remittance on economic growth: Empirical evidence from Ethiopia. *Journal of International Migration and Integration*, 23(2), 383–402. https://doi.org/10.1007/s12134-021-00833-1

Yilanci, V., Bozoklu, S., Gorus, M. S. (2020). Are BRICS countries pollution havens? Evidence from a bootstrap ARDL bounds testing approach with a Fourier function. *Sustainable Cities and Society*, 55, 102035. https://doi.org/10.1016/j.scs.2020.102035

Zghidi, N., Sghaier, I. M., Abida, Z. (2018). Remittances, institutions and economic growth in North African countries. *Journal of the Knowledge Economy*, 9, 804–821. https://doi.org/10.1007/s13132-016-0377-5

Zhunio, M. C., Vishwasrao, S., Chiang, E. P. (2012). The influence of remittances on education and health outcomes: a cross-country study. *Applied Economics*, 44(35), 4605–4616. https://doi.org/10.1080/00036846.2011.593499