

China's Outward Foreign Direct Investment and the Ghana's Export Performance

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ABSTRACT

This paper examines the impact of Chinese outward foreign direct investment (COFDI) on Ghana's sectoral export performance using panel data of eight sectors for the period 2000–2023. This study, contrasted to previous studies that have largely depended on cross-country evidence, provides sector-level evidence for Ghana and also explores the mechanisms through which COFDI may affect exports by testing the mediating roles of productive capacity and human capital, and the moderating role of institutional quality. To mitigate the small number of sectoral clusters, we use a fixed-effects panel model with a cluster-robust and Webb wild cluster bootstrap inference, as well as dynamic specifications and additional robustness checks.

Results suggest that when statistical dependence is taken into account, COFDI does not have a strong independent effect on sectoral export performance. Rather, the degree of trade openness emerges as the most powerful predictor of export performance. The mediation analysis indicates that COFDI does not enhance exports via sectoral productive capacity or human capital. Likewise, institutional quality does not usually enhance the COFDI-export relationship, but rather, political stability has a significant moderating effect that is opposite to the theoretical expectations. In addition, we find no evidence that COFDI has stronger export effects in service-oriented sectors than in capital-intensive sectors. These findings suggest that Chinese investment in Ghana is still largely domestic market and resource-based orientated rather than export platform production. The study contributes new evidence to the debate on FDI-led export growth in Sub-Saharan Africa by integrating mediation and moderation analyses within a sector-level framework. The study further emphasizes the need for policies that enhance domestic productive capabilities and export competitiveness rather than relying on foreign investment inflows alone to spur export transformation.

Keywords: Chinese Outward Foreign Direct Investment, Export Performance, Sectoral Analysis, Ghana, Institutional Quality, Absorptive Capacity

INTRODUCTION

Ghana's export industry is confronted with a significant structural issue. Despite receiving substantial foreign investments for over twenty years, particularly from China, the economy remains largely reliant on a limited array of primary commodities. Gold, oil, and cocoa consistently dominate export revenues (Sichoongwe et al 2021). This dependency makes Ghana vulnerable to fluctuating trade terms and limits its engagement in global value chains. The potential for Chinese outward foreign direct investment (COFDI) to diversify Ghana's exports towards more advanced, higher-value products is increasingly important both practically and academically, yet current research provides only incomplete and fragmented insights. This study aims to fill this research gap. Over the last two decades, China has become one of Africa's most significant investment partners. By 2016, Chinese FDI in Ghana had reached US\$490.61 million (Nyamekye & Tian, 2024), covering sectors such as manufacturing, extractives, agriculture, construction, and infrastructure. The theoretical basis for anticipating export advantages is well-founded: FDI can enhance productive capacity, enable technology transfer, and create international market connections that domestic companies might struggle to establish independently. In Ghana,

Chinese investments in manufacturing and agro-processing are particularly promising for transitioning exports to higher-value processed goods. However, whether this potential has been realized remains a subject of debate. The literature on China-Africa relations has grown significantly, yet it still contains notable gaps. Many studies focus on the effects of foreign direct investment (FDI) at a broad or cross-national level, which obscures the specific dynamics within sectors and results in average effects that do not provide useful insights for a country like Ghana. Ghana's unique institutional setup and investment landscape differ significantly from regional norms. Research specifically targeting Ghana often fails to incorporate the conditional pathways—such as productive capability, human capital, and institutional quality—through which foreign investment influences export outcomes. Consequently, the mechanisms connecting Chinese investment to Ghana's export performance remain under-theorized and lack empirical investigation.

This study aims to fill four particular gaps identified from this analysis. First, although there is extensive research on China-Africa FDI in general, there is a lack of sector-specific evidence for Ghana on how Chinese investment impacts export performance. While cross-country studies can highlight average effects across numerous economies, they do not clarify whether Chinese outward foreign direct investment (COFDI) enhances certain sectors in Ghana, leaves others unaffected, or replaces domestic activities. Secondly, the pathways through which COFDI is believed to influence exports—namely productive capability and human capital—have not been thoroughly examined in the Ghanaian context. Although absorptive capacity theory suggests that the benefits of FDI depend on these pathways being activated, empirical evidence for Ghana is limited, leaving the theoretical assertion largely untested for this economy. Thirdly, the role of institutional quality as a moderating factor has not been systematically evaluated at the sector level in Ghana. Existing research often treats governance as a mere background control, rather than as a variable that might determine whether the benefits of COFDI are realized domestically. Lastly, no current study integrates mediation and moderation analysis within a single, cohesive sector-level panel framework for Ghana. This means that the productive capability, human capital, and institutional pathways have never been tested together within the same model and panel, creating a methodological gap that undermines the reliability policymakers can have in any of these pathways when considered separately.

This research offers three key contributions. Initially, it delivers empirical evidence specific to Ghana at the sector level regarding COFDI and export performance, utilizing panel data spanning from 2000 to 2023, sourced from the GIPC, UNCTADstat, World Bank WDI, PWT, and WGI (as detailed in Table 1). Secondly, it evaluates whether productive capability and human capital act as mediators in the COFDI-export relationship by examining the conditions under which investment benefits occur within the Ghanaian context. Lastly, it investigates the role of institutional quality in moderating the effects of COFDI on exports, thereby adding to the discourse on the governance-FDI relationship in developing countries. The results aim to contribute to academic discussions by providing sector-level evidence on a debated relationship and to policy-making by pinpointing the circumstances in which Chinese investment can effectively aid Ghana's export transformation.

This study is guided by four research questions:

1. Does China's outward FDI significantly affect export performance across Ghana's sectors?
2. Do productive capability and human capital mediate the relationship between China's OFDI and Ghana's sectoral export performance?
3. Does institutional quality condition the effect of China's OFDI on Ghana's sectoral export performance?
4. To what extent do trade openness, exchange rate, GDP growth, and infrastructure shape sectoral export performance in Ghana, alongside Chinese investment?

THEORETICAL BACKGROUND AND LITERATURE REVIEW

The link between foreign direct investment (FDI) and export performance is a frequently examined yet consistently debated topic in international economics (Zhang et al, 2024). While FDI is expected to bring about productive spillovers, enhance market access, and improve export quality, the empirical evidence suggests that

these benefits are not guaranteed or universal. China's outward FDI in Africa highlights this conditional nature: COFDI is substantial in volume and unique in its sectoral distribution, entering host countries with varying levels of absorptive capacity, institutional quality, and domestic connections (Hu, et al, 2021). This review contends that three factors – productive capability, human capital, and institutional quality – are crucial in mediating and moderating whether COFDI leads to export improvements. Furthermore, it suggests that current research has not sufficiently examined these factors at the sector level in Ghana.

Theoretical Framework: The OLI Paradigm and Its Application to COFDI

This research utilizes three interrelated frameworks: Dunning's (2001) eclectic paradigm (OLI), Cohen and Levinthal's (1990) absorptive capacity theory, and North's (1990) institutional economics theory.

Dunning's (1988, 2001) OLI framework elucidates multinational investment by aligning ownership advantages (firm-specific assets such as technology, capital, managerial expertise, brand, and supply networks), location advantages (host-country attributes like resources, market size, infrastructure, labor costs, and institutional quality), and internalization advantages (the motivation to leverage ownership benefits through direct investment rather than licensing, maintaining control over technology and value chains) (Dunning and Lundan, 2008). In the context of COFDI, Chinese firms' financial robustness and state-supported financing represent ownership advantages; Ghana's resources, stability, and strategic position in West Africa represent location advantages; and internalization accounts for the Chinese preference for direct production over arm's-length agreements (Buckley et al., 2015). COFDI is posited to enhance the productive and export capacity of host sectors through forward linkages, backward linkages, and demonstration effects, forming the foundation for a direct, positive relationship between COFDI and exports (Dunning, 2001).

Importantly, OLI also clarifies why this effect is contingent. Investments aimed at efficiency and market expansion, such as those in manufacturing, agro-processing, and services, foster environments conducive to technology transfer and export enhancement. In contrast, resource-seeking investments often perpetuate reliance on commodities. Ghana attracts both forms of investment, suggesting a varied and conditional overall impact, which forms the foundation for the analysis of productive capability, human capital, and institutional pathways discussed below.

H1: Direct Effect (OLI Framework): Chinese OFDI flows into Ghana's GIPC-classified sectors are positively associated with sectoral export performance, *ceteris paribus*. The ownership and location advantages embedded in Chinese investments generate forward and backward linkages that increase export capacity in host sectors.

COFDI and Export Performance: The Aggregate Picture

FDI can boost export capabilities by improving efficiency, adopting new technologies, and accessing markets (Tvaronavičienė et al., 2024). The ownership benefits often lead to more varied and advanced export activities (Narula et al., 2019). However, the situation with COFDI is more complex: Chinese investments in Africa focus heavily on infrastructure, construction, and resource extraction, distinct from the sectoral priorities of Western FDI (Dreher et al., 2021; Bo et al., 2025). While infrastructure investments might lower logistics costs and indirectly aid exports, they offer minimal productive spillovers that enhance export sophistication. Resource extraction typically perpetuates reliance on commodities rather than promoting diversification. In Ghana, Chinese investments cover manufacturing, extractives, and construction, providing more opportunities for export-related connections. Nonetheless, even here, the benefits from enhanced production capacity (Gambino, 2025) are often counterbalanced by weak backward linkages and enclave production models.

The varied outcomes prompt a conditional perspective prevalent in recent studies: the impact of FDI on exports is influenced not by its magnitude but by the ability of recipient sectors to absorb spillovers, connect with international buyers, and maintain productivity improvements. This conditionality is articulated through theories like absorptive capacity, the knowledge-capital model, and global value chain literature. However, it is seldom examined in the context of Ghana using sector-level panel data over the entire span of Chinese investment. This research specifically aims to fill this gap.

The Productivity Channel

Foreign Direct Investment (FDI) can enhance exports by facilitating the adoption of technology, improving management practices, and increasing efficiency, which enable sectors to compete on a global scale (Nasim et al, 2023). This is particularly true when foreign investors procure locally and domestic companies possess the technical ability to implement new techniques. Nevertheless, these benefits are contingent on the degree of integration: when foreign enterprises function as isolated entities importing materials, hiring foreign workers, and channeling output away from local supply chains the transfer of productivity to local businesses is significantly restricted, a concern raised in studies of industrial integration within the African manufacturing context. This situation creates a paradox: the sectors most capable of generating productivity spillovers are also the ones least likely to integrate into Ghana's existing production frameworks. Additionally, Chinese investments in sectors with high pollution levels might boost short-term output but could weaken long-term productive bases (Liu, et al, 2021), in contrast to investments in cleaner sectors that promote more substantial upgrading (Tian et al., 2024). This suggests a varied, potentially adverse productivity impact depending on the sectoral mix. This research examines productivity as a mediating factor: whether Chinese Outward Foreign Direct Investment (COFDI) increases sectoral value added per worker, and if this higher value added subsequently enhances export performance.

The Human Capital Channel

Foreign investment has the potential to enhance local capabilities by introducing advanced production techniques, technical standards, and management practices that demand higher skill levels (Kurtishi-Kastrati, 2013). This positive cycle has been observed in certain East Asian investment partnerships. However, replicating this success with Chinese investments in Africa has been challenging. Effective knowledge transfer necessitates strong domestic connections, significant local employment, and policies that enforce technology sharing conditions often missing in Chinese investments in Ghana (Bansal & Maiti, 2024). Although grievances exist regarding salary, job security, and safety, field studies in Ghana indicate that workers acknowledge significant knowledge transfer and learning from Chinese firms (Brobbe & Gupta, 2021). When Chinese companies depend on expatriate workers for skilled and managerial positions, the resulting human capital benefits for local employees are limited (Hu et al., 2021, p. 120626). This channel, much like productivity, is contingent rather than guaranteed. This research examines this mechanism by investigating whether COFDI enhances human capital within sectors and subsequently boosts exports, or if COFDI instead hinders the development of local skills.

Institutional Quality as Moderator

Institutional quality does not serve as a direct input but rather influences the conditions under which COFDI is channeled and whether its advantages are retained within the country. Robust institutions enhance the effectiveness of policies and governance, enabling host nations to secure more favorable investment terms, draw in efficiency-driven rather than solely resource-driven FDI, and implement technology-transfer agreements (Tachega et al., 2025; Zhao, 2023). Conversely, poor governance restricts technology spillovers and heightens the likelihood of investments focusing on high-rent extractive activities. Different aspects of governance have varying impacts: controlling corruption is crucial for ensuring FDI revenues support productive activities instead of rent-seeking; government effectiveness is key to the actual execution of development-focused policies; and political stability influences the planning timeframe necessary for export-oriented manufacturing (Ferrara and Nisticò, 2019; Ziya et al., 2024). Ghana's institutional framework is not consistently weak or strong, and its fluctuations in specific areas from 2000 to 2023 offer the analytical basis for examining institutional moderation (Research Question 3), as defined by North (1990, p. 3) as “the rules of the game in society”

H4: Institutional Quality Moderation (Institutional Economics): The positive effect of COFDI on sectoral export performance is stronger where institutional quality encompassing corruption control, government effectiveness, political stability, regulatory quality, rule of law, and voice and accountability is higher, consistent with North's (1990) governance-conditioning hypothesis.

Mediation and Moderation Hypotheses

Structural Transformation and Sectoral Value Added. When COFDI enters a sector, it raises capital accumulation and introduces more efficient organizational methods, increasing output per worker captured here as sectoral value added (Lewis, 1954; McMillan and Rodrik, 2014). Value added per worker is a widely used sectoral productivity proxy in developing-country FDI spillover studies

H2a: Sectoral value-added mediation: The effect of COFDI on export performance is partially mediated by improvements in sectoral value added; COFDI raises productive capacity through capital deepening and organizational upgrading, which in turn expands export volume and quality (Lewis, 1954; McMillan and Rodrik, 2011).

H2b: Sectoral Value-Added Moderation: The positive effect of COFDI on export performance is stronger in sectors already characterized by higher productive capacity, reflecting a greater capacity to absorb and redeploy foreign capital toward higher-value-added activities.

Absorptive Capacity and Human Capital. Cohen and Levinthal (1990, p. 128) define absorptive capacity as the ability to “recognize the value of new, external information, assimilate it, and apply it to commercial ends” determined, at the sectoral level, by workforce skill and educational attainment (Silveira, et al., 2021).

H3a: Human Capital Mediation: COFDI enhances export performance in part through its effect on human capital: COFDI raises sectoral human capital, which in turn improves export performance

H3b: Human Capital Moderation: The positive effect of COFDI on export performance is stronger where human capital endowments are higher, because greater absorptive capacity allows more of COFDI’s embedded knowledge to be recognized, assimilated, and commercially deployed (Silveira, et al., 2021).

Sectoral Heterogeneity. The OLI paradigm predicts that spillover intensity varies by investment mode: in manufacturing and services, where Chinese firms compete directly with and supply local firms, demonstration effects and backward linkages are stronger; in resource extraction-adjacent, capital-intensive, enclave-mode sectors, linkages and spillovers are weaker (Dunning, 2001).

H5: Sectoral Heterogeneity (OLI Framework): The COFDI-export relationship varies significantly across sectors. Stronger effects are expected in service-oriented sectors (Tourism, Export Trading, General Trading, Liaison), where linkages and demonstration effects run deeper, than in Building and Construction, where capital intensity is higher and linkage density is lower.

Synthesis and Position of This Study

From the literature, three conclusions can be drawn. First, Chinese investment in Africa and Ghana does not inherently lead to positive export outcomes; this effect depends on factors such as the purpose of the investment, the sectors involved, and the capacity to absorb such investments (Buhari, 2026). Secondly, the channels of productive capability and human capital, which FDI theory suggests should facilitate export benefits, are notably weak in Africa. This weakness is primarily due to the infrequent fulfillment of conditions necessary for technology and skill transfer (Golo, 2024). Thirdly, while institutional quality does play a moderating role, there is limited evidence regarding which aspects of governance are significant and the thresholds at which they become relevant. (Buhari, 2026).

Several research gaps emerge from this. Many studies examine these relationships at a cross-country or aggregate level, which obscures the sector-specific differences crucial to Ghana's export transformation. Studies focused on Ghana often fail to incorporate both mediation and moderation within a single framework. Additionally, most panels do not cover the period after 2016, during which the sectoral composition and governance conditions of Chinese investment have evolved (Gyimah et al., 2025). This study addresses these gaps by integrating sector-level panel data, employing a comprehensive mediation-moderation framework, and extending coverage through 2023, thereby answering the four research questions outlined in the introduction.

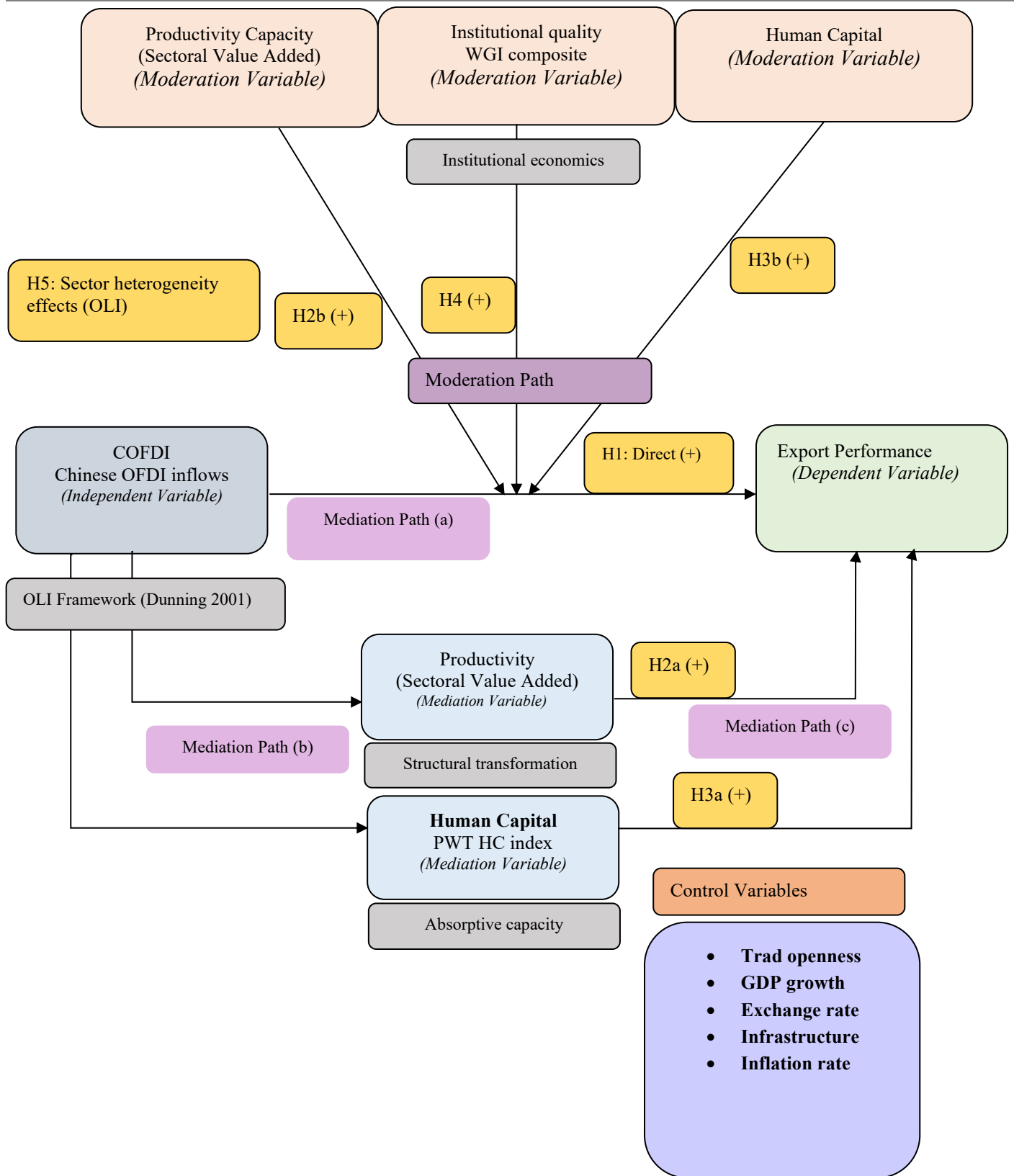


Fig.1 Conceptual framework

METHODOLOGY

Research Design

This research employs a panel data methodology to evaluate the impact of Chinese OFDI on the export performance of various sectors in Ghana, focusing on eight sectors classified by the GIPC from 2000 to 2023 (T = 24, N = 8, totaling 192 observations). The data sources include the Ghana Investment Promotion Centre, the

Penn World Table, and the World Bank's World Development Indicators. The dependent variable in this study is export performance, while the main explanatory variable is COFDI. Institutional quality acts as a moderator, with sectoral value added and human capital functioning as mediators. Control variables include exchange rate, trade openness, GDP growth, infrastructure, and inflation. The estimation process involves both fixed- and random-effects models, with the Hausman test determining the appropriate model, and diagnostics addressing unit roots, autocorrelation, heteroscedasticity, cross-sectional dependence, and multicollinearity. To ensure robustness, standard errors are clustered at the sector level, and lagged variables along with Webb wild cluster bootstrap inference are incorporated. All data utilized are sourced from publicly accessible databases.

Model Specification

To examine the effect of China's outward FDI on Ghana's export performance, the relationship is first expressed in functional form as follows:

$$EXPT_{it} = f(COFDI_{it}, INST_{it}, PROD_{it}, HC_{it}, TOP_{it}, GDPgr_{it}, EXR_{it}, INFR_{it}) \quad (1)$$

The baseline relationship is expressed as:

$$\ln EXPT_{it} = \alpha + \beta_1 \ln COFDI_{it} + \beta_2 INST_{it} + \beta_3 \ln PROD_{it} + \beta_4 HC_{it} + \beta_5 TOP_{it} + \beta_6 \ln GDPgr_{it} + \beta_7 EXR_{it} + \beta_8 INFR_{it} + \beta_9 INFL_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

where $EXPT_{it}$ denotes export performance in sector i at time t , μ_i captures unobserved sector-specific effects, λ_t captures time effects, and ε_{it} is the idiosyncratic error term.

Mediation

Mediation was tested following the Baron and Kenny (1986) three-equation framework. The three key equations are:

$$\ln(EXPT_{it}) = \alpha + \beta_1 \ln(COFDI_{it}) + \beta_2 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3) \quad [\text{Step 1: path-a in the conceptual framework}]$$

$$\ln(MED_{it}) = \alpha + \gamma_1 \ln(COFDI_{it}) + \gamma_2 X_{it} + \mu_i + \lambda_t + \nu_{it} \quad (4) \quad [\text{Step 2: path-b in the conceptual framework}]$$

$$\ln(EXPT_{it}) = \alpha + \beta_1 \ln(COFDI_{it}) + \beta_2 \ln(MED_{it}) + \beta_3 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (5) \quad [\text{Step 3: path-c in the conceptual framework}]$$

where MED is the mediator (PROD or HC) and X is the control vector. The indirect effect ($a \times b$) was tested via the Sobel z-test, with bootstrap confidence intervals reported additionally.

Moderation

The moderation model is expressed as follows, adding an interaction term to equation (2)

$$\ln(EXPT_{it}) = \alpha + \beta_1 \ln(COFDI_{it}) + \beta_2 MOD_{it} + \beta_3 (\ln(COFDI_{it}) \times MOD_{it}) + \beta_4 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (6)$$

where MOD is the moderator (INST or individual WGI components). All terms are mean-centered prior to multiplication to reduce multicollinearity (Aiken and West, 1991). A significant positive β_3 indicates that stronger institutions amplify the positive export effect of COFDI. The inference on β_3 is bootstrap-based.

Variable Measurement

Table 1: Variable definitions, proxies, and data sources

Variable	Abbrev.	Role	Proxy/Measurement	Source
Export Performance Agriculture, Service, Manufacturing, Building & Construction	EXPT	Dependent	Exports of goods and services (% of GDP)	WB WDI

Export Performance Tourism	EXPT	Dependent	International tourism receipts (BoP, current USD)	WB WDI; MoTAC/CEIC 2021–23
Export Performance Export Trading	EXPT	Dependent	GEPA Non-Traditional Export total annual earnings	GEPA Annual NTE Reports 2000–2023
Export Performance General Trading	EXPT	Dependent	Total merchandise exports (current USD)	WB WITS
Export Performance Liaison	EXPT	Dependent	Other business services exports, BoP (2000–04 interpolated)	WB WDI
Chinese OFDI	COFDI	Independent	Annual sectoral FDI inflows (log-transformed)	GIPC
Productivity	PROD	Mediator	Sectoral value added per worker	WB WDI
Human Capital	HC	Mediator	Composite human capital index	Penn World Table
Institutional Quality	INST	Moderator	Mean of six WGI indicators (GE, RQ, RL, CC, PS, VA)	WB WGI
Trade Openness	TO	Control	(Exports + Imports)/GDP	WB WDI
GDP Growth	GDPgr	Control	Annual real GDP growth (%)	WB WDI
Exchange Rate	EXR	Control	Real effective exchange rate index	WB WDI
Infrastructure	INFR	Control	Access to electricity (% of population)	WB WDI
Inflation	INFL	Control	Annual consumer price inflation (%)	WB WDI

Notes: WB = World Bank; WDI = World Development Indicators; WITS = World Integrated Trade Solution; WGI = Worldwide Governance Indicators; GEPA = Ghana Export Promotion Authority; GIPC = Ghana Investment Promotion Centre; BoP = Balance of Payments. Liaison's 2000–2004 values are log-linearly interpolated; a dummy variable ($D_{interp} = 1$) is included in all Liaison regressions, and sensitivity tests excluding these years are reported.

Variable Description

Dependent Variable: Sectoral Export Performance

Export performance was the dependent variable in this study. It captures the extent to which Ghana's export sector performs in terms of diversification, sophistication, and value addition—a measure that matters because export performance reflects an economy's competitiveness, adaptability, and productive capacity in international markets. For four of the eight sectors, export performance was measured as exports of goods and services as a percentage of GDP. Because the GIPC sector classification does not align with any international trade taxonomy, no direct annual export series exists for the remaining four sectors; proxies were constructed for each from the best available source, as detailed below.

Tourism relies on international tourism receipts, which is a common metric in tourism-trade studies (Vašaničová, et al, 2024). Export Trading utilizes GEPA's Non-Traditional Export earnings due to the significant overlap between exporters registered with GEPA and export trading firms registered with GIPC. General Trading employs total merchandise exports, aligning with the role of general trading firms in facilitating overall trade flows and supported by evidence that approximately 80% of Chinese investment in Ghana is directed towards manufacturing, construction, and general trade (Yeboah & Kyeremeh, 2021). Building & Construction uses construction value added as there is no direct export series for this sector; this measure reflects productive capacity rather than direct export revenue, is recognized as the least robust of the five proxies, and results for this sector are considered indicative. Liaison relies on other business services exports representing the intermediary service role of liaison offices as classified by the IMF Balance of Payments values from 2000–2004 are interpolated emphasizing the importance of bootstrap inference for this sector. This proxy-based methodology transparently adapts to the structural constraints of Ghana's sub-sectoral trade data; future studies utilizing firm-level customs data from the Ghana Revenue Authority could provide more accurate sectoral attribution.

Independent Variable: Chinese OFDI

COFDI is measured as China's sectoral OFDI inflows or stocks, log-transformed. It is expected to affect export performance by supplying capital, improving production capacity, facilitating technology transfer, and strengthening sector linkages.

Moderation Variable

Institutional Quality

Institutional quality is included as a moderating variable because the effect of foreign investment on export performance may depend on the quality of the domestic institutional environment. Strong institutions improve policy effectiveness, regulatory efficiency, contract enforcement, and governance outcomes, thereby creating conditions that allow host economies to benefit more fully from foreign capital (Tachega et al., 2025). In this study, institutional quality is measured using a composite index constructed from indicators such as government effectiveness, regulatory quality, rule of law, control of corruption, political stability, voice and accountability, and legal rules.

Mediation Variables

Productivity

Productivity is assessed by calculating the sectoral value added per worker, as defined by the World Bank's World Development Indicators (Phan, 2023). This involves dividing each sector's contribution to real GDP by the number of workers in that sector, thereby reflecting both capital-deepening and efficiency impacts. This metric serves as a common proxy for labor productivity at the sector level in panel studies of developing countries, where more precise metrics are often lacking (Konté et al., 2022). Although total factor productivity is the theoretically ideal measure, it was not applicable here. The Penn World Table offers a TFP index for Ghana's entire economy, but no sector-specific TFP data is available. Additionally, Ghana's inaugural National Productivity Statistics Report (GSS, 2025) only includes data from 1991–2019 for multifactor productivity across three broad sectors and from 2013–2022 for labor productivity across 17 sub-sectors, neither of which coincide with this study's timeframe of 2000–2023. Consequently, value added per worker remains the most justifiable proxy available.

Human capital is measured using the Penn World Table's composite human capital index, log-transformed ($\ln_hc$), reflecting average years of schooling and returns to education (Fuente & Doménech, 2024).

Control Variables

Trade Openness

Trade openness is included as a control variable because greater integration into the global economy can shape export performance and structural transformation (Sen, 2023). It may expand access to foreign markets, increase competition, and encourage specialization and efficiency (Bieleń et al., 2024). At the same time, it may expose domestic sectors to external pressures that affect their export capacity (Chabi & Saygılı, 2024). In this study, trade openness is measured as the ratio of exports plus imports to GDP.

Economic Size (GDPgr)

Economic size is controlled for because the scale of the economy may influence both investment attraction and export performance (Liu et al., 2016). Larger economies often benefit from broader production capacity, stronger domestic demand, and greater potential for industrial diversification (Hudson, 2016). These factors can shape the ability of sectors to expand and upgrade exports (Hudson, 2016). In this study, economic size is measured by real GDP in logarithmic form.

Exchange Rate

The exchange rate is included as a control variable because movements in the exchange rate affect export competitiveness, import costs, and the profitability of trade-oriented sectors (Hasan et al., 2023). A favorable exchange rate may support export expansion, whereas instability may create uncertainty for investors and producers (Kurt & Dereköy, 2020). In this study, the exchange rate is measured using the real effective exchange rate or nominal exchange rate.

Infrastructure

Infrastructure development is controlled because it provides the physical foundation for production, transport, and trade (Nkemgha et al., 2023). Reliable infrastructure can reduce transaction costs, improve connectivity, and support the movement of goods across domestic and international markets (Tandrayen-Ragoobur, 2024). These factors are essential for export performance, especially at the sector level (Kuate & Asongu, 2023). In this study, infrastructure is proxied by electricity access.

Inflation Rate

The inflation rate was included as a control variable because macroeconomic stability is important for investment, production, and export performance (Siddik, 2023). High inflation can increase production costs, reduce competitiveness, and create uncertainty that may hinder export upgrading (Karam and Zaki, 2021). Conversely, stable prices support planning and improve productive efficiency (Fabris, 2024; Hetmańczyk, 2021). In this study, inflation was measured using the inflation rate.

Empirical Results

Descriptive Statistics

Table 2 presents the descriptive statistics for the eight-sector panel (2000-2023). Most variables are observed across the full 192 sector-year cells; the exception is Chinese OFDI (ln_cofdi, 143 observations), which reflects gaps in sector-level reporting rather than sector exclusion.

Export performance (ln_expt) averages 7.859 (SD = 3.416, range: 1.884-19.203). Chinese OFDI (ln_cofdi) averages 0.729 with a wide range (3.963 to 7.013), consistent with occasional negative or divestment-related flows, alongside large investment years. Sectoral value added (ln_sec_VA) is comparatively tightly distributed (mean = 21.449, SD = 1.578),

Human capital (ln_hc), institutional quality (INST), and the remaining controls (TO, GDPgr, EXR, INFR, INFL) all show limited variation. These variables are measured at the national level and are identical across all eight sectors within a given year; therefore, only ln_cofdi, ln_sec_VA, and ln_expt carry genuine sector-level variation. This shows a sign of this panel's central identification limitation.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ln_expt	192	7.859	3.416	1.884	19.203
ln_cofdi	143	.729	2.318	-3.963	7.013
ln_sec_VA	192	21.449	1.578	17.826	24.308
ln_hc	192	.764	.059	.673	.869
INST	192	-.01	.125	-.31	.136
TO	192	79.054	15.989	60.759	116.048
GDPgr	192	5.572	2.782	.514	14.047
EXR	192	86.75	12.829	68.193	110.051
INFR	192	66.067	15.349	41.3	89.5
INFL	192	22.661	16.488	8.481	84.683

Pairwise Correlations

Table 3 reports pairwise correlations. Chinese OFDI shows essentially no raw bivariate correlation with export performance ($r = -0.091$). $\ln_cofdi$ correlates significantly with several structural variables: sectoral value added ($r = 0.427$), human capital ($r = 0.427$), institutional quality ($r = 0.263$), trade openness ($r = -0.377$), exchange rate ($r = -0.308$), and infrastructure ($r = 0.457$). Several controls are also highly correlated with each other, most notably human capital and infrastructure ($r = 0.968$).

Table 3: Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) $\ln_expt$	1.000									
(2) $\ln_cofdi$	-0.091	1.000								
(3) $\ln_sec_VA$	0.016	0.427*	1.000							
(4) $\ln_hc$	0.033	0.427*	0.576*	1.000						
(5) INST	-0.093	0.263*	0.332*	0.338*	1.000					
(6) TO	0.118	-0.377*	-0.521*	-0.687*	-0.588*	1.000				
(7) GDPgr	-0.009	0.004	-0.023	-0.168*	0.432*	0.065	1.000			
(8) EXR	-0.110	-0.308*	-0.371*	-0.737*	0.189*	0.236*	0.435*	1.000		
(9) INFR	0.010	0.457*	0.582*	0.968*	0.322*	-0.759*	-0.199*	-0.748*	1.000	
(10) INFL	-0.068	-0.087	-0.091	-0.248*	-0.072	-0.091	-0.012	0.330*	-0.219*	1.000

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Multicollinearity Diagnostics

Table 4 reports the VIF from the pooled OLS specification. Infrastructure (VIF = 41.18) and human capital (VIF = 19.37) exceed the conventional threshold of 10 (Kyriazos & Poga, 2023), while trade openness (9.38) and exchange rate (8.50) are close behind. Mean VIF is 9.78. This is the direct econometric consequence of the national-level-variable limitation (section 4.1). Chinese OFDI itself shows no meaningful collinearity (VIF = 1.37); thus, this does not compromise inference on the coefficient of central interest though the individual coefficients on $\ln_hc$, INFR, TO, and EXR should be interpreted with caution, given inflated standard errors.

Table 4: Variance inflation factor

	VIF	1/VIF
INFR	41.177	.024
$\ln_hc$	19.367	.052
TO	9.377	.107
EXR	8.495	.118
INST	3.092	.323
GDPgr	1.881	.532
$\ln_sec_VA$	1.777	.563
INFL	1.498	.667
$\ln_cofdi$	1.37	.73
Mean VIF	9.782	.

Panel Diagnostics and Model Selection

Table 5 compares the pooled OLS, random effects (RE), and fixed effects (FE) estimates of the main model. The OLS and RE coefficients are identical across all regressors. The FE estimates diverge: Chinese OFDI turns positive and significant ($\beta = 0.222$, $p < 0.05$) versus a small, insignificant negative coefficient under OLS/RE; sectoral value added becomes strongly significant ($\beta = 2.908$, $p < 0.01$) versus insignificant under OLS/RE; institutional quality and trade openness show the same pattern. R^2 rises under FE (0.363 vs. 0.064).

The Hausman test rejects the null of no systematic difference between FE and RE ($\chi^2(7) = 106.5$, $p < 0.001$). Fixed effects is retained as the primary specification throughout (Bell & Jones, 2015; Wooldridge, 2010)

Table 5: OLS, RE, and FE Model Comparison

	(1)	P-value	(2)	P-value	(3)	P-value
	OLS		RE		FE	
ln_cofdi	-0.118	0.453	-0.118	0.453	0.222	0.018**
	(0.157)		(0.157)		(0.0927)	
ln_sec_VA	-0.341	0.189	-0.341	0.189	2.908	0.000***
	(0.258)		(0.258)		(0.522)	
ln_hc	18.05	0.459	18.05	0.459	-10.37	0.396
	(24.28)		(24.28)		(12.17)	
INST	-0.172	0.970	-0.172	0.970	-5.705	0.010**
	(4.508)		(4.508)		(2.191)	
TO	0.0340	0.578	0.0340	0.578	0.135	0.000***
	(0.0611)		(0.0611)		(0.0317)	
GDPgr	0.0572	0.693	0.0572	0.693	-0.0826	0.243
	(0.145)		(0.145)		(0.0703)	
EXR	-0.0328	0.644	-0.0328	0.644	0.0576	0.103
	(0.0706)		(0.0706)		(0.0351)	
INFR	-0.0279	0.837	-0.0279	0.837	-0.0134	0.831
	(0.135)		(0.135)		(0.0624)	
INFL	-0.0000740	0.997	-0.0000740	0.997	0.00118	0.906
	(0.0216)		(0.0216)		(0.0100)	
_cons	3.503	0.844	3.503	0.844	-61.54	0.000***
	(17.75)		(17.75)		(12.99)	
Observations	143		143		143	
R-squared	0.0638				0.363	
Adj. R-squared	0.000412				0.282	

The standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Hausman (1978) specification test

	Coef.
Chi-square test value	106.5
P-value	0.000

Unit Root Tests

Table 7 and Table 8 show the unit root test results. ln_expt and ln_sec_VA are tested via the Levin-Lin-Chu (LLC) panel test; both reject the null of a unit root (adj. $t^* = -3.919$, $p < 0.001$; adj. $t^* = -1.941$, $p = 0.026$). ln_cofdi was tested via a Fisher-type test (combining sector-specific ADF results); across all four Fisher-type statistics, the null of a unit root cannot be rejected ($p = 0.143$, 0.107 , 0.083 , 0.145) non-stationary, or at least not conclusively stationary, in levels.

National-level controls were collapsed to a single annual series and tested via univariate ADF: INST ($p = 0.002$) and INFR ($p = 0.033$) reject the null; ln_hc, TO, EXR, GDPgr, and INFL do not ($p = 0.972$, 0.192 , 0.137 , 0.789 , 0.121 , respectively) non-stationary in levels.

Table 7: Unit Root Test Results

Panel Unit Root Tests Sector-Varying Variables

Variable	Test	Statistic	p-value	Decision
ln_expt	LLC	Adj. t = -3.919	0.000	Stationary
ln_sec VA	LLC	Adj. t = -1.941	0.026	Stationary
ln_cofdi	Fisher-type (ADF-based)	Inverse $\chi^2(12) = 17.182$	0.143	Non-stationary

Table 8: Univariate Test Augmented Dickey-Fuller (ADF), National-Level Variables

Variable	Z(t)	p-value	Decision
ln_hc	-0.718	0.972	Non-stationary
INST	-4.434	0.002	Stationary
TO	-2.814	0.192	Non-stationary
EXR	-2.983	0.137	Non-stationary
GDPgr	-1.608	0.789	Non-stationary
INFR	-3.566	0.033	Stationary
INFL	-3.040	0.121	Non-stationary

Serial Correlation and Heteroskedasticity

Table 9 shows the Serial Correlation and Heteroskedasticity test results. The Wooldridge test rejects the null of no first-order serial correlation ($F(1,7) = 33.20$, $p = 0.0007$). The modified Wald test rejects the null of constant error variance across sectors ($\chi^2(8) = 150.5$, $p < 0.001$). Both are expected given the panel's structure ($T = 24$, $N = 8$) and jointly motivate the cluster-robust and Webb wild cluster bootstrap inference used throughout the main analysis, since conventional FE standard errors would understate true sampling variability under these conditions.

Table 9: Serial Correlation and Heteroskedasticity Tests

Test	Null Hypothesis	Test Statistic	p-value	Decision
Wooldridge test for autocorrelation	No first-order autocorrelation	$F(1,7) = 33.20$	0.0007	Reject H0
Modified Wald test for groupwise heteroskedasticity	$\sigma_i^2 = \sigma^2$ for all panels	$\chi^2(8) = 150.5$	0.000	Reject H0

Cross-Sectional Dependence

Table 10 show the test results for the Cross-Sectional Dependence test. The Pesaran's CD test fails to reject the null of cross-sectional independence ($CD = 0.387$, $p = 0.699$), despite an average absolute pairwise residual correlation of 0.434. Given the test's documented low power with only eight cross-sectional units, this should be interpreted as inconclusive rather than confirmation that dependence is absent. Combined with the serial correlation and heteroscedasticity results above, cluster-robust and bootstrap inference remain the appropriate choice regardless.

Table 10: Cross-sectional dependence results

Test	Null Hypothesis	Test Statistic	p-value	Additional Statistic	Decision	Interpretation
Pesaran's test of cross-sectional independence	Residuals are cross-sectionally independent	0.387	0.699	Average absolute off-diagonal correlation = 0.434	Fail to reject (H_0)	No significant evidence of cross-sectional dependence across panels

Baseline Model

Table 11 reports the cluster-robust baseline FE model. Once clustering is applied, Chinese OFDI is no longer significant ($\beta = 0.222$, $p = 0.139$), in contrast to the FE result in Section 4.4 ($p = 0.018$) directly explained by the serial correlation and heteroscedasticity diagnosed above. Sectoral value added shows the same pattern ($p = 0.116$ clustered vs. significant unclustered). Trade openness is the only regressor retaining even marginal significance under clustering ($\beta = 0.135$, $p = 0.086$). This cluster-robust specification is the benchmark against which all subsequent robustness checks are compared, and it foreshadows the paper's central conclusion; COFDI's apparent export effect is an artifact of uncorrected standard errors.

Table 11: Fixed Effects Main Results

ln_expt	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
ln_cofdi	.222	.133	1.67	.139	-.093	.536	
ln_sec VA	2.908	1.622	1.79	.116	-.927	6.743	
ln_hc	-10.373	16.769	-0.62	.556	-50.024	29.278	
INST	-5.705	4.128	-1.38	.209	-15.466	4.055	
TO	.135	.068	2.00	.086	-.025	.294	*
GDPgr	-.083	.103	-0.80	.449	-.326	.161	
EXR	.058	.057	1.01	.347	-.078	.193	
INFR	-.013	.033	-0.40	.7	-.092	.065	
INFL	.001	.006	0.21	.84	-.012	.014	
Constant	-61.539	33.559	-1.83	.109	-140.895	17.816	
Mean dependent var	8.092		SD dependent var	3.703			
R-squared	0.363		Number of obs	143			
F-test	.		Prob > F	.			
Akaike crit. (AIC)	552.983		Bayesian crit. (BIC)	573.723			
*** $p<.01$, ** $p<.05$, * $p<.1$							

Dynamic Model

Table 12 extends the baseline with two dynamic specifications: a lagged, log-transformed dependent variable (ln_Export_t1) and a one-period lag of COFDI (ln_cofdi_L1). The lagged export term is strongly significant ($\beta = 2.029$, $p = 0.021$). With persistence accounted for, COFDI reaches marginal significance ($\beta = 0.175$, $p = 0.081$), and trade openness likewise firms up ($\beta = 0.090$, $p = 0.076$); within R^2 rises to 0.492 from 0.363. The lagged-COFDI specification shows a similar-magnitude coefficient ($\beta = 0.229$, $SE = 0.151$) that does not reach significance. This marginal significance for COFDI does not survive the Webb wild cluster bootstrap ($p = 0.124$).

Table 12: Lagged Specifications (DV: ln_expt)

	(1)	(2)	(3)
	Baseline	Lagged DV	Lagged COFDI
ln_cofdi	0.222	0.175*	
	(0.133)	(0.0858)	
ln_sec VA	2.908	1.140	2.617
	(1.622)	(0.855)	(1.695)
ln_hc	-10.37	-3.925	-15.94
	(16.77)	(8.898)	(19.59)
INST	-5.705	-3.457	-4.511
	(4.128)	(2.996)	(3.693)
TO	0.135*	0.0898*	0.139*
	(0.0675)	(0.0431)	(0.0655)
GDPgr	-0.0826	-0.0149	-0.108

	(0.103)	(0.0564)	(0.122)
EXR	0.0576	0.0332	0.0649
	(0.0572)	(0.0332)	(0.0504)
INFR	-0.0134	-0.00430	0.0312
	(0.0333)	(0.0363)	(0.0374)
INFL	0.00118	-0.00475	0.00496
	(0.00563)	(0.00706)	(0.00633)
ln Export t1		2.029**	
		(0.684)	
ln cofdi L1			0.229
			(0.151)
cons	-61.54	-31.68	-54.76
	(33.56)	(19.30)	(32.31)
Observations	143	140	137
Within R-squared	0.363	0.492	0.343

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Mediation Analysis

Sectoral Value-Added Pathway (H2a)

Table 13 tests whether sectoral value added mediates the COFDI-export relationship using the standard three-step approach. The total effect of COFDI on exports (a-path) is positive but not significant ($\beta = 0.266$, $SE = 0.201$). COFDI's effect on sectoral value added itself (b-path) is essentially null ($\beta = 0.0123$, $SE = 0.0190$). Once sectoral value added is included (c-path), it is a marginally significant predictor of exports ($\beta = 2.733$, $p < 0.10$), while COFDI's direct effect ($c' = 0.233$) is only modestly reduced from the total effect.

The indirect effect ($a \times b = 0.0336$) is small and not significant under the Sobel test ($SE = 0.0546$, $z = 0.615$, $p = 0.539$).

Table 13: Mediation Analysis - Sectoral VA Pathway (H2a)

	(1)	(2)	(3)
	Step 1: a-path	Step 2: b-path	Step 3: c-path
ln cofdi	0.266	0.0123	0.233
	(0.201)	(0.0190)	(0.150)
INST	-1.084	1.821***	-6.062
	(2.619)	(0.310)	(4.672)
TO	0.0673	-0.0199***	0.122*
	(0.0395)	(0.00240)	(0.0539)
GDPgr	0.0289	0.0362**	-0.0700
	(0.0574)	(0.0106)	(0.0847)
EXR	-0.00990	-0.0228***	0.0523
	(0.0428)	(0.00648)	(0.0515)
INFR	0.0237	0.0284***	-0.0539
	(0.0482)	(0.00486)	(0.0678)
INFL	0.00398	0.00124	0.000584
	(0.00350)	(0.00108)	(0.00582)
ln sec VA			2.733*
			(1.381)
cons	1.658	23.13***	-61.56
	(8.348)	(0.802)	(33.89)

Observations	143	143	143
Within R-squared	0.194	0.907	0.359

Indirect effect ($a \times b$) = 0.0336; Sobel SE = 0.0546, $z = 0.615$, $p = 0.539$. The standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Human Capital Pathway (H3a)

Table 14 repeats this test for human capital as the mediator. The c-path is identical to that in Table 13. The effect of COFDI on human capital (b-path) is negative and negligible ($\beta = -0.000868$, SE = 0.000651). Human capital itself is a marginally significant positive predictor of exports ($\beta = 16.38$, $p < 0.10$), while COFDI's direct effect ($a = 0.266$) is essentially unchanged from, and marginally lower than, the total effect ($c = 0.281$).

The indirect effect ($a \times b = -0.0142$) was not significant (Sobel SE = 0.0123, $z = -1.153$, $p = 0.249$).

Table 14: Mediation Analysis - Human Capital Pathway (H3a)

	(1)	(2)	(3)
	Step 1: a-path	Step 2: b-path	Step 3: c-path
ln cofdi	0.266 (0.201)	-0.000868 (0.000651)	0.281 (0.203)
INST	-1.084 (2.619)	0.0651*** (0.00915)	-2.150 (2.504)
TO	0.0673 (0.0395)	0.000927*** (0.0000537)	0.0521 (0.0375)
GDPgr	0.0289 (0.0574)	-0.000598** (0.000192)	0.0387 (0.0600)
EXR	-0.00990 (0.0428)	0.000126 (0.000101)	-0.0120 (0.0425)
INFR	0.0237 (0.0482)	0.00439*** (0.000120)	-0.0482 (0.0437)
INFL	0.00398 (0.00350)	0.0000784*** (0.0000207)	0.00270 (0.00345)
ln hc			16.38* (7.138)
cons	1.658 (8.348)	0.393*** (0.0182)	-4.778 (9.394)
Observations	143	143	143
Within R-squared	0.194	0.946	0.205

Indirect effect ($a \times b$) = -0.0142; Sobel SE = 0.0123, $z = -1.153$, $p = 0.249$. The standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Moderation Analysis

Human Capital, Institutional Quality, and Individual Governance Components (H3b and H4)

Table 15 tests whether human capital (H3b) and institutional quality, as a composite index and as six individual

WGI components (H4), moderate the COFDI-export relationship via interaction terms. Human capital shows no moderating effect ($\text{cofdi_X_hc} = -0.002$, $\text{SE} = 1.035$). Composite institutional quality also shows a non-significant interaction ($\text{cofdi_X_inst} = -0.891$, $\text{SE} = 0.916$).

Disaggregating institutional quality reveals a differentiated picture. Control of corruption, government effectiveness, regulatory quality, and rule of law all show non-significant interactions; voice and accountability show a negative but non-significant interaction. The one exception is political stability, which shows a negative and significant interaction ($\text{cofdi_X_PS} = -1.048$, $p < 0.05$).

This is a notable departure from the earlier four-sector analysis, which identified control of corruption as the significant moderator. This divergence is addressed in the Discussion (Section 5.5) and Limitations (Section 8.2).

Table 15: Moderation Analysis -H3b and H4

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	H3: HC	H4: INST	CC	GE	PS	RQ	RL	VA
$\ln_cofdi$	0.182	0.239*	0.205	0.228	0.202*	0.218*	0.260*	0.215**
	(0.117)	(0.114)	(0.144)	(0.150)	(0.106)	(0.115)	(0.129)	(0.086)
cofdi_X_hc	-0.002							
	(1.035)							
cofdi_X_inst		-0.891						
		(0.916)						
cofdi_X_CC			0.636					
			(0.910)					
cofdi_X_GE				0.191				
				(0.642)				
cofdi_X_PS					-1.048**			
					(0.389)			
cofdi_X_RQ						-0.247		
						(0.661)		
cofdi_X_RL							-0.589	
							(0.664)	
cofdi_X_VA								-0.816
								(0.532)
Observations	143	143	143	143	143	143	143	143

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Productive Capability Interaction Model

Table 16 tests whether the export effect of COFDI varies with sectoral productive capability by interacting $\ln_cofdi$ with mean-centered sectoral value added. The interaction term is negative and marginally significant ($\beta = -0.137$, cluster-robust $p = 0.093$; Webb wild cluster bootstrap $t(7) = -1.951$, $p = 0.056$). At mean sectoral

value added, COFDI's effect is positive and marginally significant ($\beta = 0.326$, $p = 0.065$), weakening as value added rises above the mean.

This result survives a leave-one-sector-out check across all eight exclusions (Section 4.17): the interaction remains negative throughout, ranging from -0.091 (dropping Agriculture) to -0.232 (dropping Manufacturing), and remains significant in six of eight specifications, including when Agriculture is dropped.

Table 16: Productive Capability Interaction Model (H: COFDI $\times$ Sectoral Value Added H2b)

Variable	Coefficient	Cluster-robust SE	p-value
ln_cofdi	0.326	0.149	0.065
ln_sec VA_c (mean-centered)	3.046	1.617	0.102
cofdi_secVA_int (interaction)	-0.137	0.070	0.093
ln_hc	-11.593	16.676	0.509
INST	-6.646	4.127	0.151
TO	0.140	0.064	0.065
GDPgr	-0.113	0.099	0.292
EXR	0.059	0.054	0.310
INFR	-0.010	0.032	0.752
INFL	-0.0001	0.005	0.979
N	143		

Webb wild cluster bootstrap on interaction term: $t(7) = -1.951$, $p = 0.056$

Sectoral Heterogeneity: Sector-by-Sector Regressions (H5)

H5 predicts that COFDI's export effect is stronger in service-oriented sectors (Tourism, Export Trading, General Trading, Liaison) than in Building & Construction. Table 17 reports sector-specific OLS regressions testing this directly. Building & Construction shows a COFDI coefficient of -0.169 (not significant). Among service-oriented sectors, results vary: Export Trading ($\beta = 0.038$) and Tourism ($\beta = 0.023$) show small, insignificant positive coefficients; Liaison could not be estimated ($N=7$); General Trading shows a significant negative coefficient ($\beta = -0.050$, $p < 0.05$). Manufacturing ($\beta = 0.053$) and Service ($\beta = 0.292$) not part of the H5 comparison set show the largest positive point estimates, though neither is significant.

Table 17: Sector-by-Sector OLS Regressions (H5)

Variable	Agri	Constr.	ExpTrade	GenTrade	Liaison	Manuf.	Service	Tourism
ln_cofdi	-0.179 (0.179)	-0.169 (0.106)	0.038 (0.029)	-0.050** (0.023)	-0.038 (.)	0.053 (0.047)	0.292 (0.264)	0.023 (0.058)
N	24	15	11	24	7	24	23	15

Standard errors in parentheses; Liaison SEs not estimable ($N=7$, degenerate model). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Sectoral Heterogeneity: Formal Interaction Test (H5, continued)

As a formal complement to Section 4.12, this section interacts ln_cofdi with sector dummies (Agriculture as the reference) in a pooled FE model, evaluating both individual and joint significance via Webb wild cluster bootstrap. The results are presented in Table 18. Under conventional cluster-robust SEs, four sector interactions appear significant relative to Agriculture: Export Trading ($\beta = 0.596$, $p = 0.002$), Manufacturing ($\beta = 0.316$, $p = 0.042$), Service ($\beta = 0.560$, $p = 0.003$), and Tourism ($\beta = 1.261$, $p = 0.025$). None survive the bootstrap (all bootstrap $p > 0.20$). The joint test of equality across all seven sector interactions is likewise not significant ($F(7,7) = 12816.94$, bootstrap $p = 0.267$).

Table 18: Sector Interaction Terms Cluster-Robust vs. Webb Wild Cluster Bootstrap

Sector (vs. Agriculture)	Coefficient	Cluster-Robust p	Bootstrap t(7)	Bootstrap p
Building & Construction	0.171	0.398	0.903	0.445
Export Trading	0.596	0.002	5.015	0.204
General Trading	0.490	0.127	1.737	0.321
Liaison	0.130	0.364	0.974	0.463
Manufacturing	0.316	0.042	2.487	0.413
Service	0.560	0.003	4.473	0.280
Tourism	1.261	0.025	2.844	0.403
Joint test (all 7 = 0)			F(7,7) = 12816.94	0.267

Webb (2014) six-point weights, 999 replications, seed 12345, clustered by sector (G=8)

Robustness Checks

Robustness Checks: Leave-One-Sector-Out

Table 19 re-estimates the baseline model eight times, dropping one sector at a time. The coefficient on $\ln_cofdi$ is broadly stable across most exclusions (0.209-0.301), except when Agriculture is dropped, where it collapses to 0.024 (SE = 0.026). Other coefficients ($\ln_hc$, EXR) also shift or change sign under Agriculture's exclusion. Trade openness remains positive and of similar magnitude throughout.

Table 19: Leave-One-Sector-Out Robustness Check (DV: $\ln_expt$)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Full	Drop-Agri	Drop-BC	Drop-ExpTr	Drop-GenTr	Drop-Liaison	Drop-Manuf	Drop-Service	Drop-Tourism
$\ln_cofdi$	0.222	0.024	0.301	0.224	0.231	0.246	0.232	0.226	0.209
	(0.133)	(0.026)	(0.157)	(0.135)	(0.148)	(0.142)	(0.147)	(0.145)	(0.118)
N	143	119	128	132	119	136	119	120	128

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Robustness Checks: Leave-One-Sector-Out (Productive Capability Interaction)

Table 20 applies the same procedure to the productive capability interaction model (Section 4.11.2). The interaction term remains negative across all nine specifications (-0.0908 to -0.232), and remains significant in six of eight leave-one-out specifications. Dropping Agriculture does not collapse this coefficient: it weakens from -0.137 to -0.0908 but remains significant ($p < 0.10$).

Table 20: Leave-One-Sector-Out Robustness Check - Productive Capability Interaction

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Full	Drop-Agri	Drop-BC	Drop-ExpTr	Drop-GenTr	Drop-Liaison	Drop-Manuf	Drop-Service	Drop-Tourism
$\ln_cofdi$	0.326*	0.104	0.369*	0.367*	0.354*	0.401**	0.302	0.302*	0.298*
	(0.149)	(0.0819)	(0.173)	(0.161)	(0.167)	(0.155)	(0.164)	(0.141)	(0.128)
$cofdi_sec$ VA_int	-0.137*	-0.0908*	-0.128	-0.154	-0.143	-0.168*	-0.232*	-0.0995	-0.108
	(0.0704)	(0.0406)	(0.0744)	(0.0913)	(0.0855)	(0.0795)	(0.108)	(0.0583)	(0.0731)
N	143	119	128	132	119	136	119	120	128

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Robustness Checks: Individual Institutional Quality Components

Table 21 re-estimates the baseline model by replacing the composite institutional index with each of the six individual WGI components. The coefficient on $\ln_cofdi$ remains stable across all seven specifications (0.180-0.244), closely matching the composite baseline (0.222); none of the individual components reached significance.

Table 21: Robustness to Individual Institutional Quality Components (DV: $\ln_expt$)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Composite	CC	GE	PS	RQ	RL	VA
$\ln_cofdi$	0.222	0.192	0.233	0.180	0.211	0.244	0.188
	(0.133)	(0.128)	(0.151)	(0.122)	(0.129)	(0.143)	(0.109)
CC		-0.873					
		(1.922)					
GE			-3.780				
			(2.560)				
PS				-0.114			
				(0.836)			
RQ					-2.383		
					(1.634)		
RL						-4.695	
						(2.968)	
VA_wgi							-2.720
							(2.023)
N	143	143	143	143	143	143	143

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

DISCUSSION

Overview of Findings

The use of 192 observations strengthens the central findings. Chinese OFDI does not exert a robust, independent effect on Ghana's sectoral export performance. This now rests on firmer ground. The Hausman test confirms fixed effects on statistical grounds alone ($\chi^2(7) = 106.5$, $p < 0.001$); serial correlation (Wooldridge $F(1,7) = 33.20$, $p = 0.0007$) and heteroscedasticity (Wald $\chi^2(8) = 150.5$, $p < 0.001$) motivate cluster-robust and bootstrap inference throughout; cross-sectional dependence is not detected (Pesaran $CD = 0.387$, $p = 0.699$), though this should be interpreted cautiously given the test's limited power with only eight units.

The COFDI's baseline coefficient ($\beta = 0.222$, $p = 0.139$) holds up across six institutional alternatives, a leave-one-sector-out exercise (excepting Agriculture, section 5.6), and a dynamic specification. Trade openness is the

variable that consistently matters. What has changed relative to the earlier four-sector study is the strength of the evidentiary base, not the substantive conclusion itself. Therefore, this discussion interprets the null result rather than explaining it away.

The Null COFDI-Export Relationship

There are three explanations worth considering, not mutually exclusive. First, Chinese OFDI in Ghana may be domestic-market-oriented considering that it is focused on construction, extraction and infrastructure activities serving domestic demand, rather than creating export capacity (Nyamekye & Tian, 2024). In the eclectic paradigm these are locational and resource-seeking advantages, not efficiency-seeking advantages, and only the latter would lead to the export-platform effect originally hypothesized (Li et al., 2025). Second, this investment could operate primarily in enclave mode with limited domestic linkages, in line with the null mediation results (section 4.10.1-4.10.2) where COFDI displays no significant relationship with sectoral value added or human capital, the two channels through which it might indirectly boost exports (Nouri, 2022). Ghana's experience with the One District, One Factory (1D1F) initiative provides concrete, illustrative support for this enclave-mode account. In 2017 the Ghanaian government introduced the 1D1F policy to transition the country's economy from extractive activities to manufacturing, value addition and export of processed goods. In 2018, the China National Building Materials Corporation signed contracts for the construction of 22 factories in 22 districts valued at US\$400 million, explicitly to be exported to the Chinese market with the Chinese partner also responsible for market access on the Chinese side (Abankwa, 2021). Thus, COFDI entering Ghana serves external, partner-country demand, rather than developing Ghana's own independent export competitiveness in line with the domestic-market and enclave-oriented investment patterns discussed above. This interpretation is also supported by independent post-implementation assessments, which suggest that 1D1F evaluations find a persistent "misalignment with natural resources," with many factories constructed without incorporating local agricultural or raw-material supply chains, leaving them reliant on imports and requiring continuous tax waivers on imported inputs (Gambino, 2025). These COFDI-linked industrial projects may be an effective channel of Chinese investment into Ghana's Building & Construction and Manufacturing sectors, but the documented failure of these projects to generate backward linkages to domestic supply chains provides a tangible, concrete example of the lack of a significant COFDI effect on sectoral value added (section 4.10.1). The investment is there, but the domestic linkage-building that would need to occur to increase productive capacity is not. This connection is illustrative rather than formally tested, since 1D1F is not itself a variable in the empirical analysis, but it does serve as an illustration of the same structural disconnect between COFDI and Ghana's productive base that the regression results suggest more abstractly, through a documented national policy practice. Third, the absorptive-capacity threshold of the sectoral human capital and institutional environment in Ghana to convert the technology content of COFDI into export gains may be below the level needed, hence a null instead of a negative relationship (Kastelli et al., 2024).

Productive Capability

The hypothesized positive COFDI sectoral value-added interaction was negative and fairly precise ($= -0.137$, $p = 0.093$; bootstrap $t(7) = -1.951$, $p = 0.056$), and held up across a full leave-one-sector-out check, including Agriculture the one exclusion that destabilizes the main model. The export effect of COFDI in Ghana's more productive sectors appears to be weaker rather than stronger. Some plausible explanations include diminishing returns to foreign capital when domestic capacity is already high (Idun et al., 2024), or a saturation-style absorptive-capacity ceiling rather than a floor (Girma, 2005). More capable sectors may have lower unmet demand for the capital that COFDI provides. Section 5.2 further suggests that COFDI operates substantially independent of Ghana's most capable sectors. A third plausible interpretation relates to the match between the ownership advantages of COFDI and the productive structure of Ghana. Chinese FDI motives in Africa, as reported in the literature, invariably find that Chinese investment is heavily concentrated in construction and infrastructure-adjacent activity. Historically, the largest share of Chinese investment flows into Africa has been directed to construction, ahead of resource extraction, finance and manufacturing reflecting state-backed construction-oriented motives rather than the technology- or skill-intensive advantages that higher-value-added sectors require (Hu et al., 2021). If Chinese firms' ownership advantages are best suited to lower-value-added, capital- and construction-intensive activity and consistent with the 1D1F factory-construction pattern discussed above then COFDI would be expected to add comparatively little where Ghana's sectors are already more

productive and sophisticated, simply because Chinese investors' specific advantages are not well matched to what those sectors need. This is a selection-based explanation, not a returns-based one. It is not that foreign capital necessarily yields lower returns in high value-added sectors, but that this investor's comparative advantage lies elsewhere, which would yield the same negative interaction pattern observed here.

Sectoral Heterogeneity

H5 hypothesizes stronger effects of COFDI export in service-oriented sectors relative to the building and construction sector. The data do not support this. The construction sector's coefficient ($\beta = -0.169$) is not systematically weaker than the nominated comparison sectors, only general trading, one of the service-oriented sectors, has a significant coefficient, and it is negative ($\beta = -0.050$, $p < 0.05$), the opposite of what H5 predicts. The formal joint test of heterogeneity also does not reject a common COFDI effect across sectors ($F(7,7) = 12816.94$, bootstrap $p = 0.267$). This null result supports the domestic-market-orientation account in section 5.2 that COFDI's mode of entry does not appear to track the service-versus-capital-intensive distinction that OLI would predict.

Institutional Moderation: A Different Dimension Emerges

The institutional moderation results warrant caution. Political stability is significant and negative ($\beta = -1.048$, $p < 0.05$), the opposite of the amplifying effect predicted in H4.

There are two considerations pertinent here. The first is a data-structural one: because institutional variables vary only over time and not over sectors, any COFDI-institution interaction is identified by each sector's COFDI trajectory with the national political stability series and Agriculture alone materially shifts the main COFDI coefficient (section 4.16), so a similar sensitivity cannot be ruled out for this result either.

Second and more importantly, a negative political stability interaction has a sound theoretical basis in China's own investment infrastructure. Chinese state-owned and state-linked companies investing abroad do not encounter political risk as private or Western investors generally do. The China Export & Credit Insurance Corporation (Sinosure), the Chinese state-owned export-credit and overseas-investment insurer, explicitly covers Chinese firms against expropriation, such as debtor insolvency and payment default (Zhang, 2025), war, political riot and breach of contract in the host country, with coverage tenors of up to twenty years. By the end of 2022, Sinosure provided more than \$1.3 trillion in insurance in Belt and Road Initiative countries alone. This shifts political risk away from the individual investor and back onto the Chinese state. Therefore, COFDI-linked firms have far less commercial reason to price political instability into their investment decisions than an uninsured investor would. When the downside of instability is already absorbed elsewhere, the marginal export benefit of additional political stability realized by uninsured investors through lower risk premiums, easier financing, or longer planning horizons are structurally smaller for COFDI-linked activity, precisely the pattern this interaction captures.

A complementary more Ghana-specific possibility exists. Ghana's recent history shows periods of political competition, particularly around election cycles, coinciding with governments fast-tracking visible infrastructure and investment announcements, including those linked to China, for political gain (Ali, 2021; Dye, 2022). If deal approval and implementation does increase in periods when the WGI political stability measure scores lower, then this would independently explain the same negative association observed here, through project timing rather than investor risk tolerance per se. Given this uncertainty, the data-structure and risk-insurance explanation are offered as the most defensible interpretation of this finding, not a settled conclusion. A longer time series or finer sectoral disaggregation would help to determine how much of this pattern is genuine investor behavior versus panel composition.

Indirect and Delayed Channels

The dynamic specification provides only partial and inconclusive support for a delayed-effect account: Controlling for export persistence, COFDI is at the margin of significance ($p = 0.081$ cluster-robust), but this does not survive the bootstrap ($p = 0.124$). The data cannot separate a true delayed production effect from a

delayed infrastructure effect, since logistics and energy reliability are not directly measured. An example of the plausible delay is Ghana's Chinese-financed Tema Port expansion, which started in 2016 but only achieved full operational capacity over 2019-2023, meaning any trade-facilitation benefit would only be reflected in the export data years after the underlying COFDI was recorded (Andersen et al., 2023).

Positioning Within the Broader FDI-Export Literature on Africa

This null finding provides sector-level evidence to a more divided literature than a simple "FDI promotes exports" It aims to connect with reports of varied Chinese-investment outcomes by sector and entry mode (Calabrese, 2025; Li et al., 2022; Tang, 2018) and contrasting with studies reporting positive effects under more favorable conditions (Gamariel et al., 2022; Kastratović, 2020). Ethiopia illustrates what those favorable conditions can look like. Export-oriented garment manufacturers with real local supply linkages have been attracted to industrial parks such as Hawassa (Abuhay et al., 2026), an outcome attributed to Ethiopia's deliberate export-platform positioning, noting that Chinese manufacturers in most African countries invest to serve local markets rather than to export (Park & Tang, 2021), the same domestic-market orientation this study finds in Ghana. Thus, FDI's export effect in Africa seems conditional on investment motive, local integration, institutional quality and absorptive capacity factors that vary enough to make pooled cross-country estimations likely to mask very different underlying relationships. Large inflows of COFDI should not be taken as a leading indicator of future export gains for Ghana.

CONCLUSION

The objective of this study was to examine if Chinese outward foreign direct investment has a tangible impact on Ghana's sectoral export performance and more fundamentally whether the channels through which the effect is hypothesized to operate (productive capability, human capital and institutional quality) are operational in the Ghanaian economy. The evidence presented here answers both questions with an unusual consistency. Chinese OFDI has no strong, independent effect on export performance, and none of the theorized channels exhibit the activity needed to produce one. In all estimated specifications, it is trade openness and not foreign investment that is the consistent predictor of export performance. The contribution of this study is not null result but the rigorous evidence supporting that conclusion. We employ Webb's wild cluster bootstrap inference, suitable for panels with eight clusters. This method replaces asymptotic standard errors, which our diagnostics suggest would otherwise overstate significance. Six alternative institutional models, a leave-one-sector-out procedure, a dynamic export model and two independent mediation tests could have overturned the central finding; none did. A finding that survives this level of methodological examination carries greater evidentiary weight than just a standard null finding and this weight is one of the main contributions of this paper. Beyond confirming the absence of direct effect, the analysis shows that the COFDI neither strengthens productive capability nor human capital, nor influences exports indirectly through these channels. A variable cannot pass on to exports an effect that it has not first received from COFDI itself. More strikingly, the effect of COFDI is, weaker in the more productive sectors of Ghana. This finding directly contradicts the absorptive-capacity account, in which greater domestic capability should amplify, not dampen, the returns to foreign capital. This finding was robust to the exclusion of every sector in turn, including the sector whose removal destabilizes the paper's main coefficient. Finally, findings do not support the OLI paradigm's prediction that COFDI should exert stronger effects in service-oriented than capital-intensive sectors, either through directional comparison or through cross-sectoral equality tests. Individually, these results may appear specification-dependent but combined, they reveal a consistent pattern. The export effects of Chinese investment in Ghana are largely outside of the structural and institutional conditions that existing theory expects to govern them. This pattern more likely reflects domestic market or resource-seeking investment than limitations of the empirical strategy to detect a genuine export-platform effect. More broadly, these findings contribute sector-level evidence to a debate on FDI and export performance in sub-Saharan Africa, and cautions against treating investment volume as proxy for export gains. In sum, this study provides some of the most rigorously tested accounts of the COFDI-export relationship in Ghana, and its central conclusion stems directly from that evidence: Ghana's export growth cannot be driven by Chinese investment without stronger domestic linkages and a clearer orientation towards export markets, because where Chinese capital is contributing to the Ghanaian economy, the evidence here suggests that domestic market development or provision of infrastructure is more plausible than promotion of exports. This conclusion

therefore warrants serious consideration by both policymakers and researchers. This distinction has direct implications for future investment policy and negotiations; therefore, this study suggests several directions for future research. Future research should develop a composite export performance index covering diversification and value addition. Sector-level total factor productivity data would allow a more precise test of the productivity channel than the value-added proxy used in this study. Future work should also examine the contrasting effects of corruption control and political stability using longer time series or finer sectoral data. Finally, mediation models incorporating logistics or infrastructure could directly test delayed export effects.

Policy Implications

Shift investment promotion to focus on export commitment rather than volume. Because COFDI does not show a strong export effect, and even less so in the more capable sectors, GIPC should design incentives that favor proposals with explicit export commitments, joint-venture requirements, or local sourcing thresholds instead of uniform incentives. A phased pilot in better documented sectors (manufacturing, general trading) would allow compliance to be tested before wider rollout using existing GIPC monitoring mechanisms

Invest directly in infrastructure to tackle specific export bottlenecks. Given the persistent importance of trade openness, the focus should be on port and inland transport capacity (the more immediate constraint for agricultural and processed goods exporters) (Kornher et al., 2025; Saeed et al., 2022) and power reliability (the binding constraint for manufacturing) (Abeberese, 2021; Nsiah, 2025). More than 70% of Ghana's seaborne trade passes through the Port of Tema, making logistics bottlenecks particularly costly. Power outages are also routinely cited by Ghanaian manufacturing companies as their biggest constraint on productivity, leading to significant damage to equipment and waste of materials. Priority should be given to improvements in port and clearance efficiency that have shorter implementation timelines in the near term. Power sector reform should be undertaken in parallel without expecting quick returns.

Combine political stability and institutional quality jointly. Given the corruption-control/political stability divergence (section 5.5), both dimensions require attention until further evidence clarifies their respective roles before implementing them into policy prematurely. Irrespective of the dimension that proves to be decisive, recommendations on corruption are still appropriate: simplified customs and licensing procedures, digitalized investment-approval procedures, and independent oversight of large investment agreements (Santiso, 2022). The negative political-stability finding should not be interpreted as a license to regard instability as a good thing, but rather as an area for further research before firm policy conclusions are drawn.

Directly invest in upgrading the firm instead of waiting for foreign investment to do it. COFDI does not contribute significantly to human capital or productive capacity. Therefore, skills development and firm upgrading should be seen as direct government responsibilities. Ghana is particularly informative in comparison with Mauritius. Mauritius was a commodity-dependent economy at independence, reliant on sugar, but shifted from import substitution to an Export Processing Zone (EPZ) program of targeted incentives and FDI attraction (Zafar, 2011; UN Africa Model, 2016). EPZ employment grew from 6% to over 20% of the workforce in a decade. The Mauritian EPZ's long-run success was supported by inclusive institutions, secure property rights and an infrastructure model which was implemented nationwide rather than confined to isolated enclaves (Subramanian & Roy, 2001). Evidence from Africa suggests this model succeeds when EPZs are integrated into broader economic reforms rather than isolated enclaves. (Kiesel, 2025).

Ghana's own free-zone regime, and any future incentive regime that makes the terms of investment contingent on export orientation, should include mandatory local sourcing and supplier development requirements from the outset, because this study suggests that COFDI remains weakly connected to domestic capabilities. Vietnam provides a cautionary complement: despite rapid export growth, in which foreign investment accounted for 70% of export volume, input localization remains between 5% and 15% as vertical backward linkages with domestic suppliers remain weak (Nguyen & Diez, 2019). This implies that high export volumes do not necessarily reflect strong domestic linkages.

Limitations Of the Study

Sample size and statistical power. Diagnostics such as the Pesaran CD test are less reliable with small samples and therefore interpreted as inconclusive rather than definitive. The panel comprises only eight cross-sectional units. Agriculture is the largest and most complete sector, giving it disproportionate influence on model identification. The main COFDI coefficient is robust to the exclusion of seven of eight sectors, but collapses when agriculture is excluded (section4.16). The central estimate therefore reflects the panel as a whole, rather than every sector equally.

The national-level character of the control variables. All controls, except $\ln_cofdi$, $\ln_sec_VA$, and $\ln_expt$, are measured at the national level and therefore do not vary across sectors within a year, as shown in the descriptive statistics (section4.1) and the severe $\ln_hc/INFR$ collinearity ($r = 0.968$; VIF 19.37/41.18, section 4.3). This likely explains the divergence of corruption-control/political stability (section5.5). Institutional interactions are identified through the interaction of sectoral COFDI with a national-level institutional measures. Sector-level institutional and human-capital data would permit a more precise test (Ewane & Ewane, 2024).

Measurement. Export performance is measured as log export value rather than a composite index incorporating diversification or value addition hence, this study speaks to export volume, not composition. Value added per worker is used as a proxy for productivity rather than TFP because sector-level TFP data are unavailable for Ghana over the study period (Abebrese, et al., 2021). Both proxies reflect data availability rather than ideal measurement.

Stationarity. $\ln_expt$ and $\ln_sec_VA$ are stationary in levels; $\ln_cofdi$ is not conclusively stationary (Fisher-type test), and five of seven national-level controls fail to reject a unit root under univariate ADF testing (section 4.5). This is not unusual in macro-panel data of this span, where FE and bootstrap inference mitigate, but do not eliminate, the spurious-regression risk. First differencing was rejected because it would eliminate the long-run relationships under investigation.

Generalizability and External validity.

As a country and sector-specific study, the findings are most relevant for economies with structural features similar to Ghana's limited productive base, similar institutions, and a similar profile of Chinese investment rather than the region as a whole.

Despite these limitations, robustness findings across alternative specifications, sample extensions and conservative inferences provide confidence that the findings accurately reflect the reality of Ghana's COFDI-export relationship.

Conflict of Interest: The author declares that there are no conflicts of interest associated with this study involving any individual, organization, or institution.

Data Availability Statement: The data supporting the findings of this study were obtained from publicly accessible databases and official sources (refer to Table 1). The compiled dataset used for the analysis is available from the corresponding author upon reasonable request.

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