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Environmental pollution, trade balance, human development index, foreign direct investment, and natural resources rent impacts on initial public offering (IPO) variability in Pakistan: using asymmetric nardl co-integration approach

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Abstract
This study looked at the asymmetric (nonlinear) links between Pakistan's environmental pollution, trade balance, human development index, foreign direct investment, natural resource rent, and IPO variability. The research used an annual data set from 1992 to 2019 and applied a unique co-integrating method known as asymmetric ARDL co-integration approach. The macroeconomic variables of environmental pollution, trade balance, human development index, foreign direct investment, and natural resource rent were found to have significant influences on IPO variability in both long-run and short-run asymmetric impacts. These findings highlight the important roles of the used variables in increasing IPO variability. This research suggests that Pakistan's weak macroeconomic conditions reflect the country's inadequate capital market growth. The country's lower IPO variability indicates a lack of trust among potential issuers and investors as a result of Pakistan's weak macroeconomic indices. The determined asymmetric results may be valuable for Pakistan's policymaking and stock market forecasting. Ignoring fundamental asymmetries may lead to misrepresentations of the implications.

Keywords IPO variability · Environmental pollution · Trade balance · Human development index · Foreign direct investment · Natural resource rent

1 Introduction

The Pakistani stock market had a total of 272 initial public offerings (IPOs) between 1992 and 1997. However, the United States (U.S) sanctioned Pakistan due to the country's nuclear programme in 1997, resulting in an economic halt and a drastic drop in IPO activity in Pakistan to only one in 1998 and none in 1999 (Mehmood et al., 2020). This declining trend in

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IPO activity continued from 2000 through 2022, where only 95 companies went public. Various macroeconomic factors, such as unemployment, terrorism, political instability, sluggish gross domestic product (GDP) growth, high-interest rates, and inflation, may explain Pakistan's weak IPO activity. Researchers have examined the macroeconomic factors influencing IPO issuance in both developing and developed nations (see Ameer, 2012; Angelini & Foglia, 2018; Mehmood et al., 2021a), but few have studied the Pakistani market. The current study is intended to overcome this gap by investigating Pakistan's economic fundamentals and its uniqueness in order to establish links between the identified macroeconomic determinants and IPO variability.

Unfavourable macroeconomic circumstances may influence IPO issuance choices in various ways. First, the decision to go public can be made at any time, but once made, it becomes irreversible. A delay in an IPO issuance indicates possible deteriorations in the participating company's macroeconomic circumstances. Companies decide to go public when they can raise the most cash proportional to their value. However, because of weak macroeconomic performance, there are concerns about acquiring the planned capital amounts through IPOs, forcing companies to postpone their IPO activities until the worries dissipate. According to Lowry (2003), weak economic development creates uncertainty that makes businesses uncertain about their capital requirements. During extreme situations of uncertainty and when macroeconomic conditions are unfavourable, the overall business environment may deteriorate, resulting in lower consumption and production rates (Christiano et al., 2014). Unfavourable macroeconomic variables are said to be the causes and drivers of variations in IPO activity, despite the insufficient evidence to support this claim. Therefore, it is necessary to investigate the impacts of macroeconomic conditions on IPO variability. Thus, the current research investigated the impacts of macroeconomic factors, particularly environmental pollution (EP), trade balance (TB), human development index (HUDI), foreign direct investment (FODI), and natural resources rent (NARE), on the variability of IPOs.

This research utilised the impacts of EP, TB, HUDI, FODI, and NARE in two distinct methods to examine IPO variability. This research contributes to the existing knowledge on the effects of macroeconomic factors on the performance of financial markets in emerging economies. Secondly, according to this study's findings, the links between EP, TB, HUDI, FODI, NARE, and IPO variability are due to a high degree of market uncertainty that is likely to impact the availability, value, and control of private benefits. In addition, the findings of this research indicate that the composite dynamics of inadequate macroeconomic conditions influence the relative strength of investors and entrepreneurs in an environment characterised by severe information asymmetry and uncertainty. In addition, unstable macroeconomic conditions may affect corporate financial behaviour in various ways, such as when firms underutilise their funds and the accessible mechanisms to outside investors, due to the significant weak performance of the country's macroeconomic conditions. The conclusion of this research offers new insights into whether the impacts and severities of adverse macroeconomic conditions and low IPO activity are comparable to those in developed markets.

2 The current scenario in Pakistan

Pakistan is the fourth most polluted country in the world. The life expectancy in Pakistan has reduced by 4.3 years in the past few years due to worsening environmental pollution.[1] The entire 212 million citizens of Pakistan live in regions where the average annual levels of particle pollution exceed the recommendation by the World Health Organization (WHO). About 99% of the people live in places where the environmental qualities exceed Pakistan's own criteria. Particulate pollution has been increasing in Pakistan. The country's most polluted regions include southern Punjab and northern Sindh. Permanently lowering the particle pollution to the WHO's recommendation would increase the citizens' life expectancy by more than 5 years. The population of Karachi, the biggest metropolis in Pakistan, would gain 3.6 years. The population of Lahore, the second biggest metropolis, would gain 5 years. The residents of the capital city, Islamabad, would gain 4 years.

Pakistan had a TB of $-24.39 billion in 2020, a decrease of 24.92% from 2019. In 2019, Pakistan's TB was –32.49 billion dollars, a 12.81% drop from 2018. In 2018, Pakistan's TB was –37.26 billion dollars, a 21.66% rise from 2017. Despite Shahbaz Sharif's ban on non-essential luxury goods above $800, the trade deficit has reached alarming proportions. Pakistan's trade deficit grew by more than 32% to $4.84 billion (June 2020), up from $3.66 billion in the previous year.[2] This was primarily due to an almost twofold rise in imports compared to exports. In 2017–2018, the trade imbalance surpassed $37 billion, mainly owing to purchases related to the China–Pakistan Economic Corridor.[3] The trade deficit decreased to $31.8 billion in 2018–2019, $23.2 billion in 2019–2020, and $30.8 billion in 2020–2021, but it rose to a staggering $48.64 billion in 2021–2022, according to Pakistan's official statistics. The trade imbalance of the preceding year was fuelled by the highest-ever rise in oil prices and commodities in the international market, a result of supply chain interruptions caused by the continuing conflict in Ukraine. The trade imbalance has worsened due to increases in global commodity prices leading to a massive rise in imports, while exports have been stuck at between $2.5 billion and $2.8 billion each month. Most of these exports consist of raw materials and semi-finished goods. Thus, a lack of economic development has led to lower financial inclusivity in emerging markets like Pakistan (Murshed et al., 2023).

Further, Pakistan's HUDI ranking for 2019 was 0.557, placing it in the category of medium human development and putting it at number 154 out of 189 countries. Pakistan's HUDI improved by 38.6% between 1990 and 2019 from 0.402 to 0.557. However, this latest score is still very weak compared to other developed and developing countries. Likewise, Pakistan's FODI in 2020 was $2.06 billion, a decrease of 7.92% compared to 2019. Pakistan's FODI for 2019 increased by 28.61% from the 2018 level to $2.23 billion. In contrast, in 2018, Pakistan's FODI was $1.74 billion, a decrease of 30.41% from 2017. In 2017, Pakistan's FODI was $2.50 billion, which was a 3.11% fall from 2016.[4] The total NARE includes natural gas rents, oil rentals, mineral rents, hard and soft coal rents, and forest rents. The total NARE (as a percentage of GDP) in Pakistan was 0.90501% in 2020, according to the World Bank's database of development indicators gathered from officially

[1] https://aqli.epic.uchicago.edu/country-spotlight/pakistan/#:~:text=Air%20pollution%20shortens%20the%20average,in%20the%20most%20polluted%20areas.

[2] https://www.dawn.com/news/1697938.

[3] https://www.dawn.com/news/1697938.

[4] https://www.macrotrends.net/countries/PAK/pakistan/foreign-direct-investment.

recognised sources. Thus, it is suggested that improvements in EP, TB, HUDI, FODI, and NARE contribute to improvements in IPO variability in Pakistan.

3 The institutional context of the Pakistani IPO market

The Pakistani government established the Corporate Law Authority (CLA) in 1981 to promote and facilitate economic activity. However, trading activity on the stock market remained minimal until 1989. Due to liberalisation, deregulation, and privatisation, the Pakistani government implemented reforms in 1991 to enhance the stock market's transparency and efficiency. The significant number of shares offered by private enterprises in an effort to raise money, diversify ownership, and create exit alternatives demonstrated that the reforms had a favourable impact on the listing activity. The number of IPOs increased between 1991 and 1996. The Securities and Exchange Commission of Pakistan (SECP) was established in 1997 to replace the CLA in an effort to boost stock market activity. However, Pakistan's institutions continued to operate inadequately, showing distressing signs. As per Hassan (2002), the U.S has witnessed severe institutional deterioration over the last three decades, with a climax in the 1990s. Weak governance isolated the general public from decision-making and institutional failure reduced the Country's per capita income, resulting in poor economic development and, as a result, fewer IPOs in Pakistan. Between 1992 and 1997, there were 272 IPOs in Pakistan, but only one was launched in 1998 and none in 1999 (Mehmood et al., 2020).

4 Literature review

4.1 Market timing theory

The semi-strong market efficiency assumption underpins market timing theory (MTT). As a result, as long as the cost of stocks fluctuates for legitimate or illegitimate reasons, a wide range of options exist. Since a company's financial conditions change over time and market complexities may significantly impact corporate finance, MTT has evolved. Lucas and McDonald (1990) investigated the information-based model for stock issuance decisions and found that, on average, equity issuers had positive abnormal returns before issuance. This finding indicates that all companies, regardless of valuation, will try to time the stock market. Nonetheless, due to the variability of adverse selection across organisations, both timing methods would vary. Ritter (1991) investigated the variability of IPO performance across time and industry. The study demonstrated that IPO underperformance varied significantly from year to year and across sectors, showing that issuing companies were aiming to capitalise on "windows of opportunity." Based on the examination of issue periods, Choe et al. (1993) discovered that companies sold seasoned stock when adverse selection costs were minimum. This finding implies that companies attempt to invest in the stock market during seasons with more opportunity and less capital uncertainty and that adverse selection fluctuates over time. Loughran and Ritter (1995) noted that a company's long-term performance would drop following its stock issuance, confirming the notion that companies take advantage of a brief window of opportunity by issuing shares while they are significantly overvalued.

Baker and Wurgler (2002) demonstrated that market timing activity had substantial and lasting effects on a company's capital structure. They contended that the capital structure is merely the result of efforts to time the stock market. MTT hypothesises that when information asymmetry and adverse selection evolve over time, the financing order will not remain static. Frank and Goyal (2004) found a link between a high market-to-book ratio and future debt reduction, but not impact was detected on the issuance of stock. Alti (2006) discovered the existence of market timing behaviour, demonstrating that hot-market IPO companies issued much more stocks and had lower leverage ratios than cold-market companies. Chen et al. (2013) demonstrated that market timing seemed to be the preferred strategy on the Taiwanese stock exchange since net equity followed the fiscal deficit more closely than debt issuance. Therefore, it is difficult to establish that corporate finance choices adhere to a unique capital structure theory. Instead, it is more plausible to believe that it is influenced by internal (e.g., financial deficits) and external (e.g., market values) elements, which need additional examination. Therefore, this study intends to add new insights to the study by Angelini and Foglia (2018) by testing for the first time whether MTT is able, at once, to explain the capital structure decisions in the Pakistani IPO market.

4.2 Environmental pollution and IPO variability

According to recent research by the insurance giant Swiss Re, climate change might save as much as 18% off the global GDP by 2050, which would have enormous economic implications for investors and the industries in which they invest.[5] Numerous financial and tangible assets, such as stocks, have included climate risk in their pricing (Bansal et al., 2019), corporate bonds (Huynh & Xia, 2021), bank loans (Javadi & Masum, 2021), derivatives (Ilhan et al., 2021), municipal bonds (Painter, 2020), commodities (Barnett, 2019), and real estate (Baldauf et al., 2020).

Climate risk, which relates to climate change and initiatives to minimise its effect, is categorised by Krueger et al. (2020) and Li et al. (2023) as regulatory, physical, and technical risks. Regulatory risk is possibly the most imminent of the three, given that governments worldwide are pursuing regulatory policies to combat climate change. According to statistics from the World Bank, many countries have already adopted carbon pricing programmes, and many more are expected to do so in the coming years.[6] With the urgency of regulatory risk, a study pertaining to institutional investors conducted by Krueger et al. (2020) reveals that several regulatory concerns have materialised. Ilhan et al. (2021) argued that investors are unable to estimate regulatory risk owing to climate policy uncertainty. Therefore, investors cannot engage in IPOs owing to increased climate uncertainty since they cannot assess the regulatory risk related to new offerings.

Similarly, economic growth, the quantity of money raised, and the revenues from IPOs may be used to assess the effect of expanded production scales. However, IPO proceeds, self-reported by corporations in their IPO prospectuses before going public, often reflect the trend of increased investment in production scale growth, which uses more resources and produces more pollution (Khan et al., 2022). Accordingly, past research suggests that larger IPO revenues correlate with higher severe environmental pollution.

[5] https://www.swissre.com/media/news-releases/nr-20210422-economics-of-climate-change-risks.html.

[6] https://carbonpricingdashboard.worldbank.org/map_data.

In Pakistan, however, the tendency is reversed owing to higher pollution. As higher emissions impact human lives, it decreases people's ability to work, impact essential products such as food, harm cultural and historical values, reduce ecosystems' ability to perform necessary functions, and cost money in mitigation or restoration, resulting in lower economic and financial growth, similar to the findings of Chen et al. (2023). Following this, the study of Orlitzky et al. (2003) implies that companies with fewer resources are less likely to participate in corporate social responsibility activity. However, there is no evidence of environmental pollution's effect on IPO variability. This finding is unexpected, considering that a large portion of the value of an IPO company is connected to future growth forecasts, which are especially sensitive to economic growth (Bansal et al., 2019). Thus, it is argued that increased pollutions threaten the new offerings and operational performance of IPO enterprises owing to financial uncertainty.

4.3 Trade balance and IPO variability

Trade deficit is harmful to long-term economic growth. To sustain its TB, a country must obtain loans from the International Monetary Fund (IMF) or the World Bank. Due to excessive interest repayments on loans, the nation has less money to spend on new initiatives, thus hindering economic growth. Alternatively, when current account deficits occur, they may be funded by international companies. It is feasible that foreign investors may acquire a country's most valuable asset and capitalise on it in the future. Economic insolvency is possible, causing investors to lose trust and withdraw their investments from the nation. In addition, this scenario creates a significant decline in the value of a currency, lowering the quality of living and discouraging new investment. It decreases the income level over an extended period of time. Similarly, if a country's current account deficit causes a trade imbalance, the country must rely on consumer spending. The export industry expands less as a result of less competitive products. This scenario will eliminate the country's industry, curtailing the expansion of the country's economy. Pakistan is a developing country that has been experiencing a persistent TB deficit since the emergence of globalisation. The trade imbalance poses an excessive amount of risk to the economy of Pakistan. Thus, economists and policymakers need to take serious steps to fix this problem (Muhammad, 2010). Increasing exports is the best strategy to address a trade imbalance (Aurangzeb & Asif, 2012). Since exchange rate depreciation increases the value of exports, the exchange rate plays a significant role in determining TB (Nazeer et al., 2015).

Income and money supply are the primary factors that strongly influence the TB's short- and long-term behaviour in Pakistan. Exchange rate depreciation had a less significant effect than monetary policy did on trade (Kakar et al., 2010). The exchange rate did not help Pakistan maintain its TB (Khan & Aftab, 1995). The study by Muhammad (2010) found that that the exchange rate had a favourable effect on TB and that there was a significant correlation between exchange rate depreciation and trade surplus increase. Between 1976 and 2003, the trade imbalance decreased from $1.2 billion to $1.1 billion. After 2003, the trade imbalance seemed to be quite significant. In 2008, the amount was $24.7 billion. Pakistan's trade deficit in 2021 was $34.47 billion, a 41.33% rise over the 2020 level. However, due to a higher trade deficit trend from 1992 to 1997, a total of 272 IPOs were issued on the Pakistani market, which exhibited an inconsistent trend. As a result, only one company went public in 1998, and none in 1999. In response to Pakistan's nuclear endeavour, the USA implemented many sanctions on the country that were detrimental

to the country's economic progress (Mehmood et al., 2021b). The country's continuously expanding trade deficit may explain Pakistan's declining trend of financial development.

A study of the current literature determined that no evidence exists regarding the influence of TB on the variability of IPOs in Pakistan. TB, a crucial predictor of Pakistan's economic development, has been neglected in past IPO research. Thus, this research addresses this gap and contributes to the current body of knowledge by exploring the effect of TB on IPO volatility.

4.4 Human development index and IPO variability

In the UNDP's (2020) report concerning the effects of poverty on human development in Asia, Pakistan scored 0.557 points on the HUDI and was ranked 154 out of 189 countries. Similarly, a World Bank report on poverty found that poor facilities, food insecurity, old agricultural facilities, low nutrient values, limited access to savings and credit, and an inability to meet basic needs were all linked to poverty in rural societies. Poverty alleviation is regarded as one of the most contentious subjects among academics and policymakers. Based on the HUDI, Hong Kong (China) was the only Asian economy in the top 50 in terms of development. Further, Norway (0.957) attained the best score in the world, followed by Ireland (0.955) and Hong Kong (0.955). However, in Pakistan, where human development and economic growth are both inadequate, the issue arises as to how the capital market has impacted the economic development of Pakistan.

Adoms et al. (2020) argued that the money collected by emerging countries is unable to boost HUDI and economic growth. They further argued that to stimulate capital formation, boost investment, and maintain the financial system's stability, the government should develop and execute policies that assure relative stability in the economy's market-based stock market. Thus, based on the above arguments, this study believes that a lack of human development results in a lacklustre financial market growth, such as a low number of IPO offerings.

4.5 Foreign direct investment and IPO variability

Despite the large number of research papers on the FODI–economic growth link in developing nations, there is a lack of data in the literature about the association between FODI and IPO variability. This research aims to demonstrate the relationship between FODI and IPO variability, given that FODI has been found to boost economic growth in recipient nations. FODI is a significant investment inflow that may boost economic wealth, increase the number of new employment possibilities, enhance technology transfer, and stimulate economic growth (Adegboye et al., 2020). Using the fully modified ordinary least squares (FMOLS) approach, Osabohien et al. (2020) hypothesised that FODI positively influences employment and economic growth.

According to the World Investment (2020) report [1], Pakistan's FODI for 2020 was $2.06 billion, a 7.92% decrease from 2019. In 2019, the total FODI inflows amounted to USD34.8 billion. Furthermore, Pakistan's GDP trend is currently declining, approaching the lowest level in the country's history, while inflation and taxes have been rising. These developments do not portend well for FODI inflows, which will result in lower IPO volatility. The worldwide openings of local stock markets mean that foreign investors can now access local stock markets to broaden their portfolios. According to Kaminsky et al. (2001), the development of the East Asian region's emerging capital markets depends on

mutual fund investments or net private equity flows. A significant percentage of foreign capital inflows into emerging markets came from mutual funds in the USA (Aggarwal & Wysocki, 2005). Foreign investors are drawn to the higher returns of emerging markets, allowing local companies to gain from risk-sharing strategy and reduce equity costs.

4.6 Natural resources rent and IPO variability

Minerals and natural resource rents are regarded as the determinants of economic growth. According to Koirala and Pradhan (2020), the natural environment should not be damaged, NARE should be balanced, and present human demands should not be fulfilled at the expense of future generations. Carbonnier and Wagner (2011) examined the impacts of resource dependency and governance on sustainable development. They found a negative association between resource dependency and sustainable development but a positive relationship between governance and sustainable development in developing countries. Din et al. (2022) discovered a significant negative effect of NARE and a considerable positive impact of financial development on the sustainable development of South Asian countries. He et al., (2023) explained that budgetary allocations are proposed for funding renewable energy, increasing the effectiveness rate of natural resource consumption, and implementing environmentally sustainable policies in order to meet the SDG13 goals.

Similar to the natural resource–growth scenario, it is often thought that a country's financial sector would develop according to its natural resource revenue. The natural resource advantage of resource-rich countries may be used to attract financial flows. The money produced by resource exports and foreign capital inflows, if channelled via the financial sector, might result in FODI. However, previous studies have found inconsistent results. Gylfason and Zoega (2006) found that revenue from natural resources promoted economic growth via saving and investment. They established that reliance on natural resources inhibited economic growth by decreasing savings and investment in resource-dependent nations. Given the significance of saving and investing in FODI, these results have motivated scholars to examine the financial sector's resource curse hypothesis (RCH).

Consequently, several academics have investigated the link between NARE and FODI in various scenarios, with different results. Yuxiang and Chen (2011) empirically assessed the impact of NARE on FODI in China and discovered a negative link between NARE and FODI, confirming the prevalence of the resource curse in the financial sector. The recent research conducted by Guan et al. (2020) found that NARE had a detrimental effect on FODI. Similarly, Asif et al. (2020) experimentally assessed the impact of NARE on FODI in the context of Pakistan and identified an adverse effect of external NARE on FODI, indicating a natural resource curse in Pakistan's financial sector. In conclusion, NARE hinders FODI by destabilising the manufacturing sector, squeezing out human and social capital, undermining contract enforcement, increasing corruption and rent-seeking, and reducing human and social capital. Thereby, this study contends that in a country where natural resources are continuously decreasing, production factors from both the manufacturing and service sectors tend to be reduced (Aluko & Ajayi, 2018; Zhang et al., 2015), and this is one of the reasons for Pakistan's low IPO activity.

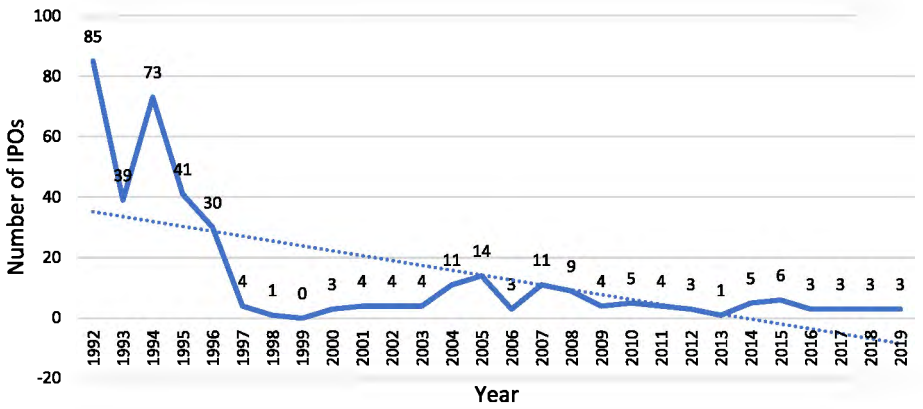


Fig. 1 IPO offerings trend from 1992 to 2019. *Source* Pakistan Stock Exchange

Table 1 Variable operationalisation

Variable name	Measuring unit	Sources
IPO variability (TNIPO)	Number of IPO offerings	Pakistan Stock Exchange
Environmental pollution (EP)	Carbon dioxide emissions, thousands of tonnes	World Bank
Trade balance (TB)	Trade balance as a percentage of GDP	World Bank
Human development index (HUDI)	Human development index (0–1)	World Bank
Foreign direct investment (FODI)	Foreign direct investment, as a percentage of GDP	World Bank
Natural resources rent (NARE)	Income from natural resources, as a percentage of GDP	World Bank

5 Research methodology

This study used the sample of IPOs issued in the Pakistani stock market from January 1992 to December 2019. From 1992 to 1998, Pakistan had a strong history of IPOs, but in 1999, due to several U.S sanctions in response to the country's nuclear tests, the number of IPOs dropped to zero. The number of IPOs was taken from the flotation section of Pakistan Stock Exchange's statistics database. Macroeconomic variable statistics such as EP, TB, HUDI, FODI, and NARE were extracted from the World Governance Indicators database and DataStream. Figure 1 illustrates the IPO variability trend from January 1992 to December 2019. It shows that the largest number of IPOs occurred between 1992 and 1996, while none was issued in 1999. A low IPO variability persisted beyond the year 2000, and the trend continued in 2017 with just three IPOs issued. According to Angelini and Foglia (2018), the low IPO activity was due to macroeconomic conditions.

Table 1 shows the dependent and independent variables of the present study. The dependent variable was measured from the newly listed IPOs on Pakistan Stock Exchange throughout the years. The independent variables are EP, TB, HUDI, FODI, and NARE. Each variable is explained in Table 1.

The asymmetric links between EP, TB, HUDI, FODI, NARE, and IPO fluctuation were examined in this study, and the NARDL model was applied for this aim. The NARDL model is capable of simulating the nonlinear influence of the independent variables on the dependent variable. The standard ARDL might not be able to capture the asymmetric effect, and the bound test might show a lack of co-integration. The NARDL permits the independent variable to be examined at four distinct points. Multiple signals might be acquired at various times throughout the research in both the short and the long run and during the variable's upward and downward trend. This new approach has previously been used by Du et al. (2022) and Tang and Bethencourt (2017).

Below is the equation used for the time series, where β0 is the constant term, β1 to β5 are the coefficients of the independent variables representing EP, TB, HUDI, FODI, and NARE, respectively.

$$\text{TNIPO} = \beta_0 + \beta_1 \text{EP} + \beta_2 \text{TB} + \beta_3 \text{HUDI} + \beta_4 \text{FODI} + \beta_5 \text{NARE} + \epsilon_t$$

The ARDL method examines the long-run relationship between two or more variables using econometric techniques based on stationarity criteria. These models take into consideration the asymmetry of the employed data series. In contrast, linear relationships between variables are evaluated using linear regression models that do not consider the nonlinear behaviour of the variables. Shin et al. (2014) expanded the ARDL framework of Pesaran et al. (1999) and Pesaran et al. (2001) to an asymmetric ARDL co-integration technique owing to the non-linear nature of the variables. This method excels at recognising short-term volatility and fundamental breakdowns (asymmetries). The asymmetric impacts of EP, TB, HUDI, FODI, and NARE on IPO volatility were studied. The asymmetric long-term IPO variability equation is as follows:

$$\begin{aligned}\text{TNIPO} =& \alpha_0 + \alpha_1 \text{EP}_t^+ + \alpha_2 \text{EP}_t^- + \alpha_3 \text{TB}_t^+ + \alpha_4 \text{TB}_t^- \\ &+ \alpha_5 \text{HUDI}_t^+ + \alpha_6 \text{HUDI}_t^- + \alpha_7 \text{FODI}_t^+ \\ &+ \alpha_8 \text{FODI}_t^- + + \alpha_9 \text{NARE}_t^+ + \alpha_{10} \text{NARE}_t^- 1_t\end{aligned}$$

where, TNIPO stands for the total number of IPO offerings, EP stands for environmental pollution, TB refers to trade balance, HUDI represents human development index, FODI stands for foreign direct investment, and NARE represents natural resources rent $\alpha = \alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7, \alpha_8, \alpha_9, \alpha_{10}$ is an estimated co-integrating vector.

In the equation, $\text{EP}_t^+, \text{EP}_t^-, \text{TB}_t^+, \text{TB}_t^-, \text{HUDI}_t^+, \text{HUDI}_t^-, \text{FODI}_t^+, \text{FODI}_t^-, \text{NARE}_t^+, and \text{NARE}_t^-$ are partial sums of positive and negative changes in IPO variability, environmental pollution, trade balance, human development index, foreign direct investment, and natural resources rent.

This investigation gave the lags orders of *m*, *n*, *p*, *q*, and *r* in equation. However, *b*1, *b*2, *b*3, *b*4, and *b*5 indicated the positive and negative long-term shock effects of environmental pollution, trade balance, human development index, foreign direct investment, and natural resources rent on IPO variability.

$$\sum_i^n = 0\delta_{2i}, \sum_i^p = 0\delta_{2i}, \sum_i^q = 0\delta_{2i}, \sum_i^r = 0\delta_{2i}, \sum_i^s = 0\delta_{2i}, \sum_i^n = 0\delta_{2i}, \sum_i^n = 0\delta_{2i}, \sum_i^n = 0\delta_{2i}$$

The short-run positive and negative consequences of environmental pollution, trade balance, human development index, foreign direct investment, and natural resources rent on IPO variability were assessed.

The NARDL approach was used in this study to depict the nonlinear long-run relationships. The asymmetric ARDL model proceeded in stages. All the variables were

Table 2 Descriptive statistics

	TNIPO	EP	TB	HUDI	FODI	NARE
Mean	13.000	126,937.300	− 5.100	0.490	1.130	1.480
Median	4.000	127,075.000	− 5.970	0.500	0.820	1.250
Maximum	85.000	208,370.000	0.940	0.560	3.670	2.600
Minimum	1.000	66,920.000	− 11.100	0.420	0.380	0.760
Std. Dev	21.410	40,029.070	3.430	0.050	0.850	0.560
Skewness	2.300	0.440	0.110	-0.100	1.940	0.500
Kurtosis	7.340	2.310	2.090	1.540	5.750	1.880
Jarque–Bera	46.770	1.450	1.020	2.550	26.320	2.600
Probability	0.000	0.480	0.600	0.280	0.000	0.270

first evaluated for stationarity using Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) unit root tests and Zivot and Andrews (ZA). This study employed the ARDL model when all variables were totally stationary at 1(0), 1(1), or a combination of 1(1) and (0). However, this model has one limitation: the ARDL model cannot progress in the presence of a 1(2) series (Ibrahim, 2015). Consequently, to avoid misleading findings, the stationarity of variables was examined in this study. Furthermore, the SIC information requirements were applied in this research as well and the general-to-specific technique was presented by Katrakilidis and Trachanas (2012). The bound test was used in this study to assess whether co-integration existed. Following the demonstration of co-integration, the asymmetric ARDL model was employed in this study. Lastly, asymmetric cumulative dynamic multiplier effects were computed using the percentage change of $EP_t^+, EP_t^-, TB_t^+, TB_t^-, HUDI_t^+, HUDI_t^-, FODI_t^+, FODI_t^-, NARE_t^+$, and$NARE_t^-$, respectively.

6 Result analysis and discussion

Table 2 displays the descriptive data for the listed IPOs and the macroeconomic variables. Between 1992 and 2019, the published results for the number of IPOs had a mean value of 13 IPOs, a maximum of 85 IPOs, and a minimum of 1 IPO. The mean value of environmental pollution was 126,937 tonnes, the maximum was 208,370 tonnes, and the minimum was 66,920 tonnes, and these findings are similar to the findings of Ullah et al. (2021). Between 1992 and 2019, the results indicated a significant variation in environmental pollution. However, the present level of environmental pollution is greater than it has been in the previous 5 years, making Pakistan the fourth most polluted country in the world. The average TB was − 5.100%, and the lowest TB was − 11.100%. The highest TB was 0.940%, suggesting that the number of IPOs was predicted to decrease with a low TB. HUDI had an average score of 0.480, with maximum and minimum values of 0.560 and 0.420, respectively. Pakistan's performance in terms of the HUDI was unfavourable between 1992 and 2019. As a consequence of higher uncertainty, it was anticipated that a lower HUDI would result in fewer IPO offerings.

The average value of FODI was 1.130%, while the highest and lowest values were 3.67% and 0.380%, respectively. The results indicate that the number of IPOs will decrease when FODI is low. Lower FODI can potentially impact the capital market and discourage enterprises from offering IPOs. Khan and Khan (2011) suggested that a decrease in FODI

Table 3 Correlation matrix

	TNIPO	EP	TB	HUDI	FODI	NARE
TNIPO	1					
EP	− 0.5540	1				
TB	0.0632	− 0.7347	1			
HUDI	− 0.5853	0.9612	− 0.7173	1		
FODI	− 0.0492	0.0576	− 0.3346	0.0637	1	
NARE	− 0.3692	0.2992	− 0.3504	0.4857	0.4025	1

Table 4 Unit root test

First difference and intercept	T-Statistics	First difference and Trend and intercept	
Augmented Dickey-Fuller (ADF) test statistic			
Test critical values:		Test critical values:	
1% level	− 7.0284	1% level	− 7.1685
5% level	− 3.4931	5% level	− 4.0469
10% level	− 2.8889	10% level	− 3.4527
Phillips-Perron (PP) test statistic			
Test critical values:		Test critical values:	
1% level	− 8.3305	1% level	− 11.92
5% level	− 3.4907	5% level	− 4.0436
10% level	− 2.8879	10% level	− 3.4511
Zivot and Andrews (ZA) test statistics			
Test critical values:		Test critical values:	
1% level (Year break 1996)	− 1.9968	1% level (Year break 2008)	− 2.3048
5% level (Year break 2008)	− 2.1566	5% level (Year break 2008)	− 3.4917
10% level (Year break 2014)	− 2.2227	10% level (Year break 2008)	− 2.8915

indicates more economic volatility in Pakistan, and this trend, which began after 1992, continues to the current day owing to Pakistan's unstable economic circumstances. In addition, the result showed that the average rent for NARE was 1.480%, while the highest and lowest levels were 2.600 percent and 0.760%, respectively.

The correlation analysis findings for the study's variables are shown in Table 3. The table shows that EP, HUDI, FODI, and NARE had a negative and substantial relationship with TNIPO, meaning that IPO variability rose with a decreasing trend of EP, HUDI, FODI, and NARE, as validated by prior research. In contrast, TB showed a significant positive correlation with TNIPO. The result suggests that improvements in TB lead to higher IPO offerings. Variance inflation factors (VIFs) were used in this investigation to establish the absence of multicollinearity between variables. Furthermore, the majority of the correlation coefficients were less than the cut-off threshold of 0.70. This study's results revealed that multicollinearity in regression analysis was not a concern in this study. Further, Table 4 shows the ADF and PP results for EP, TB, HUDI, FODI, and NARE. The results indicated that the variables were stationary without I(2) and that the study could proceed with NARDL. Additionally, Perron (1989) stated that the traditional ADF unit root test provides erroneous results in the presence of structural breaks, therefore this study utilized

Table 5 Results of the F-bounds test. *Source*: Author Estimations

Test statistic	Value	Significant	I(0)	I(1)
F-statistic	11.46156	10%	3.8	3.8
k	0.0000	5%	4.6	4.6
		2.50%	5.39	5.39
		1%	6.44	6.44

Zivot and Andrews (1992) unit root test, which analyses structural breaks to invalidate the null hypothesis of the unit root. In terms of structural breaks, it is discovered that none of the variables are stationary at 1(2) using Zivot and Andrews (1992) unit root test (Table 4). Therefore, in the present study may apply the ARDL bounds testing technique since none of the series are stationary at 1(2) or above.

Regarding the nonlinear structure of the variables, Shin et al. (2014) expanded the ARDL framework of Pesaran et al. (1999) and Pesaran et al. (2001) to an asymmetric ARDL cointegration technique. This approach can detect short-term volatility and structural breaks (asymmetries). According to Bahmani-Oskooee and Bohl (2000), long-term relationships are reliant on optimal lags. Stock and Watson (2012) demonstrated that adopting too many or too few lags might cause the model to overlook the essential information or provide erroneous predictions. In light of the relevance of optimum lags, this research used just two lags as optimal according to the SIC information criteria. The results of bound testing in the nonlinear specification are shown in Table 5. At the 5% significance level, the computed F-statistic value exceeded the upper boundary critical value, demonstrating asymmetric co-integration. Therefore, it was recommended to continue with asymmetric ARDL specification.

Equations were computed in this work utilising the general-to-specific method with $p = q = 2$ as the appropriate lag length. Shin et al. (2014) employed the same strategy to obtain the final specification of the asymmetric ARDL model. Based on the general-to-specific technique, in this research, all insignificant lagged regressors were eliminated. According to Katrakilidis and Trachanas (2012), it is necessary to remove insignificant lagged regressors because they might produce noise in dynamic multipliers. This research also examined the normality of residuals with the Jarque–Bera test, serial correlation with the Breusch-Godfrey serial correlation LM test, and heteroskedasticity with the Breusch-Pagan-Godfrey test. The results of all the tests proved that the model was free from the aforementioned issues; hence, the study could continue with a dynamic estimation of the NARDL approach. Table 6 presents the results of the NARDL estimation.

The study investigated the long-term asymmetric relationships between EP, TB, HUDI, FODI, NARE, and the total number of IPOs issued in Pakistan. The outcomes of the long-term asymmetric relationships between projected variables are shown in Table 7. The results demonstrated the existence of long-term asymmetric relationships between EP, TB, HUDI, FODI, and IPO variability.

The results showed that IPO variability increased by 0.11% in response to positive environmental pollution shocks and 0.85% in response to negative environmental pollution shocks. However, no prior studies have established a correlation between environmental pollution and IPO variability. Nonetheless, previous studies have revealed both positive and negative associations between environmental pollution and financial development. Prior studies have emphasised the role of a country's efforts in handling environmental

Table 6 Dynamic estimation of NARDL results

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
TNIPO(-1)	1.2869	0.0856	15.0191	0
TNIPO(-2)	− 0.4989	0.0741	− 6.7331	0
EP _POS	4.1481	0.9173	4.6660	0.0009
EP _NEG	− 0.2458	0.0779	− 3.2027	0.0011
TB_POS	1.6350	0.6672	2.4506	0.0161
TB_NEG	0.0429	0.4260	0.1008	0.2199
HUDI_POS	234.242	140.773	1.6639	0.0993
HUDI_NEG	− 4259.38	2628.89	− 1.6202	0.1084
FODI _POS	0.2785	0.0881	3.5553	0.0001
FODI _NEG	1.0064	1.440196	0.6988	0.4863
NARE_POS	0.1882	2.80038	0.0672	0.9465
NARE_NEG	− 0.3900	0.080	− 3.7077	0.0009
C	18.3851	5.500116	3.3426	0.0012
R-squared	0.8560	Durbin-Watson stat	2.0876	
Adjusted R-squared	0.8105			

Table 7 Long-Run Asymmetric Relationship

Variable	Coefficient	Std. Error	t-Statistic	Prob
C	18.3851	5.5001	3.3426	0.0012
TNIPO(-1)*	− 0.2120	0.0467	− 4.5358	0.0000
D(TNIPO(-1))	0.4989	0.0741	6.7331	0.0000
EP _POS	0.1127	0.5174	0.2122	0.0831
EP _NEG	− 0.8525	0.8109	− 0.9812	0.0311
TB_POS	1.63508	0.6672	2.4506	0.0161
TB_NEG	0.0429	0.4260	0.1008	0.2199
HUDI_POS	234.242	140.7732	1.7639	0.0993
HUDI_NEG	− 4259.38	2628.89	− 1.6202	0.1084
FODI _POS	4.974	1.2179	3.1146	0.0019
FODI_NEG	1.0064	1.4401	0.6988	0.4863
NARE_POS	0.1882	2.8003	0.0672	0.1145
NARE_NEG	− 2.3411	0.7040	− 3.1928	0.0001

pollution and its influence on financial and economic development. There are conflicting theoretical perspectives regarding the relationship between pollution emissions and economic development. First, it is asserted that a country with reduced pollution has a sound financial system and related institutions, thus boosting both economic activity and environmental quality by providing credit for research and development (Chandio et al., 2019). Proponents of this viewpoint believe that as financial inequality increases, industrialisation accelerates and industrial pollution rises (Jensen, 1996). Furthermore, the supply of loans for large consumer goods like environmental conditioners, refrigerators, vehicles, and houses will be made easier by rapid financial development, leading to higher energy consumption and, in turn, higher pollution emissions (Zhang, 2011). The primary cause of the

asymmetric behaviour of IPO variability is related to negative and positive environmental pollution changes. Higher pollution levels cause more financial constraints and uncertainties, which lower investor confidence to participate in IPOs, resulting in no IPO activity. Likewise, Pakistan is the fourth-ranked country in terms of high pollution and observes the lowest IPO activities.

Further, due to the positive shock in the TB, the IPO variability increased by 1.63%, while a negative shock in the TB decreased IPO variability by 0.0429%. Previous studies have shown a significant association between TB and economic development (Blavasciunaite et al., 2020; Muluh et al., 2021). However, this result suggests that even though the volume of trade in Pakistan may have increased over the years, growing trade deficits act as a drag on the economy, mainly when the deficits are a result of an increase in imports of consumer goods that can be produced domestically, as is the case in many emerging economies including Pakistan due to low productivity and consequently slow economic growth. Thus, the result suggests that a higher trade deficit in the country leads to lower financial and economic development, similar to the case of IPO variability.

Additionally, this study found that human development had an asymmetrical impact on IPO variability. Due to positive shocks in human development, IPO variability increased by 34.24%, whereas negative shocks in human development decreased IPO variability by 19.0138%. HUDI is a composite statistic comprising life expectancy, education, and income indices that are used to classify countries into four levels of human development. Witt and Redding (2013) described the value of HUDI. It assesses the available skills and knowledge in a nation's business system. The finding indicates that human development has the capacity to attract foreign capital inflows, which is a significant indication of promoting national growth and financial development. This argument is similar to the findings of Musibau et al., (2019). Thus, it is believed that an improvement in human development might boost IPO activity in both the short and the long term, similar to the findings of Musibau et al. (2019), who found a significant positive correlation between human development and economic growth.

In addition, this study found that FODI had an asymmetric impact on the variability of IPOs. Positive shocks in FODI resulted in a 4.29% increase in IPO variability, whereas negative shocks in FODI had no effect. The trajectory of Pakistan's GDP has continuously decreased, approaching the lowest level in the nation's history, while inflation and taxes have increased over time. These patterns do not signal well for FODI inflows, which will reduce IPO variability. According to Kaminsky et al. (2001), the developing capital markets in Asia are supported by net private equity flows or mutual fund investments. A substantial portion of foreign capital inflows into developing nations originates from mutual funds created in the USA and, more recently, from China. Foreign investors are attracted to the higher returns offered by emerging economies, which enable local businesses to benefit from the risk-sharing strategy and reduced equity costs. Consequently, the findings suggest that an increase in FODI would increase the variability of IPOs. Similarly, from the perspective of private equity investment, developing nations provide a good chance for investment diversification and the realisation of excess risk premiums (Errunza, 1983). Increasing external capital requirements drive managers to seek less costly means of collecting capital, such as risk sharing with foreign investors (Lowry, 2003). Since foreign investors are more eager to engage in a growing market that provides better returns, local businesses often gain from risk sharing and lower equity costs. Thus, increasing FODI may increase IPO variability.

In addition, the study found that NARE had an asymmetric impact on the variability of IPOs. Positive shocks in NARE had no effect on IPO variability, whereas negative

shocks in NARE had a − 2.3411% negative impact. The changes in revenues from exporting NARE as a result of fluctuations in raw material prices led to fluctuations in the real exchange rate; this increase had a negative impact on the effectiveness of the industrial products sector. The volatility of NARE prices also caused fluctuations in public spending policies, exacerbating fluctuations in key economic variables, resulting in a decline in capital investment and a reduction in economic development. This argument conforms to the findings of Ibrahiem and Sameh (2021). Thus, an increase in NARE reduces IPO variability, which is prevalent in a developing nation like Pakistan.

Before the ultimate deployment of the asymmetric ARDL model, a number of diagnostic tests were conducted. This study's model was free from serial correlation and heteroscedasticity, as shown by the LM 2 (*p*-values) and Breusch-Pagan-Godfrey tests, which had values of 0.37 and 0.61, respectively. In addition, the Jarque–Bera test proved the residuals' normality. Similarly, the value for Ramsey RESET (0.69) was not statistically significant, showing that the current research model was adequately stated. The VIF value of 5.4 was lower than 10, suggesting that there were no multicollinearity concerns with the current research model. Consequently, all model coefficients were robust.

7 Conclusion

This research investigated the asymmetric impacts of EP, TB, FODI, HUDI, and NARE on IPO variability in the Pakistani stock market between 1996 and 2019. This study contributes to the existing literature on IPOs by outlining the unfavourable macroeconomic factors in the Pakistani market that discourage companies from going public. NARDL models were used to examine the relationships between macroeconomic factors and IPO variability. The empirical results showed that EP, TB, HUDI, FODI, and NARE had substantial long-run and short-run asymmetric influences on IPO variability.

The econometric technique revealed that environmental pollution had positive long-term and positive and negative short-term impacts on IPO variability. Furthermore, TB and HUDI had a significant positive influence on IPO variability in both the long and the short term. FODI had a positive influence on IPO volatility in both the short and the long term. Finally, NARE had a negative impact on IPO volatility in both the short and the long term. Consequently, the findings highlight the significance of macroeconomic variables in signalling favourable economic circumstances for enterprises considering going public. If human development and FODI improve, IPO variability will increase. The substantial negative impacts of EP and NARE on IPO variability suggest that increasing these variables may lower IPO variability. As a result, the current analysis offers a thorough understanding of the causes of IPO variability, precisely their asymmetrical consequences. Previous research has also revealed that poor performance of macroeconomic indicators indicates political instability, which generates information asymmetry and escalates IPO issuance costs, hence discouraging companies from issuing new listings. Consequently, fewer IPO offerings are made during periods of political uncertainty (Çolak et al., 2017). Therefore, a company's intention to go public is influenced by a number of macroeconomic variables that influence the attractiveness of the financial market. The underlying factors of IPO variability in Pakistan include EP, TB, HUDI, FODI, and NARE. The study's conclusions may be useful to investors, companies, regulators, and policymakers.

The results indicate that investors should evaluate macroeconomic circumstances while managing investment portfolios and recognise beneficial IPO variations when making investment decisions. Favourable market circumstances may boost the number of IPOs and, as a result, their returns. Similarly, companies may choose to go public when market conditions are favourable so as to obtain full IPO subscriptions. The government should take critical measures to improve the country's macroeconomic conditions in order to ensure market growth. Stakeholders may use the findings to improve their understanding of IPOs, and policymakers can make the financial capital market more dynamic, active, and diverse. This study investigated the dynamic influences of a limited number of variables on IPO variability. Consequently, future studies may incorporate other macroeconomic determinants at the national level, such as market liquidity, volatility, and institutional quality. Expanding the data set to include other Asian nations in order to analyse various market spillovers is an additional interesting area of study.

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