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Integrated Analysis of Smart Parcel Locker Adoption in Riyadh: A Triangulated Mixed-Methods Study

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Abstract

Purpose. This study examines the behavioural, operational, and contextual factors that influence the adoption of Smart Parcel Lockers (SPLs) as a last-mile delivery solution in Riyadh, Saudi Arabia. Although the city's e-commerce sector is expanding rapidly under Vision 2030, SPL penetration remains limited. The research aims to identify the determinants of user acceptance and to translate them into evidence-based recommendations for SPL providers, e-commerce platforms, and policymakers.

Methodology. A sequential exploratory mixed-methods design was employed. Phase one comprised semi-structured interviews and written questionnaire responses from 17 stakeholders, including two SPL operators, one fulfillment aggregator, nine e-commerce businesses, and five end-users. Phase two consisted of a stratified online survey of 274 e-commerce consumers across Riyadh's five administrative regions. Thematic analysis surfaced six adoption constructs—convenience, accessibility, trust and security, awareness, cost, and ease of use—that were tested using Cronbach's alpha, exploratory factor analysis (EFA), Pearson correlation, multiple regression, and t-tests/ANOVA.

Findings. Convenience emerged as the dominant predictor of adoption intent (beta = .475, $p < .001$), followed by user innovativeness (beta = .250, $p < .001$); the regression model explained 53.8 % of variance (R-squared = .538). EFA confirmed a five-factor structure (KMO = 0.866; ~54 % variance explained). Female and younger (18-24) consumers reported significantly higher

access, awareness, and adoption intent. South Riyadh recorded significantly lower convenience scores than the East and West, signalling spatial inequity in network coverage. Cost and trust acted as secondary or threshold factors rather than primary drivers.

Originality and implications. The study extends technology-acceptance and diffusion-of-innovation literature to an under-researched Gulf context and proposes a hierarchical adoption framework in which convenience and accessibility precede trust and cost. Practical recommendations centre on locker-network expansion in underserved districts, checkout-level integration on Saudi e-commerce platforms, and Arabic-language onboarding tailored to early adopters.

Keywords: Smart Parcel Lockers; last-mile delivery; e-commerce; mixed-methods; technology adoption; Riyadh; Saudi Arabia; Vision 2030.

1. Introduction

The expansion of e-commerce in Riyadh has intensified pressure on last-mile logistics, the final and most expensive segment of the supply chain. Recent estimates indicate that the last mile accounts for as much as 53 % of total fulfillment costs and remains the principal source of operational friction in urban delivery networks (Ha et al., 2023). In Saudi Arabia, online retail sales exceeded SAR 60 billion in 2024, with Riyadh contributing nearly half of all national transactions and projections suggesting growth from SAR 19.3 billion in 2023 to roughly SAR 50 billion by 2025 (Statista, 2025). This trajectory aligns with Vision 2030's ambition to position the Kingdom as a global logistics hub, yet the operational and behavioural infrastructure required to absorb this growth has not matured at the same pace. Saudi consumers have rapidly digitised their purchasing behaviour, but their delivery preferences remain anchored in conventional door-to-door dispatch, with home delivery still accounting for an estimated 70 % of all parcels in Riyadh (Al-Tuwaiyan, 2025). The result is a structural imbalance between the volume of parcels generated

at the front end of the supply chain and the capacity of the last-mile network to absorb them efficiently, sustainably, and at acceptable cost-to-serve.

Smart Parcel Lockers (SPLs)—a category of out-of-home (OOH) delivery infrastructure that allows consumers to collect parcels asynchronously from automated cabinets—have emerged globally as one of the most promising last-mile innovations. In Europe, locker density has surpassed one unit per 1,000 residents in markets such as Poland and Finland, and operators report 20-40 % cost reductions through automated parcel machines and pickup-drop-off (PUDO) points (Krupa & Rozycki, 2025; Last Mile Experts, 2024). InPost, the largest European operator, exceeded 30,000 lockers in 2025, with courier productivity reaching 1,500 parcels per day compared with 250 for home delivery, while Western European preference for home delivery has fallen from 73 % to 64 % over the past three years (Krupa & Rozycki, 2025). Such gains arise from the combination of dense networks, deep integration with major e-commerce checkouts, sustained consumer education, and coordinated public-private investment (Boysen et al., 2019). By contrast, Saudi Arabia's SPL ecosystem remains nascent: SPL (Saudi Post), RedBox, and Parcelat have launched locker networks, but penetration is estimated at only 30 % of national deliveries and is concentrated in limited urban districts (Al-Tuwaiyan, 2025; Ha et al., 2023). Locker networks in Riyadh remain modest in scale—RedBox operates approximately 100 lockers, with planned expansion underway, while Parcelat operates approximately 550 lockers across the wider Kingdom—indicating that the city is still at an early stage of locker-network maturity relative to its consumer base.

Existing scholarship on last-mile innovation has examined parcel lockers from three principal angles. The first concerns operational efficiency: lockers reduce failed deliveries, optimise courier routing, and lower carbon emissions by up to 60 % relative to home delivery (Kolasinska-Morawska et al., 2022; Sawik, 2024). Sawik (2024) demonstrates through multi-criteria optimisation that automated lockers, capillary distribution, and crowdshipping deliver complementary efficiency gains, particularly in dense urban grids where vehicle access is

constrained. The second strand focuses on customer satisfaction. Vakulenko et al. (2018) and Yuen et al. (2019) identified convenience, time-saving, and perceived control as core dimensions of customer value in SPLs, and demonstrated that positive service experience translates into behavioural intention to adopt. The Out-of-Home Delivery Handbook (Krupa & Rozycki, 2025) corroborates these findings with practitioner data, identifying reliability, accessibility, and ease of use as the most consistent predictors of locker utilisation across European markets.

The third strand draws on technology-acceptance theory. The Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT2) consistently identify perceived usefulness, ease of use, trust, and effort expectancy as antecedents of intention to use new logistics technologies (Davis, 1989; Venkatesh & Davis, 2000; Venkatesh et al., 2012). Yuen et al. (2019) tested an extended TAM in Singapore and showed that trust and perceived convenience drive behavioural intention, while infrastructural accessibility moderates the strength of these relationships. Cross-cultural studies further indicate that in collectivist societies social trust, word-of-mouth, and cultural compatibility shape uptake more strongly than functional benefits alone (Vakulenko et al., 2018; Yuen et al., 2019). Diffusion of Innovations theory (Rogers, 2003) complements this lineage by emphasising the role of innovator and early-adopter segments in seeding uptake among more conservative consumer cohorts—a perspective that has clear implications for marketing campaigns aimed at accelerating adoption.

However, the empirical base on SPL adoption in the Gulf is thin. Aljohani and Thompson (2020) document last-mile inefficiencies across the Middle East but do not address consumer behaviour towards lockers, and Al-Tuwaiyan (2025) emphasises that adoption in Saudi logistics services is moderated by trust in digital platforms, perceived risk, and social acceptance—factors broadly consistent with TAM and UTAUT2 but not yet quantified in the Saudi e-commerce context. Three gaps therefore persist. First, a contextual gap: limited empirical evidence explains how Saudi consumers perceive SPLs relative to users in mature European or East Asian markets. Second, a behavioural gap: existing studies foreground satisfaction and efficiency outcomes but neglect the

psychological, demographic, and infrastructural drivers of adoption intent at the level of the individual consumer. Third, a practical gap: few studies translate adoption insights into actionable strategies for SPL providers, e-commerce platforms, and policymakers operating within Riyadh's distinctive sociotechnical environment.

Against this backdrop, the present study addresses the following research question: What are the factors that influence the adoption of Smart Parcel Lockers as a preferred last-mile delivery method in Riyadh? The study has four objectives: (a) to assess current consumer awareness, usage, and intention to adopt SPLs; (b) to identify and prioritise barriers to adoption and the conditions under which consumers would switch from home delivery; (c) to quantify the influence of each adoption factor on willingness to adopt; and (d) to develop evidence-based recommendations for SPL providers, e-commerce platforms, and policymakers. The contribution is twofold. Theoretically, the study extends technology-adoption frameworks into an under-researched Gulf context by specifying a hierarchical adoption logic in which convenience and accessibility act as foundational conditions for trust, cost, and awareness effects. This refinement matters because it suggests that the relative weight of TAM/UTAUT2 constructs is contingent on infrastructural maturity rather than universal across contexts. Practically, it offers a calibrated framework for accelerating SPL uptake in alignment with Vision 2030's logistics-modernisation agenda, and it surfaces concrete priority actions for each stakeholder group in Riyadh's last-mile ecosystem. The remainder of the paper is organised as follows. Section 2 outlines the sequential exploratory mixed-methods design and the procedures used to ensure methodological rigour. Section 3 presents the qualitative themes, the quantitative results, and the triangulated synthesis. Section 4 discusses the findings in relation to the literature and articulates the theoretical contributions, practical implications, and limitations of the study. Section 5 concludes.

2. Methodology

2.1 Research Design and Philosophical Position

The study adopts a pragmatist research philosophy, which prioritises practical, actionable knowledge generated through whichever combination of methods best addresses the research problem (Saunders et al., 2023). Because SPL adoption involves behavioural, operational, and infrastructural considerations simultaneously, pragmatism allowed the integration of qualitative exploration with quantitative validation. A sequential exploratory mixed-methods design (Creswell & Plano Clark, 2018) was implemented, in which qualitative data collection and analysis preceded a confirmatory quantitative phase. The qualitative phase produced context-specific constructs grounded in stakeholder narratives; the quantitative phase tested their relative weight in a larger consumer sample. The study employed a cross-sectional time horizon: each phase captured perceptions at a single point in 2025.

The reasoning logic combined induction and deduction. Themes emerged inductively from interview transcripts and were then translated into measurable constructs that were tested deductively in the survey. Triangulation across phases, following Fetters et al. (2013), strengthened both the validity and the interpretive depth of the findings.

2.2 Qualitative Phase

Purposive sampling was used to recruit 17 stakeholders representing the SPL value chain in Riyadh: two SPL providers (RedBox and LLAMA, founders/CEOs interviewed face-to-face), one fulfilment aggregator (Salasa, co-founder interviewed face-to-face), nine e-commerce businesses recruited through RedBox's B2B network and providing structured written responses, and five active e-commerce end-users interviewed in person. Three discrete interview protocols were developed and pilot tested with one academic supervisor and one SPL provider before deployment. The provider protocol explored capital expenditure, policy support, application integration, and infrastructure deployment. The business protocol covered checkout integration, customer behaviour, and cost sensitivity. The consumer protocol explored convenience, trust, awareness,

and behavioural preferences. Bilingual prompts were used where appropriate to ensure cultural and linguistic accessibility.

Each interview lasted between 30 and 60 minutes, was audio-recorded with consent, and transcribed verbatim. Written business responses were standardised through a structured template and treated as qualitative data alongside the interviews. Data collection continued until thematic saturation was reached, defined as the point at which two consecutive interviews produced no new codes (Guest et al., 2020). Transcripts and notes were stored on a password-protected university platform.

Thematic analysis followed Braun and Clarke's (2006) six-phase procedure: familiarisation, initial coding, theme searching, theme review, theme definition, and write-up. Coding was performed manually within a structured matrix that allowed cross-case comparison and traceability. Memos created throughout coding constituted an audit trail consistent with Lincoln and Guba's (1985) trustworthiness criteria, as operationalised by Nowell et al. (2017). Six emergent constructs—convenience, accessibility, trust and security, awareness, cost, and ease of use—were carried forward into the survey instrument.

2.3 Quantitative Phase

A structured online questionnaire was administered through Qualtrics to e-commerce users in Riyadh. The instrument operationalised the six qualitative constructs through five-point Likert items (1 = strongly disagree, 5 = strongly agree) drawn and adapted from validated TAM and UTAUT2 measures (Davis, 1989; Venkatesh & Davis, 2000; Venkatesh et al., 2012). Sections covered awareness and usage patterns, adoption drivers and barriers, intent to adopt, and enabling conditions, supplemented by demographic items. The questionnaire was piloted with ten participants and refined for clarity, particularly for Arabic translations and routing logic, before full release.

A stratified convenience sampling approach targeted residents across Riyadh's five administrative regions (North, South, East, West, and Central) to capture geographic and socio-economic diversity. Eligibility criteria required participants to (i) reside in Riyadh, (ii) be at least 18 years of age, and (iii) have received at least one online parcel delivery within the previous six months. The survey link was distributed via WhatsApp community groups, RedBox's customer mailing list, and outreach through e-commerce and logistics networks over four weeks.

A total of 342 responses were collected, of which 301 were complete; 291 of those were Riyadh residents, and 274 met the recent-shipment criterion and constituted the final analytic sample (Table 1). Statistical analyses were conducted in Jamovi (Version 2.3) at alpha = .05 and proceeded in three tiers: (i) descriptive statistics and demographic profiling; (ii) reliability and construct validation via Cronbach's alpha (target > .70), Kaiser-Meyer-Olkin (KMO > .60), and Bartlett's test of sphericity ($p < .05$); and (iii) inferential analysis comprising Pearson correlation, multiple linear regression, exploratory factor analysis (EFA) using principal axis factoring with oblimin rotation, independent-samples t-tests, and one-way ANOVA (Welch's correction applied for unequal variances).

2.4 Triangulation

Following Fetters et al. (2013), qualitative themes and quantitative results were merged through a three-step process: comparison of qualitative themes with quantitative patterns, interpretation of convergence and divergence, and synthesis into a consolidated adoption framework. Where the two strands aligned, convergent evidence strengthened internal validity; where they diverged, the discrepancy was interrogated to surface stakeholder-specific or systemic dynamics.

2.5 Ethical Considerations

Ethical approval was obtained from the University of Manchester's Research Ethics Committee prior to data collection, in accordance with the University's Policy on the Ethical Involvement of

Human Participants in Research (University of Manchester, 2021). Participants received an information sheet describing the study's purpose, voluntary nature, confidentiality, and data-handling procedures (University of Manchester, 2022a, 2022b). Written or verbal consent was obtained before each interview, and an explicit consent statement preceded the online questionnaire. All data were anonymised at transcription and stored on a secure, password-protected institutional platform accessible only to the research team. Approval details are given in the Declarations section.

3. Results

3.1 Qualitative Findings

Six themes emerged from the thematic analysis of stakeholder interviews and written business responses. Together, they map the conditions under which SPLs either accelerate or stall in the Riyadh ecosystem.

Theme 1 — Awareness and integration deficits. Stakeholders consistently reported limited awareness of SPL benefits among logistics operators and retailers, compounded by weak integration with the country's leading e-commerce platforms (Salla and Zid). Locker delivery options rarely surfaced at checkout, suppressing both visibility and habitual use. One SPL CEO observed that the company had been working for over a year to integrate locker delivery into platform checkouts.

Theme 2 — Adoption inertia among retailers. Fulfilment providers estimated that only around 5 % of e-commerce merchants had expressed serious interest in locker integration, indicating a perceptual gap between provider value propositions and retailer commercial priorities. Several retailers undervalued the foot-traffic and convenience benefits of hosting lockers.

Theme 3 — Cost asymmetry between providers and consumers. Fulfilment costs strongly favoured locker delivery (approximately SAR 5.5 per parcel) over conventional home delivery

(approximately SAR 10.5 per parcel). However, the high capital expenditure required for locker manufacture, installation, and maintenance, combined with long payback periods, constrained network expansion. Cost emerged as a provider-side concern rather than a consumer-side priority.

Theme 4 — Policy and regulatory gaps. Despite Vision 2030's logistics-modernisation agenda, interviewees described limited regulatory incentives, sparse public-private collaboration, and modest network coverage relative to the city's population density and order volumes. The Saudi Transport Authority was identified as a potential lever for accelerating adoption, particularly through sustainability-linked incentives.

Theme 5 — Convenience-led adoption motivations. Stakeholders identified flexible pickup, fewer failed deliveries, faster fulfilment, and streamlined returns as the principal motivations to adopt lockers. Lockers were positioned as friction-removal infrastructure rather than as a pure cost-reduction lever.

Theme 6 — Accessibility, ease of use, and reliability as priority adoption levers. When asked to rank factors influencing adoption, participants prioritised accessibility (locker proximity and operating hours), trust and security, awareness, ease of use, and reliability—particularly real-time tracking and notifications. These six factors were carried forward as constructs for quantitative measurement.

3.2 Quantitative Findings

3.2.1 Sample composition

Of the 342 responses initially collected, 274 met all eligibility criteria after data cleaning (Table 1). The final analytic sample (n = 274) was demographically aligned with active e-commerce users in Riyadh: female participants formed a slight majority, the 18-34 cohort dominated, and respondents were concentrated in the northern and eastern districts (Table 2).

Table 1. *Data cleaning and final analytic sample.*

Stage of data cleaning	n	% retained
Total responses collected	342	100.0
Completed questionnaires	301	88.0
Riyadh residents	291	85.1
Final analytic sample (received parcel in last 6 months)	**274**	**80.1**

Table 2. *Demographic profile of the final analytic sample (n = 274).*

Variable	Category	Distribution (n = 274)
Gender	Female	Slight majority
	Male	Minority
Age group	18-24	Largest cohort
	25-34	Second-largest cohort
	35-44 / 45-54 / 55+	Combined minority
Region of Riyadh	North	Largest share
	East	Second-largest share
	Central / West / South	Smaller shares

3.2.2 Reliability and descriptive statistics

Internal consistency was acceptable for all primary constructs (Cronbach's alpha between .74 and .82), with the exception of Openness (alpha = .35), which was retained for exploratory purposes only and interpreted with caution. Means were highest for Innovativeness (M = 3.89, SD = 0.86) and Convenience (M = 3.54, SD = 0.92), and lowest for Openness (M = 2.97, SD = 0.95), suggesting generally favourable attitudes towards SPLs but a degree of behavioural inertia regarding routine change (Table 3).

Table 3. *Reliability and descriptive statistics for measurement constructs (n = 274).*

Construct	Items	Mean	SD	Cronbach's alpha
Convenience	4	3.54	0.92	.82
Innovativeness	3	3.89	0.86	.75
Access & Awareness	4	3.36	0.91	.78
Trust & Security	3	3.41	0.89	.74
Openness (to behavioural change)	3	2.97	0.95	.35
Adoption Intent (DV)	3	3.52	0.94	.81

3.2.3 Correlation analysis

All five predictors were positively and significantly associated with Adoption Intent (Table 4). Convenience showed the strongest correlation ($r = .67$, $p < .001$), followed by Innovativeness ($r = .53$, $p < .001$) and Access & Awareness ($r = .48$, $p < .001$). Trust & Security ($r = .42$, $p < .001$) and Openness ($r = .30$, $p < .001$) showed weaker but significant associations. Inter-construct correlations remained below .55, indicating no immediate multicollinearity concerns.

Table 4. *Pearson correlation matrix for adoption constructs and adoption intent (n = 274).*

Construct	1	2	3	4	5	6
1. Convenience	--					
2. Innovativeness	.49**	--				
3. Access & Awareness	.52**	.44**	--			
4. Trust & Security	.46**	.39**	.42**	--		
5. Openness	.31**	.28**	.26**	.25**	--	
6. Adoption Intent	**.67****	**.53****	.48**	.42**	.30**	--

Note. ** $p < .001$ (two-tailed).

3.2.4 Multiple regression analysis

A simultaneous multiple regression with Adoption Intent as the dependent variable produced a significant model: F(5, 269) = 62.6, p < .001, R-squared = .538 (adjusted R-squared = .529). Convenience emerged as the strongest predictor (beta = .475, p < .001), followed by Innovativeness (beta = .250, p < .001). Access & Awareness, Trust & Security, and Openness were not statistically significant once Convenience was accounted for, indicating that their bivariate associations operated indirectly through Convenience (Table 5). The Variance Inflation Factor remained below 2.0 for all predictors, confirming that multicollinearity did not threaten the estimates.

Table 5. *Multiple regression of adoption constructs on adoption intent (n = 274).*

Predictor	B	SE	beta	t	p
(Constant)	0.42	0.21	--	2.00	.046
Convenience	0.49	0.06	**.475**	8.16	**< .001**
Innovativeness	0.27	0.06	**.250**	4.50	**< .001**
Access & Awareness	0.07	0.06	.073	1.17	.243
Trust & Security	0.09	0.06	.089	1.43	.153
Openness	0.04	0.05	.042	0.79	.430

Note. Model: F(5, 269) = 62.6, p < .001; R-squared = .538; adjusted R-squared = .529.

3.2.5 Exploratory factor analysis

Sampling adequacy for EFA was excellent: KMO = .866 and Bartlett's test of sphericity chi-squared(120) = 1,795, p < .001. Principal axis factoring with oblimin rotation extracted five factors with eigenvalues above 1.0, jointly explaining approximately 54 % of the total variance. The factor structure aligned with the qualitative themes: Convenience, Innovativeness, Access & Awareness, Trust & Security, and Openness loaded as conceptually expected, with all primary loadings above .55 and minimal cross-loadings (Table 6).

Table 6. *Exploratory factor analysis: pattern matrix (loadings below .35 suppressed).*

Item	F1: Conv.	F2: Innov.	F3: Access	F4: Trust	F5: Open.
Lockers reduce failed deliveries	.79				
Lockers offer flexible pickup	.77				
Lockers save time	.74				
I like trying new technologies		.82			
I am usually an early adopter		.76			
Lockers near me are easy to find			.75		
I know how to use lockers			.71		
Locker pickup feels secure				.78	
My parcels are safe in lockers				.72	
I prefer changing delivery routines					.58
Eigenvalue	**3.86**	**1.92**	**1.46**	**1.21**	**1.08**
% Variance	**21.4**	**10.7**	**8.1**	**6.7**	**6.0**

3.2.6 Demographic comparisons

Independent-samples t-tests revealed significant gender differences. Female respondents reported significantly higher Access & Awareness (M = 3.52 vs 3.25; t = 2.66, p = .008) and Adoption Intent (M = 3.65 vs 3.40; t = 1.98, p = .049). Welch's ANOVA showed significant age differences in Access & Awareness (F(4, 35) = 5.11, p = .002), with the 18-24 cohort scoring significantly higher than the 35-44 and 45-54 groups. A regional ANOVA demonstrated significant variation in Convenience (F(4, 58) = 3.82, p = .008): respondents in South Riyadh recorded significantly lower convenience scores (M = 3.06) than those in East (M = 3.71) and West (M = 3.77), consistent with infrastructural disparity in locker placement (Table 7).

Table 7. *Demographic comparisons: gender t-tests and age/region ANOVA.*

Comparison	Construct	Test statistic	p	Direction
Gender (t-test)	Access & Awareness	t = 2.66	**.008**	F (3.52) > M (3.25)
	Adoption Intent	t = 1.98	**.049**	F (3.65) > M (3.40)
Age group (Welch's ANOVA)	Access & Awareness	F(4, 35) = 5.11	**.002**	18-24 > 35-44, 45-54
Region (ANOVA)	Convenience	F(4, 58) = 3.82	**.008**	E (3.71), W (3.77) > S (3.06)

3.2.7 Behavioural drivers and barriers

Open-ended and multi-select items provided three behavioural insights. First, the most frequently cited barriers to SPL use were satisfaction with home delivery (over half of respondents) and the absence of a nearby locker (~48 %), with trust concerns appearing as a secondary rather than primary obstacle. Second, when ranking decision criteria, respondents prioritised flexibility, reliability, and locker proximity over price, reinforcing the regression result that cost is not the dominant lever. Third, the most commonly cited triggers for future adoption were: (i) closer locker placement, (ii) cheaper locker delivery than home delivery, and (iii) clearer usage instructions. Together, these findings indicate an adoption threshold that can be shifted through coverage, education, and incentive alignment.

3.3 Triangulated Synthesis

Integration across the qualitative and quantitative phases produced three convergent and two divergent findings. Convergence emerged on Convenience (the universal driver, dominant in both interview narratives and regression coefficients), Accessibility (a structural barrier triangulated across interviews, the regional ANOVA, and behavioural barriers), and Awareness (a foundational

enabler reinforced by the gender and age effects observed in the survey). Divergence emerged on Cost—prominent for providers but secondary for consumers—and on Integration, which qualitative respondents identified as decisive but consumers did not consciously perceive, suggesting it acts indirectly by lowering SPL visibility at the moment of purchase.

Reconciling the divergence between qualitative and quantitative results on Trust deserves emphasis. Trust correlated significantly with adoption intent ($r = .42$, $p < .001$) but was not a significant regression predictor (beta = .089, $p = .153$). The most plausible interpretation is that Trust functions as a threshold condition: once functional convenience and accessibility thresholds are crossed, trust no longer differentiates between adopters and non-adopters. This pattern is consistent with TAM and UTAUT2 evidence that perceived usefulness and effort expectancy precede trust in the adoption sequence (Davis, 1989; Venkatesh et al., 2012).

4. Discussion

4.1 Convenience as the Hierarchical Anchor of Adoption

The dominant finding of this study is that Convenience operates as the hierarchical anchor of SPL adoption in Riyadh. Both the magnitude of its bivariate correlation ($r = .67$) and the size of its standardised regression coefficient (beta = .475) far exceed those of any other construct, and its primacy is mirrored in the qualitative narratives of providers, fulfilment aggregators, businesses, and consumers. This is consistent with Vakulenko et al. (2018) and Yuen et al. (2019), who position perceived convenience as the central value driver of locker services in mature markets, but the present study extends their argument by showing that convenience does not simply outrank trust and cost—it conditions them. Trust correlates with adoption intent until convenience is in the model, and then loses statistical force; cost is a strategic concern for providers but does not differentiate consumers' decisions once flexibility and reliability are addressed. This 'convenience-first' logic supports a hierarchical reading of TAM-style models in emerging markets, in which

perceived usefulness and effort expectancy must be satisfied before secondary constructs gain traction (Davis, 1989; Venkatesh et al., 2012).

4.2 Accessibility, Awareness, and the Geography of Inequity

The regional ANOVA revealed that South Riyadh residents perceive significantly lower convenience than residents of East and West Riyadh, mirroring the qualitative testimony that locker network density is uneven and concentrated in specific commercial corridors. This finding aligns with European evidence that adoption rates correlate with locker density per capita (Krupa & Rozycki, 2025; Last Mile Experts, 2024), and it points to a Riyadh-specific equity dimension: SPL benefits accrue disproportionately to consumers in already-served districts, reinforcing rather than reducing spatial inequities in last-mile service. Awareness exhibits a parallel demographic dimension. Female and 18-24 respondents reported significantly higher Access & Awareness than their counterparts, consistent with Rogers's (2003) characterisation of digitally engaged segments as innovators and early adopters. Awareness functioned in this study less as an active motivator than as a precondition: it gates entry into the consideration set rather than directly influencing intent once Convenience is adequately perceived.

4.3 Trust and Cost as Threshold Variables

Trust and Cost emerged as threshold rather than primary variables. Interviewees raised trust concerns about parcel security in less-monitored locker locations, particularly outside retail hours, but quantitative analyses indicated that trust influences adoption only until functional convenience has been demonstrated. This is theoretically important because it suggests that, in the Saudi context, trust is built through experience rather than persuaded through messaging. Cost reveals a more structural divergence: providers see SPL economics (SAR 5.5 vs SAR 10.5 per parcel) as the principal commercial rationale, but consumers prioritise control, predictability, and proximity over modest price differences. This consumer-provider asymmetry is consistent with broader research on last-mile delivery decisions in urban e-commerce (Agatz et al., 2012). Integration challenges (e.g., absence of locker options at Salla and Zid checkout) operate similarly: they

suppress visibility and uptake systemically, even though end-users do not consciously perceive them.

4.4 Theoretical Contributions

The study makes three theoretical contributions. First, it specifies a hierarchical adoption logic for SPLs in an emerging-market context, positioning Convenience and Accessibility as foundational conditions and Trust, Cost, and Awareness as conditional or threshold variables. This refines the TAM/UTAUT2 lineage by showing that the relative importance of constructs is contingent on infrastructural maturity and prior usage. The implication for theory development is significant: rather than treating perceived usefulness, ease of use, trust, and effort expectancy as independently weighted predictors, future models should consider sequential or hierarchical specifications in which functional thresholds gate the activation of evaluative and affective constructs. Such an approach would resolve a long-standing inconsistency in the technology-acceptance literature, where trust and perceived usefulness sometimes appear as substitutes and sometimes as complements depending on context.

Second, the study integrates Diffusion of Innovations (Rogers, 2003) with adoption-acceptance models by demonstrating that demographic moderators—gender and age—operate not by changing the construct hierarchy but by shifting the awareness gate that allows the hierarchy to engage. In the Riyadh sample, female and 18-24 respondents had higher access and awareness, which positions them as innovators and early adopters in the diffusion sequence. This integration suggests that adoption frameworks gain explanatory power when behavioural antecedents (TAM/UTAUT2) are crossed with diffusion segments (Rogers, 2003), particularly in markets where awareness rather than acceptance is the binding constraint.

Third, the study reconceptualises platform integration as a sociotechnical, ecosystem-level adoption barrier rather than a user-perceived attribute. The qualitative finding that locker options are absent or inconspicuous on major Saudi e-commerce platforms (Salla, Zid) but the quantitative finding that consumers do not consciously cite integration as a barrier together imply that integration operates by suppressing the consideration set rather than by being weighed against it. This reframing has implications for measurement design—future surveys should capture choice-

architecture variables in addition to attitudinal constructs—and for adoption-acceleration strategy, which must work upstream of consumer perception. Together, these three contributions broaden the lens for future research on technology adoption in last-mile logistics, particularly in contexts where infrastructure, platform design, and consumer behaviour co-evolve.

4.5 Practical and Policy Implications

For SPL providers, the findings recommend a coverage-led adoption strategy. Network density should expand in underserved districts, particularly South Riyadh, where convenience scores were significantly lower. Locker sites should be selected to maximise 24/7 access—petrol stations, transport hubs, malls, residential precincts, universities, and workplaces all outperform stand-alone retail locations because they are accessible at the times when consumers find pickup most convenient. Geospatial demand mapping that overlays delivery-failure hotspots with population density and order volumes provides a defensible analytical basis for site selection and capital allocation. To reduce learning friction, providers should integrate Arabic-language onboarding flows into the SPL application and place QR-triggered tutorials at every locker site, with bilingual signage explaining pickup, returns, and PIN-retrieval procedures. Predictive notifications—including locker availability, recommended pickup windows, and route suggestions—can convert passive intent into actual collection behaviour. Targeted awareness campaigns through Snapchat, Instagram, and TikTok, channels favoured by 18-34 Saudi women, should emphasise reliability, predictability, safety, and discreet pickup, the four attributes most aligned with the highest-readiness segment's stated decision criteria.

For e-commerce platforms, the binding constraint is checkout-level integration. Locker delivery options must appear by default alongside home delivery, with geolocation-based suggestions of the nearest locker and clear value labels (e.g., 'No missed deliveries', 'Flexible 24/7 pickup'). Filters allowing users to display only 24/7 lockers, only lockers within walking distance, or only lockers near workplaces would further reduce decision friction. Short multimedia explainers at checkout—

15- to 30-second video or animated assets—can reduce perceived complexity for first-time users and address the cited barrier of unclear usage instructions. Salla and Zid, the two leading Saudi e-commerce platforms, are the highest-leverage targets for integration partnerships because together they account for the majority of independent merchant traffic in Riyadh.

For policymakers, the alignment with Vision 2030 is direct. Subsidies, expedited permitting, and targeted tax incentives can accelerate locker deployment in lower-income and underserved neighbourhoods, redressing the spatial inequities documented in this study. Standardised security and lighting protocols, together with mandatory CCTV coverage at locker sites, would address the trust concerns that female users raised in qualitative interviews and that quantitative data show are particularly salient at lockers located outside retail hours. Public-private partnerships of the type that underpinned European locker scale-up (Last Mile Experts, 2024) would be especially relevant. The Saudi Transport Authority is well positioned to convene such partnerships and to embed SPL deployment within municipal logistics master plans. Embedding SPL adoption within the Vision 2030 sustainability narrative—where lockers can reduce delivery emissions by approximately 60 % relative to home delivery (Descartes Systems Group, 2024; Kolasinska-Morawska et al., 2022)—would consolidate the case for state support and align the locker agenda with the Kingdom's Net Zero by 2060 commitment.

4.6 Limitations and Future Research

The study has five limitations. First, the cross-sectional design captures perceptions at a single point in 2025 and cannot track evolving adoption patterns as locker networks mature. A longitudinal extension would clarify the causal sequence between Convenience, Accessibility, and Trust. Second, the survey sample, although demographically representative of active e-commerce users, may overrepresent digitally engaged respondents and so overstate Awareness. Third, reliance on self-reported data introduces social-desirability and intention-behaviour gaps. Fourth, although both providers and consumers were sampled, quantitative analyses focused on

consumers; future work integrating provider, fulfilment, and platform data would test the full sociotechnical model. Fifth, the geographic scope was confined to Riyadh; comparative work across smaller Saudi cities and the Gulf Cooperation Council would test the generalisability of the hierarchical adoption framework. Future research should also apply structural equation modelling (SEM) to formally test the hypothesised hierarchy of constructs and evaluate the impact of policy interventions such as subsidies and public-private partnerships.

5. Conclusion

This study examined the determinants of Smart Parcel Locker adoption in Riyadh through a sequential exploratory mixed-methods design that triangulated stakeholder interviews with a confirmatory survey of 274 e-commerce consumers. Convenience emerged as the dominant predictor of adoption intent, followed by user innovativeness, with the regression model explaining 53.8 % of variance. Access and awareness, trust, and cost operated as conditional, threshold, or indirect factors rather than primary drivers. Female and younger consumers exhibited higher adoption readiness, and South Riyadh residents reported significantly lower convenience perceptions, signalling spatial inequities in locker coverage.

The research contributes a hierarchical adoption framework that extends technology-acceptance theory into the Saudi last-mile context, and offers actionable recommendations for SPL providers (network density, Arabic-language onboarding, awareness campaigns), e-commerce platforms (checkout-level integration), and policymakers (subsidies, security standards, Vision 2030 alignment). For Saudi Arabia, accelerating SPL adoption is not a peripheral logistics question but a strategic component of the Kingdom's logistics-modernisation agenda. By prioritising convenience and accessibility, integrating SPLs at the point of purchase, and addressing trust through demonstrable operational reliability, Riyadh's last-mile ecosystem can move from an early-stage SPL market to a mainstream out-of-home delivery economy. Future longitudinal and

SEM-based research will be essential to validate the hierarchical adoption framework as the Kingdom's locker networks mature.

Declaration

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Conflict of Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement

The anonymised quantitative survey data and qualitative coding matrices supporting the findings of this study are available from the corresponding author on reasonable request, subject to the conditions of the participant consent obtained under the University of Manchester Research Ethics approval.

Ethics Approval

This study was approved by the University of Manchester Research Ethics Committee and was conducted in accordance with the University of Manchester's Policy on the Ethical Involvement

of Human Participants in Research. All interview participants gave written or verbal informed consent before taking part, and all survey respondents confirmed their consent before beginning the online questionnaire.

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Appendix A: Interview Guide for SPL Providers and Fulfilment Aggregators

Each interview lasted 30-60 minutes and was conducted face-to-face with the founder/CEO. Questions were adapted in real time based on participant responses; bilingual prompts were used as required.

Section 1 — Organisation profile.

- Briefly describe your organisation, its scale of operations in Riyadh, and your role.
- How many lockers/PUDO points does your organisation operate in Riyadh, and what are the key criteria for selecting locker sites?

Section 2 — Adoption and integration.

- In your view, what are the principal barriers to wider SPL adoption in Riyadh among (a) consumers and (b) e-commerce merchants?
- How well integrated are SPL options with the leading e-commerce platforms (e.g., Salla, Zid)? What are the main integration constraints at checkout?
- Approximately what proportion of e-commerce merchants currently express willingness to integrate SPL services?

Section 3 — Cost and infrastructure.

- How does the cost-to-serve of SPL delivery compare with conventional home delivery?
- What capital expenditure considerations shape locker network expansion, and what is your typical payback horizon?

Section 4 — Policy and regulation.

- How would you characterise the current regulatory environment for SPLs in Saudi Arabia? Where are the most important policy gaps?
- How does Vision 2030 influence your strategic planning for locker deployment?

Section 5 — Future outlook.

- What single change—technical, regulatory, or behavioural—would have the largest positive effect on adoption in the next two years?

Appendix B: Interview Guide for End-Users

Each interview lasted 30-60 minutes. Participants were active e-commerce users in Riyadh aged 18 or above who had received at least one online parcel within the previous six months.

Section 1 — Profile and current behaviour.

- How long have you been shopping online, and approximately how many parcels do you receive in a typical month?
- How do you usually receive your online orders (home delivery, branch pickup, Smart Parcel Locker, other)?
- Why do you usually choose this method?
- Have you ever used a Smart Parcel Locker? If so, what was good or bad about that experience?

Section 2 — Barriers and switching conditions.

- What would prevent you from using lockers regularly?
- Under what conditions would you switch from home delivery to lockers (e.g., locker close to home or work, lower cost, faster, more secure, better app)?

Section 3 — Factor prioritisation (top-three exercise).

Please rate each of the following factors from 1 (not important) to 5 (very important) for your decision to use SPLs regularly, then select your top three:

- Accessibility and proximity

- Trust and security
- Awareness and ease of learning
- Cost and discounts
- Ease of use
- Reliability and first-time success
- Speed of collection
- Privacy
- App notifications
- Returns handling
- Sustainability

Section 4 — Closing.

- If you have used lockers before, what would make you use them more often?
- Would you recommend lockers to a friend? Why or why not?

Appendix C: Online Survey Instrument (Summary of Sections)

The structured online questionnaire was administered via Qualtrics over four weeks. The instrument was piloted with ten participants and refined for clarity and Arabic translation. The full instrument comprised the following sections:

Section 1 — Screening and demographics. Eligibility (Riyadh residency; aged 18+; received online parcel within last 6 months); gender; age group (18-24, 25-34, 35-44, 45-54, 55+); region of Riyadh (North, South, East, West, Central).

Section 2 — SPL awareness and usage. Familiarity with SPL services in Riyadh; prior usage of SPLs; preferred delivery channel; recent SPL pickups.

Section 3 — Adoption constructs (5-point Likert). Convenience (4 items); Innovativeness (3 items); Access & Awareness (4 items); Trust & Security (3 items); Openness to behavioural change (3 items).

Section 4 — Adoption intent (dependent variable). Three Likert items measuring intention to use SPLs in the next three to six months.

Section 5 — Behavioural barriers and triggers. Multi-select barriers to SPL use; ranked decision criteria for choosing delivery method; triggers that would increase SPL usage; open-text suggestions.

Section 6 — Consent and follow-up. Confirmation of voluntary participation; option to be contacted for follow-up research.

All Likert items used the anchors: 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly agree. Reverse-coded items were screened during data cleaning.