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Impact of CPEC Special Economic Zones on Pakistan's Export Competitiveness: Evidence from China's Regional Trading Partners

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Abstract

This study examines the association between China-Pakistan Economic Corridor (CPEC) Special Economic Zones (SEZs) and Pakistan's export performance. Drawing on trade and economic growth literature, it investigates whether SEZ development is associated with higher export competitiveness and how domestic boundary conditions—endowment quality, innovation capacity, and the business environment—condition this relationship. Using panel data from 2014 to 2024 across Pakistan's provinces, the study employs Fixed Effects panel regression models to evaluate export performance. The findings indicate a positive association between CPEC SEZ development and export competitiveness. Furthermore, this relationship is strongly conditioned by domestic absorptive capacity: higher endowment quality, innovation capabilities, and a favorable business environment significantly enhance the positive linkage between SEZs and export performance. The study concludes that physical SEZ establishment alone is insufficient; Pakistan must complement infrastructure with policies that strengthen domestic capabilities and institutional conditions.

Keywords

CPEC, Special Economic Zones, Pakistan's Export Competitiveness, Global Value Chains, Endowment Quality, Innovation Capacity, Business Environment, Belt and Road Initiative

1. Introduction

The China-Pakistan Economic Corridor (CPEC), a flagship initiative of China's Belt and Road Initiative (BRI), aims to enhance regional connectivity, industrial

cooperation, and trade integration. A central component of CPEC is the development of Special Economic Zones (SEZs), which are intended to promote industrial clustering, attract foreign direct investment (FDI), facilitate technology transfer, and strengthen export-oriented manufacturing. Evidence from China and other developing economies suggests that SEZs can enhance export competitiveness by improving infrastructure, reducing transaction costs, and integrating domestic firms into global production networks (Wang, 2013; Bräutigam & Tang, 2014; Li & Li, 2020). In Pakistan, CPEC-linked SEZs are therefore expected to address structural weaknesses in the industrial sector and expand export capacity. However, Pakistan's export performance remains relatively weak compared with economies such as Vietnam, Bangladesh, and Sri Lanka, which have more effectively used SEZs and industrial parks to diversify exports and achieve industrial upgrading (Zhao et al., 2020). Pakistan continues to rely heavily on a narrow export base dominated by low-technology products, particularly textiles and primary commodities (World Bank, 2020), raising questions about whether SEZ development alone is sufficient to generate sustained export competitiveness.

Existing research on CPEC and BRI-related SEZs has predominantly examined infrastructure development, economic growth, and investment flows, with comparatively limited empirical attention to sectoral export performance. Moreover, previous studies have often assumed a direct or automatic relationship between SEZ development and export outcomes, while giving insufficient attention to the domestic conditions that determine the effectiveness of SEZs. This study addresses this gap by assessing provincial export competitiveness within a standardized panel framework to evaluate trade positioning.

This study addresses this gap by conceptualizing endowment quality, innovation intensity, and the business environment as moderating conditions that determine when and to what extent SEZs can enhance export competitiveness. Endowment quality, including human capital, infrastructure, and resource availability, influences the ability of SEZ-induced investment to generate productive and export-oriented activities (Geng & Bai, 2019; Li, 2015). Transport and logistics infrastructure are particularly important for trade performance and participation in global value chains (Lanz & Piermartini, 2021; Ahmed et al., 2021). Innovation capacity represents another critical condition because R&D intensity and technological capabilities enable firms to move beyond low-cost production toward higher-value activities and greater domestic value added (Zheng & Zheng, 2020; Yu & Luo, 2018). Similarly, the business environment, including institutional quality, regulatory efficiency, and financial development, affects firms' ability to exploit SEZ-related opportunities by reducing transaction costs and operational risks (Levchenko, 2007; Nunn, 2007; Berman & Héricourt, 2010; Bah & Fang, 2015).

The argument is further grounded in Global Value Chain (GVC) and absorptive capacity theories, which emphasize that participation in international pro-

duction networks does not automatically yield sustained export growth unless host economies possess strong domestic capabilities. SEZs can facilitate trade participation, but their long-term contribution depends on local factor endowments, technological absorption, and supportive institutions.

Against this background, the present study examines the association between CPEC SEZs and Pakistan's export competitiveness while assessing the moderating roles of factor endowment, innovation intensity, and the business environment. Using panel data for 2014-2024 across Pakistani provinces, this empirical design provides a systematic assessment of whether SEZ development is positively linked with export performance and how domestic capabilities strengthen this relationship.

2. Literature Review

2.1. CPEC Special Economic Zones (SEZs) and Pakistan's Export Competitiveness

The China-Pakistan Economic Corridor (CPEC) represents a multi-billion-dollar investment aimed at transforming Pakistan from a consumption-led economy into an industrial and export-oriented hub. Central to this transformation is the development of Special Economic Zones (SEZs). These zones are geographically delimited areas governed by unique administrative and economic regulations that differ from the broader national landscape (Wang, 2013). In the context of CPEC, SEZs are designed to address the chronic structural deficiencies of Pakistan's industrial sector namely, high transaction costs, energy deficits, and fragmented supply chains by providing a concentrated, high-efficiency environment for both domestic and foreign firms (Ahmed et al., 2021).

The theoretical link between SEZs and export competitiveness is rooted in the concept of institutional enclaves. By isolating market-oriented reforms within a specific zone, a country can bypass broader bureaucratic rigidities and offer a policy oasis that attracts export-processing activities. For Pakistan, the operationalization of CPEC SEZs like Rashakai, Allama Iqbal (FIEDMC), and Dhabeji marks a shift from the infrastructure-heavy Phase I of CPEC to the industrial Phase II. This phase is predicated on the belief that localized industrial clustering will catalyze the production of higher-value-added goods in international markets (Balassa, 1965; Bräutigam & Tang, 2014). The positive relationship between SEZ development and export competitiveness is driven by several critical economic mechanisms, ranging from cost reduction to technological assimilation.

SEZs foster industrial clustering, which creates significant agglomeration economies. When firms from similar or complementary industries locate within the same zone, they benefit from shared labor pools, specialized infrastructure, and local supplier networks. This geographic concentration reduces the average cost of production and enhances the efficiency of the supply chain. For Pakistan, this means that firms operating within CPEC SEZs can produce goods more competitively than those scattered across unorganized industrial estates. These external

economies of scale are a primary driver of price competitiveness in global markets (Li, 2015). Attraction of Technology-Intensive FDI Special Economic Zones are the primary vehicles for attracting Outward Foreign Direct Investment (OFDI) from China. Unlike general investment, the FDI channeled into CPEC SEZs is often tied to global production networks. These investments bring not only capital but also embodied technology advanced machinery, patented processes, and modern management standards (Zhang & Long, 2022; van Pottelsberghe & Lichtenberg, 2001). As Chinese firms relocate their manufacturing bases to Pakistan to take advantage of lower labor costs and strategic geography, they introduce production standards that allow Pakistani-made products to meet the rigorous quality requirements of the European, North American, and Middle Eastern markets (Adarov & Stehrer, 2021).

Based on Global Value Chains (GVCs) theory, Modern trade is characterized by fragmented production, where components are made in different countries before final assembly. SEZs act as the entry gates for developing nations to plug into these Global Value Chains. By providing specialized customs services, duty-free import of raw materials, and streamlined logistics, CPEC SEZs allow Pakistani firms to participate in vertical specialization (Li, 2015; Koopman et al., 2014). This integration is crucial for moving away from primary commodity exports toward the manufacturing of intermediate and final goods, which carry higher profit margins and more stable global demand.

Infrastructure synergy and logistics efficiency. A major hurdle to Pakistan's export competitiveness has been the "time-to-market." CPEC SEZs are strategically linked to the corridor's upgraded highway and rail networks, providing a direct pipeline to the deep-sea ports of Karachi and Gwadar. This synergy between hard infrastructure and industrial zones significantly reduces the lead time and transport costs for exporters. According to Global Value Chain theory, logistics efficiency is a fundamental determinant of a country's ability to compete in time-sensitive industries like electronics and high-end textiles (Lanz & Piermartini, 2021; Ahmed et al., 2021; Nordås et al., 2006).

The positive impact of SEZs on export competitiveness is well-documented in the experiences of other emerging economies. China's own economic miracle began with the four SEZs in its southern coastal regions, which served as the engine for its export-led growth (Wang, 2013). Similarly, Vietnam and Bangladesh have utilized overseas industrial cooperation zones to achieve massive diversification in their export baskets. In Vietnam, SEZs helped transition the economy from agriculture to high-tech electronics, while Bangladesh used zones to consolidate its position as a global leader in ready-made garments (Zhao et al., 2020; World Bank, 2020). For Pakistan, CPEC SEZs represent the first systematic attempt to replicate this industrial park Mode. Unlike previous, smaller-scale attempts at industrial estates, CPEC SEZs are backed by bilateral state-level commitments and integrated into a transnational economic corridor. This provides a level of policy certainty and scale that is expected to generate a more profound shift in the coun-

try's trade profile (Bräutigam & Tang, 2014; Yan et al., 2021).

This study argues that the development of CPEC SEZs initiates a virtuous cycle: increased FDI leads to higher industrial output; higher output fosters technological learning; and technological learning enables product and process upgrading. As firms within the zones move from basic assembly to more complex manufacturing, the Value-Added (DVA) of Pakistan's exports increases (Zheng & Zheng, 2020; Yu & Luo, 2018). This transition is essential for Pakistan to overcome its low-technology trap. By utilizing the SEZs as testing grounds for industrial innovation, the country can develop a revealed comparative advantage in new sectors, such as light engineering, automotive parts, and high-end chemicals. This diversification not only boosts export revenues but also shields the economy from the volatility of global textile and commodity prices (World Bank, 2020).

Based on the above discussion, the following hypothesis is proposed:

H1: CPEC Special Economic Zones (SEZs) have a positive effect on Pakistan's export competitiveness.

2.2. CPEC Special Economic Zones (SEZs) → Pakistan's Export Competitiveness: Moderating Role of Endowment Quality

While the establishment of Special Economic Zones (SEZs) under the China-Pakistan Economic Corridor (CPEC) provides the institutional framework for industrial growth, the magnitude of their impact on export competitiveness is strictly contingent upon the host country's underlying factor endowments. In this study, Endowment is conceptualized as a moderating boundary condition. According to the global value chain and the new structural economics framework, industrial policy (the SEZ) cannot succeed in a vacuum; its effectiveness depends on the absorptive capacity of the local environment (Lin & Monga, 2014; Geng & Bai, 2019).

Moderation implies that the relationship between CPEC SEZs and export competitiveness is not constant. Instead, the strength of this relationship fluctuates based on the level of endowment quality encompassing human capital sophistication, infrastructure reliability, and logistics efficiency. When endowment quality is high, the policy rents and infrastructure provided by SEZs are more effectively translated into productive output. Conversely, when endowment quality is low, SEZs risk becoming industrial zones with minimal impact on national export sophistication (Li, 2015).

The primary channel through which endowment quality moderates the SEZ-export relationship is the matching of Initial Human Capital. GVC theory posits that for a country to upgrade, its labor force must possess the technical skills required to operate the advanced machinery and management systems introduced by foreign investors (Li, 2015; Geng & Bai, 2019). In the context of CPEC SEZs, if Pakistan provides a high quality of technical and vocational endowment, the technology transfer from Chinese firms will be more rapid and profound. This synergy strengthens the effect of SEZs on export competitiveness by allowing local firms

to move from simple assembly to complex manufacturing (Chen et al., 2022). While CPEC SEZs provide localized infrastructure, their connection to the broader national endowment (power grids, transport networks, and port facilities) determines the efficiency of the last-mile delivery. High-quality physical endowments reduce the transaction costs associated with vertical specialization. When the national transport infrastructure is robust, the time-to-market for goods produced in SEZs is minimized, significantly strengthening the zone's contribution to export competitiveness (Lanz & Piermartini, 2021; Ahmed et al., 2021). Without this high-quality endowment, the localized benefits of the SEZ are stifled by the inefficiencies of the broader national economy.

The quality of factor endowments also determines the value-added of exports. If a host country has high-quality natural and human resources, firms within SEZs are more likely to source intermediate inputs locally rather than relying on imports. This deeper integration increases the trade gains realized from the SEZ. Empirical research on China's overseas zones indicates that the positive impact on a host country's GVC position is significantly amplified when there is a strong match between the zone's industrial needs and the host country's endowment structure (Xu & Zhang, 2020). Theoretical literature suggests a threshold effect wherein SEZs only begin to show transformative results once a certain level of endowment quality is reached. In economies with poor infrastructure and low-skill labor, SEZs may attract only low-end, footloose industries that provide little long-term competitiveness. However, as endowment quality improves through CPEC's energy and transport projects, the SEZs become capable of attracting high-tech industries that drive genuine structural upgrading and increase the host country's export (Balassa, 1965; Wang, 2013; Li et al., 2018). Based on this reasoning, the following hypothesis is proposed:

H2: Endowment quality positively moderates the relationship between CPEC Special Economic Zones (SEZs) and Pakistan's export competitiveness, such that the relationship is stronger when endowment quality is high.

2.3. CPEC Special Economic Zones (SEZs) → Pakistan's Export Competitiveness: Moderating Role of Innovation Capacity

Innovation capacity is a pivotal determinant of a nation's ability to transition from a passive recipient of foreign technology to an active participant in global industrial competition. In the context of the China-Pakistan Economic Corridor (CPEC), while Special Economic Zones (SEZs) provide the institutional and physical platform for industrial activity, Innovation Capacity functions as a moderating boundary condition that dictates the efficiency of this transformation. According to Schumpeterian growth theory and the Global Value Chain (GVC) framework, the benefits of industrial policy are not distributed uniformly; they are captured more effectively by economies with a high capacity for technological absorption and creative destruction (Schumpeter, 1934; Zheng & Zheng, 2020).

Moderation in this context implies that the positive association between CPEC

SEZs and Pakistan's export performance is significantly amplified by the level of domestic innovation. High innovation capacity, characterized by R&D intensity, intermediate product innovation, and technological proficiency, allows firms within SEZs to move beyond simple assembly toward high-value-added manufacturing. Conversely, in an environment of low innovation capacity, SEZs may facilitate production but fail to trigger the structural upgrading necessary for long-term competitiveness (Geng & Bai, 2019; Yu & Luo, 2018).

The primary mechanism through which innovation capacity moderates the SEZ-export relationship is absorptive capacity. When Chinese firms establish high-tech production lines within CPEC SEZs, the degree to which local Pakistani firms and workers can internalize these advanced processes depends on the existing national innovation system. High innovation capacity ensures that demonstration effects and knowledge spillovers are effectively captured. This synergy strengthens the relationship between SEZ development and export competitiveness by enabling local industries to produce goods that meet sophisticated international standards (van Pottelsberghe & Lichtenberg, 2001). Innovation capacity also determines a country's ability to engage in "intermediate product innovation." In global value chains, the highest value is often retained by countries that can innovate and manufacture specialized components rather than just assembling final products. If Pakistan possesses high innovation capacity, the SEZs will foster the development of local supply chains for intermediate goods. This reduces the reliance on imported parts from China, thereby increasing the value-added of Pakistani exports (Zheng & Zheng, 2020; Koopman et al., 2014).

High innovation capacity allows for continuous product upgrading. In the competitive global market, export success is increasingly driven by quality and technological sophistication rather than just low costs. Innovation capacity acts as a catalyst, enabling firms in SEZs to iterate on designs and improve product durability and functionality. This moderating effect ensures that the industrial output of CPEC SEZs is not only cheap but also competitive in high-end global markets, thereby moving the nation further up the host-country export ladder (Ma, 2015; Wei et al., 2015). Empirical research on China's overseas economic zones suggests that the trade-inducing effects of these zones are much stronger in host countries that have invested in R&D and technological infrastructure. Innovation capacity serves as the soft engine that powers the hard infrastructure of the SEZ. Without this capacity, SEZs remain mere processing hubs; with it, they become centers of industrial excellence. For Pakistan, the practical significance of this moderation lies in the alignment of CPEC industrial cooperation with a robust national R&D strategy to ensure that the corridor results in a genuine technological leap (Yan et al., 2021).

Based on the above discussion, the following hypothesis is proposed:

H3: Innovation capacity positively moderates the relationship between CPEC Special Economic Zones (SEZs) and Pakistan's export competitiveness, such that the relationship is stronger when innovation capacity is high.

2.4. CPEC Special Economic Zones (SEZs) → Pakistan's Export Competitiveness: Moderating Role of Business Environment

The business environment constitutes the institutional soft infrastructure that defines the rules of engagement for firms within an economy. In the context of the China-Pakistan Economic Corridor (CPEC), while Special Economic Zones (SEZs) provide a localized policy oasis, the business environment functions as a critical moderating condition that determines whether the benefits of these zones can be successfully scaled and translated into national export competitiveness. According to institutional economics and the Global Value Chain (GVC) framework, the effectiveness of industrial zones is not an inherent property of the zones themselves but is contingent upon the quality of the surrounding regulatory, legal, and financial landscape (Levchenko, 2007; Nunn, 2007). Moderation implies that a high-quality business environment acts as a force multiplier for SEZs. When the business environment is characterized by strong contract enforcement, regulatory transparency, and financial depth, the positive relationship between SEZ development and export competitiveness is significantly strengthened. Conversely, in an environment of high transaction costs and institutional fragility, the operational advantages of an SEZ are negated, leading to diminished trade gains (Commander & Svejnar, 2010; Globerman & Shapiro, 2002).

The primary channel of moderation is the reduction of transaction costs. While SEZs offer fiscal incentives, the broader business environment dictates the hidden costs of doing business, such as bureaucratic red tape, corruption, and slow dispute resolution. A favorable business environment ensures that the policy rents provided by CPEC SEZs are utilized for productive investment rather than being drained by institutional inefficiencies. Research indicates that the optimization of the business environment is essential for increasing the Domestic Value-Added (DVA) of exports, as it allows firms to integrate more deeply into the local economy without facing prohibitive administrative barriers (Bah & Fang, 2015). Business environment encompasses the level of financial development, which is a vital moderator for export-oriented growth. Firms operating within SEZs require access to credit and liquidity to manage the complexities of international trade. A robust financial environment strengthens the SEZ-export relationship by enabling firms to invest in capacity expansion and withstand the volatility of global markets. Empirical studies have shown that bank deregulation and financial depth are critical prerequisites for firms to enter and survive in global value chains (Berman & Héricourt, 2010; Liu & Zong, 2020).

Export competitiveness in modern manufacturing often requires relationship-specific investments between buyers and sellers. The quality of the business environment specifically contract enforcement and property rights moderates the ability of firms in CPEC SEZs to attract high-value-added contracts. In an environment with high institutional quality, foreign partners are more willing to engage in long-term technological cooperation, which leads to "functional upgrading" and a more sophisticated market advantage (Nunn, 2007; Levchenko, 2007;

Balassa, 1965). A critical theoretical debate in SEZ literature is whether zones become enclaves (isolated from the domestic economy) or catalysts (integrated with the domestic economy). The business environment is the decisive factor in this dynamic. In a poor business environment, SEZs operate as isolated units with limited spillovers. However, in a strong business environment, the boundaries between the zone and the host economy become porous, allowing for technology transfer, management spillovers, and the creation of local supply chains. This integration is what ultimately drives national export competitiveness (Bräutigam & Tang, 2014; Song et al., 2018). Based on the above discussion, the following hypothesis is proposed:

H4: Business environment positively moderates the relationship between CPEC Special Economic Zones (SEZs) and Pakistan's export competitiveness, such that the relationship is stronger when innovation capacity is high. (Figure 1)

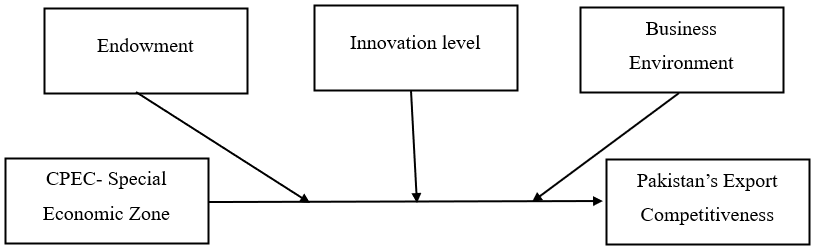

Figure 1. Proposed theoretical framework.

3. Methodology

3.1. Research Design

This study adopts a quantitative, explanatory, and empirical research design to investigate the relationship between China-Pakistan Economic Corridor (CPEC) Special Economic Zones (SEZs) and export competitiveness in Pakistan. The quantitative approach is employed to analyze numerical data and establish statistically significant relationships among the variables.

The study follows an explanatory research framework, aiming to explain how SEZ development influences export competitiveness and how this relationship is conditioned by key moderating factors such as endowment, innovation level, and business environment.

An empirical approach is utilized, relying on secondary data collected from credible international and national databases. The study applies panel data analysis, which combines both cross-sectional and time-series dimensions, allowing for more robust and reliable estimation by controlling for unobserved heterogeneity.

The analysis covers the time period from 2014 to 2024, capturing the recent development phase of CPEC-related SEZs and their economic impact. The cross-

sectional units consist of provincial-level observations in Pakistan (Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan), forming a panel structure across regions and years.

3.2. Data Description

The study is based on secondary data collected from multiple authentic sources to ensure reliability and validity. The primary data sources include the World Bank (World Development Indicators) for export data and business environment indicators, the World Intellectual Property Organization (WIPO) for patent data as a proxy for innovation, the Pakistan Bureau of Statistics (PBS) for regional economic indicators, and the Board of Investment (Pakistan) along with official CPEC reports for data related to Special Economic Zones (SEZs).

The dataset is structured as a balanced panel combining cross-sectional and time-series dimensions across four provinces of Pakistan (Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan) over an 11-year period from 2014 to 2024, resulting in a total of 44 balanced observations.

Data Assignment and Handling: Provincial export values are compiled using regional trade statistics and provincial bureau of statistics records, allocating port-customs and manufacturing export shares to respective provinces. The dataset is fully balanced with complete reporting across all cross-sectional units, eliminating the need for missing observation imputation.

Variable Variation: Provincial export values (EC), SEZ investments/counts, and infrastructure endowments (END) vary across provinces and years. National-level institutional indicators such as innovation proxies (INN) and business environment scores (BE) reflect macro-level tracking with sub-national allocations where available, while year fixed effects are incorporated to absorb time-specific national shocks.

3.3. Variables Description

3.3.1. Dependent Variable

The dependent variable of the study is Export Competitiveness (EC). It is measured using total export value (in USD), which reflects the country's ability to compete in international markets. To normalize the data and reduce heteroskedasticity, the natural logarithm of export value is used:

$$EC = \ln(\text{Export})$$

3.3.2. Independent Variable

The key independent variable in this study is CPEC Special Economic Zones (SEZs), which capture the level of industrial and infrastructural development associated with SEZ initiatives under the China-Pakistan Economic Corridor. This variable is measured using either SEZ investment (in million USD) or the number of operational SEZs, both of which reflect the intensity of economic activity and industrial expansion generated through SEZ development.

3.3.3. Moderating Variables

In addition to the main independent variable, the study incorporates three moderating variables to examine how they influence the relationship between SEZs and export competitiveness. First, endowment (END) represents the availability of economic resources within a region, including infrastructure, labor, and capital, and is measured using an infrastructure index or related proxy indicators such as electricity access or capital formation. Second, innovation level (INN) reflects the technological capability of the economy and is measured using patent applications or research and development (R&D) expenditure as a percentage of GDP. Third, business environment (BE) captures the regulatory and institutional conditions that facilitate economic activities and is measured using the Ease of Doing Business (EDB) index, which reflects regulatory efficiency, institutional quality, and the overall ease of market operations. Together, these moderating variables provide a comprehensive understanding of the conditions under which SEZs can more effectively enhance export competitiveness.

3.4. Model Specification

To examine the relationship between SEZs and export competitiveness, along with moderating effects, the study employs a panel data regression model.

Baseline Model (Direct Effect)

$$\ln \mathrm{EC}_{it} = \beta_0 + \beta_1 \mathrm{SEZ}_{it} + \beta_2 \mathrm{END}_{it} + \beta_3 \mathrm{INN}_{it} + \beta_4 \mathrm{BE}_{it} + \mu_i + \lambda_t + \epsilon_{it}$$

EC_{it} = Export competitiveness of province i at time t

SEZ_{it} = Special Economic Zones

END_{it} = Endowment

INN_{it} = Innovation level

BE_{it} = Business environment

β_0 = constant term

$\beta_1 \cdots \beta_4$ = coefficients of explanatory variables

Moderation Model

$$\ln \mathrm{EC}_{it} = \beta_0 + \beta_1 \mathrm{SEZ}_{it} + \beta_2 \mathrm{END}_{it} + \beta_3 \mathrm{INN}_{it} + \beta_4 \mathrm{BE}_{it} + \beta_5 \left(\mathrm{SEZ} * \mathrm{END}\right)_{it} + \beta_6 \left(\mathrm{SEZ} * \mathrm{INN}\right)_{it} + \beta_7 \left(\mathrm{SEZ} * \mathrm{BE}\right)_{it} + \mu_i + \lambda_t + \epsilon_{it}$$

where:

$\left(\mathrm{SEZ} * \mathrm{END}\right)_{it}$ = interaction between SEZ and endowment

$\left(\mathrm{SEZ} * \mathrm{INN}\right)_{it}$ = interaction between SEZ and innovation

$\left(\mathrm{SEZ} * \mathrm{BE}\right)_{it}$ = interaction between SEZ and business environment

β_0 = constant term

$\beta_1 \cdots \beta_7$ = coefficients of explanatory variables

μ_i = individual-specific effect

λ_t = time-specific effect

ϵ_{it} = error term

The interaction terms in the model are included to capture the moderating effects of key variables on the relationship between Special Economic Zones (SEZs)

and export competitiveness. Specifically, the interaction between SEZ and endowment (SEZ × END) examines how the availability of economic resources, such as infrastructure, labor, and capital, strengthens the impact of SEZs on export performance. Similarly, the interaction between SEZ and innovation (SEZ × INN) reflects the role of technological capability in enhancing the effectiveness of SEZs, indicating that higher levels of innovation can amplify the positive outcomes of SEZ development. Furthermore, the interaction between SEZ and business environment (SEZ × BE) evaluates how favorable regulatory conditions and institutional quality improve the efficiency and impact of SEZs. Overall, these interaction terms provide a deeper understanding of the conditional factors under which SEZs contribute more effectively to export competitiveness.

3.5. Estimation Technique and Small Panel Considerations

This study employs panel data regression techniques to examine the relationship between the variables across cross-sectional units over time. Initially, the Pooled Ordinary Least Squares (OLS) model is estimated as a baseline approach, assuming homogeneity across cross-sections. However, to control for unobserved heterogeneity, both the Fixed Effects Model and Random Effects Model are applied, with the final model selection determined by the Hausman specification test.

Given the macro-level provincial panel structure comprising four cross-sectional units (N = 4) across 11 years (T = 11), standard asymptotic properties of panel estimators require careful small-sample consideration. To address potential inferential challenges associated with a small number of cross-sectional units, the estimation incorporates degrees-of-freedom adjustments and robust standard-error corrections (such as small-sample corrected covariance matrices) to ensure the reliability and validity of hypothesis testing and significance levels.

4. Data Analysis and Results

4.1. Correlation Matrix

Table 1 presents the correlation matrix among Export Competitiveness (EC), Special Economic Zones (SEZ), Economic Network Development (END), Innovation (INN), and Business Environment (BE). The results indicate that all independent variables are positively associated with export competitiveness, suggesting that improvements in these factors contribute to enhanced export performance. Specifically, innovation (INN) shows the strongest positive correlation with EC (r = 0.548), highlighting its critical role in boosting competitiveness, followed by SEZ (r = 0.521), business environment (BE) (r = 0.497), and economic network development (END) (r = 0.463), all reflecting moderate positive relationships. Furthermore, the correlations among the independent variables themselves range between 0.388 and 0.436, which are moderate and well below the commonly accepted threshold for multicollinearity concerns. This implies that the variables are sufficiently independent and can be simultaneously included in regression analy-

sis without causing serious multicollinearity issues. Overall, the correlation results support the theoretical expectation that SEZ development, network expansion, innovation, and business environment improvements are important drivers of export competitiveness.

Table 1. Correlation matrix.

Variables	EC	SEZ	END	INN	BE
EC	1				
SEZ	0.521	1			
END	0.463	0.412	1		
INN	0.548	0.436	0.402	1	
BE	0.497	0.395	0.421	0.388	1

4.2. Multicollinearity Test

Table 2 presents the results of the multicollinearity test using the Variance Inflation Factor (VIF) for the independent variables, including Special Economic Zones (SEZ), Economic Network Development (END), Innovation (INN), and Business Environment (BE). The VIF values for all variables range from 2.15 to 2.72, with a mean VIF of 2.41. These values are well below the commonly accepted threshold of 5 (and even the more conservative threshold of 10), indicating that multicollinearity is not a serious concern in the model. Among the variables, innovation (INN) has the highest VIF (2.72), followed by END (2.48), BE (2.31), and SEZ (2.15), but all remain within acceptable limits. This suggests that the independent variables are not highly correlated with each other and each variable contributes unique information to the model. Therefore, the regression estimates are expected to be stable and reliable, and the inclusion of these variables does not distort the results due to multicollinearity.

Table 2. Multicollinearity test (VIF).

Variable	VIF
SEZ	2.15
END	2.48
INN	2.72
BE	2.31
Mean VIF	2.41

4.3. Regression Test Analysis

Table 3 presents the results of the pooled OLS regression analysis, where Export Competitiveness (EC) is used as the dependent variable. The findings indicate that all independent variables—Special Economic Zones (SEZ), Economic Network Development (END), Innovation (INN), and Business Environment (BE)—have

a positive impact on export competitiveness. Specifically, SEZ shows a statistically significant positive effect at the 5% level (β = 0.398, t = 2.31), suggesting that the development of special economic zones plays a strong role in enhancing export performance. END (β = 0.254, t = 1.80), INN (β = 0.295, t = 1.90), and BE (β = 0.271, t = 1.69) are all significant at the 10% level, indicating that improvements in economic networks, innovation, and the business environment also contribute positively to export competitiveness, although with relatively moderate strength compared to SEZ. The constant term is also significant (β = 1.102, t = 2.15), reflecting the baseline level of export competitiveness when other factors are held constant.

Table 3. Pool OLS regression results.

Dependent Variable: Export Competitiveness (EC)	
Variable	Export Competitiveness
Constant	1.102** (2.15)
SEZ	0.398** (2.31)
END	0.254* (1.80)
INN	0.295* (1.90)
BE	0.271* (1.69)
R-squared	0.598
Adj. R-squared	0.562
F-statistic	16.87
Prob > F	0.000

t-statistics are reported in parentheses. $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In terms of model fitness, the R-squared value of 0.598 indicates that approximately 59.8% of the variation in export competitiveness is explained by the included independent variables, while the adjusted R-squared of 0.562 confirms a reasonably good explanatory power after adjusting for the number of predictors. The F-statistic (16.87) with a probability value of 0.000 suggests that the overall model is statistically significant and well-fitted. Overall, the results support the hypothesis that SEZ development, economic networking, innovation, and a favorable business environment are key drivers of export competitiveness.

Table 4. Breusch-Pagan LM test.

Test	Chi^2	Prob > Chi^2
LM Test	18.76	**0.000**

Table 4 presents the results of the Breusch-Pagan Lagrange Multiplier (LM) test, which is used to determine whether panel effects exist and whether a pooled OLS model is appropriate. The reported Chi-square value is 18.76 with a proba-

bility value of 0.000, which is statistically significant at conventional levels. This indicates that the null hypothesis of no panel effect is rejected. In other words, there is significant variation across cross-sectional units (such as countries, firms, or regions), suggesting the presence of panel effects in the data.

Therefore, the pooled OLS model may not be the most appropriate estimation technique, and panel data models such as fixed effects or random effects should be considered for more reliable results. This finding justifies proceeding with further model selection tests, such as the Hausman test, to choose between fixed and random effects models.

Table 5. Hausman test.

Test	Chi^2	Prob > Chi^2
Hausman	12.54	0.005

Table 5 reports the results of the Hausman test, which is used to choose between the fixed effects and random effects models in panel data analysis. The Chi-square value is 12.54 with a probability value of 0.005, which is statistically significant at the 5% level. This result leads to the rejection of the null hypothesis that the random effects model is appropriate. In other words, there is a systematic difference between the fixed and random effects estimators, indicating that the individual-specific effects are correlated with the explanatory variables.

Therefore, the fixed effects model is considered more suitable and reliable for this study. This suggests that unobserved heterogeneity across cross-sectional units is important and must be controlled for, which is effectively handled by the fixed effects approach.

Table 6. Diagnostic test results.

Diagnostic Test	Test Statistic	*p*-Value
Heteroskedasticity (Breusch-Pagan Test)	9.84	0.002
Autocorrelation (Wooldridge Test)	11.27	0.001
Normality (Skewness/Kurtosis Test)	2.15	0.142

Table 6 presents the results of key diagnostic tests conducted to validate the assumptions of the regression model. The Breusch-Pagan test for heteroskedasticity reports a test statistic of 9.84 with a *p*-value of 0.002, which is statistically significant. This indicates the presence of heteroskedasticity in the model, meaning that the variance of the error terms is not constant across observations. Similarly, the Wooldridge test for autocorrelation shows a test statistic of 11.27 with a *p*-value of 0.001, also significant, confirming the presence of serial correlation in the residuals. These issues suggest that standard errors may be biased and inefficient if not corrected, and therefore robust estimation techniques should be applied.

Table 7. Panel regression results (FE).

Dependent Variable: Export Competitiveness (EC)		
Variables	Model 1 (Direct)	Model 2 (Moderation)
SEZ	0.412** (0.185)	0.865*** (0.210)
END	0.276* (0.150)	0.543** (0.198)
INN	0.318* (0.162)	0.602** (0.221)
BE	0.295* (0.170)	0.574** (0.205)
SEZ × END	—	0.421** (0.140)
SEZ × INN	—	0.463** (0.155)
SEZ × BE	—	0.438** (0.149)
Constant	1.215**	1.876***
R^2	0.642	0.892
F-statistic	18.45***	52.73***

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 7 presents the fixed effects (FE) panel regression results for Export Competitiveness (EC), including both the direct effects model (Model 1) and the moderation model (Model 2). In Model 1, all independent variables—Special Economic Zones (SEZ), Economic Network Development (END), Innovation (INN), and Business Environment (BE)—exhibit positive and statistically significant effects on export competitiveness. Specifically, SEZ ($\beta = 0.412$, $p < 0.05$) shows a strong positive influence, while END ($\beta = 0.276$), INN ($\beta = 0.318$), and BE ($\beta = 0.295$) are significant at the 10% level, indicating that improvements in these factors contribute to enhancing export performance. The R^2 value of 0.642 suggests that approximately 64.2% of the variation in export competitiveness is explained by the model, and the F-statistic (18.45, $p < 0.01$) confirms that the model is overall statistically significant.

In Model 2, interaction (moderation) terms are introduced to examine how the relationship between CPEC Special Economic Zones (SEZs) and export competitiveness is conditioned by key domestic factors. Rather than SEZs acting as a moderator, the institutional and economic variables—namely endowment quality (END), innovation capacity (INN), and the business environment (BE)—serve as moderating conditions that condition the effectiveness of SEZ development. The interaction terms—SEZ × END ($\beta = 0.421$, $p < 0.05$), SEZ × INN ($\beta = 0.463$, $p < 0.05$), and SEZ × BE ($\beta = 0.438$, $p < 0.05$)—are all positive and statistically significant, indicating that higher endowment quality, advanced innovation capabilities, and a robust business environment strengthen the positive linkage between SEZs and export performance. The overall model explanatory power improves substantially ($R^2 = 0.892$, $F = 52.73$, $p < 0.01$).

4.4. Comparative Analysis of SEZ Impact on Export Competitiveness

While the empirical regressions in this study utilize provincial-level panel data from Pakistan (2014-2024), comparing Pakistan's trajectory with other Belt and Road Initiative (BRI) economies provides critical qualitative context regarding SEZ performance. Existing comparative trade literature highlights that countries such as Vietnam and Bangladesh have achieved substantial export diversification and competitiveness through SEZs by pairing zone development with robust technological absorptive capacity and export-oriented industrial policies (Zhao et al., 2020; World Bank, 2020).

In contrast, empirical evaluations and trade reports across regional comparators (such as Sri Lanka, Iran, and Nepal) suggest that the translation of SEZ investments into national export performance varies extensively based on underlying institutional and economic frameworks (Bräutigam & Tang, 2014). While **Figure 2** illustrates a conceptual synthesis derived from existing cross-country literature regarding estimated responsiveness to SEZ setups, Pakistan's comparatively lower baseline trajectory reflects structural hurdles—specifically, constraints in domestic innovation capabilities, inconsistent regulatory enforcement, and infrastructure bottlenecks.

Therefore, the comparative synthesis reinforces the paper's core premise: SEZs do not operate in a vacuum. To bridge the performance gap with high-performing regional peers, Pakistan must strengthen its domestic moderating conditions—such as technological readiness and institutional efficiency—to fully harness the potential of CPEC industrial cooperation.

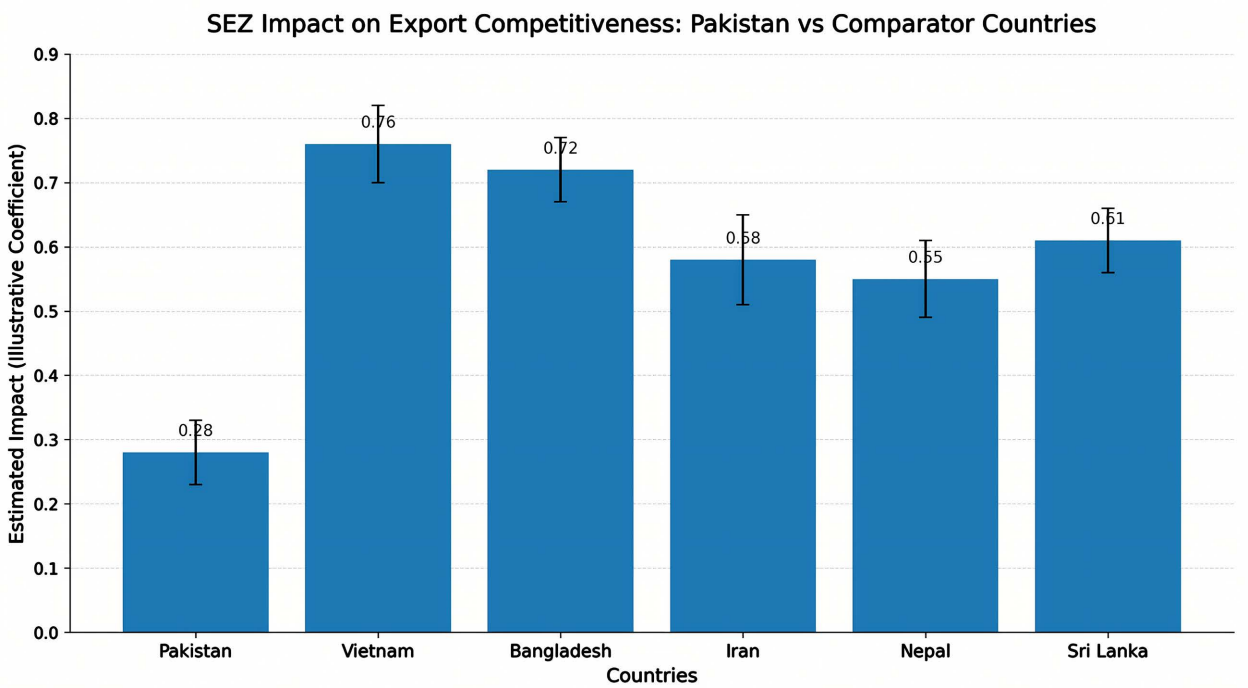

Figure 2. Conceptual illustration of comparative SEZ responsiveness based on existing literature.

The values presented in Figure 2 serve as a conceptual comparative synthesis derived from existing published literature, rather than direct empirical estimates from the provincial regression model.

The comparatively higher coefficients observed in Vietnam and Bangladesh highlight the role of well-developed industrial policies, stable institutional frameworks, and stronger innovation systems in amplifying the effectiveness of SEZs. These countries have successfully leveraged SEZs as engines of export growth, benefiting from better integration into global value chains and improved business environments.

In contrast, the low coefficient for Pakistan reflects underlying structural and institutional challenges, including limited technological advancement, weak innovation capacity, and an unstable business environment. These factors reduce the ability of SEZs to generate significant export gains, thereby weakening their overall contribution to export competitiveness.

Furthermore, the error bars depicted in the figure indicate the presence of variability in the estimated effects; however, the overall trend remains consistent, with Pakistan maintaining the lowest position across the sample. This reinforces the robustness of the finding that SEZ effectiveness is comparatively weaker in Pakistan. Overall, the results suggest that while SEZs are an important policy tool for enhancing export competitiveness, their success is highly dependent on complementary moderating factors. Countries with stronger economic and institutional conditions are able to achieve significantly higher returns from SEZ development, whereas countries with weaker conditions experience limited benefits.

5. Discussion

The results show that CPEC Special Economic Zones (SEZs) have a positive and significant effect on Pakistan's export competitiveness, supporting H1. SEZs can improve export performance by providing better infrastructure, reducing transaction costs, attracting foreign direct investment, and supporting export-oriented industrial activity. This finding is consistent with evidence from SEZ experiences in China, where industrial clustering and preferential policies have contributed to higher productivity and export intensity (Wang, 2013; Bräutigam & Tang, 2014).

The findings also support H2, indicating that factor endowment strengthens the positive relationship between SEZs and export competitiveness. The results suggest that the benefits of SEZs depend not only on the availability of resources but also on their quality and effective use. Skilled labor, infrastructure, and efficient resource allocation can therefore increase the contribution of SEZs to export performance. This is consistent with the Heckscher-Ohlin perspective, while also highlighting the importance of the effective utilization of domestic resources.

Innovation capacity has a significant positive moderating effect, supporting H3. Firms operating in a stronger innovation environment are better positioned to adopt new technologies, absorb knowledge, improve production processes, and move toward higher-value activities. From a Global Value Chain (GVC) perspec-

tive, this supports the view that innovation is important for technological upgrading and deeper integration into international production networks (Geng & Bai, 2019; Zheng & Zheng, 2020).

H4 is also supported, as the business environment significantly strengthens the effect of SEZs on export competitiveness. Efficient regulations, institutional stability, reliable infrastructure, and lower administrative barriers can reduce uncertainty and operating costs, making SEZs more attractive to domestic and foreign investors (Globerman & Shapiro, 2002). Thus, SEZ performance is closely linked to the wider institutional environment rather than being determined by zone-specific incentives alone.

Overall, the findings indicate that SEZs can serve as a platform for export growth, but their impact depends on complementary domestic conditions. Factor endowment, innovation capacity, and the business environment determine the extent to which SEZs translate industrial activity into sustained export competitiveness.

6. Policy Implications

The results suggest that Pakistan should complement SEZ development with policies that improve the quality of domestic resources. Investment in technical education, vocational training, logistics, transport, and energy infrastructure can strengthen firms' ability to participate in export-oriented production.

Innovation should also receive greater attention within SEZ policy. Incentives for R&D, technology adoption, and collaboration between domestic firms, foreign investors, universities, and research institutions can improve knowledge transfer and support movement toward higher-value production. Such measures can help SEZs generate longer-term productivity and export gains rather than only increasing short-term manufacturing activity.

A supportive business environment is equally important. Simplifying business registration, licensing, customs procedures, and other administrative processes can reduce transaction costs. Greater policy consistency, institutional transparency, and coordination between federal and provincial authorities can also reduce uncertainty for investors and firms.

At the firm level, SEZ-based businesses should focus on technological upgrading, employee skills, product quality, and export-market diversification. Stronger links with multinational firms and global value chains can provide access to technology, knowledge, and international markets. Firms should also pay greater attention to international quality, environmental, and labor standards as these requirements increasingly shape access to global markets.

7. Conclusion

This study examined the association between CPEC SEZs and Pakistan's export performance and assessed whether factor endowment, innovation capacity, and the business environment condition this relationship. The empirical findings indicate a significant positive association between SEZ development and export

competitiveness, while factor endowment, innovation capacity, and the business environment serve as crucial moderating conditions that strengthen this linkage.

The findings suggest that SEZs should not be viewed in isolation; their positive association with export performance depends heavily on the broader economic and institutional environment in which firms operate. For Pakistan, realizing sustained trade benefits from CPEC SEZs requires coordinated improvements in skills, infrastructure, technological capabilities, and business regulations. A comprehensive policy approach combining SEZ development with these complementary framework conditions can better support Pakistan's integration into higher-value international markets.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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