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A nonlinear autoregressive distributed lag approach to remittances and access to financial inclusion in Jordan

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Background: Financial inclusion and its relationship with remittances has been widely an area of investigation among researchers.

Aim: The study investigates the asymmetric effects of remittance inflows on financial inclusion (FI) in Jordan.

Setting: Annual time series data (1990–2022) constitute 33 observations.

Method: This study uses the nonlinear autoregressive distributed lag (NARDL) model.

Results: The empirical evidence showed a long-run equilibrium relationship among the model's variables. Furthermore, the standard Wald test provides evidence of the asymmetric long-run and short-run effects of remittance inflows on FI and, hence, the nonlinear relationship.

Conclusion: The Jordanian government should promote efforts to simulate the inflow of remittances to the country. This study uncovered the vital relationship between FI and remittance inflows and its important role in enhancing financial sector development.

Contirbution: This study contributes to the existing literature on the remittances-FI nexus. First, it uncovered the vital and important relationship between FI and remittance inflows, and its crucial role in enhancing financial sector development. Second, unlike previous studies that used linear ARDL or traditional estimation methods, it applied the NARDL approach to test for the existence of a nonlinear relationship between the model's variables. Third, it suggests that policymakers in Jordan government should put effort into stimulating the inflow of remittances to promote FI and, hence, economic growth and development.

Keywords: remittances; financial Inclusion; Jordan; cointegration; NARDL; normality; stationary; linearity.

Introduction

Economic theory and applied economic research both confirm that remittance inflows constitute a significant and vital source of finance in developing countries (Yoshino, Taghizadeh & Otsuka 2019). This is demonstrated as Jordan has been ranked second in foreign direct investment (FDI) inflows since 1996 among low- and middle-income (LMICs) countries (Anzoategui et al. 2014). In the past three decades, the volume of remittance inflows has witnessed a substantial surge reaching its highest level in 2019 at $549 billion, surpassing that of FDI inflows at $534 billion (Chuc et al. 2020; Sami, Ralph & Mohamed 2020).

The various dimensions of labour migration (skilled and unskilled) issues have occupied the attention of scholars and policymakers in both sending and receiving countries due to their effects on major macroeconomic and microeconomic activities. Consequently, an exclusive body of empirical and theoretical literature has emerged to investigate the impact of remittance flows on various economic activities using modern estimation approaches. For example, financial development (FD) (Ahamed & Mohamed 2020; Azizi 2020; Bhattacharya, Inekwe & Paramati 2018; Donou-Adonsou, Pradhan & Basnet 2020; Faheem et al. 2019; Fromentin 2018; Mehta, Ayesha & Asad 2021; Misati, Kamau & Nassir 2019), economic growth (Al-Abdulrazag & Abdel-Rahman 2016; Chuc et al. 2020; Hassan, Sanchez & Yu 2011; Shairil 2021), education (Azizi 2018b), labour supply (Azizi 2018; Evans & Xavier, 2016), imports (Al-Abdulrazag 2018), and poverty (Sami et al. 2020; Yoshino et al. 2019).

A recent strand of applied research focuses on the remittance inflows-financial sector linkage stressing the role of a strong financial sector at home in enabling low costs for money transfer for the senders, and easy access to funding for the recipients, thus facilitating increased remittance inflows. Financial inclusion (FI), as an aspect of FD, has gained importance since being integrated by the G20 in 2013 into its development agenda. The FI indicators show that the percentage of people with bank accounts worldwide remains relatively low in some regions: 55% in East Asia, 39% in Latin America, 35% in Eastern Europe, 33% in Southeast Asia, and 25% in sub-Saharan Africa (Aga & Martínez 2014; Lukman 2020). The importance of the remittance inflows-FI linkage stems from observing the considerable body of research that shows that promoting and encouraging FI would have significant benefits to households (Anzoategui et al. 2014).

Enhancing the FI level would enable the poor and vulnerable to have easy access to financial products and services (loans, saving facilities, credit, insurance services, and financial education). Consequently, they can stand a better chance of taking themselves out of poverty by saving more, raising their investment, and earning more income to enjoy high standards of living (Ebenezer, Godfred & Gloria 2020). Theoretical and empirical works suggest that remittance inflows could enhance access to financial services by the poor and eventually ensure their FI (Ebenezer et al. 2020). This study tests the proposed hypothesis of a positive impact of remittance inflows on access to FI in Jordan over the 1990–2022 period in a nonlinear environment by addressing the asymmetric effects of positive and negative shocks. To do so, a nonlinear econometric empirical framework (NARDL) has been applied to test the hypothesis and estimate the quantitative impact of remittance inflows on FI. In addition to the conventional diagnostic test, the nonlinearity among the variables is investigated by performing the Brock, Dechert and Scheinkman (BDS) test (Brock et al. 1996). Moreover, the short-run and long-run asymmetric relationships are investigated by applying the nonlinear ARDL proposed by Shin, Yu and Greenwood-Nimmo (2014).

Despite the considerable research conducted in Jordan, the remittance inflows-FI linkage has so far been insufficiently investigated. To the best of the authors' knowledge, this is the first study of its kind to tackle the remittances-FI nexus in Jordan by examining the asymmetric relationship. A few studies have examined the impact of FI on economic growth and poverty in Jordan but not the remittance inflows-FI nexus (Abdullah 2018; Al-Ma'aitah 2021; Alshorman 2018; Shaker 2018). This article is expected to add to the economic knowledge and understanding of the remittance-FI linkage in Jordan. Its contribution lies in filling the applied gap in the literature by shifting the attention from the remittance inflows-FD related to the remittance inflows-FI nexus. This article uses a multidimensional FI index introduced by Immaculate (2018), applies the NARDL framework, and performs the nonlinearity BDS test proposed by Brock et al. (1996). The empirical evidence reveals a long-run equilibrium relationship; furthermore, the standard Wald test provides evidence of the long-run asymmetric effects of remittance inflows on FI and, hence, the asymmetric nonlinear relationship between the two variables. The article suggests that policymakers need to design policy actions to promote remittance inflows to enhance FI for recipients. The Jordanian government should promote efforts to simulate the remittance inflows, since the magnitudes of the access financial indicator are relatively low ranging (0.34–0.88). Promoting FI will, in turn, affect economic growth and development by enhancing financial sector development.

The article is structured as follows: 'Financial inclusion in Jordan' provides the stylised facts. The section 'Review of related literature' reviews the relevant applied literature, 'Econometric methodology' presents the data source, methodology framework, and variable description. The 'Results and discussion' section presents and discusses the empirical estimation results. Finally, 'Conclusion' contains the conclusion and provides some policy recommendations.

Financial inclusion in Jordan

The Jordanian government has been working for several years to develop an integrated financial ecosystem to achieve FI for all Jordanians. In 2016, the Central Bank of Jordan (CBJ) announced its vision for the National Financial Inclusion Strategy for 2018–2020. The CBJ has implemented several steps toward improving and activating a conducive environment for FI. The CBJ believes that expanding FI thoughtfully and prudently supports inclusive, sustainable growth, and promotes financial and economic stability. To achieve this goal, the CBJ's policy focuses on several axes, including improving access to finance, especially for micro, small and medium companies, spreading the financial and banking culture, protecting the financial consumer, setting the necessary controls to enhance transparency and justice, and establishing laws for the work of credit information companies that are concerned with exchanging credit information (CBJ 2021). Some of the stylised facts of FI in Jordan are as follows (Nagham & Ahmad 2018):

1. 60% of Jordan's adult population within the age group 18 years to 80 years have a bank account, which is lower than developed countries where it reaches about 80% – 90%.
2. The percentage of individuals borrowing from banks and microfinance institutions is about 17%, while the share of companies is that small and medium-sized companies account for about 7.3% of bank facilities, compared to the average ratio in advanced economies of 20% – 25%.
3. Concerning the percentage of those who own a credit card, the percentage reached 53%.
4. The CBJ launched the mobile payment platform – JoMoPay – in 2014, and the initial work on the system began by licensed financial companies in the second half of 2016.
5. The Jordanian banking system consists of the CBJ and 25 banks, including 13 Jordanian commercial banks, four Islamic banks, three of which are Jordanian, eight foreign banks, including 6 Arab banks – Association of Banks in

Jordan. They have 770 branches spreading throughout the Kingdom at the end of 2014. In 2014, the population ratio to the number of bank branches reached about 8669 people per branch 2014, and the number of automatic teller machines (ATMs) reached 1434, which is 4655 people per machine.

6. The number of international bank branches in Jordan was 786 at the end of 2015, with an increase of 2.1%. The number of branches of Jordanian commercial banks reached 592, 73.32% of the total number of branches, 141 branches of Islamic banks, 17.94% of the total number of branches, and 53 branches of foreign commercial banks, 6.74 of the total number of branches, and the number of Association of Banks in Jordan in 2016 was 25.
7. The number of ATMs affiliated with banks inside Jordan increased from 1434 in 2014 to 1488 in 2015, an increase of 3.8%, while the number of ATMs for Jordanian commercial banks reached 1120, representing 75.3% of the total number of machines; the number of ATMs for Islamic banks reached 297, or 20% of the total number of machines.

Review of related literature

Recently, there has been a rise in interest by economic researchers and policymakers in the importance of remittance inflows and their impacts on various economic activities (Tu et al. 2019). In recent years, the applied research has shifted toward the FI issue (Aga & Martínez 2014; Anzoategui et al. 2014; Ebenezer et al. 2020; Helen & Robert 2007; Inoue & Hamori 2016; Manuel & Julia 2015; Murat et al. 2020; Nitin 2013; Sami et al. 2020). However, the existing applied research provides mixed evidence on the remittance inflows-FI linkage.

The literature on the remittance inflows-FI linkage can be broadly divided into two major strands: the household micro-level and the aggregate macroeconomic strands. At the micro-level, the investigation has been motivated by the belief that remittances are mostly used for consumption (Kenneth 2019), whereas the macro-level focuses on the impact of remittances on FI, FD, and consumption, among others.

At the micro-level strand, the applied research examined the impact of socio-economic variables such as education level, age, income, gender, remittances, and demographic characteristics on FI and found a positive linkage between remittance inflows and FI. For instance, Ajefu and Ogebe (2019) used the Linear Probability Model (LPM), Simon et al. (2018) employed the binary regression technique, and Anzoategui et al. (2014) applied the maximum likelihood estimation of the Probit model. In contrast, Meldina, Jasmina and Danijel (2019) reported a negative impact of remittances on youth FI. The other strand of applied research focused on the macroeconomic-level variables; the results were mixed. Ebenezer et al. (2020) applied a panel (VAR) in sub-Saharan Africa, Emmanuel, Salome and Festus (2020) used multiple regressions, Murat et al. (2020) and Kenneth (2019) applied the least squares regressions, Tu et al. (2019) applied dynamic panel estimation, Immaculate (2018) applied the fixed effects estimations and generalised methods of moments (GMM)-IV estimation method, Inoue and Hamori (2016) used panel data in Asia, Anzoategui et al. (2014) used household surveys in El Salvador, and Nitin (2013) applied GMM, and found a positive linkage. On the other hand, some researchers found a negative relation, for example Sami et al. (2020) in 187 countries, whereas, Lukman (2020) found no significant relation.

These differences are due partly to differences in econometric models, the sample of countries, and the FI measurement used. Many cross-country empirical studies have used panel data regression frameworks that impose cross-sectional homogeneity on coefficients with the hope that the results can apply to all countries under consideration.

A stream of researchers advocated the positive impact of remittances (Ahamed & Mohamed 2020; Chuc et al. 2020; Ebenezer et al. 2020; Hayot, Lee & Yessengali 2020; Inoue & Hamori 2016; Murat et al. 2020). The impact of remittances on FI can take place indirectly via FD response to remittance inflows. The increases in remittance inflows stimulate FD by creating a demand for opening bank accounts and saving instruments (Anzoategui et al. 2014), credit opening accounts, and increased savings (Hayot et al. 2020). On the other hand, that might not be the case as indicated by Brown, Carmignani and Fayad (2013), and other researchers who have reported a detrimental effect of remittances on the credit market (Calderon, Fajnzylber & Lopez 2007). Remittances could serve as either a complement or a substitute for credit, where in the first case, neither need be linked to FI, leading to a negative impact on FI (Brown et al. 2013). Conversely, when remittances are complementary to the credit market, it positively affects FI.

Many cross-country empirical studies have used panel data regression frameworks that impose cross-sectional homogeneity on coefficients with the hope that the results can apply to all countries under consideration. In the Jordanian case specifically, a few studies have dealt with the impact of FI on economic growth and poverty (Abdullah 2018; Alshorman 2018; Bouguerra 2018; Jouini & Habib 2021; Omet & Abdel-Halim 2017; Shaker 2018) but none have dealt with the role of the remittances-FI nexus.

Econometric methodology

This section deals with the utilised methodology to explore the quantitative impact of remittance inflows on FI by presenting the econometric framework, data sources, and the estimation technique, the NARDL model proposed by Shin et al. (2014).

Functional form and variable description

Following previous surveyed applied work in formulating the empirical framework of the formal empirical migrant

workers' remittances-FI nexus, this study adapts the following model:

$$FI = \beta_0 + \beta_1 REM_t + Z_{it}\beta + \varepsilon_t \quad \text{[Eqn 1]}$$

In Equation 1, β_0 refers to the constant term, FI is a multidimensional access to the FI index rather than all other dimensions, because we believe (as defined) that the essence of FI is the ability of a group of people to access the financial services provided by a financial system (banks); therefore, we attempt to study the factors that affect the ability of individuals to access banking goods and services. Migrant workers' remittances (REM) are measured as the personal remittances per capita (in US$), and $Z_{it}\beta$ is a set of other control variables including FD proxied by the domestic credit to the private sector (%GDP), the trade openness (Open) measured by trade share to gross domestic product (GDP), Inflation as proxied by the Consumer Price Index (CPI), and economic performance proxied by the GDP per capita (GDPC, Constant, measured in US$).

Variables and data source

This study uses yearly data covering the period 1990–2022. The current research utilised secondary data gathered from numerous sources, mainly the World Development Indicators (WDI) of the World Bank.

Remittances inflows

There is little disagreement among applied researchers regarding the measurement of remittance inflows. Following previous studies (Ahamed & Mohamed 2020; Ebenezer et al. 2020; Chuc et al. 2020; Inoue & Hamori 2016; Murat et al. 2020), this article uses remittance inflow measured as the ratio of personal remittances received in US dollars to GDP (REM/GDP). Moreover, it is expected that remittances would increase FI (Inoue & Hamori 2016; Kenneth 2019; Sami et al. 2020).

Financial development

The present article uses the ratio of domestic credit to the private sector to GDP to proxy FD (Al-Tarawneh 2016; Maxwell & Nicholas 2021). The variable measures the financial depth that captures the size of the financial sector (banks, other financial institutions, and financial markets) relative to GDP; hence, it excludes credit issued to governments, government agencies, public enterprises, and credit issued by central banks. A more developed financial sector would facilitate the banking transaction by the public. It is expected that FD would positively influence FI, as reported by a large majority of applied literature (Maxwell & Nicholas 2021).

Economic growth

Per capita GDP in constant US dollars is used to proxy economic growth. Gross domestic product is expected to positively affect FI since a higher level of income would promote demand for deposits and the available financial instruments in the banking system (Chuc et al. 2020; Ebenezer et al. 2020; Hayot et al. 2020; Inoue & Hamori 2016; Kenneth 2019; Maxwell & Nicholas 2021; Murat et al. 2020; Sami et al. 2020).

Inflation

This article employs the CPI to proxy inflation and it is expected to negatively influence FI (Hayot et al. 2020; Inoue & Hamori 2016; Kenneth 2019; Meldina et al. 2019; Sami et al. 2020). When people wittiness an episode of inflation, they tend to increase their demand for physical assets rather than for financial assets to hedge against their asset erosion, hence reducing the cost of loanable funds and leading to a reduction in the demand for financial assets.

Trade openness

The sum of total trade (exports and imports) to GDP ratio has traditionally been used to measure trade openness (Chuc et al. 2020; Inoue & Hamori 2016; Kabuga & Hussaini 2017; Kundan & Paramanik 2020; Malefane & Odhiambo 2018). It is expected to have a positive influence on FI. The expectation is built on the ground that a higher volume of trade would generate more payments to the involved trade partners and, hence, trade partners would demand access to formal financial instruments (Kenneth 2019; Meldina et al. 2019; Sami et al. 2020).

Human capital

Human capital represents the embodied knowledge, skills, and experience in individual workers which is measured by education. This study uses primary enrolment, years of education by adults, to proxy human capital. It is believed that remittances help ease the poor's liquidity constraints and investments in human capital (Hayot et al. 2020). According to previous studies (Ajefu & Ogebe 2019; Anzoategui et al. 2014; Ari, Kemala & Yuli 2020; Chuc et al. 2020; Evans & Xavier 2016; Inoue & Hamori 2016; Murat et al. 2020), human capital is expected to positively influence FI. The rationale for such a positive effect is that education promotes the knowledge of finance and the reach out for financial products and services (Murat et al. 2020).

Measuring financial inclusion indicators

Financial inclusion is measured by quite a few indicators, namely access, usage, and penetration (Immaculate 2018). This article uses the access dimension to proxy FI, which is measured by two indicators; ATMs per 100 000 adults and commercial bank branches per 100 000 adults. It was argued that ATMs are widely used and are more practical in the sense that they are easily accessible and operate beyond banking working hours (Ajefu & Ogebe 2019; Bkwayep & Tsasack 2020; Sami et al. 2020). Moreover, commercial bank branches provide financial services to customers and they are physically separated from the main office (Bkwayep & Tsasack 2020; Inoue & Hamori 2016; Kenneth 2019; Sami et al. 2020). This article follows Immaculate (2018) in constructing

the access index (FI) in Jordan, taking into consideration the availability of data for the access FI dimension. The calculation of the proposed procedure comes in two steps. The first step involves the computation of dimension indices (ATMs and bank branches), by applying the following formula for each one:

$$d_{i,t}^{j} = \left(\frac{A_{i,t}^{j} - m^{j}}{M^{j} - m^{j}} \right) \quad \text{[Eqn 2]}$$

In Equation 2, i and j = 1,2 are the numbers associated with a specific access indicator per country. $A_{i,t}^{j}$ is the actual value of the variable j, m^{j} is the minimum value for the variable j and M^{j} is the maximum observed value for variable j. The computed $d_{i,t}^{j}$ lies between 0 and 1. This implies that a maximum value of 1 indicates complete FI. In contrast, the minimum observed value of 0 denotes financial exclusion. The second step involves a combination of dimension index with respect to the access indicator by finding the average sum of the dimension as:

$$\tilde{d}_{1,i,t} = \frac{d_{1,i,t} + d_{2,i,t}}{2} \quad \text{[Eqn 3]}$$

Model specification

This section presents the procedure used to examine the asymmetric effects remittance inflow has on financial inclusion in Jordan. The ARDL (Pesaran et al. 2001) model has some advantages over the Johansen approach to cointegration (Johansen & Juselius 1988, 1990) and Engle and Granger's (1987) approach to cointegration. First, it can be applied regardless of the order of integration of the variables: I(0) or I(1) but not I(2). Furthermore, following Pesaran et al. (2001), the unrestricted ARDL model specification for the standard log-linear functional specification of the long-run and short-run between FI indicators FI_t and remittance inflows of Equation 1 without the asymmetry take the following form:

$$\begin{aligned} \Delta LFI_t = {} & \alpha_0 + \sum_{i=1}^{p} \gamma_{1i} \Delta LFI_{t-i} + \sum_{i=0}^{q} \beta_{1i} \Delta LREM_{t-i} \\ & + \sum_{i=0}^{q} \varphi_{1i} \Delta Z_{t-i} + \gamma_{2i} LFI_{t-i} \\ & + \beta_{2i} LREM_{t-i} + \varphi_{2i} Z_{t-i} + \varepsilon_t \end{aligned} \quad \text{[Eqn 4]}$$

Equation 4 also can be viewed as an ARDL of order (p, q) for the multidimensional FI index, where ε_t, and Δ denote the white noise and the first difference terms. The Akaike information criteria are used to determine the appropriate optimal lag length structure, and later the equation is run by order of least squares (Pesaran et al. 2001). Shahbaz and Feridun (2012) indicated that the calculated F-statistic is sensitive to the lag length selection.

The ARDL model requires testing for the existence of long-run equilibrium relationships among the model's variables. Equation 4 captures only the symmetric effects of remittance inflows on FI under the assumption that the underlying long-run association is described as following a symmetrically linear combination. In addition, it is assumed that there is no difference between the decomposed partial sum processes of negative and positive impacts of these nonstationary stochastic explanatory variables on economic growth (Maxwell & Nicholas 2021).

However, this approach is found to provide profoundly misleading results in terms of nonlinearity and asymmetries. To address this problem, this article uses the NARDL modeling strategy suggested by Shin et al. (2014) with the belief that the cointegrating association could be asymmetric or nonlinear. The NARDL approach is an asymmetric extension of the linear (ARDL) cointegration model proposed by Pesaran et al. (2001). The linear ARDL approach does not consider the possibility that negative and positive variations of the explanatory variables have different effects on the dependent variable. The NARDL model does not allow detecting the asymmetric effects, permits testing for cointegration in a single equation framework, and works regardless of the order of integration, I(0) or I(1), but not I(2), as it follows the bounds tests F-values.

More importantly, this methodology allows us to test the asymmetrical effects of LREM_t^+ and LREM_t^- on FI in Jordan. It provides the possibility to differentiate between the impact of positive (negative) changes in remittance inflows on FI (Maxwell & Nicholas 2021). Thus, this article uses a nonlinear modeling framework, which provides a simple and flexible vehicle for the analysis of joint long-run and short-run asymmetries (Maxwell & Nicholas 2021).

The following is the construction of Shin et al.'s (2014) asymmetric long-run model describing the relationship between remittance inflows and financial inclusion:

$$\mathrm{LFI}_t = \alpha_0 + \alpha_1 x_t + \alpha_2 \mathrm{LREM}_t^+ + \alpha_3 \mathrm{LREM}_t^- + \mu_t \quad \text{[Eqn 5]}$$

In Equation 5, LFI_t is the multidimensional FI indicator, LREM_t is the flow of remittances, x_t is a (k × 1) vector of control variables, and $\alpha = (\alpha_0 + \alpha_1 + \alpha_2 + \alpha_3)$ is a cointegrating vector of long-run parameters. In addition, LREM_t^+ is the positive effects and LREM_t^- is the adverse effects on LFI_t, while LREM_t^+, and LREM_t^- are partial sums process which accumulate positive and negative changes. The NARDL model is built around the following asymmetric long-run equilibrium relationship where the effect of LREM_t is decomposed into these effects:

$$LREM_t = x_0 + LREM_t^+ + LREM_t^- \quad \text{[Eqn 6]}$$

x_0 is a random initial variable.

$$LREM_t^+ = \sum_{i=1}^{t} \Delta LREM_j^+ = \sum_{t=1}^{t} max\left(\Delta LREM_j, 0\right) \quad \text{[Eqn 7]}$$

$$LREM_t^+ = \sum_{i=1}^{t} \Delta LREM_t^+ = \sum_{t=1}^{t} max\left(\Delta LREM_j, 0\right) \quad \text{[Eqn 8]}$$

Employing positive and negative partial sum decompositions setting, NARDL enables the detection of the long-run and the short-run asymmetric effects by allowing for the joint investigation of the issues of nonstationarity and nonlinearity in the setting of an unrestricted error correction model. From Equation 5, the long-run relationship between FI and remittances inflows is captured by α_2, (α_3) Which is expected to be positive (positive). It is posited that the remittance inflows increase (decrease) will result in higher (lower) long-run changes in the financial inclusion index (i.e. $\alpha_2 > \alpha_3$). Thus, the long-run association presented by Equation 5 indicates asymmetric long-run remittance inflows pass through to the financial inclusion index.

By extending the ARDL model in Equation 1 and replacing the LREM variable with $LREM^{+}_{t-1}$ and $LREM^{-}_{t-1}$, the combined short-run and long-run dynamics proposed by Pesaran et al. (2001) are:

$$\begin{aligned}\Delta LFI_t = {} & \beta_0 + +\beta_1 LFI_{t-1} + \beta_2 Z_{t-1} \\ & + \beta_3 LREM^{+}_{t-1} + \beta_4 LREM^{-}_{t-1} \\ & + \sum_{i=1}^{p} \gamma_i \Delta\, LFI_{t-i} + \sum_{i=1}^{K} \theta_i \Delta\, Z_{t-i} \\ & \sum_{i=0}^{q} \left(\varphi_i^{+} \Delta\, LREM^{+}_{t-1} + \varphi_i^{-} \Delta\, LREM^{-}_{t-1}\right) + \varepsilon_t \end{aligned} \qquad \text{[Eqn 9]}$$

All variables in Equation 9 were described in Equation 1 and K,p, and q are lags order. The long-run coefficients $\left(\beta_3 = -\varphi_i^{+} / \beta_1, \beta_4 = -\varphi_i^{-} / \beta_1\right)$ are the long-run effects of LREM increase (decrease) on LFI. $\sum_{i=0}^{q} \varphi_i^{+}$ $\left(\sum_{i=0}^{q} \varphi_i^{+}\right)$ captures the short-run effect of increases (decreases) in LREM on LFI. The model specification of Equation 9 indicates the asymmetric short-run (long-run) impact of remittance inflows on FI. Next, we test for the presence of asymmetric long-run equilibrium relationships by applying the bounds testing approach of Pesaran et al. (2001) using the Wald F-statistic test: the null of no cointegration H_0:$\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ against the alternative H_1:$\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$.

The F-test considers the stationarity properties of the variables. Specifically, Pesaran et al. (2001) compute lower and upper bounds for the critical values at any significance level. The lower (upper) bound assumes that the variable is I(0). If the F-statistic is higher (lower) than the upper (lower) bound critical value, the null is rejected (accepted). If the statistic lies between the two bounds, the inference remains inconclusive.

Finally, testing for the presence of long-run (short-run) asymmetry between FI and remittance inflows required applying the Wald test, where the null hypothesis of no asymmetry H_0:$\beta_3 = \beta_4$ $\left(H_0 : {}^{+}_{i} = {}^{-}_{i}\right)$ is tested against the alternative hypothesis of the existence of asymmetry $H\alpha$: $\beta_3 \neq \beta_4$ $\left(H_a : {}^{+}_{i} \neq {}^{-}_{i}\right)$

Linearity feature

It is highly recommended that the linearity feature of the series should be examined before performing the unit root tests. Using a unit root test for exploring the structure of the series is very important and crucial for the reliability and interpretation of the estimation results (Mehmet 2019). Among several tests for linearity available in the literature, this study uses the BDS linearity test developed by Brock et al. (1996) and the Jarque–Bera on the individual series tests were applied to test for the presence of nonlinearity in the relationship between remittances and access to financial inclusion.

Unit root test (stationarity test)

The application of the bounds test for cointegration requires that the variables under review should not be integrated of order two, I(2), otherwise the conclusion implies that employing the ordinary estimation would yield inconsistent and spurious results (Maxwell & Nicholas 2021; Yusuf, Yahya & Nasiru 2012). To account for this problem, the commonly used Augmented Dickey-Fuller (ADF; Dickey & Fuller 1979) unit root test approach was applied. If we fail to reject the nonlinearity feature of the series, the nonlinear unit root test is applied for determining the order of integration. In this study, the Kruse (2011) nonlinear unit root test was used for this task, where the null hypothesis states that the series has a unit root against the alternative where the series does not have a unit root. Kruse (2011) proposes a τ test by comparing the critical values presented by Kruse with the statistical values of the estimated parameter in question, and in case the null hypothesis is rejected, then the series is said to be stationary.

Results and discussion

Nonlinearity test

The Jarque–Bera on the individual series test was applied to test for the presence of nonlinearity in the relationship between remittances and access to FI. The normality test results presented in Table 1 provide support for the rejection of normality, thus indicating the nonlinearity dependence of the series. Furthermore, the BDS test for individual time

TABLE 1: Nonlinearity test results.

Variable	LGDPC	LREM	LFD	LHC	LOPEN	LFI	LCPI
Jarque–Bera	3.106	4.347	0.165	3.588	6.593	269.1165	2.697564
Probability	0.212	0.114	0.921	0.166	0.037	0.000000	0.259556
BDS	Sig*	Sig*	Sig*	Sig*	Sig*	Sig*	Sig*

LGDPC, logged GDP per capita (GDPC, Constant, measured in US$); LREM, the personal remittances per capita; LFD, Financial Development Index; LHC, Human capital; LOPEN, Trade Openness; LFI, Financial Inclusion Index; LCPI, Consumer price Index (2010 = 100); BDS, Brock, Dechert and Scheinkman test; Sig, significance.

*, Significant at the 1% level of significance based on *t*-statistics.

series rejects the null hypothesis that they are independent and identically distributed. As a result, both Jarque–Bera and the BDS test indicate that the series are nonlinear. The nonlinearity results imply estimating the paramaters of these series in nonlinear models, otherwise the researcher encounters the misspecification problem.

Furthermore, the BDS test was applied to the residuals of the fitted linear model. The results of the BDS test approach proposed by Brock et al. (1996) reported in Table 2 reveal that the test statistics is overwhelmingly at a 1% significant level, thus providing support for the rejection of the null hypothesis that the residuals are linearly dependent at all possible dimensions at all levels of significance. The rejection of linearity dependence implies that the relationship is nonlinear, hence paving the way for using nonlinear modeling. Therefore, the result provides strong evidence of nonlinearity in the relationship between access to FI and remittances which is preferred in detecting the asymmetric effects.

Stationarity test (unit root test)

The application of the bounds test for cointegration requires that the variables under review should not be integrated of order two, I(2); otherwise, this conclusion implies that employing the ordinary estimation would yield inconsistent and spurious results (Maxwell & Nicholas 2021; Yusuf et al. 2012). The ADF (Dickey & Fuller 1979) unit root test approach was applied. Table 3 reports the ADF results for all unit root tests, where they demonstrate that none of the series under review is I(2). They are indeed either integrated of order zero (at level) or one (at the first difference), hence justifying the application of linear and nonlinear ARDL models.

TABLE 2: BDS test on resuals of fitted linear model.

Dimension	BDS statistic	Standard error	*z*-statistic	Probability
2	0.035506	0.015212	2.334134	0.0196
3	0.045962	0.024865	1.848457	0.0645
4	0.085508	0.03047	2.806298	0.005
5	0.112129	0.032699	3.429092	0.0006
6	0.104118	0.032488	3.20482	0.0014

BDS, Brock, Dechert and Scheinkman test.

Nonlinear unit root test

As indicated in Table 1, the time series lack the linearity feature; hence, the nonlinear unit root test is implemented to explore the features of unit roots. Table 4 presents the Kruse (2011) nonlinear unit root test results of the three cases of raw, demeaned, or detrended series. The results of rejecting the null hypothesis are mixed in the three cases. Therefore, these results indicate that the series is stationary and nonstationary depending on the test type (raw, demeaned, or detrended).

Analysing and discussing nonlinear autoregressive distributed lag results

Bounds – Test to cointegration test

Table 5 reports the bounds test to cointegration results. The result of the i-statistic of the bounds test of cointegration (12.29), is greater than the upper value (4.10) at a 1% level of

TABLE 4: Results of Kruse nonlinear unit root test.

Variable	tua (τ)-statistics		
	Raw	Demean	Detrend
LREM	2.426	1.972	22.548
LFI	14.945	15.970	16.287
LGDPC	4.951	9.209	11.160
LCPI	46.826	2.123	2.136
LHC	1.815	6.360	6.361
LOPEN	2.358	9.470	6.690
LFD	11.381	13.685	12.187
Critical values:			
1%	13.150	13.750	17.100
5%	9.530	10.170	12.820
10%	7.850	8.600	11.100

Source: Kruse, R., 2011, 'A new unit root test against ESTAR based on a class of modified statistics', *Statistical Papers* 52(1), 71–85. https://doi.org/10.1007/s00362-009-0204-1

Note: The critical values are obtained from Kruse (2011). The optimum lag length is selected according to Akaike information criteria.

LREM, the personal remittances per capita; LFI, Financial Inclusion Index; LGDPC, logged GDP per capita; LCPI, Consumer price Index (2010 = 100); LHC, Human capital; LOPEN, Trade Openness; LFD, Financial Development Index.

TABLE 3: Results of Augmented Dickey-Fuller unit root test.

Variable	Category	LGDPC	LREM	LFD	LHC	LOPEN	LFI	LCPI
At level:								
With constant	*t*-statistic	-1.5112	0.1878	-2.2112	-0.7583	-0.8752	-3.3805	-1.3507
	Probability	0.5148	0.9675	0.2065	0.8173	0.7831	0.0193	0.5935
	sig	no	no	no	no	no	*	no
With constant and trend	*t*-statistic	-1.0158	-1.7028	-2.5632	-3.0046	-1.5917	-4.3244	-1.5344
	Probability	0.9271	0.7266	0.2982	0.1481	0.7739	0.0088	0.7961
	sig	no	no	no	no	no	**	no
At first difference (d):								
With constant	*t*-statistic	-3.3749	-4.6109	-4.1219	-4.1213	-4.1865	-8.8508	-5.2862
	Probability	0.0198	0.0009	0.0032	0.0032	0.0027	0.0000	0.0001
	sig	*	**	**	**	**	**	**
With constant and trend	*t*-statistic	-3.5651	-6.0712	-4.0518	-4.0488	-4.6555	-8.7049	-5.2192
	Probability	0.0498	0.0001	0.0172	0.0173	0.0043	0.0000	0.0010
	sig	*	**	*	*	**	**	**

Note: Null hypothesis: The variable has a unit root.

LGDPC, logged GDP per capita; LREM, the personal remittances per capita; LFD, Financial Development Index; LHC, Human capital; LOPEN, Trade Openness; LFI, Financial Inclusion Index; LCPI, Consumer price Index (2010 = 100); sig, significance; no, not significant.

*, Significant at the 5%; **, Significant at the 1%.

significance. The result provides evidence of the existence of a long-run equilibrium relationship among model's variables.

Gregory-Hansen cointegration test

Despite the fact that the bound test shows the existence of a cointegrating long-run equilibrium relationship among the variables, it does not show the structural break points. This may need more investigation related to the probability of existence of structural breaks in the series. Gregory and Hansen (1996) introduced another test procedure to examine the existence of a long-run cointegrated relationship among variables in which data may have a structural break. Table 6 shows that the value of the test statistics (–5.845) is less than the critical values (–5.28) at 5% significance level. Subsequently, the Gregory-Hansen test result rejects the null hypothesis of no cointegration and, hence, indicates the existence of a long-run equilibrium relationship among variables in the presence of a structural break; moreover, the Gregory-Hansen test shows that the break has occurred in 2007.

Statistical diagnostic tests

Table 7 presents the results of statistical diagnostic tests. The residuals are normally distributed, as shown by the Jarque–Bera test; the model is free of the autocorrelation problem indicated by the insignificant Lagrange multiplier test, and the variance of the error term is homoscedasticity as indicated by the insignificant Breusch-Pagan-Godfrey test. The Cumulative Sum (CUMUS) and Cumllative Sum of Square (CUSMUSQ) stability tests indicate that the parameters are free of any structural break. It can be observed that the model is free of statistical problems, which indicates its validity.

TABLE 5: Bounds test results.

F-bounds test		Null hypothesis: No levels relationship		
Test statistic	**Value**	**Significance (%)**	**I(0)**	**I(1)**
F-statistic	12.29075	10	1.95	3.06
k	8	5	2.22	3.39
-	-	2.5	2.48	3.7
-	-	1	2.79	4.1

TABLE 6: Result of the Gregory-Hansen test – Augmented Dickey-Fuller.

***T*-statistic**	**Break point**	**Date**	**Critical value**
-5.845*	18	2007	-5.28*

Note: H0: there no cointegration. Critical values of Gregory-Hansen test reported in Gregory and Hansen (1996:109, Table 1).

*, 5% significant level.

TABLE 7: Statistical diagnostic tests.

Statistical test	**Breusch-Godfrey serial correlation LM test**	**Heteroskedasticity Test: Breusch-Pagan-Godfrey**	**Jarque–Bera**	**Stability**
Value	14.672	0.928	223.000	CUSUM (stable)
F-statistic [D-9]	0.064	0.611	0.895	CUSMSQ (stable)

Note: Breusch-Pagan-Godfrey: H_0: No heteroscedasticity· Lagrange multiplier test of residual serial correlation (LM): H_0: No autocorrelation between residuals. Jarque–Bera: H_0: Normal distribution of residuals. Structural stability test for the NARDL model: H_0: Parameters are stable.

CUMUS, cumulative sum; CUSMUSQ, cumulative sum of square.

Short-run estimation results

Table 8 presents the short-run estimation results. It shows that all included variables are significant at a 1% significance level. Focusing on the effects of positive and negative changes in the level of the flows of remittances, the estimation results show that the effect of positive changes is negative, whereas it is positive for negative changes. Moreover, the effect of negative changes is greater than that of the positive changes. A 1% increase in remittance inflows reduces FI by 5.46%, whereas a 1% decrease in remittance inflows increases the access to FI by 9.59%. In addition, the results indicate a rapid tendency toward long-run equilibrium indicated by the negative significant error correction coefficient (–5.499). Accordingly, it takes about (2.18) months to restore long-run equilibrium due to a short-run sudden impact.

Long-run estimation results

The long-run estimation results are reported in Table 9. It is clear that all variables have significant impacts on access to FI at the 1% significance level, except the human capital

TABLE 8: Results of nonlinear autoregressive distributed lag ARDL (2, 2, 2, 2, 2, 2, 1, 2, 2).

Variable	**Coefficient**	**Standard error**	***t*-statistic**	**Probability**
C	-1.771952	0.094925	-18.66694	0.0000
D(LFI(-1))	3.209545	0.212060	15.13508	0.0001
D(LREM_POS)	-5.461719	0.299390	-18.24284	0.0001
D(LREM_POS(-1))	1.687995	0.153719	10.98106	0.0004
D(LREM_NEG)	9.599643	0.506571	18.95024	0.0000
D(LREM_NEG(-1))	-3.877743	0.308370	-12.57495	0.0002
D(LGDPC)	-10.57125	0.753041	-14.03808	0.0001
D(LGDPC(-1))	-4.564663	0.405959	-11.24416	0.0004
D(LCPI)	22.78526	1.366161	16.67831	0.0001
D(LCPI(-1))	-2.615544	0.672089	-3.891665	0.0177
D(LOPEN)	-3.484067	0.207456	-16.79426	0.0001
D(LOPEN(-1))	2.286052	0.249111	9.176847	0.0008
D(LFD)	4.870552	0.294264	16.55166	0.0001
D(LHCS)	2.441408	0.639685	3.816581	0.0188
D(LHCS (-1))	7.849874	0.640800	12.25011	0.0003
D(DUM2007)	2.398279	0.129327	18.54426	0.0000
D(DUM2007(-1))	-3.637828	0.251244	-14.47926	0.0001
CointEq(-1)*	-5.499092	0.301870	-18.21676	0.0001

ARDL, autoregressive distributed lag; D, difference; LFI, Financial Inclusion Index; LREM_POS, the personal remittances per capita positive; LREM_NEG, the personal remittances per capita negative; LGDPC, logged GDP per capita; LCPI, Consumer price Index (2010 = 100); LOPEN, Trade Openness; LFD, Financial Development Index; LHC, Human capital.

*, Significant at the 10% level of significance based on *t*-statistics.

TABLE 9: Asymmetric ARDL long-run coefficients.

Variable	**Coefficient**	**Standard error**	***t*-Statistic**	**Probability**
LREM_POS	-2.359762	0.187920	-12.55727	0.0002
LREM_NEG	3.180874	0.267516	11.89041	0.0003
LGDPC	-1.186787	0.269213	-4.408362	0.0116
LCPI	5.605505	0.620943	9.027406	0.0008
LOPEN	-2.525589	0.310014	-8.146694	0.0012
LFD	1.589943	0.194869	8.159024	0.0012
LHC	-1.098511	0.613981	-1.789161	0.1481
DUM2007	1.015553	0.080665	12.58979	0.0002

Note: EC = LFI – (-2.3598*LREM_POS + 3.1809*LREM_NEG -1.1868*LGDPC +5.6055*LCPI -2.5256*LOPEN + 1.5899*LFD -1.0985*LHC + 1.0156DUM2007).

ARDL, autoregressive distributed lag; LREM_POS, the personal remittances per capita positive; LREM_NEG, the personal remittances per capita negative; LGDPC, logged GDP per capita; LCPI, Consumer price Index (2010 = 100); LOPEN, Trade Openness; LFD, Financial Development Index; LHC, Human capital.

TABLE 10: Results of asymmetric short-run and long-run tests.

Wald test	F-statistic	Probability
Short run	24.465*	0.0078
Long run	14.983*	0.0139

*, 1% significance level.

variable. The positive shock in the flow of remittances has a negative impact on the access to FI index. A 1% increase in the flow of remittances decreases the access to FI by a 2.359%. On the other hand, the negative shock in remittance inflows increases the access to FI index while a 1% decrease in remittance inflows increases access to FI by 3.18%. In addition, the negative shock exerts a greater impact on access to FI than the positive shock.

The result of the negative shock reflects the fact that remittances act as a substitute for financial products and services. Thus, remittances are used for consumption purposes rather than investment ones. Thus, the decrease in remittance inflows to the recipients increases the demand for financial products and services. The level of economic activity measured by per capita income negatively affects access to FI. The result implies that as the individual's income increases by 1% their desire to access financial products and services decreases by 1.867%. Moreover, the positive and significant impact of the price level (LCPI) on FI clears out the direct relationship between the price level and access to FI. When people wittiness an episode of inflation, they tend to increase their demand for FI services. Therefore, inflation leads to an increase in the demand for financial assets. The FD indicator positively and significantly affects FI. A well and sophisticated financial sector encourages people to seek financial products and services.

The level of human capital promotes access to financial sector services. This can be attributed to the effect of education on the importance of the financial sector. More educated people would gain adequate financing processes, and in turn go forward seeking financial services and products (Ajefu & Ogebe 2019; Anzoategui et al. 2014; Chuc et al. 2020; Inoue & Hamori 2016; Murat et al. 2020). However, the estimated results revealed a negative impact of education on access to FI index.

Finally, trade openness negatively influences access to FI. A high rate of trade requires less demand for banking services. This results contradicts previous research (Kenneth 2019; Meldina et al. 2019; Sami et al. 2020) which reported a positive impact of trade openness. The 2007 dummy variable shows a positive impact on FI. According to the Wald F-statistics test reported in Table 10, short-run and long-run asymmetry results are 24.465 and 14.982, and the probabilities are 0.0139 and 0.0078. Based on these results, there is a difference between the effects of positive LREM on FI in the short run and long run; hence, on the margin, one can conclude that there is a long-run asymmetric relationship between LREM and FI.

The results obtained from the Wald test reject the null hypothesis of the equality of the positive innovation coefficients and negative innovation coefficients in the long and short term. Our empirical findings confirm the existence of an asymmetric relationship between LREM and access to FI.

Conclusion

The impact of remittances on macroeconomic and microeconomic variables has gained the attention of both researchers and policymakers in Jordan. This may be because remittance inflows could influence FI. Despite the considerable body of applied research on the role of remittances in economic activities, the remittances-FI nexus has not been investigated in Jordan. Therefore, this article uses the recently developed econometric techniques of the NARDL approach to examine the long-run asymmetric relationship between remittance inflows and access to FI over the period 1990–2022. The FI as the dependent variable was measured as a multidimensional index by using the Immaculate (2018) computation method, whereas remittances and a set of control variables were taken as independent variables. The applied work revealed that none of the variables is I(2). The BDS normality test provides evidence of the rejection of the dependency between access to FI and remittance inflows. The bounds test to cointegration indicates the existence of a long-run relationship among the variables. Furthermore, the standard Wald test provides evidence of the asymmetric long-run effects of remittance inflows on FI and, hence, the nonlinear relationship between the two variables.

The long-run test indicates that a significant positive (negative) shock in remittance inflows exerts a negative (positive) impact on FI. This shows that a negative shock in remittance inflows would lead to an increase in access to FI, whereas a positive shock decreases the access to FI. Furthermore, the Wald test indicates that there is asymmetric impact of remittance inflows on FI both in short run and the long run. For policy recommendation, the Jordan government should promote efforts to simulate the inflow of remittances to Jordan, since the magnitudes of the financial indicators range from 0.34 to 0.88. Moreover, promoting FI will in turn affect economic growth and development by enhancing financial sector development.

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Competing interests

The authors have declared that no competing interest exists.

Authors' contributions

B.A.A. contributed to the economic modeling and methodology as well as the analysis, while M.A.A. drafted the introduction, review of literature, and the conclusion.

Ethical considerations

The ressearch is mainly office work and did not use any human or animal materials. Therefore, it does not require any ethical consideration such as a clearance certificate.

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Data availability

Derived data supporting the findings of this study are available from the corresponding author B.A.A. on request.

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