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Does an asymmetric nexus exist between exports and economic growth in Pakistan? Recent evidence from a nonlinear ARDL approach

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Abstract

A fundamental economic question is how nations can achieve long-term economic growth. One of the responses to this question is the export-led growth (ELG) hypothesis, which claims that rising exports are a key predictor of economic growth. In response, this study empirically investigates the asymmetric (nonlinear) and causal relationship between exports and economic growth using annual data from 1973 to 2020 in Pakistan. The asymmetric cointegration among variables is confirmed by the non-linear autoregressive distributed lag approach with a structural break. Long-term estimates conform to theoretical expectations, except for imports which are found to influence growth negatively. Further, human and physical capital both are positively contributing to economic growth. The major finding is that the effects of exports on economic growth are asymmetric, and economic growth in Pakistan reacts positively to the rise and fall of exports. The causality analysis supports the above findings and confirms a long-run asymmetric unidirectional causality from exports (with positive/negative change) to economic growth in Pakistan, clearly demonstrating the ELG hypothesis. From a policy perspective, the findings suggest that Pakistan should adopt and implement an export growth strategy to achieve economic prosperity as part of its development policy.

Keywords Exports · Economic growth · Asymmetry · Structural break · Causality · Pakistan

JEL Classification F14 · F43 · C22 · O47

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1 Introduction

The study of the forces that drive and accelerate economic growth has been a prominent topic of policy debate in the economic literature (Chirwa and Odhiambo 2019; Vedia-Jerez and Chasco 2016). Economic growth is widely assumed to be a highly complex concept influenced by a wide range of factors. Export growth is regarded as the most essential factor of economic growth, affecting every economy (Adedoyin et al. 2020). The key role of exports in promoting long-term economic growth has been one of the most divisive issues in the literature on economic growth, development, and trade over the last few decades, with little consensus among experts. Economic growth believers claim that increased exports and resultant gross domestic product (GDP) growth are essential to people's well-being through enhancing quality of life and increasing the economy's per capita GDP. Export growth is recognised as a significant component in increasing productivity in both emerging and developed economies. The export sector is not isolated from the rest of the economy; rather, it is considered an essential component of the entire economy's production process. Export expansion, according to economic theory, stimulates the production of goods and services through a variety of potential channels, including the diffusion of technical knowledge for efficient distribution of resources and higher output (Grossman and Helpman 1991), it has the potential to spur indirect economic growth by increasing export sector income and employment (Awokuse 2008), it improves efficiency by increasing competition and providing economies of scale (Helpman and Krugman 1985), it helps to reduce foreign exchange barriers and allows a special means of importing the necessary raw materials and capital goods, thus increasing capital formation (Balassa 1978; Grossman and Helpman 1991; McKinnon 1964), and as a result, the economy's domestic and export production is stimulated (Begum and Shamsuddin 1998; Esfahani 1991). The export-led growth (ELG) hypothesis is used to describe this tendency in the economic literature.

Governments support the ELG strategy to promote economic growth; however, is export growth driving Pakistan's economic growth or vice versa? The appropriate response to this question is to rely on causality testing, which has important policy implications for domestic policymakers seeking to implement appropriate growth policies. Although this is not a new topic, it is still a hotly debated topic among economists due to the uncertainty of the causality results. In this context, the economic literature generally focuses on four specific hypotheses, which are as follows: (a) the ELG hypothesis proposes that causality flows from exports to economic growth; (b) the growth-led export hypothesis suggests that causality runs from economic growth to exports; (c) the two-way causal hypothesis, which is a combination of (a) and (b); and (d) the neutrality hypothesis proposes that economic growth and exports are independent.

Foreign trade, according to Nurkse, is a growth engine. Foreign trade is critical for developing countries such as Pakistan. Increased exports generate more revenue, which facilitates more trade at the right time (Abdulai and Jacquet 2002;

Bhagwati 1988). Trade is also enviable and inescapable because countries must meet their economies' expanding requirements. South Asian economies, like many other emerging Asian nations, have had tremendous economic growth as a result of the ELG strategy, and their living standards have risen in the modern era (Din 2004; Liu et al. 2009; Shan and Sun 1998; Thangavelu and Rajaguru 2004).

1.1 Economic growth and export performance in Pakistan

Pakistan has implemented a number of policy changes to stimulate economic growth. Pakistan recognized the significance of trade from the start of its independence and began to establish trade relations with the rest of the globe. Since 1947, the Pakistan government has adopted a variety of measures to resolve trade imbalances. Pakistan relied on import substitution policies to encourage domestic industry and improve the balance of payments in the 1950s and 1960s. Pakistan, however, shifted its focus from import substitution to export promotion strategy in the 1970s, with promising results such as increased resource utilisation, a lower capital-output ratio, improved technology to increase labour productivity, a favourable balance of payments, and domestic market expansion (Afzal 2006). In the late 1980s, however, Pakistan expanded its export-led growth strategy even further. Pakistan's exports increased significantly in the first half of the 1990s. The imposition of economic sanctions on Pakistan as a result of the nuclear test, the global economic recession, and the leaf curl virus was all factors that led to low export growth in the latter half of the 1990s. During the 1990s, the composition of exports changed dramatically. The share of primary exports fell, while semi-finished and finished goods export grown exponentially. Between 2005 and 2015, Pakistan's economy faced various challenges, including poor GDP growth, energy restrictions, the war on terror, a budget deficit, and a weak industrial base. In the strategic trade policy framework 2009–2015, the government of Pakistan has made many initiatives to promote exports. Pakistan's exports climbed 54% from US $ 16.05 billion in 2005 to US $ 24.71 billion in 2014 (NTC 2015). However, exports fell precipitously in subsequent years. The main reasons for the drop in exports were a drop in global demand, high production costs, energy shortages, and outdated technology (GOP 2019). Despite this, Pakistan has made every effort to keep exports on track, recognising that an export-led growth strategy is the country's future. The effective exchange rate, export refinancing scheme, refunds to exporters and industrialists, and tariff rationalisation on inputs are the most notable steps (GOP 2020). Pakistan's exports are now well-defined and targeted at a variety of markets.

As indicated in Table 1, Pakistan's real GDP increased at an acceptable pace of 5.0% over the last 48 years (IMF, International Financial Statistics). The average real GDP growth rate was 6.4%, the highest since the 1980s. In all other eras, however, it was close to 5.0%. In contrast, Pakistan's real exports of goods and services increased at a 5.0% annual pace from 1973 to 2020. Exports increased at an average rate of 5.2% from 1973 to 1979, 9.8% in the 1980s, the highest for the entire time, and 5.5% in the 1990s, while exports fell at an average rate of 2.7% to 2.3% in the 2000s and 2010s, respectively.

Table 1 Growth rates of real GDP and exports of goods and services. *Source*: IMF, International Financial Statistics Database Authors' estimates

Periods	GDP growth rate (%)	Exports growth rate (%)
1973–1979	5.2	5.2
1980s	6.4	9.8
1990s	4.5	5.5
2000s	4.7	2.7
2010s	3.9	2.3
1973–2020	5.0	5.0

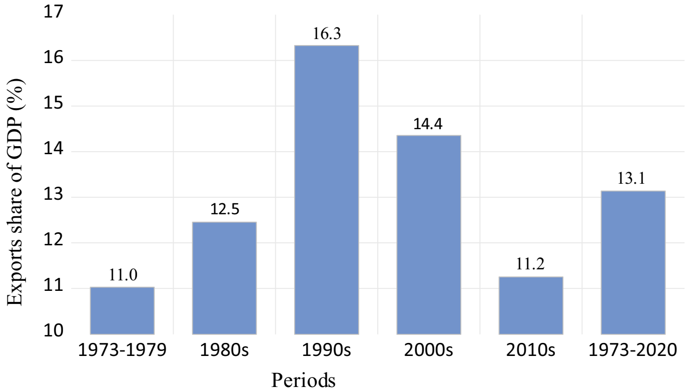

Fig. 1 Importance of exports of goods and services. *Source*: Authors' estimations based on data from IMF, International Financial Statistics database

As can be seen in Fig. 1, Pakistan's average share of exports of goods and services in GDP gradually climbed from 11.0% in 1973–1979 to 12.5% in the 1980s. However, it peaked at 16.3% in the 1990s and 14.4% in the 2000s, while it averaged 13.1% from 1973 to 2020. This demonstrates that exports have been critical to Pakistan's economic progress.

Accordingly, the primary objective of the study is to empirically investigate the asymmetric and causal relationship between exports and economic growth in Pakistan from 1973 to 2020, in order to propose relevant policy options for increasing and maintaining long-term economic growth. The present study adds to the literature in several ways: First, we examine the asymmetric effects of exports on economic growth by using the nonlinear or asymmetric autoregressive distributed lag (NARDL) method suggested by (Shin et al. 2014) in the presence of a structural break. There has been little research on the nexus between export growth and economic growth in Pakistan thus far. To the best of the authors' knowledge, no research study has been done to examine the negative and positive effects of exports on economic growth in general or in Pakistan specifically. In addition, we examine the ELG hypothesis using an appropriate theoretical framework to supplement our investigation. Second, the study investigates the influence of human and physical capital on economic growth. Third, it incorporates imports as a growth-enhancing element that had hitherto been overlooked in Pakistani research to prevent specification bias. Fourth, in terms of methodology, we use multiple unit root tests to decide order of integration, including the PP test proposed by Phillips and Perron (1988), the ADF test developed by Augmented Dickey and Fuller (1979), the ZA test developed by Zivot and Andrews (1992) with a structural break, the Lee and Strazicich test proposed by Lee and Strazicich (2003) with two structural breaks, BDS test developed by Broock et al. (1996) to check nonlinearity, and the increasingly popularised asymmetric ARDL estimation technique for determining long-and-short run asymmetries in the variables. Finally, is the ELG hypothesis true or false in the case of Pakistan? The Toda–Yamamoto Granger causality testing method is used to investigate asymmetric and non-asymmetric causality between the variables in order to explore this answer. The results will shed light on the relations between export growth and economic growth in general. The findings, which will include an assessment of non-linear interactions, are expected to be more robust and will benefit policymakers and practitioners in designing export promotion policies, as policymakers rely on the literature, systematic research, and unambiguous evidence to build their policies.

The following sections comprise the remainder of the paper: Sect. 2 presents a literature review, Sect. 3 describes and discusses the research methodology, Sect. 4 reports and explains the empirical findings and discussion, and Sect. 5 presents the conclusion with policy implications and future research recommendations.

2 Literature review

The importance of exports as a growth engine has been a source of ongoing debate in the literature on economic growth. Trade fosters economic growth by making use of excess exports (Smith 1776), comparative advantage (Ricardo 1817), and specialisation based on their factor endowments (Heckscher and Ohlin 1991). The underlying idea of these theories is that increasing foreign trade leads to better resource allocation, international competitiveness, and higher productivity, all of which contribute to higher economic growth. However, these theories do not explain why and how international trade drives long-term economic growth.

2.1 The export-led growth (ELG) hypothesis

The role of exports in economic growth has piqued the interest of economists attempting to explain the disparity in economic growth rates between countries. Several empirical studies have shown that the positive effects of exports on economic growth are significant (Ali and Li 2017; Balassa 1978; Parida and Sahoo 2007; Shahbaz et al. 2011; Siddiqui et al. 2008; Tang and Abosedra 2019), while some other studies found the opposite (Debnath et al. 2014; Dreger and Herzer 2013; Lee and Huang 2002; Quaicoe et al. 2017). Several prior research studies investigated the link between exports and economic growth using ordinary least squares (OLS) method cross-sectional data, time-series data, and regression equations based on the neoclassical production function. These studies discovered a positive relationship between economic growth and exports (Balassa 1978, 1985; Feder 1983; Fosu 1990; Heller and Porter 1978; Kavoussi 1984; Kravis 1970; Krueger 1978; Michaely 1977; Moschos 1989; Ram 1987; Salvatore and Hatcher 1991; Sheehey 1992; Tyler 1981). However, this group of studies has been criticized on various grounds; for instance, earlier studies found plausible results based on a simple bivariate correlation coefficient. If this correlation coefficient is positive, it means that the ELG hypothesis is valid. But, a significant positive relationship does not represent causality unless it is tested (Ghatak and Price 1997). This was a major flaw in these studies (Choong et al. 2005; Lussier 1993; Moosa 1999; Shirazi and Manap 2004). Further, cross-sectional studies assumed a homogeneous production function based on a shared economic, political, and financial structure, which is incorrect (Federici and Marconi 2002; Huang and Wang 2007; Shirazi and Manap 2004). Time-series studies, on the other hand, used non-stationary data; thus, their conclusions will be spurious as well. However, the direction of causality between exports and economic growth was largely overlooked in these analyses. In response to these concerns, another group of studies investigated the causality between economic growth and exports, employing Granger (1969) or Sims (1972) causality tests, for instance (Bahmani-Oskooee et al. 1991; Chow 1987; Ghatak and Price 1997; Jung and Marshall 1985; Mei-chu 1987; Riezman et al. 1996). It is important to remember that both the integration order and the presence of cointegration are necessary before carrying out causality tests. Otherwise, it produces false findings, which is this method's principal disadvantage. In light of these considerations, various studies have used cointegration and causality methodologies to analyse the link between economic growth and exports. Most of these studies reach this conclusion that the causality is from exports to economic growth, and hence, export growth leads to economic growth, see, for instance (Abdulai and Jacquet 2002; Abual-Foul 2004; Agrawal 2015; Al Mamun and Nath 2005; Awokuse 2003, 2008; Choong et al. 2005; Jordaan and Eita 2007; Kim et al. 2020; Roshan 2007; Shan and Tian 1998; Siliverstovs and Herzer 2006). Other research studies, on the other hand, believe that economic growth causes exports or that there is a two-sided causality between GDP growth and exports (Awokuse 2005; Awokuse 2006; Balaguer and Cantavella-Jorda 2004; Chaudhary et al. 2007; Chen 2007; Chuang 2000; Dhawan and Biswal 1999; Ghatak and Price 1997; Henriques and Sadorsky 1996; Hye 2012; Kalaitzi and Cleeve 2018; Mahadevan 2007). Despite this fact, some studies have found no direct association between exports and economic growth (Abu-Qarn and Abu-Bader 2004; Shan and Sun 1998; Sharma and Panagiotidis 2005; Tang 2006).

Recent research studies have employed time-series methods to eliminate issues and errors found in previous studies. Advanced multivariate cointegration and causality techniques, as well as augmented production functions, are used in these studies (Adedoyin et al. 2020; Ali and Li 2017; Kalaitzi and Chamberlain 2020, 2021;

Tang and Abosedra 2019). Therefore, better and more sophisticated standard techniques are necessary to produce reliable results for the ELG hypothesis.

2.2 Pakistan's case

In Pakistan, few research studies have been done to examine the relationship between economic growth and exports, but their findings are disparate and contradictory. For example, Afzal and Hussain (2010), Akbar and Naqvi (2000) discovered the absence of cointegration, while Shirazi and Manap (2004), Hye and Siddiqui (2011), and Ali and Li (2017) found the presence of cointegration between exports and economic growth. Export growth helps to economic growth in a positive way (Aurangzeb 2006; Azam 2011; Bashir et al. 2015; Parida and Sahoo 2007; Quddus and Saeed 2005; Shahbaz et al. 2011; Siddiqui et al. 2008). The validity of the ELG hypothesis has been confirmed by some empirical studies in Pakistan(Bahmani-Oskooee 1993; Bashir et al. 2015; Din 2004; Ekanayake 1999; Khan et al. 1995; Saleem and Sial 2015; Shahbaz et al. 2011; Siddiqui et al. 2008; Tang and Abosedra 2019), while Jung and Marshall (1985) found a one-way causality from economic growth to exports. However, Hutchison and Singh (1992), Ahmed et al. (2000), Akbar and Naqvi (2000), Love and Chandra (2005), Quddus and Saeed (2005), Hye et al. (2013), all disagreed with the ELG hypothesis's validity. Lastly, Shirazi and Manap (2004) focussed on imports and discovered bidirectional causality between economic growth and imports. In contrast, Akbar and Naqvi (2000) found that imports have no substantial impact on Pakistan's economic growth. In brief, the differences in results may be attributed to variable selection, lag length selection, time analysed, and estimating techniques utilised.

Despite all this debate, the economic literature paints a disparate picture of exports–economic growth relationship, and that is why there is little consensus among researchers on this issue. According to Perron (1989), if time series variables are encountered a structural break and are ignored, then standard stationary tests can produce biased estimates. Furthermore, structural breaks in unit root testing methods have been ignored in Pakistani studies. Gregory et al. (1996) argue that if the structural break is ignored, when evidence is available to support its existence, then it is wrong to accept null hypothesis of no cointegration. It can lead to results, but it is not accurate. Evaluating a relationship that has potentially asymmetric with symmetric methods seems unfair and may lead someone to some seriously inappropriate policy consequences(Enders 2015). To address these issues, this research study examines the asymmetric effects of exports on GDP growth, with a particular emphasis on the possibility of structural breaks in the sample data. It is widely acknowledged that economic growth is a highly complex process that is influenced by a wide range of other factors (Adedoyin et al. 2020). Therefore, imports and human capital, which were excluded in previous studies, are now incorporated in the growth model. Finally, the Toda and Yamamoto Granger causality test is performed to explore long-term symmetric and asymmetric causality between the variables to verify the ELG hypothesis.

3 Research methodology

3.1 Model specification

A Cobb–Douglas function with exports and imports is used to analyse the nexus between economic growth and exports. Exports are incorporated into the production function by following Balassa (1978) and Siliverstovs and Herzer (2006), while imports are included in the model by following Esfahani (1991) and Riezman et al. (1996). Imports of capital goods, in particular, can be viewed as inputs to both exports and domestic production; thus, excluding imports from the model produces a misspecification problem, leading to erroneous conclusions regarding the link between economic growth and exports (Abu-Qarn and Abu-Bader 2004; Shan and Sun 1998; Shan and Tian 1998). Moreover, imports are seen as a major source of production know-how and foreign technology knowledge, which boosts GDP growth (Grossman and Helpman 1991). The labour force can perform more efficiently and effectively with more education, training, knowledge, and skills (Rogers 2003). They become more innovative and modern. As a result, human capital can act as a factor of production and have a positive impact on other factors of production. Human capital not only aids in the creation of new capital stock but also enhances the economy's attraction to new technologies (Lopez-Bazo and Moreno 2008). New or endogenous growth theory postulates that both physical and human capital together represent increasing returns to scale (Hossain and Karunaratne 2004; Hye and Lau 2015; Mankiw et al. 1992). Therefore, this study incorporates human capital into the production function with other inputs rather than ordinary labour force. The study assumes that aggregate production of the economy can be specified as a function of human capital, physical capital, imports, and exports as suggested by Kalaitzi and Chamberlain (2020), Kalaitzi and Chamberlain (2021), and Kalaitzi and Cleeve (2018):

$$Y_t = A_t \mathrm{HK}_t^{\alpha_1}, K_t^{\alpha_2} \tag{1}$$

where Y_t is the output of the country at time t, A_t means total factor productivity, HK_t is human capital at time t, and K_t represents physical capital stock at time t. The constants α_1 and α_2 measure the impact of human capital and physical capital on aggregate output. Total factor productivity, as previously stated, is assumed to be a function of exports (X_t), imports (M_t), and other exogenous factors (C_t) to investigate the relationship between exports and economic growth.

$$A_t = f(X_t, M_t, C_t) = X_t^{\alpha_3} M_t^{\alpha_4} C_t \tag{2}$$

Combining Eqs. (1) and (2), the following is obtained:

$$Y_t = C_t \mathrm{HK}_t^{\alpha_1}, K_t^{\alpha_2}, X_t^{\alpha_3}, M_t^{\alpha_4} \tag{3}$$

where α_1, α_2, α_3, and α_4 are the partial elasticities of HK_t, K_t, X_t, and M_t, respectively. The following double logarithm model is used for estimation:

$$\ln Y_t = \alpha_0 + \alpha_1 \ln(\mathrm{HK}_t) + \alpha_2 \ln(K_t) + \alpha_3 \ln(X_t) + \alpha_4 \ln(M_t) + \varepsilon_t \quad (4)$$

where all coefficients are constant elasticities, subscript t represents the year,α_0 is the constant, notation 'ln' stands for natural logarithm, and ε_t is the error term.

This study makes use of the latest annual time series data from 1973 to 2020, sourced from the Pakistan Economic Survey (different issues)(PES), the Pakistan Bureau of Statistics (PBS), and the International Financial Statistics (IFS) database, based on the availability of reliable data. The data collection includes observations on human capital[1] (HK_t), real gross fixed capital formation[2] (K_t), exports of goods and services (X_t), imports of goods and services (M_t), and real GDP (Y_t) as a proxy of economic growth. To get figures in real terms, the GDP deflator (2010 = 100) is utilized. These variables are converted into natural logarithmic forms, which allow the coefficients to be represented as elasticities. Figure 2 shows log-transformed data plots with years and logarithmic values of the variables on the horizontal and vertical axes, respectively.

3.2 Estimation strategy

The stationary properties are tested before performing the cointegration test to ensure the integration order of variables. ADF and PP tests, which are both widely used unit root tests, are employed for this purpose. However, when the data contain structural breaks, these unit root tests perform poorly. Since, the time series has been subjected to a number of shocks (e.g. fiscal crisis, policy changes, and structural changes). These shocks/structural breaks are not detected by the PP and ADF unit root tests (Lee and Chang 2005; Shahbaz et al. 2015). In general, if a single structural break in a series of level data is suspected, the ZA unit root test is considered a more sophisticated test because it yields more reliable results regardless of whether the break point is determined endogenously or is unknown, and thus, it is used in this analysis. Another potential benefit of using a single structural break unit root test is that it is closely related to the cointegration process between the level series (Mahalik et al. 2017; Shahbaz et al. 2016). Furthermore, we may not be able to determine the true nature of stationarity behaviour in the level series unless we effectively capture the structural break originating in the time level series data. Plots of time series variables also suggest that the data may have structural breaks in trend (see please,

[1] Graduates of higher education are more likely to promote technology and innovation (Maneejuk and Yamaka 2021) and to be more capable of learning on the job/working (Lucas 1993). Higher education assists the country move to a knowledge-based economy by providing the labour market with highly trained and qualified people, which ultimately stimulates economic growth (Maneejuk and Yamaka 2021). As a result, the study selects higher education as an indicator of human capital, following Akinlo (2004),Cheng and Hsu (1997), Chuang (2000), Pahlavani et al. (2005), and Maneejuk and Yamaka (2021). Furthermore, we measure the stock of human capital per worker by dividing the number of students enrolled in universities by the total labour force, as Cheng and Hsu (1997) do.

[2] We use real gross fixed capital formation as a proxy for physical capital due to difficulties in measuring physical stock of capital and unavailability of data (i.e., depreciation rate and initial base year for physical capital stock).

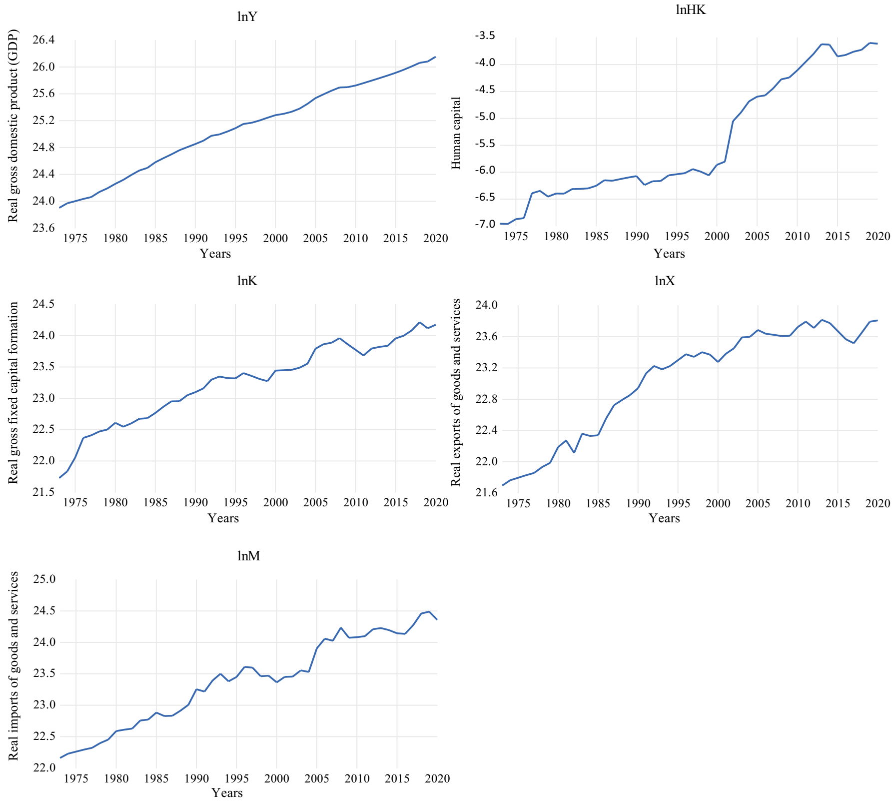

Fig. 2 Patterns of time series variables, 1973–2020. *Source*: Gross domestic product, exports and imports of goods and services, and gross fixed capital formation are taken from the IFS database, while human capital is obtained from PES and PBS databases

Fig. 2). However, because the data may contain multiple structural breaks, we also use the Lee and Strazicich unit root test, which accounts for two breaks in the time series (Lee and Strazicich 2003), to ensure that our results are robust.

3.2.1 The asymmetric (nonlinear) ARDL approach

To capture the possible asymmetries and non-asymmetries that arise from positive and negative shocks in exports, we employ a nonlinear ARDL cointegration approach, which is an asymmetric version of the linear ARDL method proposed by Pesaran and Shin (1998) and Pesaran et al. (2001). The non-linear ARDL method divides the regressors into negative and positive partial sums, capturing the asymmetric relationship between the regressors and regressand. It also looks into the possibility of asymmetric cointegration between the variables (Fousekis et al. 2016). This technique has several advantages over other cointegration methods, including the following: (i) it captures short-and-long-run asymmetries among variables, (ii) it allows testing for hidden cointegration proposed by Granger and Yoon (2002), (iii) it is a suitable technique for a small sample size (Katrakilidis and Trachanas 2012), (iv) it is not necessary that all series have the same integration order, it can be stationary at the first difference or the level. This is one of the most significant advantages of ARDL and non-linear ARDL over more traditional cointegration methods like Johansen (1988), Engle and Granger (1987), Johansen and Juselius (1990), Johansen (1991), which require all variables to be $I(1)$ processes.[3] It does not work, however, if the variables are stationary at integrated of order two (Hoang et al. 2016; Yeap and Lean 2017), and lastly, it also develops an asymmetric cumulative dynamic multiplier that detects the dynamics adjustment pattern from initial equilibrium to the new equilibrium.

Several empirical studies have used the nonlinear ARDL approach to determine whether increasing or decreasing in regressors has different effects on regressand (Aladejare 2019; Ali et al. 2018; Fousekis et al. 2016; Hoang et al. 2016; Kisswani 2019a, 2019b; Mihajlovic and Marjanovic 2020; Udeagha and Ngepah 2021). Based on these investigations, we develop and estimate a nonlinear model to consider the potential asymmetrical effects of exports on Pakistan's GDP growth. Linear Eq. (4) is transformed into asymmetric Eq. (5) by incorporating their positive and negative partials as shown below:

$$\ln Y_t = \alpha_0 + \alpha_1 \ln(\mathrm{HK}_t) + \alpha_2 \ln(K_t) + \alpha_3 \ln(X_t^+) + \alpha_4 \ln(X_t^-) + \alpha_5 \ln(M_t) + e_t \quad (5)$$

where α_3 and α_4 are the coefficients of positive and negative partial sums of exports. The independent variable that is $\ln X_t$, in particular, is decomposed into its positive and negative partial sums as follows:

$$\ln X_t^+ = \sum_{j=1}^{t} \Delta \ln X^+ = \sum_{j=1}^{t} \mathrm{MAX}(\Delta \ln X_j, 0) \quad (6)$$

$$\ln X_t^- = \sum_{j=1}^{t} \Delta \ln X^- = \sum_{j=1}^{t} \mathrm{MIN}(\Delta \ln X_j, 0) \quad (7)$$

The partials sums of positive and negative change in exports $\ln X_t^+$ and $\ln X_t^-$ are then incorporated into the basic ARDL model to estimate long-and-short run asymmetries. Following Shin et al. (2014),the general form of nonlinear ARDL (unrestricted error correction model) is as follows:

[3] Apart from that, the Johansen's cointegration approach has some drawbacks, inculding (i) faililing to account for structural breaks and nonlinearity in time-series data (Dogan 2016; Nusair and Al-Khasawneh 2022), (ii) working best with large sample sizes (Iqbal et al. 2022), and (iii) providing no information about the short run dynamics (Sahoo et al. 2016; Shahbaz et al. 2016). This also demonstrates why the asymmetric ARDL approach outperforms these traditional methods.

$$\Delta \ln Y_t = \delta_0 + \delta_1 \ln Y_{t-1} + \delta_2 \ln HK_{t-1} + \delta_3 \ln K_{t-1} + \delta_4 \ln X^+_{t-1} + \delta_5 \ln X^-_{t-1} + \delta_6 \ln M_{t-1} + \sum_{i=1}^{m} \alpha_{1i} \Delta \ln Y_{t-i} + \sum_{i=0}^{n} \alpha_{2i} \Delta \ln HK_{t-i} + \sum_{i=0}^{s} \alpha_{3i} \Delta \ln K_{t-i} + \sum_{i=0}^{v} (\alpha^+_{4i} \Delta \ln X^+_{t-i} + \alpha^-_{4i} \Delta \ln X^-_{t-i}) + \sum_{i=0}^{q} \alpha_{5i} \Delta \ln M_{t-i} + \delta_D \mathrm{DUM}_t + \varepsilon_t \tag{8}$$

where Δ is the first difference operator, δ_0 is the constant term, m, n, s, v, and q represent the optimum lags[4] for the regressors and regressand, and ε_t is the white noise error term. The dummy variable DUM_t, which is also included in the asymmetric ARDL F-test equation, is utilised to capture the influence of the structural break date.[5] The long-run coefficients $\gamma_1^+ = -\frac{\delta_4}{\delta_1}$ and $\gamma_1^- = -\frac{\delta_5}{\delta_1}$, respectively, will show the long-run effects of positive and negative changes in exports on economic growth. Likewise, $\sum_{i=0}^{v} \alpha^+_{4i}$ and $\sum_{i=0}^{v} \alpha^-_{4i}$ represent the short-run effects of positive and negative changes in exports on economic growth, respectively. Therefore, the structure of Eq. (8) describes the asymmetric long-and-short run effects of exports on economic growth.

To test the existence of asymmetric cointegration[6] among variables, Shin et al. (2014) employ the bounds testing approach developed by Pesaran et al. (2001), which considers all lagged levels of variables. For this purpose, the standard Wald (F-statistic) is used to test the null hypothesis of no asymmetric cointegration ($H_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$) against the alternative hypothesis of the presence of asymmetric cointegration if at least one of the delta(s) is not equal to 0. In this regard, Pesaran et al. (2001) provide a pair of critical boundaries (say, upper and lower) values when the variables are either $I(0)$ or $I(1)$. The critical values for the lower bound assume that all variables are $I(0)$, whereas the critical values for the upper bound assume that all variables are $I(1)$. If the calculated F-statistic value is greater than the upper critical bound value, the null hypothesis is rejected, and we can conclude that asymmetric cointegration exists and vice versa. Finally, if the same calculated F-value is found between the lower and upper critical bound values, cointegration choice is inconclusive (Narayan 2005; Pesaran et al. 2001). Equation (8) can be rewritten to include the error correction term (ECM) to describe the short-run dynamics and consistency of the long-run parameters as follows:

[4] The Akaike information criterion (AIC) is used to determine optimum lags because of its superior explanatory power.

[5] The ZA unit root test is used to justify the use of a dummy variable, which assumes that the dependent variable (economic growth) series has one structural break. According to Pesaran et al. (2001), incorporating a dummy variable (1-0) has no effect on the conclusions drawn about cointegration among variables. The dummy variable has a value of 1 for the years 1982-2019 and a value of 0 for the rest of the time. In addition, 1982 marked the end of nationalisation and military dictatorship in Pakistan, as well as a rise in economic activity.

[6] See, for example, Al Mamun et al. (2016), Shahbaz et al. (2017), Fareed et al. (2018), Meo et al. (2018), Baz et al. (2019), Kocaarslan and Soytas (2019), Naseem et al. (2020), Rehman et al. (2020), Udeagha and Ngepah (2020), Majeed et al. (2021), Okere et al. (2021), Yusuf and Mohd (2021), and Eregha (2022), who investigate asymmetric cointegration in the presence of a structural break using the asymmetric or non-linear ARDL approach.

$$\Delta \ln Y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_{1i}\Delta \ln Y_{t-i} + \sum_{i=0}^{n} \alpha_{2i}\Delta \ln HK_{t-i} + \sum_{i=0}^{s} \alpha_{3i}\Delta \ln K_{t-i} + \sum_{i=0}^{v} (\alpha_{4i}^{+}\Delta \ln X_{t-i}^{+} + \alpha_{4i}^{-}\Delta \ln X_{t-i}^{-}) + \sum_{i=0}^{q} \alpha_{5i}\Delta \ln M_{t-i} + \eta ECT_{t-1} + \varepsilon_t \quad (9)$$

where ECM_{t-1} is the error correction term, and η represents the coefficient of ECM_{t-1}. The annual speed of adjustment towards long-run equilibrium is shown by the value of the lagged error correction term. Besides that, once cointegration is established, we use the standard Wald test to test for long-and-short run asymmetries (Shin et al. 2014). For long-run asymmetry, if the null hypothesis of symmetry $H_0 : \gamma_1^{+} = \gamma_1^{-}$ against the alternative hypothesis of asymmetry $H_1 : \gamma_1^{+} \neq \gamma_1^{-}$ is rejected, the long-run asymmetrical effects of exports on economic growth are recognised, where the long-run positive and negative coefficients are given by $\gamma_1^{+} = -\frac{\delta_4}{\delta_1}$, $\gamma_1^{-} = -\frac{\delta_5}{\delta_1}$, respectively. Similarly, the short-run asymmetry requires that the sum of the short-run coefficients estimates of $\Delta \ln X_{t-i}^{+}$ and $\Delta \ln X_{t-i}^{-}$ are statistically different, that is, if $\sum_{i=0}^{v} \alpha_{4i}^{+} \neq \sum_{i=0}^{v} \alpha_{4i}^{-}$ in Eq. (8). The next step is to evaluate the asymmetric cumulative dynamic multiplier effects of a 1% change in $\ln X_t^{+}$ and $\ln X_t^{-}$ on economic growth, which can be obtained as follows:

$$m_h^{+} = \sum_{j=0}^{h} \partial \ln Y_{t+j} / \partial \ln X_{t-1}^{+} \text{ and } m_h^{-} = \sum_{j=0}^{h} \partial \ln Y_{t+j} / \partial \ln X_{t-1}^{-}, h = 0, 1, 2, ... \quad (10)$$

Note: $h \rightarrow \infty$, $m_h^{+} \rightarrow \gamma_1^{+}$, and $m_h^{-} \rightarrow \gamma_1^{-}$, where $\gamma_1^{+} = -\frac{\delta_4}{\delta_1}$ and $\gamma_1^{-} = -\frac{\delta_5}{\delta_1}$ are the asymmetric long-run coefficients (Shin et al. 2014), as defined above. It shows the asymmetric reaction of regressor ($\ln X_t$) into their corresponding shocks ($\ln X_t^{+}$ and $\ln X_t^{-}$) in the regressand ($\ln Y_t$).

3.2.2 Long-run Granger causality test (Toda–Yamamoto procedure)

The presence of cointegration in a nonlinear ARDL model does not reveal anything about the direction of causal relationship between the variables. The use of a causality test is required for this purpose. Toda and Yamamoto (1995) developed a method for determining the direction of a variable cause-and-effect relationship. The technique does not necessitate any complex pre-testing procedures and is quite simple to implement. The key advantage of this technique over other traditional causality tests is that it can explore causality whether the underlying variables are $I(0)$, $I(1)$, or $I(2)$, and whether or not they are cointegrated. The approach developed by Toda and Yamamoto (1995) employs a modified Wald (MWALD) test with an asymptotic χ^2 distribution. This approach consists of three major steps: First, a level VAR is estimated to establish the best lag length (i.e. n). Second, it determines the maximum possible integration order ($d_{\max}$) of the variables in the system. Lastly, a level

VAR model with additional d_{max} lags is re-estimated and becomes VAR $(n+d_{max})$.[7] Using insights from Aladejare (2019), Hatemi-j (2012), Kisswani (2019a), Kisswani (2019b), and Mihajlovic and Marjanovic (2020), we investigate the asymmetric and non-asymmetric causality between economic growth, exports, imports, physical capital, and human capital, including the partial sums of positive and negative changes in exports specified in Eqs. (6 and 7) in the augmented VAR system developed by Toda and Yamamoto (1995). We extend Eq. (5) for the analysis of asymmetric and non-asymmetric causality by using the Toda and Yamamoto technique in the following VAR model:

$$\begin{aligned}\ln Y_t = \alpha_{10} + \alpha_{1i}\sum_{i=1}^{n+d\max} \ln Y_{t-i} + \alpha_{2i}\sum_{i=1}^{n+d\max} \ln HK_{t-i} + \alpha_{3i}\sum_{i=1}^{n+d\max} K_{t-i} \\ + \alpha_{4i}\sum_{i=1}^{n+d\max} X^{+}_{t-i} + \alpha_{5i}\sum_{i=1}^{n+d\max} X^{-}_{t-i} + \alpha_{6i}\sum_{i=1}^{n+d\max} M_{t-i} + \varepsilon_{1t}\end{aligned} \tag{11}$$

$$\begin{aligned}\ln HK_t = \beta_{20} + \beta_{1i}\sum_{i=1}^{n+d\max} \ln HK_{t-i} + \beta_{2i}\sum_{i=1}^{n+d\max} \ln Y_{t-i} + \beta_{3i}\sum_{i=1}^{n+d\max} K_{t-i} \\ + \beta_{4i}\sum_{i=1}^{n+d\max} X^{+}_{t-i} + \beta_{5i}\sum_{i=1}^{n+d\max} X^{-}_{t-i} + \beta_{6i}\sum_{i=1}^{n+d\max} M_{t-i} + \varepsilon_{2t}\end{aligned} \tag{12}$$

$$\begin{aligned}\ln K_t = \gamma_{30} + \gamma_{1i}\sum_{i=1}^{n+d\max} \ln K_{t-i} + \gamma_{2i}\sum_{i=1}^{n+d\max} \ln Y_{t-i} + \gamma_{3i}\sum_{i=1}^{n+d\max} HK_{t-i} \\ + \gamma_{4i}\sum_{i=1}^{n+d\max} X^{+}_{t-i} + \gamma_{5i}\sum_{i=1}^{n+d\max} X^{-}_{t-i} + \gamma_{6i}\sum_{i=1}^{n+d\max} M_{t-i} + \varepsilon_{3t}\end{aligned} \tag{13}$$

$$\begin{aligned}\ln X^{+}_t = \delta_{40} + \delta_{1i}\sum_{i=1}^{n+d\max} \ln X^{+}_{t-i} + \delta_{2i}\sum_{i=1}^{n+d\max} \ln Y_{t-i} + \delta_{3i}\sum_{i=1}^{n+d\max} HK_{t-i} \\ + \delta_{4i}\sum_{i=1}^{n+d\max} K_{t-1} + \delta_{5i}\sum_{i=1}^{n+d\max} X^{-}_{t-i} + \delta_{6i}\sum_{i=1}^{n+d\max} M_{t-i} + \varepsilon_{4t}\end{aligned} \tag{14}$$

$$\begin{aligned}\ln X^{-}_t = \phi_{50} + \phi_{1i}\sum_{i=1}^{n+d\max} \ln X^{-}_{t-i} + \phi_{2i}\sum_{i=1}^{n+d\max} \ln Y_{t-i} + \phi_{3i}\sum_{i=1}^{n+d\max} HK_{t-i} \\ + \phi_{4i}\sum_{i=1}^{n+d\max} K_{t-1} + \phi_{5i}\sum_{i=1}^{n+d\max} X^{+}_{t-i} + \phi_{6i}\sum_{i=1}^{n+d\max} M_{t-i} + \varepsilon_{5t}\end{aligned} \tag{15}$$

[7] We use d_{max} is equal to one because it outperforms other orders of d_{max} (Dolado and Lutkepohl 1996).

Table 2 Descriptive statistics, 1973–2020. *Source*: Authors' calculations

	$\ln Y_t$ Economic growth	$\ln HK_t$ Human capital	$\ln K_t$ Physical capital	$\ln X_t$ Exports	$\ln M_t$ Imports
Mean	25.0921	−5.4165	23.2532	23.0447	23.3877
Maximum	25.1604	−6.0284	23.3350	23.3201	23.4537
Minimum	26.1533	−3.5986	24.2144	23.8152	24.4886
SD	23.9015	−6.9607	21.7292	21.6963	22.1623
Skewness	0.6676	1.1260	0.6357	0.6938	0.6980
Kurtosis	−0.1961	0.4592	−0.5139	−0.6792	−0.1646
Jarque–Bera	1.8627	1.6289	2.4722	1.9810	1.8113
Probability	2.8945	5.4464	2.6699	5.7671	3.0423

Table 3 ADF and PP unit root tests results

Variables	ADF			PP		
	At level	First difference	Decision	At level	First difference	Decision
$\ln Y_t$	−1.9494	−5.1782***	$I(1)$	−1.8195	−5.2360***	$I(1)$
$\ln HK_t$	−0.0325	−6.0046***	$I(1)$	−0.0734	−6.0004***	$I(1)$
$\ln K_t$	−2.7195*	−5.4526***	$I(1)$	−2.6246*	−5.4393***	$I(1)$
$\ln X_t$	−2.0102	−6.4634***	$I(1)$	−2.0958	−6.4571***	$I(1)$
$\ln M_t$	−0.0970	−7.0454***	$I(1)$	−1.1055	−7.0490***	$I(1)$

***, **, and * represent a level of significance of 1%, 5%, and 10%, respectively

$$\begin{aligned}\ln M_t = \eta_{60} + \eta_{1i} \sum_{i=1}^{n+d\max} \ln M_{t-1} + \eta_{2i} \sum_{i=1}^{n+d\max} \ln Y_{t-i} + \eta_{3i} \sum_{i=1}^{n+d\max} HK_{t-i} \\ + \eta_{4i} \sum_{i=1}^{n+d\max} K_{t-1} + \eta_{5i} \sum_{i=1}^{n+d\max} X_{t-i}^{+} + \eta_{6i} \sum_{i=1}^{n+d\max} X_{t-i}^{-} + \varepsilon_{6t}\end{aligned} \tag{16}$$

where '*n*' represents the optimum lag length, d_{max} represents the highest possible integrated order of the variables in the model, and $\varepsilon_{1t} \rightarrow \varepsilon_{6t}$ are the error terms. Since this test is run under an unrestricted VAR system, the model includes an intercept.

4 Empirical findings and discussion

The descriptive statistics for the variables employed in this investigation are shown in Table 2. Economic growth and exports have mean values of 25.0921 and 23.0447, respectively, demonstrating the importance of these variables. Furthermore, with the exception of human capital, the mean and standard deviation values of all variables are uniform and close to each other. Except for human capital, all variables

Table 4 ZA unit root test results

Variables	Level		First difference		Decision
	T-statistic	Break year	T-statistic	Break year	
$\ln Y_t$	−2.9246	1982	−5.7448***	1993	I(1)
$\ln HK_t$	−6.0169***	2002	−7.3468***	2000	I(1)
$\ln K_t$	−4.6284	2009	−6.0568***	2012	I(1)
$\ln X_t$	−3.3678	1986	−7.1302***	1993	I(1)
$\ln M_t$	−3.3074	1998	−7.2263***	2005	I(1)

***, **, and * denote a level of significance of 1%, 5%, and 10%, respectively

Table 5 Lee and Strazicich unit root test results

Variables	Level		First difference		Decision
	Crash model		Crash model		
	T-statistic	Break years	T-statistic	Break years	
$\ln Y_t$	−1.6894	1977,1984	−4.4154***	1977,1980	I(1)
$\ln HK_t$	−2.1898	1978,2003	−6.1077***	1977,1980	I(1)
$\ln K_t$	−2.1740	1979,1998	−6.1459***	1977, 2008	I(1)
$\ln X_t$	−1.9564	1982,2011	−5.3067***	1977,1979	I(1)
$\ln M_t$	−3.2915	1989,2005	−6.0181***	1977,1985	I(1)

***, **, and * denote a level of significance of 1%, 5%, and 10%, respectively

Table 6 Nonlinearity BDS test results

Variables	$m=2$	$m=3$	$m=4$	$m=5$	$m=6$
$\ln Y_t$	0.2021***	0.3439***	0.4439***	0.5180***	0.5712***
$\ln HK_t$	0.1851***	0.3032***	0.3780***	0.4552***	0.4520***
$\ln K_t$	0.1970***	0.3365***	0.4334***	0.5034***	0.5551***
$\ln X_t$	0.1989***	0.3368***	0.4357***	0.5040***	0.5513***
$\ln M_t$	0.1898***	0.3199***	0.4117***	0.4772***	0.5230***

*** shows the rejection of the null hypothesis of linearity at a 1% significance level

are negatively skewed, indicating asymmetric distributions. The findings of the Jarque–Bera test confirm that the associated variables have a normal distribution with no outliers, indicating that the data are suitable for further empirical research.

4.1 Unit root testing without and with structural breaks

It is critical to check the integration order of variables before performing any cointegration tests. For that purpose, the ADF and PP unit root tests are used, and the findings suggest that all variables are stationary at the first difference reported in

Table 7 Asymmetric ARDL bounds cointegration test results

Estimated Model	Optimum lags	F-Statistic	Break year	Cointegration
$\ln Y_t = f(\ln \mathrm{HK}_t, \ln K_t, \ln X_t^+, \ln X_t^-, \ln M_t)$	(1, 2,2, 1, 1,1)	7.6068***	1982	Exist

Significant level	Critical values	
	$I(0)$	$I(1)$
1%	3.955	5.583
5%	2.9	4.218
10%	2.435	3.6

*** represents a 1% level of significance

Table 3. However, traditional stationary tests (such as ADF and PP) do not account for structural breaks, which is the main flaw in these tests. If no action is done, it may produce erroneous findings (Perron 1989). Thus, unit root testing for structural breaks is required for accurate and unbiased estimations, and the ZA test is excellent for responding to an unknown structural break. The ZA unit root results with a structural break date are shown in Table 4, demonstrating that economic growth is non-stationary with a structural break date of 1982, physical capital in 2009, exports in 1986, and imports in 1998, but human capital is stationary with a structural break date of 2002. The ZA test inferences validate the ADF and PP test results, implying that all variables used in the study are $I(1)$ and thus stationary at the first difference. However, the ZA unit root test captures information about a single unknown structural break in the series. Nonetheless, it ignores the role of any other structural breaks that may exist. Table 5 shows the results of the Lee and Strazicich unit root test used to investigate and solve the problem of multiple structural breaks in the series. According to the findings, in the presence of two structural breaks, all variables are non-stationary at the level, indicating a unit root problem. However, after the first difference, all model variables become stationary. Thus, we can conclude that our entire set of variables has the same integration order, which is 1.

4.2 BDS test result for nonlinearity

We also applied the BDS nonlinearity test to find nonlinearity in our data. The BDS test results, as shown in Table 6, demonstrate the presence of nonlinearities in economic growth, exports, imports, physical capital, and human capital. The null hypothesis of linearity, which implies that series are identically and independently distributed (iid), is rejected, and the alternative hypothesis of nonlinearities in all variables is accepted. Structural breaks and nonlinearities in our variables motivate us to estimate the analysis using the asymmetric or nonlinear ARDL technique.

The next step is to show the results for the asymmetric ARDL bounds test in the presence of a structural break with a modified F test. The AIC criterion is employed to select the best lag order. Table 7 shows that the value of F-statistic (7.6068), the joint significance of all lagged variables, is greater than the upper critical bounds value of 5.583 at a 1% significance level when economic growth is used

Table 8 Long-run and short-run asymmetric ARDL estimates results

Dependent Variable = $\ln Y_t$			
Variable	Coefficient	*t*-stat	*p* value
Long-Run coefficients estimates			
Constant	5.9007***	4.1557	0.0002
$\ln \mathrm{HK}_t$	0.1119***	5.2250	0.0000
$\ln K_t$	0.3283***	4.5948	0.0001
$\ln X_t^+$	0.3576***	8.8207	0.0000
$\ln X_t^-$	− 0.3383**	− 6.0036	0.0200
$\ln M_t$	− 0.1055*	− 1.8121	0.0797
D_{1982}	0.0067	1.2988	0.2036
Short-Run coefficients estimates			
$\Delta\ln \mathrm{HK}_t$	− 0.0021	− 0.1920	0.8489
$\Delta\ln \mathrm{HK}_{t-1}$	− 0.0266**	− 2.2832	0.0294
$\Delta\ln K_t$	0.1084***	4.8139	0.0000
$\Delta\ln K_{t-1}$	− 0.1143***	− 5.4003	0.0000
$\Delta\ln X_t^+$	0.0413	1.4890	0.1466
$\Delta\ln X_t^-$	− 0.0094	− 0.1710	0.8653
$\Delta\ln M_t$	0.0082	0.4530	0.6537
ECM_{t-1}	− 0.2955***	− 7.2802	0.0000
Diagnostic statistics			
R^2	0.7427		
Adj. R^2	0.6784		
χ^2_{SC}	0.2249	[0.7999]	
χ^2_{HET}	0.5860	[0.8552]	
χ^2_{FF}	0.5061	[0.4823]	
χ^2_{N}	0.2778	[0.8703]	
Wald test for asymmetry			
W_{LRX}	11.1986***	[0.0022]	
W_{SRX}	0.2911	[0.5934]	

***, **, and * denote 1%, 5%, and 10%, level of significance, respectively. D_{1982} shows a structural breach as a dummy variable for economic growth. The p values are shown in brackets[ ]. W_{LRX} and W_{SRX} are the Wald tests for long-run and short-run asymmetric hypothesis testing. χ^2_{SC}, χ^2_{HET}, χ^2_N and χ^2_{FF} demonstrate tests for serial correlation, heteroscedasticity, normality, and functional form, respectively.

as regressand. Based on these findings, the study confirms that variables are asymmetrically cointegrated in the presence of a structural break.

4.3 Long-run and short-run asymmetric ARDL estimates

Table 8 presents the findings of long-run estimates after confirming an asymmetric cointegration among the variables. The results show that human capital has a positive impact on economic growth. Other things being constant, a 1% increase in human capital leads to a 0.1119% rise in economic growth. Similarly, the findings indicate that physical capital has a positive and considerable impact on Pakistan's economic growth. Other factors remaining constant, a 1% increase in physical capital enhances economic growth by 0.3283%. The findings are consistent with evidence from endogenous growth theory and emphasize the significance of both human and physical capital in Pakistan's economic growth prospects. In the long term, an unexpected negative sign for the coefficient of imports is noticed, which is statistically significant. Other things remaining constant, a 1% increase in imports slows economic growth by 0.1055%. This observation is comparable to that of Ali and Li (2017) and contradicts the findings of Siddiqui et al. (2008). Higher imports, as expected, can reduce a country's foreign reserves. Excessive imports of consumer products are also responsible for negative growth, which is unproductive and slows the economic growth process. The influence of the dummy variable on economic growth is positive and insignificant.

When it comes to long-run exports coefficients, the coefficient of positive change in exports has a positive and larger impact on GDP growth and is significant at a 1% level. This finding shows that other thing remains unchanged; a 1% rise in exports increases economic growth by 0.3576%. This finding is parallel to the results of Ali and Li (2017) and Saleem and Sial (2015) and opposite of Debnath et al. (2014) and Quaicoe et al. (2017). In the context of Pakistan, our findings support the ELG hypothesis. On the other hand, the coefficient of negative exports change is also noteworthy to notice, as it is inversely related to economic growth and significant at a 5% level. This result shows that all else being equal, a 1% decline in exports boosts economic growth by around 0.3383%. If consumer demand is centred on exportable and non-commercial products, an increase in domestic demand will almost certainly result in an increase in output and a decrease in exports. As a consequence, increased output will stifle export growth (Lee and Huang 2002). However, the magnitude of the positive change in exports is greater, reflecting the larger effect of exports on economic growth than the magnitude of the negative change in exports. These findings strongly suggest that the effects of exports on economic growth in Pakistan are asymmetric. There is, thus, a positive link between exports and economic growth in Pakistan, regardless of whether exports rise or decrease.

Table 8 also presents the results of short-run estimates. The lagged difference in human capital has been found to have a 0.0266% negative effect on GDP growth at a 5% significance level. Furthermore, the short-run coefficient of physical capital contributes positively and significantly at the 1% level to economic growth by 0.1084%. Economic growth has an inverse association with lag difference capital. Finally, the ECM_{t-1} coefficient is -0.2955, indicating that the annual rate of adjustment towards long-run equilibrium is 29%.

The asymmetric association may be seen in the size, sign, and significance of the partial sums of positive and negative changes in exports, as suggested by Bahmani-Oskooee and Ghodsi (2017). As expected, both $\ln X_t^+$ and $\ln X_t^-$ variables seem to be highly significant with distinct magnitude and signs, suggesting that a rise or drop in exports has different effects on economic growth. Furthermore, in accordance with

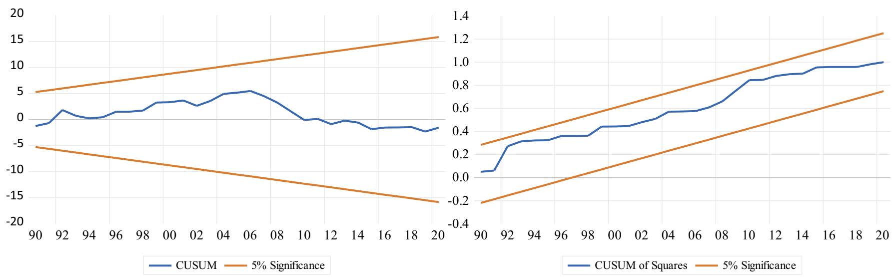

Fig. 3 Plots of CUSUM and CUSUMSQ

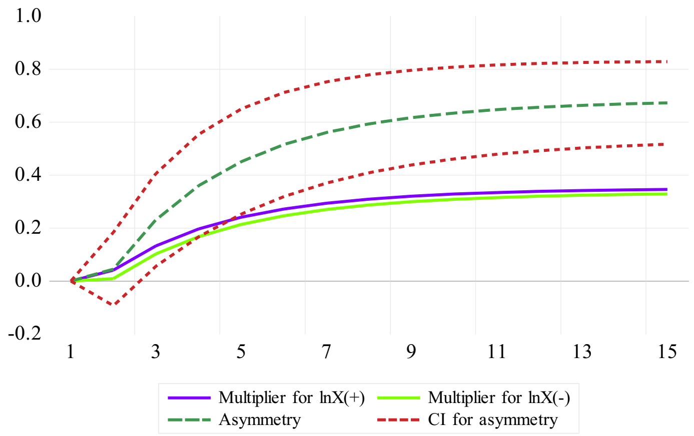

Fig. 4 Asymmetric dynamic multipliers effects of exports on economic growth

Shin et al. (2014), the standard Wald test of asymmetry is used to ensure that exports have asymmetric impacts (see, Table 8). The Wald test statistic (W_{LRX}) is 11.1986, indicating that the null hypothesis (symmetric effects) is rejected and the long-run asymmetric effects of exports are confirmed. The Wald test, however, does not support the existence of asymmetric effects of exports in the short run. This conclusion not only verifies the presence of asymmetric effects of exports, but also implies that neglecting non-linear exports behaviour can have equivocal consequences in the interaction between economic growth and exports.

4.4 Diagnostic and structural stability tests

To validate the efficiency and reliability of our nonlinear results, we have conducted various diagnostic tests. Table 8 demonstrates that our asymmetric model is free of serial correlation and heteroscedasticity, its functional form is accurate, and errors are normally distributed. We find that human capital, physical capital, exports, and imports explain economic growth by 74.27% ($R^2 = 0.7427$). This

Table 9 Asymmetric and symmetric causality test results (Toda–Yamamoto procedure)

Source of causation	Dependent variable = $\ln Y_t$				
	χ^2 (2)Statistic	*p* value	Source of causation	χ^2 (2)Statistic	*p* value
$\ln HK_t \rightarrow \ln Y_t$	2.3867	0.3032	$\ln HK_t \rightarrow \ln X_t^-$	2.0271	0.3629
$\ln Y_t \rightarrow \ln HK_t$	0.3320	0.8470	$\ln M_t \rightarrow \ln HK_t$	1.4503	0.4842
$\ln K_t \rightarrow \ln Y_t$	11.3335***	0.0035	$\ln HK_t \rightarrow \ln M_t$	1.3176	0.5175
$\ln Y_t \rightarrow \ln K_t$	2.6319	0.2682	$\ln X_t^+ \rightarrow \ln K_t$	2.7333	0.2549
$\ln X_t^+ \rightarrow \ln Y_t$	9.5508***	0.0084	$\ln K_t \rightarrow \ln X_t^+$	1.9746	0.3726
$\ln Y_t \rightarrow \ln X_t^+$	0.3365	0.8451	$\ln X_t^- \rightarrow \ln K_t$	0.1480	0.9287
$\ln X_t^- \rightarrow \ln Y_t$	4.8572*	0.0882	$\ln K_t \rightarrow \ln X_t^-$	4.0749	0.1304
$\ln Y_t \rightarrow \ln X_t^-$	3.8555	0.1455	$\ln M_t \rightarrow \ln K_t$	2.7465	0.2533
$\ln M_t \rightarrow \ln Y_t$	3.1808	0.2038	$\ln K_t \rightarrow \ln M_t$	6.3428**	0.0419
$\ln Y_t \rightarrow \ln M_t$	1.4299	0.4892	$\ln X_t^- \rightarrow \ln X_t^+$	1.7687	0.4130
$\ln K_t \rightarrow \ln HK_t$	1.2034	0.5479	$\ln X_t^+ \rightarrow \ln X_t^-$	0.3319	0.8471
$\ln HK_t \rightarrow \ln K_t$	0.2568	0.8795	$\ln M_t \rightarrow \ln X_t^+$	0.0333	0.9835
$\ln X_t^+ \rightarrow \ln HK_t$	2.1280	0.3451	$\ln X_t^+ \rightarrow \ln M_t$	5.9041**	0.0522
$\ln HK_t \rightarrow \ln X_t^+$	2.5130	0.2846	$\ln M_t \rightarrow \ln X_t^-$	0.0727	0.9643
$\ln X_t^- \rightarrow \ln HK_t$	1.0618	0.5881	$\ln X_t^- \rightarrow \ln M_t$	5.2200*	0.0735

***, **, and * show 1%, 5%, and 10%, level of significance, respectively. Besides other variables, we also employed the unit root tests to identify the integration order of the $\ln X_t^+$ and $\ln X_t^-$ variables and thus found stationary at first difference. Therefore, the maximum order of integration is one (i.e. $d_{max} = 1$). AIC determines the optimal number of lags which is 2. The test statistic has an asymptotic χ^2distribution and *df* in parentheses

demonstrates that the contribution of human capital, physical capital, exports, and imports is 74.27%, and the rest of 25.73% is explained by error term in the production function. Following Brown et al. (1975), we also tested the stability of NARDL model regression coefficients using cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ). Each blue line plot falls within 5% critical bounds, confirming the stability of short-and-log run coefficients (see, Fig. 3).

4.5 Analysis of the dynamic multiplier

The dynamic multiplier suggested by Shin et al. (2014) demonstrates how economic growth adjusts asymmetrically to the long-run equilibrium owing to positive and negative shocks in exports. The horizontal axis in Fig. 4 represents the time period, while the size of both positive and negative shocks on the vertical axis. The continuous blue and parrot green lines indicate positive and negative shocks, respectively, and show the effects on economic growth caused by 1% positive/negative shocks in exports. The dotted green line shows the asymmetric line, which measures the change between positive and negative shocks. The upper and lower red dotted lines represent the confidence interval used to determine the significance level of shocks at the 95% level. The adjustment pattern is asymmetric because positive shocks to exports have a greater influence on economic growth than negative shocks to exports. This means that an increase in exports has a greater and more positive impact on economic growth, whereas a drop in exports has a lesser but still positive impact. Finally, the graph shows that there is a positive link between exports and economic growth in Pakistan.

4.6 Asymmetric and non-asymmetric causality test results: Toda–Yamamoto Procedure

Policymakers can use the causal analysis to formulate a comprehensive export-led growth strategy. The Toda–Yamamoto approach is used in VAR management to assess long-run asymmetric and non-asymmetric causality between variables, and the results are shown in Table 9. The causality results show a unidirectional causality from positive (negative) change in exports to economic growth, implying that exports lead to economic growth. In Pakistan, the ELG hypothesis is certainly valid. This finding confirms the robustness of the nonlinear ARDL model's findings that exports contribute to long-term economic growth. As for Pakistan, the findings are consistent with those of Ali and Li (2017), Bashir et al. (2015), Saleem and Sial (2015), Shahbaz et al. (2011), Siddiqui et al. (2008), and Tang and Abosedra (2019), but contradict those of Akbar and Naqvi (2000), Quddus and Saeed (2005), Hye et al. (2013). Further, the one-way causality from physical capital to economic growth and imports indicates that physical capital gives rise to both economic growth and imports. Increased physical capital clearly assists in the support of major economic activities, which in turn stimulates both economic growth and imports of goods and services. Finally, the causality inferences indicate unidirectional causality from positive (negative) change in exports to imports. It indicates that rising level of exports stimulates imports of goods and services, particularly intermediate and capital goods imports utilised as inputs in the export industry.

5 Conclusion and policy implications

The present study is to empirically investigate the asymmetric (nonlinear) and causal relationship between economic growth and exports in Pakistan from 1973 to 2020. For this purpose, the nonlinear ARDL approach in the presence of a structural break is used to find short-run and long-run asymmetric relationships. Multiple unit root tests, including ADF, PP, ZA, Lee and Strazicich, and the BDS, are used to ensure data stationarity, structural breaks, and nonlinearity. Further, the Toda–Yamamoto technique is utilized to explore asymmetric and non-asymmetric causality between variables. According to stationary tests, all variables under consideration are $I(1)$ and hence stationary at the first difference. We detected asymmetric cointegration amid the variables. Long-term estimates are consistent with the economic theory, excluding imports, which influence economic growth negatively. Long-run estimates show that both human and physical capital positively and significantly impact Pakistan's economic growth. In contrast to prior studies that only considered a non-asymmetric relationship, the findings confirm an asymmetric relationship between exports and economic growth. This means that changes in exports, whether positive or negative, have a significant positive effect on Pakistan's economic growth. Finally, we find a significant long-run unidirectional asymmetric causality from a positive (negative) change in exports to GDP growth, confirming the ELG hypothesis's validity for Pakistan. Therefore, we conclude that the ELG hypothesis holds in Pakistan and the nonlinear ARDL approach helps in understanding the nonlinear dynamics between exports and economic growth.

Some policy implications will be useful to policymakers based on the empirical findings of this study, and the recommendations are as follows: First, the study suggests that exports are important for economic growth, and Pakistan should implement an export growth strategy as part of its development policy in order to achieve economic prosperity. It is widely acknowledged that exports of finished goods and services are more profitable under the free trade system, so the production of exportable goods, especially value-added goods, should be increased. Textiles account for more than 60% of Pakistan's exports, and their availability is heavily reliant on agricultural raw materials. As a result, agrarian reforms are critical to balancing the stability of the textile industry and agricultural production. Other measures in Pakistan, such as establishing export processing zones that not only attract foreign investors but also assist exporters in gaining access to foreign markets, increasing the size of the export market while maintaining good and long-term relations with other countries, focussing on new export sectors and investing in new technologies, and specially designed export incentive bonuses, may help to accelerate the process of export growth. Aside from that, we already know that the export market consumes a lot of resources. If firms produce items that are unattractive to foreign markets will need to work more efficiently to raise their standards or lower their prices if they want to survive. Selling exportable goods in the domestic market may be a viable option if none of these factors improves. This is analogous to money moving in a country, which stimulates consumer spending and contributes to economic growth.

Second, the importance of both human and physical capital as the primary determinants of economic growth cannot be denied. It is advised that investment project performance should be enhanced, and physical infrastructure should be modernised and upgraded through better budget allocation, in order to support economic growth. Investors should be strongly encouraged to invest in all areas, particularly exports. Investing in both human and physical capital greatly enhances the productivity of all workers. The difference between physical capital, productivity, and per worker output is determined by institutions and government policies (Hall and Jones 1999). Therefore, the study recommends that the government prioritise public investment projects, especially in the education sector, such as college, university, and technical education, as well as job training programmes, and allocate significant budgets for human capital improvement and development. Highly subsidised education systems must be implemented to increase enrolment in colleges and universities. Considering the significance of the labour force's participation in recognising the relationship between human capital and economic growth, it is recommended that the labour force be given more opportunities to improve its capabilities. It is necessary to increase the proportion of highly educated workers in the total population.

Finally, the structure of imports explains why imports are detrimental to economic growth. The share of consumer goods imports is very high, which reduces the country's foreign reserves and thus slows or negatively affects the economic growth process. Imports of raw materials, high-tech, and capital goods should be encouraged because they are necessary for domestic production, technological progress, and exports. Developing countries with limited technical resources, such as Pakistan, can benefit from knowledge through access to foreign technology and imports from industrialised nations (Grossman and Helpman 1991).

Future research should look into the relations between various types of exports, such as manufactured, primary, and services exports, and economic growth separately, as this can lead to more attractive results. Therefore, more research on this relationship is needed to fully understand the ramifications of a strong relationship.

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Consent to participate I am free to contact any of the people involved in the research to seek further clarification and information.

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