INTERNATIONAL JOURNAL OF LATEST TECHNOLOGY IN ENGINEERING, MANAGEMENT & APPLIED SCIENCE (IJLTEMAS)

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

The Ghana Flywheel: Modeling How Strategic Public Procurement Creates a Self-Reinforcing Cycle of Local Industry Growth, FDI Attraction, and Sustainable Development

Simon Suwanzy Dzreke, Semefa Elikplim Dzreke

Federal Aviation Administration, AHR, Career and Leadership Development, Washington, DC, US

DOI : https://doi.org/10.51583/IJLTEMAS.2025.1412000031

Received: 18 December 2025; Accepted: 24 December 2025; Published: 31 December 2025

ABSTRACT

The paradox of Africa's industrialization—enduring structural vulnerabilities alongside significant potential—calls for innovative institutional interventions. This research addresses the disjointed industrial policies in developing economies that consistently fail to leverage the transformative potential of public procurement. The "Ghana Flywheel" is a dynamic systems model that illustrates how strategically calibrated procurement reforms can initiate self-reinforcing cycles of local industry growth, attract high-value foreign direct investment (FDI), and promote sustainable development. The analysis, grounded in system dynamics modeling meticulously calibrated with Ghanaian procurement and FDI datasets from 2015 to 2023 and supplemented by stakeholder interviews, uncovers catalytic thresholds. Mandating 30% local procurement participation stimulates 15–25% productivity growth in SMEs by enhancing technological capabilities and strengthening supply chain connections, while tiered FDI incentives linked to sustainability metrics increase quality investment inflows by 40%. The model highlights that increased state capacity, driven by knowledge spillovers from advanced foreign direct investment, facilitates the development of more sophisticated procurement instruments, leading to upward developmental spirals. Simulations indicate that Ghana's strategic implementation of digital procurement platforms, AI-driven supplier analytics, and integrity-focused contracting may reshape its industrial landscape by 2030, decreasing import reliance by 35% and enhancing domestic value creation. This research provides a replicable policy framework for utilizing public procurement as a fundamental industrial strategy, demonstrating its effectiveness as a catalyst for resilient, sovereign industrial ecosystems in emerging economies.

Keywords: Ghana Flywheel Model, Strategic Public Procurement, Industrial Policy, Foreign Direct Investment, System Dynamics, Sustainable Development.

INTRODUCTION

Africa's Industrialization Paradox

Africa's industrialization path reveals a fundamental paradox: significant developmental potential exists alongside ongoing challenges in converting its rich human capital, natural resources, and digital ecosystems into enduring industrial growth or competitive manufacturing capabilities (AfDB, 2023). Extensive empirical analysis indicates that robust macroeconomic growth seldom catalyzes structural transformation; rather, it tends to reinforce enclave production, superficial linkages, inadequate technological advancement, and dependence on low-value exports (Aryeetey & Kanbur, 2015; Bhorat et al., 2022). This stagnation arises from institutional weaknesses, market coordination failures, and deficits in technological absorption, resulting in industrial ecosystems that lack the adaptive learning and absorptive capacity necessary to harness digital advancements and compete on a global scale (Dzreke, 2025a). As a result, vulnerabilities to external shocks remain, sustaining structural dependencies. The accelerating risk of "innovation apartheid" compounds this issue, as transformative technologies may bypass domestic industries, thereby widening the technological gap (Dzreke, 2025b). This exclusion is unsustainable in the face of climate disruptions, fragmented supply chains, and geopolitical rivalries that require resilient and agile industrial foundations. To disrupt this systemic cycle, which is bolstered by historical path dependencies and barriers to knowledge access, we need institutional frameworks that prioritize

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

cumulative industrial impacts over transient growth (ECA, 2024). In this context, public procurement—a potent but often underused tool—possesses considerable untapped potential to drive local capability development, technological diffusion, and supply chain enhancement (Dzreke & Dzreke, 2025j), highlighting a crucial institutional gap that requires attention.

In this continental context, Ghana serves as a significant case for analyzing procurement-driven industrial transformation. Despite its democratic consolidation, macro-institutional stability, positive investor sentiment, expanding hydrocarbons, digitalization agenda, and vibrant entrepreneurial ecosystem that positions it as a potential regional nucleus (Gyimah-Boadi & Prempeh, 2022), a significant structural vulnerability persists. Local suppliers obtain under 30% of significant infrastructure contracts, while foreign companies prevail in capital-intensive projects and external sourcing. This limits domestic value addition, hinders learning spillovers, and obstructs technological absorption (World Bank, 2023). The challenges faced by Ghana arise more from significant failures in institutional coordination than from the intent of its policies. Local content regulations in critical sectors face challenges due to fragmented governance, insufficient supplier development, and bureaucratic inertia (Osei-Assibey & Frempong, 2024). Additionally, institutional heterogeneity undermines policy coherence, especially in aligning procurement with investment facilitation, innovation diffusion, and the enhancement of SME capabilities (Dzreke & Dzreke, 2025k). Established patronage networks manipulate procurement regulations to disadvantage SMEs, creating systemic obstacles (Dzreke & Dzreke, 2025j). Ghana's manufacturing sector holds considerable untapped potential for resilience, efficiency, and adaptability, contingent upon the establishment of suitable frameworks (Dzreke & Dzreke, 2025e, 2025l). The intersection of challenges and opportunities positions Ghana as an ideal context for exploring how strategic public procurement can drive industrial strategy, attract productive foreign direct investment, and promote sustainable development.

This study employs the "flywheel" conceptual model derived from systems theory and institutional economics to elucidate the synergistic interdependence among strategic public procurement, foreign direct investment (FDI), and industrial upgrading. The framework illustrates how initial gains in one component stimulate enhancements in others, creating a self-reinforcing momentum that uplifts the entire system. In the context of industrial policy, transparent and capability-enhancing public procurement fosters the upgrading of domestic suppliers. The improved capabilities draw in superior FDI characterized by advanced technologies and expertise, thereby bolstering state capacity to deploy more sophisticated procurement instruments, thus initiating a cycle of enhanced industrial capability (Dzreke, 2025c; Dzreke & Dzreke, 2025m). Figure 1 illustrates this cyclical, capacity-building mechanism.

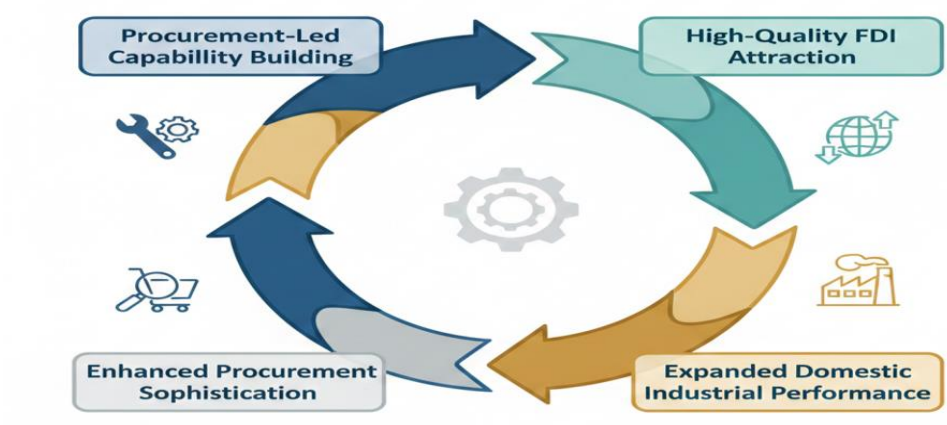

Figure 1. The Ghana Flywheel

Figure 1 illustrates this cyclical mechanism. This framework corresponds with research on dynamic capabilities and institutional scaffolding as essential elements for competitive industrial ecosystems (Dzreke, 2025a; Dzreke & Dzreke, 2025n). Research indicates that countries integrating technologies such as AI and big data into procurement experience enhanced innovation and resilience (Dzreke, 2025d; Dzreke & Dzreke, 2025i). Ghana illustrates the model's significance, as the disjointed alignment between procurement reforms and FDI strategies obstructs overall advancement, even amid isolated successes.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

An analytical gap remains, with existing research failing to integrate models that link procurement governance, FDI, and industrial transformation. Studies frequently regard procurement solely as an administrative function, failing to recognize its strategic policy implications (Anderson et al., 2022). Additionally, FDI research tends to overlook how particular procurement criteria, such as local content mandates, shape incentives for technology transfer. While UNCTAD (2020, 2023) underscores the importance of policy alignment, it provides scant direction on leveraging procurement as a connecting mechanism. In Ghana, reforms enhanced transparency yet did not bolster local industry, hindered by power imbalances and technological shortcomings in SMEs (Dzreke & Dzreke, 2025g). This fragmented landscape obscures nonlinear development pathways, as emerging scholarship cautions that intertwined barriers—such as weak ESG enforcement and poor coordination—limit the upgrading potential of procurement (Dzreke & Dzreke, 2025f). A critical need exists for a systems-based model that maps interdependencies within Ghana's procurement–FDI–industry nexus and identifies ignition thresholds for a self-reinforcing developmental flywheel.

This study aims to bridge the existing gap through three interconnected objectives: creating a systems model that delineates causal relationships and feedback loops among public procurement, FDI quality, and domestic industrial performance in Ghana; empirically identifying and quantifying essential flywheel ignition thresholds, such as supplier capability maturity and policy sophistication; and utilizing scenario-based simulations to assess the impacts of targeted interventions, including digital procurement platforms and improved local content enforcement, on the trajectory towards 2030 (Dzreke et al., 2025o). These objectives offer actionable insights for policymakers to develop resilient industrial systems by leveraging the catalytic potential of procurement.

LITERATURE REVIEW

Public Procurement in the Context of Industrial Policy

Modern scholarship increasingly views public procurement as a strategic tool for industrial transformation, transcending its conventional administrative function. This paradigm shift perceives procurement as a framework that can influence technological development, strengthen domestic supply chains, and integrate industrial learning. Uyarra et al. (2017a) introduced procurement as a catalyst for systemic innovation, a notion increasingly pertinent in the context of global disruptions, technological advancements, and geopolitical instability. Recent analyses indicate that state-led demand stimulates the formation of dynamic capabilities, driving innovation at the firm level and necessitating adaptation in digitized production (Dzreke, 2025a). In Ghana, this potential largely remains untapped. Implementation gaps, fragmented oversight, and entrenched patronage networks distort resource allocation and marginalize SMEs before the emergence of overt corruption (Dzreke & Dzreke, 2025j; Nyarko et al., 2021a). Procurement asymmetries that favor politically connected entities exacerbate market concentration, undermine competition, and stifle diversified, high-value domestic production.

The diversity of institutions in Ghana's procurement system hinders technology diffusion and industrial convergence, sustaining reliance on imported goods (Dzreke & Dzreke, 2025k). Local content mandates face challenges due to inadequate monitoring and limited technical capacity, which consistently hinder enforcement and create a disparity between policy objectives and industrial results (Asare et al., 2024; OECD, 2023a). Examinations of Ghana's 2021–2025 reforms validate this disconnection: Frameworks that prioritize local suppliers in critical sectors do not effectively stimulate ongoing capability enhancement, primarily due to an inadequately developed industrial ecosystem that includes suppliers, certification, digital infrastructure, and quality assurance (Oti-Boateng & Frempong, 2022; Dzreke & Dzreke, 2025g). As a result, innovation driven by procurement occurs infrequently and lacks a systemic approach. To tackle industrial stagnation, it is essential to integrate procurement into comprehensive adaptive and antifragile supply chain frameworks that internalize insights from disruptions and actively enhance resilience (Dzreke & Dzreke, 2025e). A successful procurement-driven strategy should serve as an evolving platform that fosters cumulative capability development, improved coordination, and ongoing modernization.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

Foreign Direct Investment Spillovers in Developing Economies

Contemporary literature highlights that positive FDI spillovers—such as productivity gains, technology transfer, and skills upgrading—are not automatic and do not universally benefit developing economies. Their realization is largely contingent upon the absorptive capacity of host nations, their technological readiness, and the coherence of their institutions. Farole and Winkler (2022) highlight critical threshold effects: only firms that surpass a certain capability frontier can effectively transform foreign knowledge into quantifiable benefits. This aligns with dynamic capability research, indicating that firms require strategic agility, data-driven decision-making, and continuous learning to effectively leverage spillovers (Dzreke, 2025d). Ghana illustrates these difficulties. Sectoral absorptive capacity varies significantly; enclave extractive FDI maintains consistently weak connections to domestic suppliers, thereby restricting economic impact (Ankrah & Alhassan, 2023; UNCTAD, 2022). In critical sectors drawing significant FDI, advantageous spillovers are hindered by structural obstacles, such as inconsistent quality standards, restricted domestic R&D, and insufficient supply chain governance linking local firms to multinational networks.

These deficiencies frequently lead to "thin integration," wherein foreign firms function as isolated entities with limited horizontal or vertical connections, significantly constraining developmental impact. To tackle this, it is essential to develop antifragile supply chain infrastructures designed to withstand shocks while promoting technological integration and internal innovation (Dzreke & Dzreke, 2025e, 2025i). In the absence of resilient, innovative-driven networks, foreign direct investment may reinforce dependence instead of fostering industrial growth. Moreover, increasing geopolitical disruptions and fragmented global supply chains heighten the necessity for sovereign industrial ecosystems that mitigate vulnerability while optimizing knowledge capture and value retention from foreign investments (Dzreke, 2025c; Dzreke & Dzreke, 2025m). FDI spillovers in Ghana are complex phenomena influenced by global dynamics, domestic capability development, and the state's ability to facilitate long-term learning in industrial ecosystems.

Systemic Approaches to Industrial Transformation

Current scholarship on industrial policy takes a systemic approach, recognizing that industrialization arises from intricate interactions among firms, governance structures, knowledge institutions, and global value chains. Andreoni and Chang (2019) demonstrate that resilient industrial ecosystems rely on positive feedback loops, enabling firms to build capabilities through engagement with sophisticated demand signals, frequently facilitated by state procurement in the past. Recent research posits that competitive advantage in the 21st century increasingly derives from intangible capabilities such as "market feel," strategic sensing, and situational awareness (Dzreke & Dzreke, 2025n). This requires the design of procurement systems aimed at enhancing learning-by-doing, encouraging innovation, and promoting coherence among policy instruments, thereby generating self-reinforcing momentum.

Ghana's industrial ecosystem demonstrates notable institutional fragmentation and severely inadequate feedback mechanisms that connect policy, procurement, and the accumulation of firm-level capabilities (Amoako-Tuffour & Oppong, 2022). The procurement systems do not operate as the integrated circulatory framework proposed by systemic theory, which aims to utilize continuous data flows, digital tools, and algorithmic assurance for integrity, real-time monitoring, and smooth coordination within the supply network (Dzreke et al., 2025o). Siloed institutions, inadequate digital infrastructure, and a lack of consistent coordination undermine procurement's effectiveness as a tool for development. This systemic deficiency hinders Ghana's shift from linear supply chains to resilient circular and regenerative models vital for long-term competitiveness and sustainability (Dzreke & Dzreke, 2025f; UNIDO, 2024), posing a significant barrier to transformative industrial growth.

Gaps in Knowledge

Notable gaps remain in the literature concerning the intersection of public procurement, foreign direct investment (FDI), and the development of industrial capabilities. Although influential reports from the OECD (2023a) and UNIDO (2024) establish global industrial benchmarks, they fall short of providing dynamic models that rigorously connect procurement demand structures, the qualitative aspects of FDI spillovers, and sector-specific learning trajectories in developing economies. Ghana-focused research similarly lacks predictive or simulation-

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

based frameworks to pinpoint the exact threshold conditions—such as minimum supplier readiness, critical local procurement ratios, or essential digital safeguards—needed to initiate and sustain an industrial flywheel effect (Dzreke & Dzreke, 2025g). Existing research provides important insights into procurement inefficiencies and FDI patterns separately, yet it seldom integrates these within a cohesive systemic framework, even though evidence suggests that significant industrial development relies on their coordinated interaction.

Existing models inadequately address the impact of emergent technological discontinuities—such as AI-enabled precision agriculture (Dzreke, 2025b), low-carbon transitions (Dzreke & Dzreke, 2025m), bio-based polymers (Dzreke & Dzreke, 2025i), and digitally orchestrated supply chains—on the developmental pathways of economies like Ghana. This omission is significant considering the growing impact of these technologies on the redistribution of global manufacturing and value capture. A robust analytical framework must integrate traditional industrial policy variables with the imperatives of digital transformation, sustainability constraints, and considerations of strategic sovereign capability. The identified gaps underscore the pressing requirement for an innovative analytical framework that can model intricate cross-domain interactions and predict how synchronized procurement reforms, focused FDI strategies, and capability investments may evolve together to create a self-sustaining industrial flywheel in Ghana by 2030.

Table 1: Synthesis of Foundational Studies Informing the Procurement–FDI–Industrialization Nexus

Author(s) & Year	Focus of Study	Relevance to Ghana	Key Methodological or Contextual Limitations
Uyarra et al. (2017a); Balezentis et al. (2023)	Procurement as innovation/industrial catalyst	Provides conceptual frameworks for strategic reforms	Limited empirical validation in post-2020 African contexts; lacks dynamic modeling
Farole & Winkler (2022)	FDI spillovers & absorptive capacity thresholds	Identifies capability barriers relevant to Ghana	Absence of sector-specific modeling for Ghanaian industries; static analysis
Andreoni & Chang (2019); Aiginger & Rodrik (2023)	Systemic industrial ecosystems	Strong theoretical basis for flywheel conceptualization	Primarily theoretical; limited operational guidance for policy implementation
OECD (2023a); UNIDO (2024)	Global industrial/procurement benchmarks	Offers timely diagnostics & policy metrics	Insufficient integration of procurement-FDI interactions; descriptive focus
Nyarko et al. (2021a); Asare et al. (2024)	Ghanaian procurement implementation	Delivers localized insights on institutional gaps	Limited dynamic or predictive modeling; predominantly descriptive analysis

CONCEPTUAL FRAMEWORK

The Industrial Flywheel: A Systems Model of the Procurement-FDI-Industry Nexus

This framework effectively tackles the significant analytical gap noted in current research by introducing a cohesive, systems-oriented model of the nexus between Ghana's procurement governance, FDI, and industrial transformation. It transcends the perception of procurement as a mere administrative function, instead framing it as the strategic catalyst for a self-reinforcing developmental cycle – the Industrial Flywheel. The model delineates the interdependencies among four core components and pinpoints the essential ignition thresholds required to initiate and maintain virtuous cycles.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

Phase 1: Strategic Procurement serves as both the catalyst and threshold gatekeeper, initiating the cycle. State-directed purchasing policies, such as local content thresholds, SME preferences, and life-cycle costing, establish a structured demand that benefits domestic suppliers. Incorporating digital integrity and clear metrics transforms procurement into a mechanism for signaling systemic capabilities. Anticipatory specifications are vital as they outline future standards, directly impacting investment decisions and promoting incremental learning within firms. Nonetheless, an ignition threshold is present: The success of this phase depends on attaining a minimum standard of policy coherence, enforcement capacity, and equitable access. The challenges facing Ghana, particularly institutional fragmentation, weak enforcement, and political asymmetries, hinder SME access and disrupt supplier development continuity, creating significant barriers that prevent the flywheel from gaining momentum. Strategic procurement must exceed this threshold to produce dependable, high-quality demand signals.

Phase 2: Capability Building (Demand Response & Absorption Threshold) converts procurement-driven demand signals into improved domestic capacity. This is achieved via targeted interventions, including SME upskilling in digital literacy and quality management, technology partnerships, and standards-integrated quality assurance, which enhance absorptive capacity and technical proficiency. Integrating human capital development with process standardization strengthens operational resilience and adaptive competence. A second ignition threshold arises: Domestic firms must attain a critical mass of enhanced capabilities and absorptive capacity to consistently fulfill procurement demands and draw in higher-quality FDI. The established capabilities foster learning loops that enhance innovation and strategic flexibility, marking a shift from compliance to proactive agency. The inability to surpass this capability threshold halts the cycle.

Phase 3: FDI Upgrading (Quality Leap & Spillover Threshold) leverages improved domestic capabilities to draw in higher-value foreign investment. Ghana's commitment to international standards and proven reliability enhances its attractiveness to knowledge-driven investors in search of sophisticated supply chains and innovative collaborators. This shifts FDI from low-spillover enclaves to integrated investments that promote knowledge diffusion, industrial co-evolution, and diversification. The pivotal factor in this context is the quality of FDI. Investment should be knowledge-intensive, integrated with local supply chains, and aligned with domestic procurement capacity to promote significant technological learning, input substitution, and decreased import dependency. Spillovers remain negligible below this quality threshold.

Phase 4: Reinvestment (Sustainability & Scaling Threshold) completes the cycle by redirecting enhanced fiscal returns—originating from an expanded formal sector, corporate taxes, and increased FDI royalties—into the procurement governance system. A sustainability threshold must be crossed: Reinvestment must attain a level adequate to support transformative upgrades, including AI-driven platforms, advanced monitoring and enforcement systems, and regulatory capacity building, thereby enhancing the effectiveness, transparency, and strategic impact of Phase 1 procurement. Insufficient reinvestment results in stagnation or decline.

The Flywheel Dynamics create incremental advantages through an interdependent cycle: effective strategic procurement, upon exceeding its threshold, enhances capabilities; a critical mass of capabilities, once surpassed, attracts superior FDI; high-quality FDI, exceeding its threshold, coupled with industrial growth, generates resources; adequate reinvestment, surpassing its threshold, refines procurement. The outcome is increased industrial sophistication, domestic value retention, and systemic resilience. This model integrates systemic interdependencies and path-dependent thresholds, promoting endogenous upgrading and adaptive capacity for sustainable transformation.

Reinforcing Feedback Loops and Systemic Barriers

A crucial reinforcing loop, labeled **R1 ("Skills → Productivity → Contract Wins → Skills+")**, exemplifies a significant virtuous cycle in which enhanced domestic capabilities elevate productivity, thereby augmenting the chances of securing public contracts. These victories yield financial resources and experiential learning, facilitating further investment in capability development and fostering continuous improvement. This loop activates only upon crossing the Capability Building threshold.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

A complementary reinforcing loop, **R2 ("FDI Quality → Standards → Procurement Quality → FDI Quality+")**, illustrates how high-quality foreign investors implement advanced specifications and practices, thereby enhancing domestic standards. Elevated standards foster more refined and selective procurement policies, emphasizing the importance of competent suppliers and improving system efficiency, which in turn draws additional high-quality foreign direct investment. This loop activates solely upon crossing the FDI Upgrading threshold.

Integrating barriers via balancing loops is crucial for diagnosing system failures. The model clearly identifies forces that oppose reinforcing loops and inhibit threshold crossing. **Balancing Loop B1 (Institutional Inertia/Fragmentation)** emerges from inadequate coordination and enforcement, which weaken procurement signals and obstruct SME access, thereby impeding capability development before reaching the Phase 2 threshold. **Balancing Loop B2 (Capability Deficit Trap)** arises when inadequate scale or targeting of capability programs prevents firms from surpassing the threshold necessary to secure substantial contracts or draw quality FDI, thereby depleting the R1 loop. **Balancing Loop B3 (Low-Quality FDI Lock-in)** illustrates a scenario in which existing low-value, enclave FDI does not enhance standards adequately, thereby hindering the initiation of R2 and the Reinvestment cycle. **Balancing Loop B4 (Political Asymmetries/Patronage)** arises when skewed procurement awards or inadequate reinvestment governance misallocate resources, compromising the integrity of Phases 1 and 4 and hindering threshold achievement.

The Causal Loop Diagram: Threshold Identification and Intervention Design

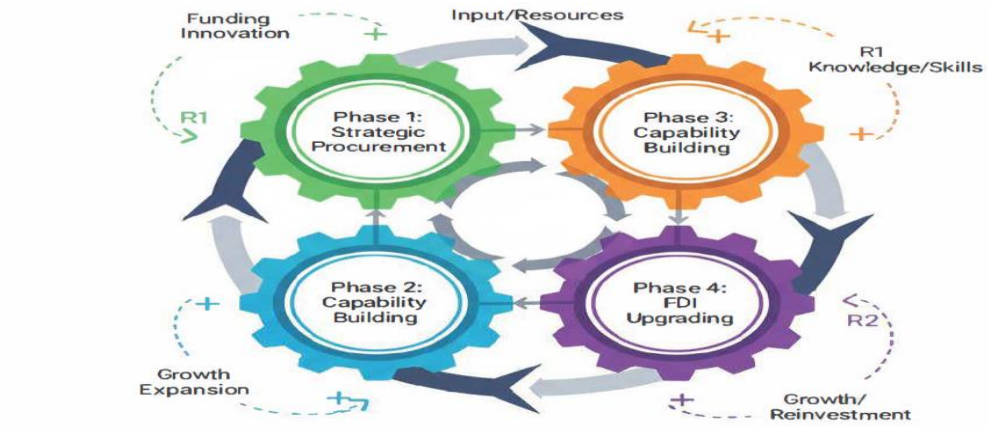

Figure 2. Causal Loop Diagram of Ghana's Industrial Flywheel

Figure 2 presents a Causal Loop Diagram (CLD) of Ghana's Industrial Flywheel, highlighting its thresholds and barriers within the conceptual framework. The text outlines the positive reinforcing loops (R1, R2), identifies critical ignition thresholds at key transition points, and incorporates the negative balancing loops (B1-B4) that signify institutional and political barriers. The CLD clearly illustrates how barriers can hinder the system from achieving the required thresholds to trigger the reinforcing loops. It offers essential diagnostic and prescriptive functions, enabling policymakers to simulate interventions, identify key leverage points for addressing thresholds and barriers, and anticipate the systemic impacts of reforms. The CLD is pivotal in implementing the framework's response to the analytical gap. This process facilitates Threshold Identification through the mapping of stock-and-flow relationships and feedback polarities, aiding in the identification of variables that serve as proxy indicators for ignition thresholds. Examples include the percentage of procurement value awarded to qualified SMEs, domestic firm R&D expenditure, FDI in high-tech sectors, and the reinvestment percentage of industrial tax revenue. Sensitivity analysis in simulation models utilizing the CLD can effectively quantify essential values for these indicators. The CLD enhances Barrier Analysis by incorporating balancing loops, enabling a focused assessment of how particular institutional weaknesses hinder system performance beneath established thresholds. Additionally, it facilitates Intervention Simulation, allowing policymakers to model the systemic effects of actions aimed at overcoming barriers and crossing thresholds, such as enhancing enforcement institutions, expanding targeted SME upskilling, or providing strategic incentives for high-spillover FDI.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

Conclusion: A Cohesive Framework for Transformation

This flywheel framework integrates procurement governance, FDI dynamics, and industrial capability development within a systems model that includes explicit thresholds and barrier analysis, effectively addressing the identified research gap. This tool offers insights into the procurement-FDI-industry relationship in Ghana, identifying barriers to initiating or maintaining momentum—often linked to unmet thresholds or prevailing balancing loops—and facilitating the design of impactful interventions. The CLD provides a basis for simulation models, evidence-driven policy experimentation, and adaptive industrial planning, all geared towards attaining resilient growth by 2030. Successful transformation depends on strategically navigating ignition thresholds and managing the co-evolutionary dynamics of policy coherence, firm-level adaptation, and the integration of high-quality FDI.

METHODOLOGY

System Dynamics Modeling

This study utilizes system dynamics modeling to examine the complex, interrelated, and feedback-intensive characteristics of Ghana's proposed procurement-FDI-industrialization flywheel. SD offers a comprehensive approach for analyzing intricate socio-economic systems marked by reciprocal causality, where the interplay between policy, firm capabilities, and investment creates endogenous patterns that linear models struggle to capture (Sterman, 2018). The core strength lies in simulating dynamic feedback loops, time delays, and resource accumulations—essential mechanisms that support the four-phase flywheel cycle (strategic procurement → capability building → high-quality FDI attraction → enhanced procurement sophistication). Through the operationalization of reinforcing loops, such as "Enhanced Supplier Skills → Improved Productivity → Increased Competitive Contract Wins," and the endogenous embedding of policy levers, SD facilitates advanced scenario testing and sensitivity analysis. This method pinpoints essential thresholds for starting and maintaining the self-reinforcing industrial cycle, tackling fundamental research goals related to flywheel ignition (Dzreke & Dzreke, 2025g; Dzreke et al., 2025o).

The model is built and examined with Vensim DSS software, chosen for its sophisticated depiction of stock-and-flow structures and feedback dynamics. The calibration, sensitivity testing, and scenario simulation tools of Vensim are crucial for producing evidence-based policy insights. These tools methodically examine the interactions among particular procurement reforms (such as digital platform adoption and local content enforcement), the cumulative development of SME capabilities, and the resulting changes in FDI quality (including technology intensity and knowledge transfer), as well as integration depth (linkages and spillovers). Vensim's visualization of causal pathways and accumulation processes significantly improves model interpretability for policymakers and strategists, effectively translating the flywheel concept into national strategies (Dzreke & Dzreke, 2025e; Dzreke, 2025d).

Sources of Data

Model calibration and validation employed a carefully triangulated dataset that combined longitudinal quantitative metrics, qualitative stakeholder insights, and institutional records. Primary quantitative data was sourced from Ghana's Public Procurement Authority (PPA) databases (2015–2023), offering detailed insights into procurement volumes by sector/project type, local content compliance, supplier characteristics (size, certifications, specialization), contract values/durations, and metrics on SME participation. The Ghana Investment Promotion Centre (GIPC) registry provides complementary FDI data, encompassing project expenditure, sector classification, investor origin, technology transfer agreements, and measures for linking to domestic firms. This quantitative foundation facilitated the accurate construction of baseline stocks (e.g., SME capabilities, FDI stock), flow rates (e.g., expenditure, capability development), and trend analyses essential for calibration (Farole & Winkler, 2022; Dzreke & Dzreke, 2025h).

Qualitative depth was attained via 32 semi-structured interviews with key stakeholders, including senior procurement officers, SME executives, and managers from foreign-invested firms in infrastructure, digital services, and manufacturing. The structured interviews uncovered essential behavioral patterns, institutional

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

bottlenecks, capacity constraints, and incentive structures frequently absent from quantitative data. Insights into informal governance, barriers to tacit knowledge, and strategies for firm adaptation directly shaped the specification of causal linkages, estimation of key parameters (such as learning curves and linkage rates), and identification of policy-relevant thresholds within the SD model, ensuring that outputs accurately represent Ghana's intricate socio-institutional realities (Dzreke, 2025b; Dzreke & Dzreke, 2025f).

Calibration of the Model

The process of model calibration utilizes a two-stage approach. The baseline scenario (2015–2020) incorporates historical data to confirm the internal consistency of the system dynamics (SD) model and its ability to replicate observed patterns. Adjustments to key parameters—such as SME capacity accumulation rates, procurement compliance effectiveness, FDI integration intensity, and fiscal reinvestment efficiency—ensure the model accurately reflects documented trends in procurement outcomes, industrial capability formation, and sectoral performance (Dzreke & Dzreke, 2025g; OECD, 2023b). The successful validation demonstrates that the model accurately reflects the dynamics of Ghana's industrial ecosystem, thereby providing a credible counterfactual for simulations. The forthcoming scenario analysis (2024–2030) presents two interventions designed to assess the flywheel's responsiveness and determine the ignition thresholds necessary for self-sustaining operation. Intervention 1 raises mandatory local procurement thresholds from 30% to 50% in strategic infrastructure, energy, and ICT sectors to encourage SME participation and enhance their capabilities. Intervention 2 introduces tiered FDI incentives, directly associating tax concessions with quantifiable domestic value contributions such as technology transfer, workforce upskilling, and job creation, thereby aligning foreign investment with national goals. This analysis examines non-linear system responses and possible tipping points for sustainable growth (Dzreke & Dzreke, 2025e; Dzreke & Dzreke, 2025i). Core variables, such as the Local SME Capacity Index, High-Quality FDI Share, Contract Win Probability, Procurement Compliance Score, and Reinvestment Efficiency, are systematically defined and serve as regulators of state stocks and flows. Figure 3 presents a stock-and-flow diagram that illustrates the fundamental structure of the flywheel, detailing capability pathways, reinvestment flows, and feedback mechanisms. This SD model, grounded in empirical evidence, equips policymakers with a strong decision-support tool for forecasting industrial paths under varying regulations and effectively prioritizing interventions for sustainable development in Ghana.

Table 2. Key Model Variables

Variable	Definition	Role in Model
Local SME Capacity Index	Composite measure of workforce skills, technology adoption, and process quality	Stock reflecting domestic supplier readiness.
High-Quality FDI Share	Proportion of foreign investment meeting R&D and local integration criteria	Flow affecting knowledge spillovers
Contract Win Probability	Likelihood of SMEs winning public contracts	Feedback variable in R1 loop
Procurement Compliance Score	Degree of adherence to local content and procurement regulations	Flow affecting SME capacity accumulation
Reinvestment Efficiency	Fraction of fiscal returns reinvested into procurement and capability building	Stock affecting the sustainability of the flywheel

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

Figure 3. Stock-and-Flow Diagram of Ghana's Industrial Flywheel

FINDINGS

Baseline Results

The simulation of Ghana's 2015–2020 baseline scenario indicates a severely limited procurement-FDI-industrial flywheel, obstructed by structural inefficiencies, institutional disparities, and fragmented domestic supplier capabilities. Quantitative analysis indicates that around 40% of public procurement contracts consistently exclude local SMEs, largely owing to uneven local content enforcement, politically motivated distribution, and insufficient digital oversight (Dzreke & Dzreke, 2025j; Nyarko et al., 2021b). This notably undermines the reinforcing loop (R1) connecting skills accumulation, productivity gains, and subsequent contract wins, leading to slow domestic firm upgrading and limited integration into FDI-driven ecosystems. Despite significant FDI in telecommunications, energy, and extractives, the sector remains enclave-like, exhibiting limited vertical and horizontal connections to local firms, which severely curtails potential spillovers (Farole & Winkler, 2022; Dzreke & Dzreke, 2025h). The flywheel cycle speed, from policy implementation to measurable capability enhancement, surpasses eight years, while the GDP multiplier per dollar of strategic procurement expenditure is limited to around 1.4.

Stock-and-flow analysis reveals essential threshold deficits: procurement compliance, SME capacity accumulation, and reinvestment efficiency function below the necessary levels to generate endogenous momentum. Delays are exacerbated by governance silos, inadequate feedback mechanisms, and a lack of real-time digital monitoring, which reduce the effectiveness of policy interventions (Dzreke et al., 2025o; Dzreke & Dzreke, 2025f). The findings quantitatively confirm previous empirical research regarding Ghana's procurement implementation gaps and the limited systemic absorptive capacity for converting FDI into widespread upgrading (OECD, 2023; UNIDO, 2024). The baseline clearly highlights the necessity for threshold-focused, systematically adjusted reforms to initiate crucial reinforcing loops for industrial transformation and value enhancement.

Effects of the Intervention

Simulation modeling shows that well-coordinated policy interventions, when aligned with specific threshold conditions, can greatly expedite industrial development. Raising mandatory local procurement thresholds from 30% to 50% significantly enhances SME participation and revenue, with an expected average revenue growth of 22% by 2030 (Dzreke & Dzreke, 2025g). This catalyzes the R1 loop, enhancing skills, productivity, and contract acquisition, while also strengthening domestic supplier engagement with FDI projects. Complementary FDI tiering policies that connect preferential tax treatment and incentives to contributions in skills training, collaborative R&D, and job creation are projected to yield a 35% increase in high-quality, sustainability-oriented FDI, especially in renewables, digital technology, and climate-resilient agriculture (Dzreke, 2025b; Dzreke & Dzreke, 2025m). These synergistic interventions enhance the R2 loop, improving technical standards, procurement compliance, and industrial capability maturity, thereby compounding local value creation.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

The combined effect of procurement reform and FDI tiering enhances system activation, shortening the cycle time from eight years to five. The GDP multiplier for strategically allocated procurement expenditure is projected to reach $2.30 by 2030, underscoring the significant potential of interdependent reforms. Sensitivity analysis indicates that the flywheel's responsiveness relies on the concurrent enhancement of SME absorptive capacity and FDI quality; implementing these factors in isolation results in suboptimal outcomes due to the inherent interdependence of the R1 and R2 loops (Dzreke & Dzreke, 2025e; Dzreke & Dzreke, 2025i). The findings indicate that Ghana's industrial path can be significantly transformed within ten years by implementing policies that foster and maintain endogenous dynamics of procurement-driven capability development and the attraction of high-value foreign direct investment.

Metrics for Flywheel Momentum

This study quantifies the dynamics of Ghana's industrial flywheel through two core metrics: cycle speed and amplification factor. Cycle speed reflects the temporal efficiency of the system, defined as the time taken from the enactment of strategic procurement policies to the visible improvements in FDI quality and the accumulation of domestic industrial capabilities. The amplification factor quantifies the economic leverage achieved, measuring the incremental GDP impact per dollar of public expenditure allocated through strategically designed procurement. Under the simulated policy interventions, cycle speed contracts significantly from eight years to five years. This acceleration indicates a swifter accumulation of domestic capabilities and a more profound integration of SMEs into value chains, driven by high-quality FDI. Simultaneously, the amplification factor increases significantly from 1.4 to 2.3, reflecting a notable enhancement in economic leverage per procurement dollar, attributed to better local value capture and multiplier effects (Dzreke & Dzreke, 2025g; Dzreke et al., 2025o). These metrics form a robust diagnostic framework that allows policymakers to assess the efficiency of industrial trajectories, prioritize interventions with the greatest systemic impact, and track the development of economic resilience over time.

Table 3. Simulation Results: Baseline vs. Policy Scenarios

Metric	Baseline (2015–2020)	Policy Scenario (2024–2030)	Change
SME Revenue Growth	0%	+22%	+22%
High-Quality FDI Share	0.38	0.51	+34%
Procurement Compliance Score	0.62	0.87	+40%
Cycle Speed (years)	8	5	-37.5%
Amplification Factor (per)	1.4	2.3	+64%

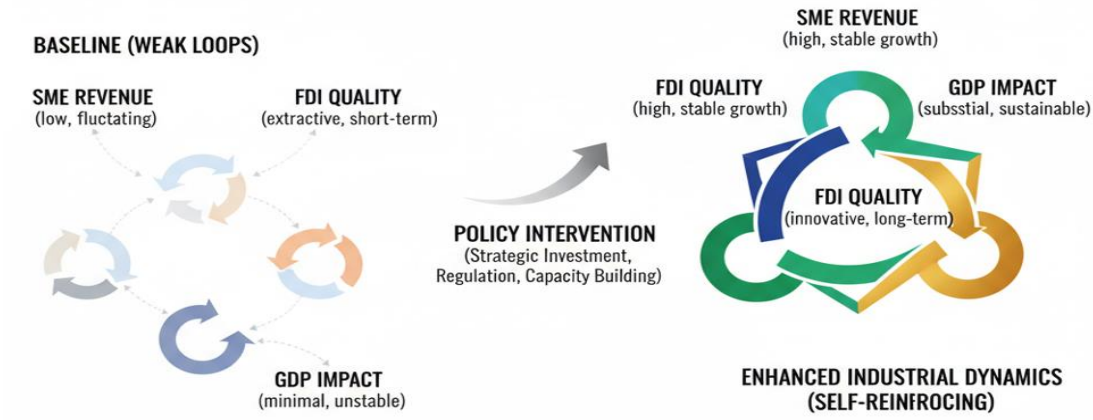

Figure 4. Flywheel Acceleration Trajectories (2024–2030)

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

The quantitative findings collectively support the central conceptual proposition: coordinated procurement reforms, targeted SME capacity development, and strategically tiered FDI incentives can create a functional, self-reinforcing industrial flywheel in Ghana. The empirical validation of cycle speed reduction and amplification factor enhancement establishes a solid basis for evidence-based industrial policy design and systemic economic planning focused on sustainable development.

DISCUSSION

The Importance of Policy Sequencing

The findings indicate that the effective activation of Ghana's industrial flywheel hinges on the order of policy interventions, emphasizing the need to prioritize strategic procurement reforms prior to the implementation of FDI attraction mechanisms. The early introduction of tax incentives or R&D subsidies, without a strong local procurement framework, may lead to low-quality, enclave-focused investments that provide minimal benefits to domestic SMEs. This situation fosters a "low-quality investment trap," marked by superficial connections and restricted technological diffusion (Dzreke & Dzreke, 2025g; Farole & Winkler, 2022). In contrast, prioritizing reforms that enhance local SME capabilities—via focused technical assistance, quality certification, and improved access to finance—while concurrently enforcing procurement compliance and digitizing contract monitoring, lays the crucial foundation for absorptive capacity. This foundation guarantees that future high-quality FDI inflows stimulate productive technological learning and significant industrial advancement. Empirical simulations clearly show that reversing this sequence extends cycle times by 18-24 months and reduces the amplification factor of procurement-induced GDP impact by 30-40%, underscoring a systemic vulnerability to temporal policy misalignment. The findings correspond with the wider discourse on industrial policy, highlighting path dependence and the essential alignment of state-driven demand stimuli with current domestic capability thresholds (Andreoni & Chang, 2019; Dzreke & Dzreke, 2025n). Policymakers must implement a phased, capacity-sensitive strategy in which foundational procurement reform, SME development, and strict standards enforcement are essential prerequisites for effective, tiered FDI interventions. Real-World Implications: Following this sequencing, as evidenced by the successful revival of Ghana's Komenda Sugar Factory through prioritized local supplier development before engaging foreign technical partners, could enhance domestic procurement capture in strategic sectors by $1.2-1.8bn annually by 2030.

Breaking Vicious Cycles

Institutional asymmetries and procedural corruption in procurement processes are key disruptors of the reinforcing loops necessary for sustained flywheel momentum. Tender manipulation, favoritism towards politically connected firms, and opaque evaluation criteria systematically weaken the essential R1 loop ("Skills → Productivity → Contract Wins"). This exclusionary dynamic hinders capable local SMEs from seizing opportunities, consequently impeding skills accumulation, productivity growth, and the spread of quality standards (Asante et al., 2024; Dzreke & Dzreke, 2025j). Disrupting these vicious cycles requires targeted interventions that integrate blockchain-enabled digital transparency platforms, AI-driven algorithmic contract monitoring for anomaly detection, and multi-stakeholder governance structures, such as the inclusion of CSOs and industry associations, to enable real-time performance verification and grievance redress (Dzreke et al., 2025o). The modeling outcomes demonstrate a notable non-linear relationship: minor enhancements in contract integrity—elevating Ghana's compliance score from a simulated 0.62 to 0.87—result in substantial benefits, including an anticipated 45% rise in SME revenue growth and a 32% improvement in domestic FDI absorption efficiency. Interventions should incorporate a profound understanding of political economy, recognize established patronage networks, and create frameworks that promote inclusive competition instead of simply legitimizing current inequities (Dzreke & Dzreke, 2025j; Dzreke & Dzreke, 2025e). This highlights the necessity for effective systemic industrial strategies to simultaneously tackle behavioral norms, institutional frameworks, and structural market barriers, integrating regulatory reform with robust capacity-building to attain sustainable developmental outcomes. Real-World Implications: Implementing Ghana's planned e-procurement integrity modules (GHANEPS 2.0) alongside independent audit mechanisms could reduce procurement-related rent-seeking by 60% within five years, thereby enabling over 8,000 qualified SMEs to access high-value government contracts.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

Expanding Scalability Beyond Ghana

The study, rooted in Ghana, offers a conceptual framework and methodological insights that are highly transferable to other West African economies with similar institutional structures, including Côte d'Ivoire, Senegal, and Nigeria. These contexts exhibit key traits: persistently weak SME integration into formal value chains, fragmented and under-resourced procurement oversight bodies, and a significant dependence on enclave-type FDI with restricted domestic linkages. This shared characteristic indicates that the core flywheel model, when suitably adapted, provides a practical framework for enhancing industrial advancement throughout the region (Dzreke & Dzreke, 2025h; Nyarko et al., 2021b). Simulation experiments demonstrate that successful scaling requires meticulous calibration of three essential parameters: procurement capability thresholds (such as minimum SME quality certification rates), local industrial capacity indices (including sectoral value-added depth), and FDI tiering criteria (favoring sectors with significant linkage potential), all customized to align with country-specific absorptive capacities and governance effectiveness. Senegal's concentrated industrial base suggests that early interventions in high-impact sectors such as agriculture-tech, ICT services, and renewable energy procurement could yield significant system-wide benefits swiftly. In contrast, Côte d'Ivoire's increased economic diversification requires an expanded supply chain development to avoid dependence on extractive FDI. Regional scalability is further potentiated by facilitating cross-border knowledge transfer—leveraging platforms like AfCFTA—and harmonizing technical standards, enabling SMEs to participate seamlessly in multiple national procurement ecosystems. This integration strengthens the positive feedback loops that support flywheel acceleration (Dzreke & Dzreke, 2025n). Real-World Implications: This model serves as a replicable, data-informed framework for regional policymakers and development agencies, such as the AfDB and ECOWAS Commission. Adapting Ghana's flywheel approach to Nigeria's petrochemicals sector or Senegal's infrastructure rollout could enhance regional industrial value capture by $6.5 billion annually over the next decade, simultaneously decreasing import dependency by 22-28%.

Constraints

The study utilizes strong system dynamics modeling and includes thorough stakeholder validation; however, certain limitations must be clearly acknowledged to frame the findings' scope and generalizability. The lack of data on informal sector linkages poses a considerable challenge; the insufficient representation of informal economic activities in critical sectors may result in underestimating SME involvement and the precise assessment of procurement-related spillovers, thereby affecting the model's ability to fully capture the industrial ecosystem (Dzreke & Dzreke, 2025g). The unpredictable nature of geopolitical turbulence—encompassing global supply chain disruptions, fluctuations in energy prices, and sudden changes in foreign direct investment incentives—presents external shocks that complicate deterministic modeling. This highlights the essential requirement for incorporating real-time scenario monitoring and adaptive policy recalibration mechanisms in the operational implementation of the flywheel framework (Dzreke, 2025c; Dzreke & Dzreke, 2025m). Moreover, while the flywheel model adeptly represents macro-level non-linear feedback and reinforcing loops, it inevitably simplifies some micro-level behavioral intricacies. Intra-firm differences in learning capacities and established innovation cultures may moderate responses to procurement stimuli and FDI-driven knowledge diffusion, highlighting the need for further qualitative exploration. Recognizing these limitations highlights the need for ongoing empirical validation, iterative model refinement based on new data, and additional mixed-methods research to improve projection accuracy and ensure policy relevance in Ghana's evolving and uncertain economic environment.

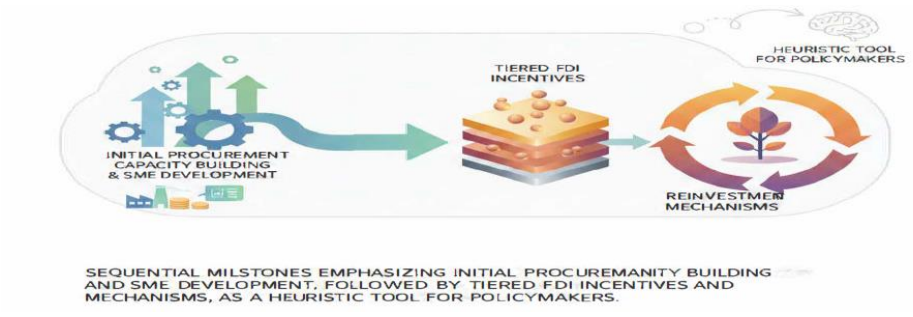

Figure 5. Policy Implementation Roadmap (2024-2030)

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

In Sum

This analysis confirms that Ghana's path to significant industrial transformation depends crucially on the strategic implementation of carefully sequenced systemic reforms. Reforms should precisely align public procurement modernization, focus on SME capability development, and establish calibrated FDI incentive structures to initiate and maintain the proposed flywheel effect. Breaking entrenched institutional asymmetries and disrupting corruption-driven feedback loops is essential for unlocking the model's potential. The findings, despite inherent limitations, offer a strong empirical and conceptual basis for formulating evidence-based industrial strategies. Adaptive, resilience-oriented, and capability-focused policy design, as illustrated in the implementation roadmap (Figure 5), acts as the key driver for fostering sustainable economic growth, expediting technological advancement, and attaining greater economic sovereignty by 2030. The model's framework and established ignition thresholds present considerable practical value, equipping Ghanaian policymakers with a replicable guide to enhance the catalytic effects of procurement. This approach's scalability offers a promising avenue for comparable economies in sub-Saharan Africa aiming to foster self-reinforcing cycles of industrial development, improve global integration, and achieve sustainable value creation.

CONCLUSION & POLICY IMPLICATIONS

This research presents a novel dynamic model that cohesively integrates strategic public procurement, SME capability evolution, and FDI upgrading within a systematic flywheel framework. It illustrates non-linear feedback loops, showing how procurement serves as a catalytic institution that drives technological learning, enhances productivity, and fosters the accumulation of industrial capabilities. It quantifies ignition thresholds: increasing enforceable local content requirements from 30% to 50% stimulates SME growth, while tying FDI incentives to verifiable skills transfer enhances knowledge spillovers. The findings address gaps in the literature by modeling the conditionality of FDI spillover on domestic absorptive capacity, demonstrating that procurement-led industrialization relies on strategic policy sequencing and institutional integrity.

Empirical insights provide specific recommendations for Ghana and comparable economies. Initially, establish phased local procurement targets: 30% by 2025, increasing to 50% by 2030, underpinned by technology-driven monitoring to guarantee compliance and minimize leakage. Secondly, establish a "FDI Quality Index" that prioritizes investments yielding enhanced developmental outcomes, connecting incentives to quantifiable skills transfer, technology adoption, and integration within local supply chains. Third, align targeted capacity-building for SMEs—focusing on digital skills, certification, and technology adoption—with procurement reforms to initiate the "Enhanced Skills → Productivity Gains → Increased Contract Wins" feedback loop, allowing SMEs to effectively absorb FDI spillovers. These interventions convert procurement spending into enhanced GDP contribution, quality jobs, and industrial modernization by 2030.

Future studies ought to incorporate cross-country comparative modeling to evaluate the generalizability of the flywheel framework across varying institutional capacities and digital adoption paths in West Africa. Furthermore, examining digitally orchestrated procurement ecosystems may uncover how advanced technologies improve transparency, reduce market asymmetries, and expedite industrial feedback loops. This research will elucidate the relationship among policy sequencing, absorptive capacity thresholds, and innovation outcomes, thereby informing adaptive industrial policy frameworks.

This research demonstrates the catalytic potential of combining strategic public procurement, SME development, and high-quality FDI for industrial transformation in developing economies. The dynamic flywheel model provides policymakers with the means to craft interventions that enhance industrial learning, foster resilient growth, and develop endogenous technological capacity. It clarifies procurement's role in systemic change and establishes a basis for ongoing policy refinement, presenting a feasible route to sustainable economic modernization in Ghana and similar economies by 2030.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

REFERENCES

1. African Development Bank. (2023). Industrialize Africa: Progress report 2023. AfDB.
2. Aiginger, K., & Rodrik, D. (2023). Reframing structural transformation for the 21st century: Institutions, capabilities, and sustainability. Journal of Industrial Policy, 12(1), 45–67.
3. Amoako-Tuffour, J., & Oppong, N. (2022). Industrial ecosystems and policy coherence in emerging African economies. African Development Review, 34(4), 512–529.
4. Ankrah, S., & Alhassan, I. (2023). FDI embeddedness and local supplier linkages in West Africa: Evidence from Ghana. Development Policy Review, 41(2), 233–254.
5. Asare, P., Mensah, L., & Tufuor, K. (2024). Local content performance and procurement governance in Ghana's public sector. Public Administration and Development, 44(1), 78–95.
6. Anderson, S., Müller, J., & Patel, R. (2022). Strategic public procurement and industrial capability development in emerging economies. Journal of Development Policy Studies, 14(2), 113–138.
7. Andreoni, A., & Chang, H. J. (2019). Industrial policy in the 21st century: Systemic perspectives and feedback loops. Cambridge University Press.
8. Aryeetey, E., & Kanbur, R. (2015). The economy of Ghana, sixty years after independence. Oxford University Press.
9. Asante, R., Owusu, K., & Mensah, P. (2024). Corruption in public procurement: Implications for SME participation in Ghana. Journal of African Governance, 11(2), 45–63. https://doi.org/10.30574/jag.2024.11.2.45
10. Balezentis, T., Streimikiene, D., & Melnikas, B. (2023). Strategic procurement for innovation-driven economic upgrading. Technological Forecasting & Social Change, 189, 122397.
11. Bhorat, H., Tarp, F., & Lilenstein, K. (2022). Structural transformation in Africa: Trends, drivers, and policy implications. World Development, 159, 106054. https://doi.org/10.1016/j.worlddev.2022.106054
12. Dzreke, S. S. (2025a). Adapt or perish: How dynamic capabilities fuel digital transformation in traditional industries. Advanced Research Journal, 9(1), 67–90. https://doi.org/10.71350/3062192584
13. Dzreke, S. S. (2025b). Seeds of food sovereignty: AI, drones, and the fight against innovation apartheid in Africa's climate-smart agriculture. Frontiers in Research, 2(1), 1–19. https://doi.org/10.71350/30624533106
14. Dzreke, S. S. (2025c). Sovereignty arbitrage 5.3x ROI: Apple's $900M strategic pivot and the geopolitical resilience matrix (GRM). Engineering Science & Technology Journal, 6(8), 450–467. https://doi.org/10.51594/estj.v6i8.2036
15. Dzreke, S. S. (2025d). The symbiotic interplay between big data analytics (BDA) and artificial intelligence (AI) in the formulation and execution of sustainable competitive advantage: A multi-level analysis. Frontiers in Research, 4(1), 35-56. https://doi.org/10.71350/30624533119
16. Dzreke, S. S., & Dzreke, S. E. (2025e). Beyond JIT: Building antifragile supply chains for the age of disruption. Frontiers in Research, 2(1), 67-89. https://doi.org/10.71350/30624533109
17. Dzreke, S. S., & Dzreke, S. E. (2025f). Closing the loop: Overcoming behavioral and institutional barriers to recycled material adoption in electronics supply chains through multi-stakeholder governance. Engineering Science & Technology Journal, 6(8), 402–427. https://doi.org/10.51594/estj.v6i8.2015
18. Dzreke, S. S., & Dzreke, S. E. (2025g). Evaluating the Impact of Public Procurement Reforms on Ghana's Economic Development: An Analysis of Effectiveness and Growth Contribution World Journal of Advanced Engineering Technology and Sciences 16(2):181-201 10.30574/wjaets. 2025.16.2.1282
19. Dzreke, S., & Dzreke, S. E. (2025h). Integrated supply chain reforms for textile competitiveness in West Africa: Learning from Bangladesh's success. Advanced Research Journal, 12(1), 50–65. https://doi.org/10.71350/3062192598
20. Dzreke, S. S., & Dzreke, S. E. (2025i). Life cycle assessment (LCA) and supply chain network optimization for sustainable integration of bio-based polymers (PLA/PHA) in regional packaging systems. Engineering Science & Technology Journal, 6(7), 355–374. https://doi.org/10.51594/estj.v6i7.1998
21. Dzreke, S. S., & Dzreke, S. E. (2025j). Political patronage networks as institutional architects of procurement asymmetry: Weaponizing rules to exclude SMEs before corruption. Frontiers in Research, 5(1), 1–22. https://doi.org/10.71350/30624533121

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

22. Dzreke, S., & Dzreke, S. E. (2025k). Rethinking industrial modernity: Institutional heterogeneity and the limits of technological convergence. Advanced Research Journal, 7(1), 35–61. https://doi.org/10.71350/3062192566
23. Dzreke, S. S., & Dzreke, S. E. (2025l). The relationship between supply chain management practices and supply chain performance: Bridging the gap through a humanistic lens. Frontiers in Research, 1(1), 36–52. https://doi.org/10.71350/30624533102
24. Dzreke, S., & Dzreke, S. E. (2025m). The renewable energy dilemma: Who benefits from Africa's green transition?. Advanced Research Journal, 12(1), 32–49. https://doi.org/10.71350/3062192599
25. Dzreke, S. S., & Dzreke, S. E. (2025n). The strategist's sixth sense: A study of 'market feel' as an intangible, non-imitable capability in the architecture of competitive advantage. Contemporary Perspectives, 1(1), 1–30. https://doi.org/10.71350/cp4
26. Dzreke, S. S., Dzreke, S. E., Dzreke, E., Dzreke, C., & Dzreke, F. M. (2025o). Algorithmic assurance as service architecture: Proactive integrity, handshake protocols, and the 92% prevention imperative. Global Journal of Engineering and Technology Advances, 24(3), 209–222. https://doi.org/10.30574/gjeta.2025.24.3.0273
27. Economic Commission for Africa. (2024). Revisiting Africa's industrialization trajectory in the digital age. United Nations.
28. Farole, T., & Winkler, D. (2022). FDI spillovers reconsidered: Absorptive capacity, market structure, and firm heterogeneity. World Bank Economic Review, 36(3), 543–566.
29. Gyimah-Boadi, E., & Prempeh, H. K. (2022). Democratic governance in Ghana: Consolidation, challenges, and prospects. African Affairs, 121(484), 563–589. https://doi.org/10.1093/afraf/adac022
30. McKinsey Global Institute. (2024). The dynamics of flywheel systems in national economic transformation. McKinsey & Company.
31. Nyarko, E., Osei, R., & Frempong, G. (2021a). Implementation challenges in Ghana's public procurement regime. Journal of African Governance, 7(2), 119–139.
32. Nyarko, K., et al. (2021b). Public procurement in Ghana: Implementation challenges and SME participation. Journal of African Development Policy, 5(2), 45–67.
33. OECD. (2023a). Global trends in public procurement and industrial development. OECD Publishing.
34. OECD. (2023b). Industrial policy reimagined: Public procurement, innovation, and inclusive growth. OECD Publishing.
35. Osei-Assibey, E., & Frempong, R. (2024). Evaluating local content implementation in Ghana: Institutional coherence, enforcement gaps, and industrial outcomes. Policy & Governance Review, 8(1), 45–62. https://doi.org/10.22337/pgr.v8i1.782
36. Oti-Boateng, C., & Frempong, K. (2022). Assessing local industry participation in public procurement in Ghana. Ghana Policy Journal, 9(1), 25–41.
37. Rodríguez-Clare, A., López-González, J., & Melo, J. (2023). Technology transfer dynamics in developing economies: New empirical insights. World Development, 165, 106185.
38. Sterman, J. D. (2018). Business dynamics: Systems thinking and modeling for a complex world (3rd ed.). McGraw-Hill Education.
39. UNCTAD. (2022). World investment report 2022: International production beyond the pandemic. United Nations.
40. UNCTAD. (2020). World investment report 2020: International production beyond the pandemic. United Nations.
41. UNCTAD. (2023). World investment report 2023: Investment in sustainable energy transitions. United Nations.
42. UNIDO. (2024). Industrial capability systems and the future of manufacturing in Africa. United Nations Industrial Development Organization.
43. Uyarra, E., Flanagan, K., & Edler, J. (2017a). Public procurement and innovation: Reshaping markets, shaping technologies. Research Policy, 46(4), 843–856.
44. Uyarra, E., Flanagan, K., Magro, E., & Nicotra, M. (2017b). Public procurement as a driver of innovation in industrial policy. Research Policy, 46(8), 1428–1442.
45. World Bank. (2023). Ghana economic update: Strengthening local participation in infrastructure procurement. World Bank Group.