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### Unveiling the Economic Nexus: How Foreign Direct Investment, Gross Domestic Product, and Energy Consumption Shape Pakistan's Export Trajectory?

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	Abstract
<p><b>Ihsan Ullah</b> Department of Economics, PhD Scholar Abdul Wali Khan University Mardan Khyber Pakhtunkhwa Pakistan. <a href="mailto:safiihsan904@gmail.com">safiihsan904@gmail.com</a></p> <p><b>Noor Jehan</b> Associate Professor, Department of Economics, Abdul Wali Khan University Mardan Khyber Pakhtunkhwa Pakistan. <a href="mailto:noorjehan@awkum.edu.pk">noorjehan@awkum.edu.pk</a> ORCID: <a href="https://orcid.org/0000-0002-2816-5232">0000-0002-2816-5232</a></p> <p><b>Arif Hussain</b> Associate Professor, Department of Accounting and Finance, Abdul Wali Khan University Mardan Khyber Pakhtunkhwa Pakistan</p>	<p>High population growth in developing countries is generating an extraordinary rise in demand for energy, urban development, and agricultural infrastructure. Global environmental obligations will be challenging when fulfilling growing demands. These issues promote unfavorable settings and major constraints in turning the economy into a green growth economy. This shows the countless stakeholders in the economy's accountability towards sustainability. This study investigates the dynamic nexus between FDI, GDP, energy consumption, and exports in Pakistan for the period 1991-2022 by using the NARDL approach. The findings demonstrate a statistically significant positive relationship between FDI and GDP, indicating that increased FDI drives GDP growth. By addressing gaps in cross-sectional analyses, this research enriches existing literature and highlights opportunities for comparative studies with other developing countries.</p>
<p><b>Keywords:</b></p>	<p>FDI, Energy Consumption, Exports, GDP, NARDL, Pakistan</p>

### 1. Introduction

High population growth in developing countries is generating an extraordinary rise in demand for energy, urban development, and agricultural infrastructure. Many countries across the world are very desperate for their growth and development. In emerging economies, the role of FDI is very important for economic growth. FDI not only supports economic growth but helps regions to increase the level of productivity, i.e., shifting toward using advanced technology for production, and managerial skills, bringing reforms in the economy, and boosting modernization. FDI encourages entrepreneurship to bring new job opportunities, which play a vital role in the rapid growth of emerging economies (Fernandes & Paunov, 2012; Hermes & Lensink, 2003; Lee & Brahmasurene, 2013; Mallampally & Sauvart, 1999; Reiter & Steensma, 2010). Similarly, Mutafoğlu (2012) examine the relationship between FDI and economic growth in Turkey, by using Granger causality techniques. Currently, FDI and economic growth relations have been improved due to the emergence of internationalization and deindustrialization manufacturing techniques. Similarly, Grahovac and Softić (2017) documented that due to this technique FDI mixes some countries into the world market. The collecting of physical capital and the formation of human capital investment has a significant role. However, Anwar and Nguyen (2010) reported the impact of FDI on economic growth is bigger when a high amount of capital is capitalized in education, training, reduction of the technological difference between external and local business, and improving the economic market. Likewise, Crow (2012) explained the association of FDI and GDP in the case of Jordan, and that there the relation has significant relations between FDI and output with imports and production. However, Yaseen (2014) applying the ARIMA model, the model projected the importance of foreign direct investment inflows from 2004 & 2005 for Jordan. The relationship between energy consumption and GDP suggested that the energy consumption and GDP may be equally determined because the more GDP want more energy consumption. Similarly, extra energy consumption requires a higher amount of GDP. Similarly, Kraft and Kraft (1978) asserted that the Granger causality test is a common tool to detect the nexus between GDP and energy consumption in several countries (Ozturk & Bilgili, 2015).

This article explores the role of governance along with other variables in economic growth. Fourteen (14) counter rise Caribbean and Latin American were study from 2023Q1 to 2018 Q4. The ARDL protect mean group estimation technique was used for empirical findings. The PMG result showed the poor governance / corruption has a poor significant and adverse effect on the economic growth of those selected fourteen counter rises. While good governance in terms of political stability and effectiveness of government has positive effect on the economic growth in the long run. Empirical results indicate that effective rise and political stability have a significant and positive impact on economic growth while corruption needs to be addressed to minimize its adverse effect. This study is different from other studies in three aspects. i) It studies the highest number of countries i.e. 14 countries from Latin America and Caribbean regions. ii) This studies data of long-time span of 16 years. iii) These studies relatively a holistic panel data and empirical technique for estimation of the model. This is clearly a broad-based study and has come to be extreme in other regions and countries.

### 1.2 Does foreign Aid Stimulate Economic Growth in Developing Countries

This research empirically investigates the impact of foreign aid on the growth in developing countries using fixed effects and robust least square estimation. In this study of developing countries, middle income was divided into three income groups i.e. low-income group, lower middle-income group and upper middle-income group. The firm period for the analysis over 1985 to 2018. They empirically period for that foreign aid do stimulate economic growth in developing countries. They also find that in low-income countries exports works better as encompass to foreign aid and FDI effect positively economic growth. For upper middle-income countries only FDI affects their economic growth positively and foreign aid does not affect economic growth.

### 1.3 Energy And Energy Growth In Asian Developing Countries

Energy plays a key role in the economic growth in developing of a country. This study empirically investigates the effects of energy in the production function framework. A group of 10 Asian countries were examined for the period of 1990 to 2014 fully modified OLS and dynamic OLS were used to stimulate the model. The results revealed that this model is a strong positive relationship between the growth and energy used as input. This study suggests that as energy as an input to production principles, the economics growth and hence the Asian developing countries are advised to use more energy and stimulate the growth which will increase the social welfare as well.

This study examines the long-run association between FDI, GDP, energy consumption, and export, and assumed that the variables might be in long-run relation. FDI and export are to be known as the factor of GDP (Asafu-Adjaye, 2000). Export and the development of economic capacity led to the development of production level and resulted in GDP enhancement. As mentioned, the concept, FDI contributes to the exports of the region. Additionally, a positive effect of the economic growth of a region is assigned to FDI like the concept, (Dritsaki, Dritsaki, & Adamopoulos, 2004; Pacheco-López, 2005; Szkorupová, 2014).

The article is categorized into 6 parts. Section 1 introduction. Section 2 represents a brief literature review, theoretical framework, and hypothesis development. Section 3 represents methodology. Section 4 is dedicated to results and discussion and lastly section 5 concludes the study.

## 2. Literature Review

### 2.1 FDI and Economic Growth

In the present era, several kinds of literature observe the bivariate nexuses, either empirically or theoretically, between the pairs of exports and economic growth, GDP and Foreign Direct Investment or exports and FDI. Despite the associations between them, there are very few studies that have examined empirically the causality nexus among these three variables in a group of countries. Several researchers used the panel framework to carry out their analysis. Many studies investigated the Granger causality with these variables in a region. Likewise, X. Liu, Burrige, and Sinclair (2002) investigated bidirectional causality between each pair of real exports, real FDI, and real GDP for China using seasonally familiar quarterly data during the period 1981 to 1997. However, Dritsaki et al. (2004) asserted the nexuses between consumption, exports, GDP, and FDI of Greece throughout 1960 to 2002. The researchers found that there are a long-run association and a causality nexus between the observed variables.

The role of FDI inflow in the GDP of receiving economies has been observed broadly. Whereas several pieces of literature expose a positive influence of FDI on the host country's GDP. Practical research concludes diverse results about the impact of FDI on GDP. Similarly, (Blomstrom, Lipsey, & Zejan, 1992; Reganati & Sica, 2007) investigated a positive impact of FDI on GDP. Moreover, Borensztein, De Gregorio, and Lee (1998) found that other empirical literature failed to find a positive influence of FDI on economic growth. The association between foreign direct investment and GDP has been explained from many aspects. Literature exposes that the nexuses between foreign direct investment and host country GDP are dependent upon several other related aspects and distinctions in these issues significantly vary the association. Absorptive size in the shape of human capital is an important factor for the host country to extract the growth benefit of foreign direct investment (Borensztein et al., 1998). Other literature exposes the significance of several related factors in determining the foreign direct investment host country GDP associations. Many previous studies highlighted the nexus between FDI and Economic Growth (Abdouli & Hammami, 2017; Acquah & Ibrahim, 2019; Adedoyin, Bekun, Driha, & Balsalobre-Lorente, 2020; Doku, Akuma, & Owusu-Afriyie, 2017; Elkomy, Ingham, & Read, 2016; Iamsiraroj, 2016; Ibrahim & Acquah, 2020; Malik et al., 2020; Omri, Daly, Rault, & Chaibi, 2015; Rao, Sethi, Dash, & Bhujabal, 2020; Raza, Shah, & Arif, 2019; Szkorupová, 2014; Wu, Yuan, Wang, Cao, & Zhou, 2020; Zeeshan et al.; Zeeshan, Han, Alam Rehman, et al., 2021)

### 2.2 FDI and Export

Previous literature observed the nexus between these variables that FDI impact on an export which analyzes by various econometric techniques. Every literature has various results because of the time difference, the analysis of the data, and other estimation techniques. Similarly, Borensztein et al. (1998) used regression analysis for 69 emerging economies for 20 years' time period to observe the associations between FDI and export in their research and found a positive effect of FDI on economic growth. Likewise, Dritsaki et al. (2004) used VAR autoregressive model to inspect the nexuses between FDI, and export in the study. Likewise, Iqbal and Sattar (2010) explored the effect of FDI on GDP and export in Pakistan. By employing VAR autoregressive model for the empirical analysis used quarterly data for the period 1998 to 2009. The outcomes of the study verified a positive impact of FDI on export and GDP in Pakistan.

Some literature examines a positive effect and some others found a negative effect, like Buckley, Clegg, and Wang (2002) explained that the degree to which FDI contributes to development depends on the financial and social settings in the receiver region. They asserted that regions with a higher number of reserves, open trade system and greater technical point would more advantage from the enhance of FDI to their countries. Likewise, Duasa (2007) asserted the nexus between FDI and output growth in the context of Malaysia. And found that there is no strong connection between GDP and FDI.

The literature suggests ARDL (Autoregressive distributed lag) bound testing techniques to explain the nexus between variables. The literature shows that FDI inflow has statistically significant and positive connections with economic growth in the short and long-run. If FDI inflows rise, economic growth will rise. But for exports it has statistically significant and negative relations with GDP growth in long-run. Likewise, Gu, Awokuse, and Yuan (2008) investigated the effect of FDI on China export performance employing the indication from the disaggregated sector during 1995-2005. They found a statistically significant and positive relationship with Chinese export. Several studies like (Kutan & Vukšić, 2007; Prasanna, 2010) investigate the evidence that FDI has a positive effect export of a receiver region. However, Sultan and Mason (2010) using the VECM to examine the nexus between FDI inflows and export in the context of India during 1980-2010. The study found that FDI and export have a constant and long-run association. However, (Goldberg, Tracy, & Aaronson, 1999) Goldberg & Klein (1998,99) and N. T. K. Nguyen (2017) affected and claimed that FDI does not affect export growth.

Moreover, several previous types of research explain the association between FDI and Export (Anwar & Nguyen, 2011; Dritsakis & Stamatou, 2018; Hayakawa, Mukunoki, & Yang, 2020; Iwaisako & Nakata, 2017; Mohanty & Sethi, 2019; C. H. NGUYEN, 2020; V. C. NGUYEN & DO, 2020; Xu et al., 2019; Zhou, 2020).

### 2.3 Energy Consumption and FDI

From the last 30 years, the nexus between energy consumption and FDI has become a very important issue on both the local and foreign levels. But, due to the rise in the scale of production switches and environmental deficiency. In Durban in December 2011, this worry clears itself internationally (Blankenship et al., 2009; Fischer, Fischer, & Wennberg, 1992). Currently, several regions are facing key challenges, like the multi-directional nexus between social, environmental parts, and economic development. They strive to contest poverty, save the environment and increase the chances of economic. Currently, in Asia markets, private capital flows have become an issue of the study. The variation in these flows is examined the weakness of economic systems associated with the volatility in developing market in Latin America, Russia, and Asia, the monetary disasters result can seem like a source of motive this topic has received. There are three private groups of capital flows that is FDI, bank loans, and portfolio investment, the latter has built up in a very important class as the mid-1990. Its part in private capital flows to markets of developing economies enhance significantly, particularly, reduced portfolio investment, reflecting a more careful way of the investors of the international stock market. No such study has been conducted who's applied GMM, ordinary Least square regression, fixed and random effect to find outcross regions impact of bilateral FDI, energy consumption, and economic growth in Asia regions. To cover the gap, we investigate the nexus of bilateral FDI, energy consumption, and economic growth in thirty-four host regions of Asia and 115 source regions during 2001 to 2012 utilizing GMM, ordinary least square regression, fixed and random effect by (Arellano & Bond, 1991). We investigate the association in the Asian region due to the large use of energy, CO<sub>2</sub> emissions, and natural resources. This research would be fruitful for policymakers to make greater policies for the use of energy and increase the economy in Asian regions. Likewise, Saidi, Mbarek, and Amamri (2018) study the association between energy consumption, FDI, and GDP utilizing the panel data of 13 MENA countries for the time 1990–2012. By using panel unit-root and co-integration tests, to test the Granger causality. The findings of the empirical study show that there is a bidirectional association between energy used and GDP, known as the feedback hypothesis. While the outcomes support the presence of unidirectional causality from GDP to FDI. Likewise, many previous studies have explored the relationship between FDI and Energy Consumption (Buhari, Lorente, & Nasir, 2020; Caglar, 2020; Gökmenoğlu & Taspınar, 2016; Muhammad & Khan, 2019; Nathaniel, Aguegboh, Iheonu, Sharma, & Shah, 2020; Naz et al., 2019; Olaoye, Ayomitunde, Nwagwu, Jude-Okeke, & Ezinwa, 2020; Rafindadi, Muye, & Kaita, 2018; Saidi et al., 2018; Zeeshan et al.; Zeeshan, Han, Alam Rehman, et al., 2021).

### 2.4 GDP and Energy Consumption

Many researchers explored the association between GDP and energy consumption. Likewise, Caraianni, Lungu, and Dascălu (2015) asserted the connection between energy consumption and GDP for Poland, Bulgaria, Turkey, and Hungary between 1980 to 2012-13. However, Paul and Bhattacharya (2004) examined the nexus between energy consumption and GDP from 1950-1996 in the case of India and found that there is both a bidirectional causality and same direction causality between the 2 variables. While, Asafu-Adjaye (2000) verifies in his research on India, the Philippines, Indonesia, and Thailand that the nexus between income and energy is not a neutral one, hereafter, energy consumption is affected by income variation. Likewise, Aqeel and Butt (2001), also found that the economic growth of a region directly affected the growth of energy consumption in that region. However, Apergis and Payne (2010) and Zeeshan, Han, Rehman, et al. (2021) found that there is bidirectional causality between energy consumption and GDP, based on their research on various sets of regions. Many types of research examine the nexus among variables that is GDP trade openness and energy consumption by using a bivariate or multivariate framework (Chandran & Tang, 2013; Narayan & Smyth, 2009; Shanthini & Perera, 2010; Xepapadeas, 2005; Zare, Akhash, Hasanshahi, & Rahimi, 2012) asserted that economic growth is caused by energy for Taiwan, USA, Pakistan, Korea, African, Soviet Union, Fiji, Malaysia, South American and Middle Eastern, correspondingly. Many panel studies have been conducted in-country cases to analyze the nexus between economic growth and energy consumption. Likewise, Lotfalipour, Falahi, and Ashena (2010) asserted a unidirectional causality running from economic growth and energy consumption to CO<sub>2</sub> emissions in the context of Iran, using time series data from 1967 to 2007 through the Toda-Yamamoto method. Similarly, Apergis and Payne (2010) asserted that energy consumption is positively connected with CO<sub>2</sub> emissions and the economic Kuznets curve hypothesis verify by applying the Vector Error Correction Model for six Central American regions. The same findings were determined for the ASEAN economies (Apergis, Payne, Menyah, & Wolde-Rufael, 2010; Lean & Smyth, 2010). The causal relation between energy consumption and GDP has attracted much care from economists and researchers because this connection has significant policy implications.

The nexus between energy consumption and GDP proposed that energy consumption and GDP may be equally determined because more GDP needs more energy consumption. Likewise, more effective energy consumption needs a greater level of GDP. However, Kraft and Kraft (1978) studied that the Granger causality test method has become a

common instrument to observe the association between economic growth and energy consumption in various regions (Sajal Ghosh, 2010; Ozturk & Acaravci, 2010). While Yang (2000) and Zeeshan et al. (2022) indicates that there is bidirectional causality between energy use and GDP in Taiwan. Some of the previous studies have also highlighted the relationship between Energy Consumption and GDP (Acheampong, 2018; Adams, Klobodu, & Apio, 2018; Adedoyin & Zakari, 2020; Balsalobre-Lorente, Shahbaz, Roubaud, & Farhani, 2018; Hanif, Raza, Gago-de-Santos, & Abbas, 2019; Saldivia, Kristjanpoller, & Olson, 2020; ŠKARE, TOMIĆ, & STJEPANOVIĆ, 2020; Zeeshan et al.; Zeeshan, Han, Alam Rehman, et al., 2021).

### 2.5 GDP and Export

Many kinds of literature explore the association between GDP and export. However, Szkorupová (2014) also asserted the nexus between GDP and export. He used the data from 2001- to 2010 for the estimation effect on GDP was performed for Slovakia. On quarterly data, the vector error correction model and co-integration techniques were used. And the findings approve the presence of long-term causal links between variables in Slovakia. Export and development of economy frankness lead to the development of productivity level and growth of the economy. Likewise, Borensztein et al. (1998) employ regression analysis to investigate the association between GDP and export. The study was conducted for 69 emerging economies over 20 years and found a positive effect of FDI on GDP. However, Dritsaki et al. (2004) using the VAR model to investigate the association between FDI, GDP, and export. This study was conducted for the period 1960 to 2002, using annual data in the case of Greece. Their findings of the research show a bi-directional connection between export and GDP. Likewise, the effect of FDI on export as well as on GDP confirm in Greece. However, Fabry and Maximin (2001) studied the nexus between FDI, GDP, and export by employing the Johansen co-integration test and Granger causality test on a sample of regions from Central and Eastern Europe. At the end of the research, the author states that export has a robust effect on economic growth than FDI in Central and Eastern Europe, and on opposing the effect of FDI on export has not been shown by the study in regions of Central and Eastern Europe. Economic development is the key purpose of every society in the world and economic growth is the ultimate of economic development. Several contributors to economic growth. However, export is to be considered as one of the vital contributors among them. There are also some concerns about trade, particularly between primary and industrial products exporting economies where the terms of trade are declined against the poorer economies. While several empirical kinds of literature support the exports led GDP hypothesis, there is no complete consent on this subject. However, some expert in the field of economics (Kavoussi, 1984; Salvatore & Hatcher, 1991) seems to normally settle that export helps economics growth (Akanegbu & Chizea, 2017; Yaghmaian, 1994) did not found the help of export-led GDP hypothesis. Several empirical kinds of literature have been conducted based on cross-section data sets however there is a huge difference between economic and demographics structures of various regions. Some of the previous researchers documented the nexus between Export and Economic Growth (Bahramian & Saliminezhad, 2020; Edo, Osadolor, & Dading, 2020; Athanasia S Kalaitzi & Cleeve, 2018; Kibria & Hossain, 2020; Mensah & Okyere, 2020; Sahin, 2019; Temiz Dinç & Gökmen, 2019).

### 2.6 Energy Consumption and Export

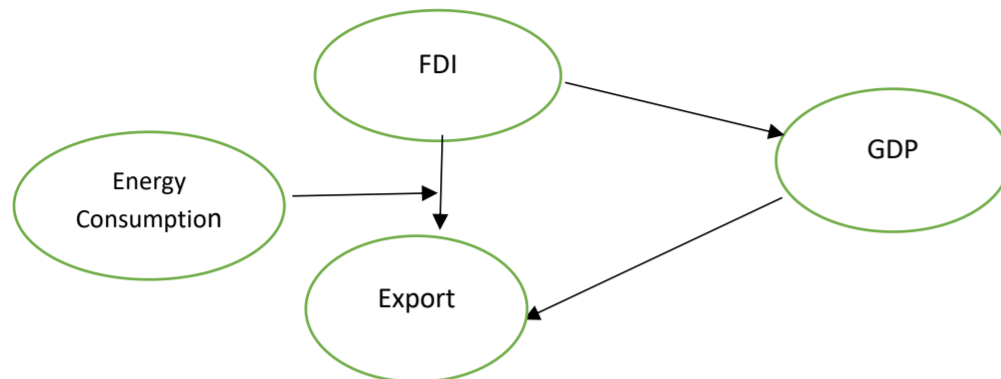
The significance of energy has risen particularly later the two oil disasters in 1970. Energy consumption has started to be known as a factor of production and is comprised in the production function. Later manufacture course complete involves the conversion and signal of matter, particularly, whole manufacturing process needs energy. Therefore, trade development enhances energy use. Furthermore, transferring the exported products also requires energy. Likewise, Sadorsky (2012) asserted that a rise in exports enhances the financial events in an export-oriented and similar segment, which is why increases the energy demand. Furthermore, later imports require energy consumption for the conveyance of imported products, enhance in trade inflows needs a rise in energy use. IEA (2011) reported that in OECD transport was one-third in 2009, of the total final energy use. However, Sadorsky (2012) explained that the import structure is another issue that can increase energy consumption particularly if the imports are energy concentrated goods i.e., machines, automobiles, air conditioners, dishwashers, etc. The more imports of energy exhaustive products need more energy. Moreover, Sadorsky (2012) asserted that the deficiency of available energy may reduce the usefulness and efficacy of energy-dependent imported goods like equipment or machinery which need the energy to operate which makes it less similar that similar products will be imported. Energy consumption to be known as the production factor, the reverse connection running from energy demand to export is probable. A reduction in energy demand can affect the volume of production of the tradeable product, however, the rise in the energy demand can have a positive impact on the production volume of tradeable products.

The output of energy use and trade output literature is wide while the energy consumption trade study seems like the area which is understudied. Likewise, Narayan and Smyth (2009) explained for a panel of 6 middle eastern regions i.e. (Iran, Israel, Oman, Kuwait, Syria & Saudi Arabia) by applying Granger causality running from electricity use to economic growth from income to exports. They also found proof in the favor of the long-run Granger causality association running from electricity use and exports to real income and exports and real income to electricity use. Likewise, several researchers explored the nexus between Economic Growth and Export (Arteaga, Cardozo, & Diniz, 2020;

Chrid, Saafi, & Chakroun, 2020; Edo et al., 2020; Filimonova, Cherepanova, Provornaya, Kozhevin, & Nemov, 2020; Athanasia Stylianou Kalaitzi & Chamberlain, 2020; Koch, 2020; Olayungbo, Olaniyi, & Ojeyinka, 2020; Shakeel, 2020; Waheed, Sarwar, & Dignah, 2020).

### 3. Theoretical Framework and Hypothesis Development

Figure 1- Theoretical Model



#### 3.1 Testing of the Hypothesis

##### 1. FDI Increase DGP

The hypothesis tests and verify that FDI positively affects GDP and sometimes has an ambiguous effect of FDI on economic growth. Likewise, some of the previous literatures are also in the line (Acquah & Ibrahim, 2020; Asongu & Odhiambo, 2020; Kobilov, 2020) found that FDI enhances GDP. In this research, we employ the Granger Causality test to test the hypothesis.

##### 2. Export raise Economic growth

This theory is verified due to the footprints of the earlier researchers (Sampath & Anwar, 2000; Stamatiou & Dritsakis, 2014; Subasat, 2002), who explored that export enhances economic growth that is why for testing the hypothesis we utilized the Granger Causality.

##### 3. Export rise FDI

The hypothesis checks the effect of export on FDI; meanwhile, we try to check the hypothesis the first time, therefore a similar study was found (Hayakawa et al., 2020). For this checking of the hypothesis, we apply NARDL techniques. The Non-linear Auto-Regressive Distributed Lag, the methodology is the most accurate technique as compared with the Autoregressive distributed lag, etc.

### 3. Methodology

#### 3.1 Data and Variables

Table 1 Variables Dissipation

Symbols	Variable	Definitions & (Measurement)	Previous Researcher	Data Source
FDI	Foreign Direct Investment	% of GDP	(Zeeshan, Han, Alam Rehman, et al., 2021; Zeeshan, Han, Rehman, & Afridi, 2020; Zeeshan, Rehman, & Afridi, 2020)	WDI
GDP	Economic Growth	% of USD	(I. Ullah et al., 2019; Zeeshan, Han, Alam Rehman, et al., 2021)	WDI
EC	Energy Consumption	% of total final energy consumption	(I. Ullah et al., 2019; Zeeshan, Han, Alam Rehman, et al., 2021)	WDI
Ex	Export	.....	.....	WDI

### 4.2 Model and Method

The above table 1 displays the description and definition of the variable by using the following model for the estimations

$$GDP_t = \beta_0 + \beta_1 FDI_t + \beta_2 EC_t + \beta_3 EX_t + \mu_t \quad (1)$$

$$\mu_t \sim \text{n.i.i.d}(0, \sigma^2),$$

Whereas

FDI = Denote Foreign Direct Investment

EC = Represent Energy Consumption

Ex = Used for Export

GDP = Economic Growth

$\mu$  = Used for Normally Distributed Error Term

GDP is used for economic growth which is used as the dependent variable, whereas FDI, energy consumption, and export represent independent variables. The earlier researcher proposed a positive relation between FDI and energy consumption and export, which also positively affects the GDP (Al-Mulali & Tang, 2013; Alsaedi & Tularam, 2020). The export and FDI lead to a high level of energy consumption which is positively connected with GDP (Buhari et al., 2020). The more exports attract FDI which suggests that the larger amount of energy will be used. We collect the data of the variables from the World development indicator. The scholar employs co-integration techniques for the long-run connections between the variables, specifically when we have the time series data for long period. Short-term assessments are required mostly to detect the dynamics from the long-term symmetry. Through the error correction model, we have taken the short-run dynamic and the short-run dynamic information by ECT. We can re-write equation one (1) permitting the short-run dynamic as follow:

$$\Delta GDP_t = \beta_0 + \sum_{i=1}^{n1} \beta_{1i} \Delta FDI_{t-1} + \sum_{i=0}^{n2} \beta_{2i} \Delta EC_{t-1} + \sum_{i=0}^{n3} \beta_{3i} \Delta EX_{t-1} + \lambda e_{t-1} + \mu_t \quad (2).$$

The above eq 2 resents the ECT for the economic growth and descriptive variables similarly FDI, energy consumption, and export. Through an error correction model we can adjust short-run form long-run equilibriums ( $\lambda e_{t-1}$ ). It is to be supposed that the coefficient symbol of the error correction would be adverse and important to reinstate shortly in the short-run dynamic. The previous long-run methods like Engle and Granger (1987) technique recommend all variables would come after sequence I (1), which suggests that all variables should hold the order of addition equivalent to 1. Johansen (1995a) methods are suitable when the cointegration is not 1(1) for instance the cointegration is 1(2). However, (Pesaran, Shin, & Smith, 2001) propose utilizing the autoregressive distributed lag technique for the co-integration level if the variables do not have the same order of integration. They change ECT ' $e_{t-1}$ ' in eq two (2) by a linear mixture of lagged level variables in the model and we can redraft the equation of typical autoregressive distributed lag as follow. The order of the variables must be 1(1) and the error term should be 1(0) previous studies inline (Engle & Granger, 1987). However, Johansen (1995b) and Pesaran et al. (2001) asserted if the variables are not I(1), then employ the autoregressive distribute lag methodology. The ' $e_{t-1}$ ' replace in eq two (2) by a linear mixture of lagged equal variables in the model. That is why we use the following equation:

$$GDP_t = \rho_0 + \sum_{i=1}^{n1} \rho_{1t} FDI_{t-1} + \sum_{i=0}^{n2} \rho_{2t} \Delta EC_{t-1} + \sum_{i=0}^{n3} \rho_{3t} \Delta EX_{t-1} + \rho_4 GDP_{t-1} + \rho_5 GDP_{t-1} + \rho_6 FDI_{t-1} + \rho_7 EC_{t-1} + \rho_8 EX_{t-1} + \mu_t \quad (3)$$

The equation comprises co-efficient of the variables subsequent are the variance operator ' $\Delta$ ' to display short-term connection and equal lag operators. The limits  $\rho_5$ ,  $\rho_6$ ,  $\rho_7$ , and  $\rho_8$  denotes the long-run constants. The selection of the lag length is very complex to the long-run approximation, various methods have used the selection of lag length. While earlier researchers employ linear techniques to examine the nexus between GDP, FDI energy consumption, and export, which imitate the symmetrical association and do not capture the dynamic performance of the variables. Therefore, the symmetrical supposition is looked to be idealistic as GDP only follows a linear association with FDI, energy consumption, and export (Sudeshna Ghosh, 2020). Consequently, to explore the asymmetric effect of DGP, energy consumption, FDI, and export (Raggad, 2020; Rehman, Khan, Khan, Pervaiz, & Liaqat, 2020) purposed NARDL that permits both the short and long-run coefficients. Likewise (Fan & Hao, 2020; Pao & Tsai, 2011) explore the difference of GDP, FDI, energy consumption, and export into positive and negative fractional sums as under:

$$GDP_t^+ = \sum_{j=1}^t \Delta GDP_j^+ = \sum_{j=1}^t \max(\Delta GDP_j, 0) \quad (4)$$

$$GDP_t^- = \sum_{j=1}^t \Delta GDP_j^- = \sum_{j=1}^t \min(\Delta GDP_j, 0) \quad (5)$$

$$FDI_t^+ = \sum_{j=1}^t \Delta FDI_j^+ = \sum_{j=1}^t \max(\Delta FDI_j, 0) \quad (6)$$

$$FDI_t^- = \sum_{j=1}^t \Delta FDI_j^- = \sum_{j=1}^t \min(\Delta FDI_j, 0) \quad (7)$$

$$EX_t^+ = \sum_{j=1}^t \Delta EX_j^+ = \sum_{j=1}^t \max(\Delta EX_j, 0) \quad (8)$$

$$EX_t^- = \sum_{j=1}^t \Delta EX_j^- = \sum_{j=1}^t \min(\Delta EX_j, 0) \quad (9)$$

$$EC_t^+ = \sum_{j=1}^t \Delta EC_j^+ = \sum_{j=1}^t \max(\Delta EC_j, 0) \quad (10)$$

$$EC_t^- = \sum_{j=1}^t \Delta EC_j^- = \sum_{j=1}^t \min(\Delta EC_j, 0). \quad (11)$$

Positive and negative shocks in GDP is decomposed, for example,  $GDP^+$  and  $GDP^-$ . Likewise, we decompose FDI and EC, while utilizing the EX without varying into negative and positive shocks. The +ive shock suggests the rise, while -ive shock specifies the reduction in every variable. Giving to Granger, if 2-time series variables (-ive and +ive) are co-integrated then they are in unseen co-integration which is a specific circumstance of co-integration. Thus, the linear combination is converted into nonlinear co-integration. The bound test proposed by Pesaran et al. (2001) is used to test the asymmetric association for the following equation.

$$\Delta GDP_t = \gamma_0 + \sum_{i=1}^{n1} \gamma_{1i} \Delta GDP_{t-1} + \sum_{i=1}^{n2} \gamma_{2i} \Delta FDI_{t-1}^+ + \sum_{i=1}^{n3} \gamma_{3i} \Delta FDI_{t-1}^- + \sum_{i=1}^{n4} \gamma_{4i} \Delta EC_{t-1}^+ + \sum_{i=1}^{n5} \gamma_{5i} \Delta EC_{t-1}^- + \sum_{i=1}^{n6} \gamma_{6i} \Delta EX_{t-1}^+ + \sum_{i=1}^{n7} \gamma_{7i} \Delta EX_{t-1}^- + \gamma_8 GDP_{t-1}^+ + \gamma_9 FDI_{t-1}^+ + \gamma_{10} EC_{t-1}^- + \gamma_{11} EX_{t-1}^+ + \gamma_{12} EX_{t-1}^- + \mu_t \quad (12)$$

The last eq shows the full picture of the NARDL model, the model has been projected in 3 stages; Firstly, we check the bound test; second stage use for short-term assessments, whereas in the last stage number three we check the long-run estimate. Additionally, the baseline non-linear autoregressive distributed lag model estimate would be confirmed through the Granger Causality test.

#### 4. Results and Discussion

To know the stationarity properties in the model the ADF unit test was employed. The time-series data are usually probable to hold changeable variance and mean and predictable ordinary least square gives false outcome. If there are stationarity problems, then we can use the co-integration test. Also, the co-integration test needs a certain order of integration, particularly Autoregressive distributed lad estimations supposed that no one series are stationary at 1(2). Likewise, Ouattara (2004) proposes that Auto-Regressive Distributed Lag findings will be ambiguous if data is united at I (2). Consequently, it is vital to recognize the stationary rank of the variables.

**Table 2 Augmented Dickey-Fuller, Unit Root Test**

Notations	ADF	ADF at Difference	Conclusion
GDP	0.795281 (-1.944574)	-2.209335 (-1.944574)	At 1st Difference Stationary
FDI	0.034401 (-1.944404)	-9.433981 (-1.944445)	At 1st Difference Stationary
EC	-2.683849 (-1.944574)		At 1st Difference Stationary



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EX	1.727243 (-1.944404)	-1.74633 (-1.944404)	At1st Difference Stationary
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Source: Author's calculations

### Table 3 Auto-Regressive Distributed Lag Bounds Test

Ho: No associations exist of long-run

GDP/(FDI\_POS, FDI\_NEG, EC\_POS, EC\_NEG, EX\_POS, EX\_NEG,)

Test Statistic	Value	K
F-statistic	8.285	7
Critical Value Bounds		
	Lower	Upper
Significance	Bound	Bound
10%	2.45	2.94
5%	2.11	3.31
1%	2.73	4.12

Source: Author's calculations

The results of Augmented Dicky-Fuller table 2 display that overall variables are stationary at the first difference and non-stationary at the level. This suggests that the variable trails the conventional statement of cointegration. We can check the existence of long-run associations of cointegration in 1<sup>st</sup> step. The outcome of the bound test is displayed in table no 3; F-statistics values represent the upper bound value and lower statistics at various levels of significance. The Pearson and Shin Conditions of the long-term cointegration are satisfied through calculated F-statistics and greater the upper bound values. The Auto-Regressive Distributed Lag bound test displays the presence of a long-run association between the variables. This suggests that all variables have long-term relations. The 2<sup>nd</sup> stage represents the short-run dynamics from the long-run equilibrium. To test the short-term dynamics, we used ECM.

### Table 4 Error Correction Model

Auto-Regressive Distributed Lag Cointegration And Long-run

Dependent Variable: LOG(GDP)

Cointegrating Form

Variable	Coefficient	Std. Error	t-Stat	Prob.
ΔLOG (GDP (-1))	0.5169	0.1536	5.416	0.000
ΔLOG (GDP (-2))	0.2049	0.1635	1.513	0.225
ΔLOG (GDP (-3))	0.2028	0.1635	1.491	0.231
ΔLOG (GDP (-4))	-0.0035	0.1810	0.040	1.046
ΔLOG (GDP (-5))	0.3030	0.1541	2.841	0.078
ΔLOG(EC)	5.3696	2.8855	1.952	0.135
Δ (FDI_POS)	-0.0339	0.1442	-0.398	0.712
Δ (FDI_POS (-1))	-0.0161	0.1596	-0.121	0.919
Δ (FDI_POS (-2))	-0.0006	0.1588	0.063	1.065
Δ (FDI_POS (-3))	0.4456	0.1641	4.059	0.002

$\Delta$ (FDI_POS (-4))	-0.3441	0.1350	-6.299	0.000
$\Delta$ (FDI_NEG)	0.0224	0.1104	-1.107	0.314
$\Delta$ (FDI_NEG (-1))	0.1136	0.1412	0.682	0.613
$\Delta$ (FDI_NEG (-2))	0.0703	0.1411	0.075	1.066
$\Delta$ (FDI_NEG (-3))	-0.3392	0.1566	-4.652	0.000
$\Delta$ (FDI_NEG (-4))	0.5105	0.1361	6.734	0.000
$\Delta$ (LOGEX_POS)	-0.2156	0.1562	-3.244	0.002
$\Delta$ (LOGEX_NEG)	-1.8056	0.3222	-7.368	0.000
$\Delta$ (LOGEX_NEG (-1))	-0.0522	0.3369	-0.388	0.719
$\Delta$ (LOGEX_NEG (-2))	0.0711	0.3193	0.074	0.987
$\Delta$ (LOGEX_NEG (-3))	1.4035	0.3523	4.793	0.000
$\Delta$ (LOGEX_NEG (-4))	-0.9870	0.2558	-5.618	0.000
Error Correction Term (-1)	-0.1184	0.0988	-6.477	0.000

$$\text{Cointeq} = \text{LOG}(\text{GDP}) - (-8.6919 * \text{LOG}(\text{FDI}) + 0.3901 * \text{EC\_POS}$$

$$-0.2587 * \text{EC\_NEG} + 0.8180 * \text{LOGEX\_POS} - 2.8651 * \text{LOGEX\_NEG} + 4.9117 *$$

Source: Author's calculations

NARDL approximation is sensitive to lags length, the long-run association depends on optimal lag (Bahmani-Oskooee & Bohl, 2000). Likewise, Stock and Watson (2012) explored that several lags or utilizing so minimum lags projection ignore vital information of a model or leads to ambiguous findings. For autoregressive distributed lags the optimal lag plays a vital role therefore we use only one lag known as optimal lag resulting in SIC information criteria. Since optimal lags are an important component for the ARDL estimation therefore we use only 1 lag as optimal following SIC information criteria. Table 4 displays the short-run dynamics for the optimal lag length selection we used the AIC & SIC criterion. The ECT (-1) value displays a statistically significant and negative coefficient meaning that the model having convergence property and every year the model converged to the long-term symmetry at 11% which represents that the model reinstates the long-term equilibrium shortly.

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**Table 5 Long-Run Estimations**

<b>Long Run Coefficients</b>				
<b>Variables</b>	<b>Coefficient</b>	<b>Sd. Error</b>	<b>t-Statistic</b>	<b>P. value</b>
LOG(FDI)	-8.6919	1.9312	-4.6376	0.0000
EC_POS	0.3902	0.1994	2.5449	0.0159
EC_NEG	-0.2588	0.2106	-2.2686	0.0230
LOGEX_POS	0.8182	0.2327	4.6695	0.0000
LOGEX_NEG	-2.8652	0.2908	-13.2210	0.0000

Source: Author's calculations

The above table no 5 displays the long-run estimates of the model, finding of the results explains that the FDI shows statistically significant and negative related to the GDP, it is because of the energy consumption positive shock, that resultantly enhance energy consumption by 2.54% at the significance level of 5%. However, negative shock displays that unit one in every shock minimizes energy consumption by 25% at a significance level of 5%. This shows that GDP and energy consumption are affecting in the same way in the long term. However, the expansion or reduction in energy consumption statistically significantly impacts GDP in long run. The export positive shock enhances GDP by .081 units at the significance level of 1%. However, decrease GDP with negative shock by 2.82 units at the significance level of 1%. This suggests that export affects the GDP in long run, the enhancement of export significantly leads to an increase in GDP vice versa. The finding of the research validates by earlier literature (Demirhan & Masca, 2008; Narayan & Smyth, 2009; Sayari, Sari, & Hammoudeh, 2018).

**Table 6 Diagnostic Tests**

Diagnostic tests	Problem	Prob Value	Results
Lagrange Multiplier	Serial correlation Exist	0.62	There is no serial correlation exist in the model
Breusch–Pagan–Godfrey	Heteroscedasticity Problem	0.927	The hetero issue does not exist in the model
Ramsey RESET test	Model Conditions	0.415	Model is properly defined
Variance Inflation factor	Multi-collinearity issue	0	Multicollinearity not exist
CUSUM & CUSUMSQ	Model Stable	0	Stability in the Model

Source: Author's calculations

Several diagnostics test is applied to confirm the findings of NARDL. Therefore, we apply the Lagrange multiplier test to find the serial correlation problem, likewise Breusch–Pagan–Godfrey test was used to check the heteroskedasticity. The CUSUM and CUSUMSQ were used to check stability in the model. Table 6 displays the results of a diagnostic test which represent that there is no such problem in the model for instance the LM test outcome represents that there is no serial correlation issue in the model. Similarly, for the heteroskedasticity problem, we used Breusch–Pagan–Godfrey and in the model, no such issue was found. Finally, we check the stability of the model for which we apply the CUSUM and CUSUMSQ test and the results display the stability of the model and having no problem of instability. The results validate the model that there is no such issue exists in the model. For more robustness and further verification of our bassline NARDL results, we employ the standard Granger causality test.

**Table 7 Granger Causality Tests**

Null Hypothesis:	F-Statistic	P. Value
FDI does not Granger Cause GDP	2.419	0.284
GDP does not Granger Cause FDI	3.098	0.070
EX does not Granger Cause GDP	0.569	0.906
GDP does not Granger Cause EX	1.123	0.510
EC does not Granger Cause GDP	27.132	0.003
GDP does not Granger Cause EC	0.706	0.677
EX does not Granger Cause GDP	2.008	0.466
GDP does not Granger Cause EX	2.287	0.461

EC does not Granger Cause EX	2.199	0.400
EX does not Granger Cause EC	3.197	0.090

Source: Author's calculations

Table 7 display the results of Granger causality, the findings explored that unidirectional causality from GDP to FDI, it confirms the results of baseline and displays that FDI are due to GDP in a country. The GDP and FDI are in association with previous studies (Alkhasawneh, 2013; Bekhet & bt Othman, 2011; Hossain & Hossain, 2012), asserted that FDI enhances GDP. No causality is shown in export and GDP. A unidirectional causality from energy consumption to GDP is originated, which supports the result of autoregressive distributed lag suggesting that energy consumption cause GDP (Bildirici, Bakirtas, & Kayikci, 2012; Y. Liu, 2009; Ozturk & Acaravci, 2010) explored that energy consumption increase GDP. Additionally, a causality exists between energy consumption and export, the previous researchers confirm the relationship (Mohammadi & Parvaresh, 2014; Qamruzzaman & Jianguo, 2020; Rahman & Kashem, 2017; Shahbaz, Khan, & Tahir, 2013). Empirical results found that export enhances FDI and FDI increases GDP in the long and short run. The NARDL association between FDI, energy consumption, export, and economic growth supports using NARDL for empirical investigating.

### 5: Conclusion

Research indicates that increased FDI enhances GDP. A positive inflow of FDI is significantly linked to higher energy consumption. The more exports brings more FDI which resultantly increase economic growth of a country. This research is a fresh attempt in the field of export and GDP. This study examines the association between FDI, energy consumption, export, and economic growth of Pakistan for the time 1991-2022. The findings suggest a positive relationship suggesting the increase in FDI also increases the GDP of a country, which is in line with the findings of (Sokhanvar, 2019; Zeeshan, Han, Alam Rehman, et al., 2021). Likewise, export also positively affect economic growth which is verified through causality tests and Non-linear ARDL (Temiz Dinç & Gökmen, 2019; A. Ullah, Zhao, Kamal, Riaz, & Zheng, 2020). The outcomes display the short and long-run association between FDI, energy consumption, export, and GDP, and validate the presence of asymmetric nexus between these variables in Pakistan.

This research has policy implications for academicians and management. By implementing proper techniques and clarifying validity and reliability, this research is a sound basis for managerial and theoretical suggestions. This research empirically investigates the occurrence of the long-term relationship between these variables in Pakistan. Future studies can compare different regions with the same variables to measure the variations in this regard. This research has some limitations because this research focused only on a single country, it is better to check the effect of FDI, energy consumption, export and GDP by employing the countries case. Also, this research has some limitations of data, because its covers the time from 1990-2019. Future studies can compare the top countries of the world which have more FDI, energy consumption, export, and economic growth.

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