“Logistics competence and e-commerce-relevant logistics performance in MENA economies: Evidence from official LPI survey waves”

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LOGISTICS COMPETENCE AND E-COMMERCE-RELEVANT LOGISTICS PERFORMANCE IN MENA ECONOMIES: EVIDENCE FROM OFFICIAL LPI SURVEY WAVES

Abstract

Electronic commerce growth across Middle East and North Africa economies has increased the importance of logistics capability, shipment visibility, and delivery reliability. This study corrects an earlier United Arab Emirates-only annual time-series framing by aligning the empirical design with the official survey-wave structure of the World Bank Logistics Performance Index. The analysis uses only the official Logistics Performance Index waves: 2007, 2010, 2012, 2014, 2016, 2018, and the 2023 editions. It examines whether logistics competence, measured by the competence and quality of logistics services sub-index of the Logistics Performance Index, is associated with tracking-and-tracing performance and delivery timeliness. Green human capital is used only as a theoretical boundary-setting lens; the empirical construct is explicitly limited to logistics competence because the Logistics Performance Index does not directly measure environmental training, green skills, or workforce sustainability capability. A separate exploratory test uses macro carbon efficiency, calculated as the negative logarithm of World Bank carbon intensity of gross domestic product. The country-wave panel covers 20 conventional Middle East and North Africa economies, with two-way fixed-effects regressions estimated on 116 complete observations from 19 economies. Logistics competence is positively associated with tracking-and-tracing performance (coefficient = 0.519; p-value < 0.01) and delivery timeliness (coefficient = 0.416; p-value < 0.01), while its within-country association with macro carbon efficiency is statistically insignificant. The findings support a conservative logistics-competence/performance association but not claims that logistics competence alone produces cleaner logistics at the macro level.

Keywords sustainability, competence, e-commerce, tracking, timeliness, carbon, performance, MENA, Emirates

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INTRODUCTION

The rapid growth of e-commerce and digitally coordinated trade has reshaped consumption and logistics systems across MENA economies. Online transactions depend on shipment visibility, delivery reliability, fulfillment coordination, and service quality. These functions can support market access and service integration, but they can also increase fragmented deliveries, packaging flows, urban transport demand, and pressure on energy systems. The policy issue is therefore not simply whether digital commerce expands, but whether the logistics systems supporting it are sufficiently competent to coordinate growth reliably, transparently, and efficiently.

The United Arab Emirates remains an important focal case because it combines advanced digital infrastructure, strong logistics-sector ambitions, and explicit sustainability objectives. However, a UAE-only annual time-series design is not defensible when the main logistics indicator is the World Bank Logistics Performance Index. The LPI is a survey-wave indicator rather than a continuous annual series. Any empirical design using it must follow the official survey waves instead of creating artificial annual observations or applying methods that require longer annual data.

This study preserves the original theoretical problem while correcting the empirical design. Sustainability research on e-commerce logistics often emphasizes platforms, infrastructure, and technology, while the human-capability dimension of logistics execution remains less clearly specified. Green human capital theory explains why skills, knowledge, and operational routines may matter for sustainability-oriented logistics. However, the available LPI competence indicator measures general logistics professionalism and service capability, not environmental training, green skills, or workforce sustainability capability. The study therefore does not test green human capital directly; it uses that theory only to frame why logistics competence may matter and where the measurement boundary lies. This distinction is central to the paper's construct validity.

Accordingly, the study estimates a MENA country-wave panel and treats the UAE as a focal regional benchmark rather than a stand-alone statistical sample. It examines whether logistics competence is associated with LPI-based tracking-and-tracing performance and delivery timeliness, and it includes only an exploratory macro-level carbon-efficiency check. The contribution is to retain the theoretical relevance of green human capital while limiting the empirical claims to what the official LPI and World Bank indicators can support. The paper therefore advances a cautious, association-based account of logistics competence in digitally coordinated trade.

1. LITERATURE REVIEW

E-commerce has expanded rapidly and reshaped production, trading, and consumption patterns, creating diversification and productivity opportunities while simultaneously increasing sustainability pressures through transport intensity, packaging volumes, and energy demand. In emerging and high-growth digital markets, online delivery systems can scale faster than mitigation capacity, so the environmental footprint of fragmented shipments, congestion, and pollution can become a structural feature of digital trade rather than a temporary side effect. Hendricks and Mwapwele (2024) show that e-commerce adoption in developing countries depends on enabling infrastructure, institutional readiness, and logistics capacity. Paun et al. (2024) identify digital and structural drivers of e-commerce adoption at the global level. Elamin et al. (2025) provide UAE evidence on e-shopping attitudes and digital-market participation. Malhotra and Kharub (2025) connect AI-enabled logistics capability to e-commerce logistics performance. This tension is important because e-commerce can improve information efficiency while simultaneously multiplying delivery events, returns, and last-mile coordination requirements. Broader regional communication research likewise shows that social media can shape professional information agendas (Ahmad et al., 2023). Information-flow research during the COVID-19 period in Yemen also documents the interaction of traditional and new media environments (Al-Muntasir, 2022). Jordanian evidence on Facebook further highlights platform features, usage motives, and achieved gratifications as dimensions of digital engagement (Oreqat, 2021).

Environmental economics provides a useful lens for interpreting this tension, but it does not support a simple 'growth first, clean later' assumption. Environmental Kuznets Curve debates suggest that environmental pressure may eventually decline when economies acquire cleaner technologies, stronger institutions, and higher-quality human capital, yet the relationship is conditional and sector-specific. Akar et al. (2025) provide comparative evidence on the Environmental Kuznets Curve hypothesis across advanced and late-industrializing economies. Gupta et al. (2025) show that the growth-environment relationship differs across sectors. Lau et al. (2025) demonstrate that Environmental Kuznets Curve evidence remains diverse across three decades of research. Schneiter and Mellon-Bedi (2025) emphasize spatial and coefficient heterogeneity. McNeil and Barnes (2025) highlight the economic trade-offs that shape support for environmental protection. E-commerce complicates the growth-environment relationship because convenience-driven demand, platform competition, and delivery-speed expectations can create rebound effects. More efficient digital ordering may reduce search and transaction costs, but it can also generate more frequent, smaller, and time-sensitive shipments. The relevant issue is therefore not whether digital trade is inherently clean, but which capabilities help logistics systems become reliable, productive, and potentially less resource-intensive.

Green human capital is central to this theoretical discussion because environmental performance depends on the knowledge, skills, and routines through which sustainability priorities are embedded in everyday decisions. Abbas and Najam (2025) link green human capital to firm green technological innovation within a broader sustainability framework. Asghar et al. (2025) show that green human capital can support green creativity when organizational conditions enable employee voice. Badwy et al. (2025) connect green human resource management, green innovation, and green human capital to sustainable success. Chakraborty and Mazzanti (2025) model green knowledge production in relation to human-capital spillovers and fiscal policy. Ozbay (2025) frames green innovation through a green knowledge-production function. In logistics, this reasoning is particularly important because many environmental consequences arise from routine operational choices: route planning, load consolidation, carrier selection, warehouse discipline, return management, waste handling, and compliance with service standards. A logistics system can possess advanced digital tools yet fail to reduce inefficiency if staff and service providers lack the competence to use those tools effectively. Related MENA evidence shows that remote communication can mediate the relationship between electronic human resource management practices and organizational performance in Iraqi commercial banks (Taqa, 2025).

The resource-based view and the natural-resource-based view strengthen this argument. The resource-based view treats valuable, rare, and difficult-to-imitate knowledge as a source of sustained advantage (Barney, 1991), while the natural-resource-based view extends capability logic to pollution prevention, product stewardship, and sustainable development (Hart, 1995). Dynamic-capability theory adds that organizations and systems must integrate, reconfigure, and renew skills as technologies, markets, and environmental requirements change (Teece et al., 1997). These theories do not imply that competence automatically causes environmental improvement; rather, they explain why capability may be a necessary mechanism through which infrastructure, digital systems, and sustainability goals become operationally effective. In this study, this theoretical logic supports attention to logistics competence while requiring careful measurement boundaries.

In e-commerce logistics, competence becomes visible through service professionalism, coordination ability, digital readiness, reliable delivery processes, and the effective use of tracking systems. Dovbischuk (2022) shows that innovation-oriented dynamic capabilities shape logistics-provider performance and resilience. Lagorio et al. (2024) emphasize the role of human factors in logistics technology adoption. Tsao et al. (2024) connect sustainability and technological management within Logistics 4.0. Malhotra and Kharub (2025) show that AI-enabled logistics capability can elevate e-commerce logistics performance. Kolinski and Tubis (2025) focus directly on competence development among logistics and transport staff as part of digital maturity. Pacheco-Velazquez et al. (2025) examine logistics simulation for Industry 4.0 education and training. Nasution et al. (2021) link knowledge management and dynamic capabilities to e-commerce adoption. These studies support the idea that logistics outcomes depend not only on physical assets but also on knowledge, routines, and the quality of human-system interaction. Jordanian banking research on artificial intelligence and big data in accounting further illustrates the wider diffusion of data-intensive capabilities across regional service organizations (Bader et al., 2025).

The green logistics literature further supports a capability-based interpretation. El Moussaoui (2025) shows how logistics pooling can reduce CO2 emissions in last-mile logistics. Fan et al. (2025) connect ESG-oriented digitalization to logistics-enterprise competitiveness. Prataviera et al. (2025)

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examine how logistics environmental sustainability can be aligned with corporate strategy. Thanh Ha (2025) provides global evidence on green logistics and environmental sustainability. Bucak et al. (2025) evaluate decarbonization strategies in port facilities from a natural-resource-based view. However, this literature also warns against overgeneralization. Environmental improvement usually requires direct operational practices and sector-specific indicators, such as route-level fuel use, delivery emissions, warehouse energy, fleet electrification, and packaging waste. Broad national indicators can reflect many forces outside logistics. Therefore, a country-level study should not infer cleaner e-commerce logistics from competence alone unless direct logistics-sector environmental data are available.

The logistics-performance literature is especially relevant because the present empirical design relies on the World Bank LPI. Shepherd and Sriklay (2023) apply machine-learning methods to extend and interpret the World Bank LPI. Hasan et al. (2025) analyze the LPI from a global network perspective. Jonasikova et al. (2025) examine the evolution and structure of LPI indicators across selected countries. Yilmaz (2025) assesses digitalization levels among leading LPI countries. Yu and Rakshit (2025) propose an alternative H-DEA approach for global logistics–performance evaluation. The LPI competence sub-index captures the competence and quality of logistics services, including transport operators and customs brokers. It is useful for measuring service capability, but it does not directly observe green training, sustainability values, or environmental workforce capability. For this reason, logistics competence can be theoretically linked to green human capital, but it should not be presented as a direct measure of green human capital.

A related measurement issue is common-source covariance among LPI components. Competence, infrastructure, tracking-and-tracing, and timeliness all come from the same LPI survey system. Associations among these components may partly reflect shared respondent perceptions and the integrated nature of logistics-system quality. Common-method and common-source concerns are well recognized in survey-based research (Podsakoff et al., 2003). This does not make the LPI unusable, but it requires conservative interpretation. Strong associations between LPI competence and LPI tracking or timeliness should be reported as relationships among LPI-based logistics dimensions, not as causal estimates of workforce capability effects. In Jordan, financial and non-financial information has also been examined in relation to investment decision-making, underscoring the broader importance of clearly specified information constructs in business research (Alshehadeh et al., 2025). A recent literature review likewise synthesizes the role and implications of finance revaluation as a distinct financial construct (Alsmadi & Alrawashdeh, 2025). Emerging-market evidence also evaluates internal-audit standards as a foundation for carrying out a range of value-added tasks (Shaban & Barakat, 2023).

The UAE and broader GCC context make the competence-performance question policy relevant. The UAE combines e-commerce growth, service-sector digital transformation, logistics ambition, and sustainability-policy narratives. Al Harrasi et al. (2023) document logistics and supply-chain skills gaps in Oman. Yousef (2024) examines supply-chain management and logistics education in the UAE. Salem et al. (2024) analyze the relationship between logistics-performance indicators and GCC competitiveness. Alawadi et al. (2025) evaluate the translation of GCC urban-sustainability plans into practice. Blaique et al. (2024) show how human capital mediates the relationship between digital competence and service-innovation capability in the UAE. Kumarasamy et al. (2024) discuss business strategies adopted by UAE companies under digitalization and regulation. Othman (2025) examines green innovation, digital transformation, and project success in the UAE service sector. Atieh Ali et al. (2024) link digital supply chains, resilience, and sustainability. These studies justify retaining the UAE as a focal benchmark within the region. However, they do not overcome the data limitation that the LPI is not an annual UAE-only series. A stronger design must therefore use the official LPI survey waves and widen the empirical base beyond a single country. Jordanian evidence also examines AI-driven financial transparency in relation to corporate governance and accounting practice, illustrating the broader regional relevance of digital transparency (Shaban & Omoush, 2025).

MENA economies provide a defensible comparative setting because they differ in income, trade openness, internet penetration, urbanization, infrastructure quality, energy structure, and institutional capacity. This heterogeneity allows the analysis to compare within-country changes across official LPI waves while controlling for persistent country characteristics and common survey-wave effects. The region also includes economies with advanced logistics platforms and others facing stronger infrastructure and capability constraints, making it suitable for an observational test of competence-related logistics performance.

The literature supports two cautious hypotheses and one exploratory research question. First, logistics competence should be associated with stronger tracking-and-tracing performance because shipment visibility depends on professional coordination, digital routines, carrier interaction, and exception management. Second, logistics competence should be associated with delivery timeliness because reliable delivery depends on planning discipline, service quality, and the ability to meet scheduled delivery windows. Third, green human capital theory suggests that capability may support environmental improvement, but the available carbon indicator is economy-wide rather than logistics-sector-specific; therefore, the carbon relationship is treated only as an exploratory question rather than a hypothesis.

The aim of this study is to examine whether the measurable LPI competence dimension is associated with LPI-based tracking-and-tracing performance and delivery timeliness across the official survey-wave structure. In doing so, the study addresses the empirical gap while retaining green human capital as a secondary theoretical lens and keeping the empirical contribution centered on logistics competence within a defensible MENA country-wave panel design.

H1: Logistics competence is positively associated with LPI tracking-and-tracing performance in MENA logistics systems.

H2: Logistics competence is positively associated with LPI delivery timeliness in MENA logistics systems.

The exploratory research question is as follows: Is logistics competence associated with macro-level carbon efficiency, measured as lower economy-wide carbon intensity, in MENA economies? Figure 1 shows the conceptual model of the study.

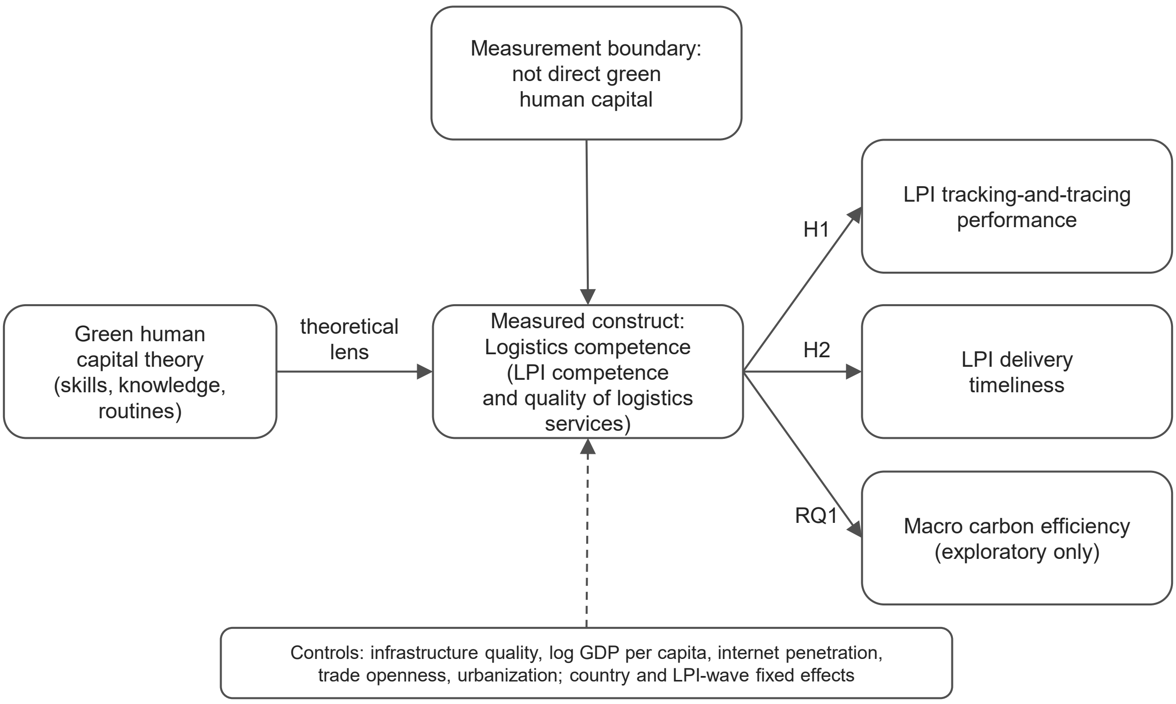

Figure 1. Conceptual framework

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2. METHODS

A quantitative country-wave panel design is used to examine the association between logistics competence, LPI-based logistics performance, and economy-wide carbon intensity in MENA economies. The design follows the non-annual structure of the World Bank LPI and treats LPI indicators as survey-wave observations rather than continuous annual observations. Hasan et al. (2025) support this survey-wave treatment because LPI indicators are multidimensional, survey-based logistics-system measures rather than annual administrative records. This choice directly addresses the data-integrity problem that would arise if the LPI were treated as an annual series. The analysis uses only official survey waves: 2007, 2010, 2012, 2014, 2016, 2018, and the 2023 edition. The official LPI observations and sub-indices were obtained from the World Bank Logistics Performance Index dataset (World Bank, 2026a). The country-level macroeconomic and environmental indicators were obtained from the World Development Indicators dataset (World Bank, 2026b). No interpolation, extrapolation, or artificial annualization is applied. Table 1 reports the exact World Bank series names and indicator codes to support replication.

The unit of analysis is the country-wave observation. The target sample consists of 20 conventional MENA economies: Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, the United Arab Emirates, West Bank and Gaza, and Yemen. The maximum balanced structure would provide 140 country-wave observations. The main regression sample contains 116 complete observations from 19 economies after missing-data deletion because the West Bank and Gaza lack usable LPI observations in the downloaded indicator files. Cross-country LPI studies after COVID-19 show that comparative logistics-performance designs are more defensible when the data structure is respected rather than forced into an artificial annual series (Bayraktar et al., 2025). The UAE is retained as a focal regional benchmark, but it is not treated as a stand-alone annual time-series sample.

The main independent variable is logistics competence, measured by the World Bank LPI sub-index for competence and quality of logistics services (LP.LPI.LOGS.XQ) (World Bank, 2026a). This indicator captures survey perceptions of the competence and quality of logistics services, including transport operators and customs brokers. It is interpreted as a logistics-service capability measure. It is not interpreted as a direct green human-capital measure because it does not observe environmental training, green skills, sustainability values, or workforce-development programs. Alternative LPI assessment studies also treat competence as one logistics-performance dimension among several rather than as a direct human-capital stock (Yu & Rakshit, 2025). This distinction is central to construct validity.

The two main dependent variables are LPI tracking-and-tracing ability and LPI delivery timeliness (World Bank, 2026a). Tracking and tracing capture the ability to track and trace consignments, while timeliness captures how often shipments reach consignees within scheduled or expected delivery times. These indicators are relevant to e-commerce because platform-mediated fulfillment depends on shipment visibility and reliable delivery windows. Recent methodological work on LPI rankings confirms that tracking, timeliness, infrastructure, and competence are separate but related dimensions within the same logistics-performance system (Stevic et al., 2024). However, they do not directly measure platform-level orders, firm-level delivery records, or last-mile operational performance. They are therefore described as e-commerce-relevant LPI logistics indicators.

The exploratory macro-carbon outcome is economy-wide carbon efficiency. It is calculated from the World Bank carbon-intensity-of-GDP indicator, Carbon intensity of GDP (kg CO_2e per constant 2015 US$ of GDP; EN.GHG.CO2.RT.GDP.KD) (World Bank, 2026b), as $CE\_it = -\ln(CI\_it)$, where CI_it is carbon intensity of GDP for country i in LPI survey wave t. Higher values therefore indicate lower economy-wide carbon intensity. This transformation improves interpretability by making a higher value correspond to greater carbon efficiency. Country-level LPI evolution studies show that national logistics indicators can be compared across waves, but they do not directly observe sector-level environmental mechanisms (Jonasikova et al., 2025). The measure is macro-level and should not be read as a direct indicator of logistics-sector emissions, e-commerce delivery emissions, warehouse energy use, or packaging waste.

Control variables include LPI infrastructure quality, log GDP per capita, internet penetration, trade openness, and urbanization. LPI infrastructure quality is drawn from the Logistics Performance Index dataset (World Bank, 2026a), whereas GDP per capita, internet penetration, trade openness, and urbanization are drawn from World Development Indicators (World Bank, 2026b). Infrastructure quality controls for the physical logistics environment; GDP per capita captures income and development level; internet penetration captures digital diffusion; trade openness captures exposure to international commerce; and urbanization captures spatial and demographic structure. Evidence from GCC logistics-performance research supports controlling for broader competitiveness and infrastructure conditions when interpreting logistics indicators in Gulf and MENA settings (Salem et al., 2024). These controls reduce the risk of attributing broad macroeconomic or infrastructure differences to logistics competence alone.

The main empirical model is a two-way fixed-effects panel regression. For each outcome Y_it, the model estimates the association between logistics competence and the outcome while controlling for observable covariates, country fixed effects, and LPI survey-wave fixed effects. The baseline specification is: Y_it = beta_1 Competence_it + beta_2 Infrastructure_it + beta_3 LogGDPpc_it + beta_4 Internet_it + beta_5 Trade_it + beta_6 Urban_it + mu_i + tau_t + epsilon_it. In this expression, i denotes country, t denotes LPI survey wave, mu_i represents country fixed effects, and tau_t represents survey-wave fixed effects. Recent LPI digitalization research supports analyzing logistics-performance dimensions in relation to digital and structural conditions rather than isolating them from country context (Yilmaz, 2025). Standard errors are clustered at the country level.

Because the complete-case sample contains 19 country clusters, conventional clustered *p*-values are treated as approximate rather than definitive. The interpretation follows small-cluster inference caution: conclusions are considered more credible where coefficients are substantively large, stable across specifications, and statistically significant in the reported models. Recent econometric work on few-cluster inference supports caution when the number of clusters is limited and conventional asymptotic inference may be fragile (Wang & Zhang, 2024). Marginal results are not overinterpreted. The study is observational and association-based; it does not claim causal identification.

A further measurement constraint is that logistics competence, infrastructure quality, tracking-and-tracing ability, and delivery timeliness all come from the LPI survey system. This creates possible common-source covariance among LPI components. The analysis therefore does not interpret large coefficients between LPI competence and other LPI indicators as causal effects. Recent reviews of common-method bias emphasize that shared measurement sources can inflate, attenuate, or otherwise complicate associations between constructs (Podsakoff et al., 2024). Instead, the estimates are treated as within-country associations among related LPI-based logistics dimensions.

The study deliberately avoids unit-root tests, structural-break tests, ARDL bounds testing, VAR, impulse-response functions, and forecast-error variance decomposition. These procedures are not appropriate for a short, non-annual survey-wave panel and were a major methodological risk in the earlier UAE-only design. Robustness checks are intentionally simple and aligned with the data structure. First, the infrastructure control is removed to reduce overlap among LPI components and to assess whether the competence coefficient is driven by collinearity with infrastructure quality. Second, pooled OLS with heteroskedasticity-robust standard errors is reported as a non-fixed-effects comparison. Recent methodological guidance on common-method variance supports transparent acknowledgment of measurement limits rather than overcorrecting with complex diagnostics unsupported by the data structure (Manata & Boster, 2024). The study uses public country-level secondary indicators and involves no human participants, private records, or identifiable individual-level information. A supplementary replication package is uploaded with the submission and records the cleaned country-wave dataset, variable dictionary, missing-data rules, indicator codes, and estimation syntax.

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Table 1. Variable definitions, transformations, and exact source indicators for the country-wave panel

Variable	Role	Measurement / transformation	Indicator code
Logistics competence	Independent variable	LPI competence and quality of logistics services, 1 low to 5 high	LP.LPI.LOGS.XQ
Tracking and tracing	Dependent variable	LPI ability to track and trace consignments, 1 low to 5 high	LP.LPI.TRAC.XQ
Delivery timeliness	Dependent variable	LPI frequency with which shipments arrive within scheduled or expected time, 1 low to 5 high	LP.LPI.TIME.XQ
Carbon efficiency	Exploratory dependent variable	CE_it = -ln(CI_it), where CI_it is carbon intensity of GDP; higher values indicate lower economy-wide carbon intensity	EN.GHG.CO2.RT.GDP.KD
Infrastructure quality	Control	LPI quality of trade- and transport-related infrastructure, 1 low to 5 high	LP.LPI.INFR.XQ
GDP per capita	Control	Log of GDP per capita, constant 2015 US dollars	NY.GDP.PCAP.KD
Internet penetration	Control	Individuals using the Internet, percentage of population	IT.NET.USER.ZS
Trade openness	Control	Trade in goods and services as percentage of GDP	NE.TRD.GNFS.ZS
Urbanization	Control	Urban population as percentage of total population	SP.URB.TOTL.IN.ZS

3. RESULTS

The corrected empirical analysis is based on the official LPI survey-wave panel rather than a UAE-only annual time series. The panel contains 140 possible observations before missing-data deletion, based on 20 screened economies and seven official LPI waves. Usable observations vary by variable. The LPI competence, infrastructure, tracking, and timeliness indicators provide 122 non-missing observations; carbon intensity provides 129 observations; and the main fixed-effects models use 116 complete observations from 19 economies. The sample is therefore a regional country-wave panel, not a continuous annual time series. This structure is consistent with recent e-commerce logistics research that treats logistics capability as a system-level condition for digital trade rather than a single-firm operational variable (Malhotra & Kharub, 2025).

The descriptive statistics (Table 2) indicate substantial cross-country and within-region variation. Logistics competence averages 2.734 on the LPI 1-5 scale, while tracking-and-tracing performance averages 2.805 and delivery timeliness averages 3.243. These values suggest that timeliness is generally rated more strongly than tracking and tracing in the regional sample, while competence remains moderate on average. Carbon intensity also varies considerably, which is expected in a region with different levels of hydrocarbon dependence, industrial structure, income, and urbanization. Recent ESG and logistics-enterprise evidence also shows that logistics outcomes vary with digitalization and organizational capability rather than infrastructure alone (Fan et al., 2025). The descriptive evidence is important because it confirms that the panel contains meaningful variation rather than simply reproducing a UAE-only trajectory. The UAE remains a high-performing benchmark in the region, but the empirical base is broader and more defensible. This matters for interpretation: the analysis can discuss the UAE as a focal case, but the statistical estimates are regional within-country associations across official LPI survey waves. UAE e-shopping evidence sup-

Table 2. Descriptive statistics for the MENA country-wave panel

Variable	N	Mean	Std. dev.	Min	Max
Logistics competence	122	2.734	0.543	1.394	4.000
Tracking and tracing	122	2.805	0.567	1.640	4.100
Delivery timeliness	122	3.243	0.511	2.190	4.380
Carbon intensity	129	0.798	0.398	0.157	2.206
Carbon efficiency	129	0.344	0.502	–0.791	1.854
Infrastructure quality	122	2.723	0.604	1.238	4.100
Log GDP per capita	136	8.997	1.178	6.568	11.298
Internet penetration	136	51.738	29.406	0.930	100.000
Trade openness	136	90.140	46.910	30.247	302.285
Urbanization	140	76.744	17.575	29.609	100.000

Table 3. Correlations among key variables

Variable	Competence	Tracking	Timeliness	Carbon efficiency	Infrastructure
Competence	1.000				
Tracking	0.898	1.000			
Timeliness	0.826	0.785	1.000		
Carbon efficiency	0.339	0.318	0.284	1.000	
Infrastructure	0.872	0.841	0.756	0.301	1.000

ports the relevance of the local benchmark, but it does not replace the need for a broader comparative empirical base (Elamin et al., 2025).

The correlations (Table 3) show strong positive associations between logistics competence and the two LPI-based logistics-performance outcomes. The correlation with tracking and tracing is 0.898, and the correlation with delivery timeliness is 0.826. These values are consistent with the theoretical expectation that professional logistics-service competence is closely related to shipment visibility and reliable delivery. Human-factors research in logistics technology adoption similarly indicates that operational competence shapes the use and value of logistics technologies (Lagorio et al., 2024). However, the results also reinforce the need for caution because competence, tracking, timeliness, and infrastructure are all LPI subcomponents. Part of the strength of these correlations may therefore reflect common-source covariance and the integrated nature of logistics-system perceptions.

The correlation between logistics competence and carbon efficiency is weaker at 0.339. This descriptive result already suggests that economy-wide carbon intensity is less directly connected to logistics competence than tracking and timeliness are. The weaker carbon relationship is not surprising because macro carbon intensity is shaped by energy mix, industrial structure, fuel prices, regulation, and national economic composition. Sector-level environmental-economics evidence also shows that carbon trajectories differ across sectors and cannot be inferred from one broad capability indicator (Gupta et al., 2025). It cannot be reduced to the competence of logistics services.

The main estimates support H1. Logistics competence is positively associated with tracking-and-tracing performance after controlling for infrastructure quality, income, internet penetration, trade openness, urbanization, country fixed effects, and LPI wave fixed effects (Table 4). The coefficient is 0.519 and statistically significant at the 1% level in the reported specification. Substantively,

Table 4. Two-way fixed-effects estimates for logistics competence and performance outcomes

Variable	Tracking and tracing	Timeliness	Carbon efficiency
Logistics competence	0.519*** (0.141)	0.416*** (0.131)	−0.002 (0.051)
Infrastructure quality	0.207 (0.151)	0.075 (0.120)	−0.017 (0.054)
Log GDP per capita	0.216 (0.160)	0.768** (0.385)	0.537*** (0.127)
Internet penetration	0.002 (0.003)	0.000 (0.004)	−0.004** (0.002)
Trade openness	0.001 (0.001)	−0.000 (0.002)	0.000 (0.000)
Urbanization	0.021* (0.013)	0.005 (0.013)	0.009 (0.008)
Observations	116	116	116
Countries	19	19	19
Country FE	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes
R-squared	0.884	0.809	0.973

Note: Clustered standard errors are in parentheses. Country and LPI survey-wave fixed effects are included in all models. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Because the sample contains 19 country clusters, p-values are interpreted cautiously.

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this suggests that within-country improvements in the LPI competence sub-index are associated with stronger shipment visibility and traceability. Logistics 4.0 research supports the interpretation that sustainability and technology management depend on the capability to convert digital tools into operational performance (Tsao et al., 2024). The result is consistent with the view that professional logistics services are better able to use coordination routines, digital tracking systems, and service processes to make consignments more visible across the supply chain.

The main estimates also support H2. Logistics competence is positively associated with delivery timeliness, with a coefficient of 0.416 and significance at the 1% level. This result is consistent with the argument that competence matters for reliability, scheduling, exception management, and the capacity to meet expected delivery windows. The estimate should still be interpreted as an association among LPI-based logistics dimensions, not as a causal effect of green human capital on firm-level e-commerce delivery performance. Nevertheless, the result is theoretically coherent and consistent enough to support a cautious competence-performance association.

The exploratory carbon-efficiency question is not supported. The coefficient of logistics competence in the carbon-efficiency model is –0.002 and statistically insignificant. This result is important because it prevents the manuscript from claiming that logistics competence alone produces cleaner logistics. Global green-logistics evidence also cautions that environmental sustainability depends on direct green logistics choices and country conditions rather than on broad logistics capability alone (Thanh Ha, 2025). The fixed-effects evidence supports a relationship between competence and logistics-performance indicators, but it does not provide robust within-country evidence that logistics competence is associated with lower economy-wide carbon intensity. The result also confirms that the carbon measure is too broad to support sector-level environmental conclusions.

The control variables provide additional context. Infrastructure quality is positive but not statistically significant in the tracking and timeliness models once competence and fixed effects are included. This does not mean infrastructure is unimportant; rather, it indicates that the competence coefficient is not simply eliminated after controlling for infrastructure. Log GDP per capita is positively associated with timeliness and carbon efficiency, suggesting that income and development level may support reliable logistics and lower carbon intensity. Internet penetration is not significant in the two logistics-performance models, possibly because internet diffusion is already partly captured by broader country and wave effects. Last-mile sustainability research also suggests that digital and infrastructure conditions must be interpreted alongside operational design barriers and delivery-system requirements (Ojha & Agarwal, 2025).

The robustness checks (Table 5) reinforce the distinction between logistics-performance outcomes and the exploratory carbon-intensity outcome. The competence coefficient remains positive and statistically significant for tracking and tracing when the infrastructure control is removed. This is important because competence and infrastructure are highly related LPI dimensions. Removing infrastructure increases the coefficient to 0.645, which suggests that the competence-performance association is not dependent on the specific inclusion of the infrastructure

Table 5. Robustness and sensitivity checks focused on logistics competence

Outcome	Specification	Competence coefficient	p-value	Observations	Countries
Tracking and tracing	FE without infrastructure control	0.645*** (0.098)	p < 0.001	116	19
Tracking and tracing	Pooled OLS, robust SE	0.565*** (0.121)	p < 0.001	116	–
Timeliness	FE without infrastructure control	0.462*** (0.105)	p < 0.001	116	19
Timeliness	Pooled OLS, robust SE	0.411*** (0.149)	0.006	116	–
Carbon efficiency	FE without infrastructure control	–0.012 (0.037)	0.742	116	19
Carbon efficiency	Pooled OLS, robust SE	0.440*** (0.170)	0.009	116	–

Note: *** indicates statistical significance at the 1% level (p < 0.01); standard errors are reported in parentheses.

control. Recent research on e-commerce adoption also shows that digital-trade outcomes depend on multiple enabling conditions, making robustness checks important when isolating one capability channel (Paun et al., 2024).

The pooled OLS comparison also shows a positive association between logistics competence and tracking performance. Although pooled OLS does not control for unobserved time-invariant country characteristics, it provides a non-fixed-effects benchmark. The coefficient remains positive and statistically significant. For timeliness, both the fixed-effects model without infrastructure and the pooled OLS model also retain positive and statistically significant coefficients. These patterns support a cautious conclusion that the competence-performance relationship is stable across simple, transparent specifications. Systematic evidence on e-commerce in developing countries similarly indicates that logistics capability is one part of a broader digital-commerce adoption environment (Hendricks & Mwapwele, 2024).

The carbon-efficiency robustness results are more cautious. In pooled OLS, logistics competence is positively associated with carbon efficiency. However, that association disappears after country and survey-wave fixed effects are introduced. The difference between pooled OLS and fixed effects suggests that the positive pooled relationship may reflect cross-country differences rather than within-country changes over time. Countries with better logistics competence may also have different income levels, energy structures, institutions, or policy environments. The conservative interpretation is therefore that the environmental relationship remains unconfirmed.

Taken together, the results support only a bounded claim. Logistics competence is robustly associated with LPI-based tracking and timeliness, which are important logistics-system capabilities for digitally coordinated trade. The evidence does not support strong claims that logistics competence directly improves macro carbon efficiency or produces cleaner e-commerce logistics. Direct environmental claims would require sector-specific emissions, fuel-use, fleet, warehouse-energy, or packaging data.

Across the official LPI survey waves, the UAE is positioned above the MENA regional mean for logistics competence and tracking-and-tracing performance, and above the regional average in most waves for delivery timeliness. This supports treating the UAE as a focal regional benchmark for logistics-service capability and e-commerce-relevant delivery reliability. However, this benchmark position should not be interpreted as evidence of cleaner e-commerce logistics. Carbon performance is not inferred from LPI scores and requires direct sector-level evidence on logistics emissions, fuel use, fleet composition, warehouse energy, or packaging-related resource use.

4. DISCUSSION

The results support a cautious capability-based interpretation. Logistics competence is positively associated with LPI tracking-and-tracing ability and delivery timeliness across MENA economies. This finding is consistent with green human capital, resource-based, natural-resource-based, and dynamic-capability reasoning: logistics systems require not only infrastructure and digital technology, but also professional coordination, service reliability, and the competence to use operational tools effectively. Green-human-capital evidence links capability development to green technological innovation, supporting the theoretical relevance of the human-capability lens (Abbas & Najam, 2025). The empirical evidence, however, is deliberately limited to logistics competence as measured by the LPI, not direct green human capital. A recent green-HRM meta-analysis reinforces that human-capability mechanisms matter for green innovation, but it also implies that direct workforce measures are needed for stronger claims (Bindeeba et al., 2025).

The findings are relevant to e-commerce because tracking and timeliness are central to digitally coordinated fulfillment. Online retail and platform-mediated trade depend on shipment visibility, reliable delivery windows, and the ability to coordinate exceptions across carriers and customers. The positive association between competence and these outcomes suggests that logistics-service capability is an important

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part of the e-commerce support system. Green creativity research also suggests that employee voice and capability can influence environmental innovation when organizational routines support such capability (Asghar et al., 2025). However, the evidence should not be interpreted as direct proof of firm-level e-commerce performance because the outcomes are LPI survey indicators rather than platform delivery records or transaction-level data. Green-human-capital research further indicates that sustainable performance mechanisms usually operate through organizational practices, not through national indicators alone (Badwy et al., 2025).

The environmental finding is deliberately limited. The fixed-effects estimates do not show a significant association between logistics competence and carbon efficiency. This does not mean that logistics competence is environmentally irrelevant; rather, it means that economy-wide carbon intensity is shaped by broader energy, industrial, and macroeconomic structures that cannot be reduced to logistics-service competence. Last-mile logistics-pooling evidence shows that emissions reductions require direct operational interventions rather than broad competence measures alone (El Moussaoui, 2025). A stronger environmental claim would require direct logistics-sector emissions, delivery fuel use, low-emission fleet adoption, warehouse energy, packaging waste, or shipment-level indicators. Corporate-strategy research in logistics sustainability also shows that environmental improvement depends on strategic alignment and specific logistics practices (Prataviera et al., 2025). Recent sector-focused research on Hungary's automotive industry likewise examines environmental transformation at the industry level, reinforcing the value of sector-specific evidence when interpreting environmental change (AlSheikh, 2025).

The UAE evidence should also be interpreted carefully. The UAE performs above the MENA average on competence and tracking, which supports its use as a focal regional benchmark. Yet the analysis does not justify claiming that the UAE has achieved cleaner e-commerce logistics. The policy implication is narrower: logistics competence can strengthen e-commerce-relevant logistics reliability, while environmental performance requires complementary measures related to fuel efficiency, low-emission fleets, packaging reduction, warehouse energy, and sector-level emissions monitoring. Recent environmental economics evidence shows that public support and policy choices often depend on perceived trade-offs between environmental protection and economic consequences (McNeil & Barnes, 2025). Recent EKC research also shows that environmental improvement is conditional and cannot be assumed from economic or capability growth alone (Akar et al., 2025).

Methodologically, the study is now aligned with the structure and limits of the data. It treats the LPI as a survey-wave indicator, avoids artificial annualization, avoids short-sample time-series procedures, and distinguishes logistics competence from direct green human capital. The study also acknowledges that several core variables come from the same LPI survey system, so the competence–performance relationship may partly reflect common-source covariance among related sub-components. Green-knowledge production research supports this cautious separation between human capital theory and the actual empirical indicators used to test it (Chakraborty & Mazzanti, 2025). The findings should therefore be read as conservative, association-based evidence rather than causal proof.

The study's limitations define the scope of its contribution. The analysis uses country-level survey-wave indicators, so it cannot observe firm-level green training, platform-specific logistics practices, route-level fuel use, shipment-level emissions, or the quality of workforce-development programs. The carbon-efficiency variable is economy-wide, not logistics-sector-specific. Future research should use firm, platform, carrier, or shipment data to test whether logistics competence is associated with route-level fuel use, delivery emissions, electric-fleet adoption, packaging waste, and warehouse energy intensity. Green knowledge-production research also indicates that stronger environmental conclusions require better measurement of green knowledge, human capital, and policy mechanisms (Ozbay, 2025).

CONCLUSION

This study revises the original research problem by preserving a secondary theoretical concern with green human capital and sustainable logistics while correcting the empirical design. The evidence is based on official World Bank LPI survey waves rather than an artificial annualized UAE-only logistics series. The MENA country-wave panel shows that logistics competence is positively associated with tracking-and-tracing performance and delivery timeliness. These findings support the argument that logistics competence is an important capability for e-commerce-relevant logistics reliability. At the same time, the fixed-effects estimates do not support a robust association between logistics competence and lower economy-wide carbon intensity. The conclusion is therefore conservative: logistics competence appears to matter for LPI-based logistics performance, but claims about cleaner logistics require direct environmental evidence. The UAE remains a strong focal regional benchmark because it consistently performs above the MENA average on competence and tracking, but its environmental logistics performance should not be inferred without sector-specific emissions or resource-use indicators. The study's value lies in correcting the data structure, retaining a bounded capability-based theoretical foundation, and avoiding unsupported causal or environmental claims.

AUTHOR CONTRIBUTIONS

Conceptualization: Dina Alkhodary, Amer Morshed, Ramzi Tarawneh.
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Validation: Laith Khrais.
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Writing – review & editing: Dina Alkhodary, Amer Morshed.

DATA AVAILABILITY AND REPLICATION STATEMENT

The study uses only public country-level secondary data. The replication package records the official LPI survey-wave years, included economies, missing-data deletion rules, exact World Bank indicator codes, the transformation $CE_{it} = -\ln(CI_{it})$, and the commands used to reproduce the descriptive statistics, correlations, two-way fixed-effects models, and robustness checks. No private, firm-level, human-participant, or identifiable individual-level data are used.

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