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Social Innovation, Gendered Resilience, and Informal Food Traders in Windhoek, Namibia

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Abstract

Informal food trading is a cornerstone of urban livelihoods and food security in Namibia, yet traders operate under fragile conditions marked by limited capital, policy exclusion, and exposure to shocks such as COVID-19. Despite this vulnerability, traders exhibit resilience through everyday forms of social innovation. This study investigates how adaptive pricing, customer credit, and digital communication and e-payment practices function as pathways of resilience among 470 informal food traders in Windhoek, using Structural Equation Modelling to assess gender-differentiated determinants and outcomes. The analysis reveals that women's adoption of adaptive pricing and digital tools is driven primarily by education and startup capital, while men's innovation practices are shaped by vendor type and access to financing. Social innovations mediate the effects of these structural factors on enterprise growth, demonstrating that innovation acts as a critical mechanism linking resources and resilience. The study concludes that enhancing informal traders' resilience requires policies that strengthen human and financial capital, improve digital inclusion, and recognize gendered differences in access to opportunity. It recommends targeted support for women's entrepreneurial training, affordable credit, and digital infrastructure to transform the informal food sector into a more equitable and sustainable component of Namibia's urban economy.

Keywords: social innovations; informal economy; resilience pathways; gender and entrepreneurship; structural equation modelling; Namibia

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1. Introduction

Urbanization in Africa has been accompanied by the rapid expansion of informal economies that provide critical livelihoods for millions of low-income urban communities. In Sub-Saharan Africa, the informal economy accounts for more than 85% of total employment [1]. In Namibia, over half (57%) of the employed population works informally, with women disproportionately concentrated in vulnerable, low-protection segments of the sector [2]. Informal enterprises typically operate outside formal labour laws, tax regimes, and social protection systems, often in precarious spaces such as informal markets, roadside stalls, and mobile vending sites [3,4]. In African cities, the informal economy provides women with an accessible entry point into income generation but simultaneously reinforces their exposure to instability and risk [5–7].

The risks and vulnerabilities of informal traders include insecure workspaces, limited access to finance, exclusion from government support and policy frameworks, and a lack of formal protections such as contracts, insurance, or pensions. Informal traders are also highly susceptible to shocks such as pandemics and climate-related disruptions [8]. The COVID-19 pandemic highlighted these vulnerabilities and exposed the fragility of informal livelihoods. Lockdowns, reduced demand, and disruptions to supply chains magnified vulnerability, underscoring the absence of formal safety nets [9–11]. Despite the challenges, informal traders demonstrated considerable adaptability and acumen, ensuring business survival and continuity through social innovation [12].

The emerging literature on Namibia's booming informal economy has focused on a variety of key issues, including the governance of informality, trader motivations, competition with supermarkets, food safety practices, climate risks, digital microwork, and the role of informal traders in making food accessible to low-income urban communities [13–21]. Most traders in Windhoek are survivalists rather than opportunists who lack alternative means of generating income for their household's daily survival [13]. Business income and stock are transferred to meet household needs, reducing the amount available for reinvestment in the business. The operating challenges facing participants in the informal economy have been examined in several recent studies. The major challenges articulated by traders include low sales, fierce competition, input costs, storage problems, and customers failing to pay their debts [22]. Other significant challenges facing informal traders include a lack of access to financial assistance, inadequate management and marketing skills, limited financial resources, inadequate infrastructure, and marginalisation in formal urban planning [23]. Another recent study of over 200 young entrepreneurs in Windhoek found that three-quarters of youth-owned enterprises fail within their first three years, due to a combination of limited entrepreneurial skills, inadequate funding, and other systemic barriers [24].

In the capital, Windhoek, two-thirds of enterprises are owned and operated by women who must navigate economic insecurity, household responsibilities, regulatory constraints, and police raids while sustaining the city's food economy [22]. The Namibia Labour Force Survey 2018 reports that 58% of employed people are in informal employment, but this is significantly higher for women (61%) than men (54%). In the Windhoek region of Khomas, informal employment is also higher for women (43%) than men (35%). In 2019, we conducted a comprehensive spatial mapping of informal food enterprises in Windhoek, identifying 2421 food vendors. A stratified random sample of 470 enterprises found that 65% were women and 35% were men [22]. Recent findings from the 2023 Population and Housing Census show that among own-account workers, 11% were women, compared to 8% men [25]. This gender imbalance directly supports a structural segmentation story: women are systematically more likely to be in informal work arrangements, even as human capital improves. These disparities persist alongside earnings differentials and are consistent with occupational and sectoral sorting and unequal access to stable wage employment. For example, in the 2018 NLFS, the average monthly wage was higher for males (N$8052) than for females (N$7789). The dominance of women in the informal economy is consistent with broader global trends, particularly in countries and cities of the Global South [25]. Much of the research literature on gender segmentation in the informal economy has focused on women as traders, their labour-market exclusion and reasons for participation, the gendered challenges they face, and their resilience and adaptability in an often-hostile policy environment [7,26–30]. In Namibia, studies of women's involvement in informal trading have focused on issues such as mobile vending, economic empowerment, the lack of social protection, and coping strategies during the COVID-19 pandemic [31,32]. Although gender is often invoked as a conceptual lens, there have been no empirical studies

to date of gendered inequality in the Namibian informal economy [33]. There has also been limited empirical work examining the role of social innovations as a resilience strategy in Namibia, and even less is known about the gender dimensions of innovation in the informal economy.

Certainly, there is evidence that some informal traders were more opportunistic, entrepreneurial, and innovative in orientation, but the gender dimensions of opportunism have not been teased out [13]. Informal traders also stimulate local economic activity through innovation by creating jobs, generating income, providing affordable goods and services, and fostering social inclusion, but again, how this is impacted by gendered inequality is largely unknown [23]. There are also examples of women traders using social media apps to exchange knowledge, share pricing information, and discuss market access [34]. However, there is a significant gap in our understanding of the range, types, determinants, and effectiveness of social innovations in the informal trading economy of the country, and in the mediating role of social innovations in gender-differentiated enterprise pathways for women and men.

Social innovation has become increasingly popular as a way of framing complex social and economic challenges, particularly in contexts where formal institutions are weak or absent [35–39]. In general, social innovations are new ideas, practices, products, services, governance mechanisms, or institutional arrangements that enhance collective well-being and resilience [40–42]. Unlike formal-sector innovations, which are market-driven and capital-intensive, these practices in the informal economy emerge from necessity and are embedded in community trust, reciprocity, and social capital [43–45]. In the informal economy, social innovations are evident in everyday coping strategies that enable enterprises to survive amid structural and policy exclusion [46–48]. These adaptive responses position innovation not as a luxury but as a necessity for enterprise survival and growth.

Social innovations take the form of grassroots coping strategies such as flexible pricing, shifting locations, extending credit to customers, leveraging mobile technology, collective purchasing, and forming small-scale collaborative networks and associations [49,50]. Such innovations are often overlooked in mainstream policy debates on urban food systems in Africa but can potentially function as a form of informal social protection, cushioning traders against shocks, and building resilience [51–55]. For women in particular, social innovations shed light on gendered resilience and the broader potential of informal economies as "hidden engines" of adaptive capacity [56–59].

Resilience has been defined as the ability of individuals, enterprises, or systems to absorb shocks, adapt to change, and maintain functionality in the face of adversity [60]. In the informal economy, resilience is achieved more often through incremental, small-scale, and localised innovations rather than big policy interventions. Evidence from several African countries shows that informal traders employ low-level innovations that can collectively sustain enterprise survival during crises [61–65]. The literature suggests that resilience in informal trading also depends on bundles of innovation strategies rather than isolated practices [66,67]. Social trust and reciprocity can also facilitate cooperation, knowledge sharing, and the diffusion of innovations [68,69]. Gender-based analysis of informal sector innovation is less common in the literature, although one study of two Ghanaian cities found no significant differences between male and female-owned enterprises [70]. A related study found that female-owned enterprises were less likely to introduce product innovations but were more likely to sell innovative products [56].

In this study, we conceptualise social innovation as a multidimensional construct that enhances resilience in informal economies. We first adapt Schneckenberg et al.'s five dimensions of innovation: adaptive pricing, customer centricity, capability evolution, value co-creation, and ecosystem growth [71]. These domains reflect how traders adapt,

collaborate, and innovate to sustain their businesses and livelihoods in precarious urban economies. Together, these five domains define a multidimensional construct of innovativeness as a pathway to resilience. In this study, they are treated both as individual coping strategies and as indicators of a latent construct of "innovativeness." They highlight that resilience in informal economies is not achieved through isolated strategies, but a web of adaptive, relational, technological, and collective practices that reinforce one another. In turn, innovativeness is hypothesised to positively influence enterprise resilience, operationalised as the ability to sustain operations under shocks such as pandemic disruptions, the death of breadwinner, drought, and other natural disasters.

This framework is grounded in two theoretical strands. The first is institutional theory, which explains how informal entrepreneurs develop innovative practices to fill gaps created by weak or absent formal institutions [72–74]. The other is grassroots innovation theory, which emphasises bottom-up, community-driven solutions that prioritise social value and resilience over profit maximization [75–77]. By combining these two perspectives, the framework situates social innovations as de facto social protection that emerges organically within informal trading communities. The analysis thus tests the proposition that innovation mediates the relationship between trader vulnerabilities (gender, education, formalisation status) and enterprise resilience.

The main objective of this study was to examine the role of social innovations in enhancing enterprise resilience among informal food traders in Windhoek, Namibia, with particular attention to gendered adaptations during shocks such as COVID-19. The paper addresses three main questions: What every day social innovations do informal food traders deploy, and are these strategies the same for women and men? Which individual and enterprise characteristics are associated with the adoption of social innovations and how do these determinants differ by sex? To what extent do these innovations increase the likelihood of enterprise growth and mediate the effects of education and capital for women and men? To answer these questions, we model innovativeness as a latent construct and assess its relationship with determinants of innovation adoption, including gender, education, business formalisation, and exposure to shocks. From the analysis, we draw policy implications for strengthening resilience in Namibia's informal economy, with a focus on women entrepreneurs.

This study makes three key contributions to the literature on informal economies, gender, and urban resilience. First, it provides the first empirical analysis of gendered inequality within Namibia's informal food economy, addressing a significant gap in country-specific evidence where gender is often invoked but rarely measured explicitly. Second, it advances conceptual understanding of resilience by demonstrating that enterprise resilience operates through social innovation pathways, including adaptive pricing, customer credit, and communications/e-payments, that mediate the relationship between structural constraints and enterprise outcomes. Third, methodologically, the study integrates Structural Equation Modelling with bias-reduced logistic regression to model rare enterprise growth outcomes, offering a robust analytical framework for examining innovation-mediated resilience in informal economic contexts.

Section 2 of the paper first discusses the drawing of a sample of 470 food traders in Windhoek and the distribution of sampled enterprises by type. The section also provides a detailed rationale for the construction of three social innovation variables used in the statistical analysis, i.e., Adaptive Pricing (AP), Customer Credit (CC), and Communications and E-payments (CE). Finally, the section identifies various limitations of the study. Section 3 of the paper presents the results of the analysis in two formats. First, a descriptive statistical profile of Windhoek's food traders is provided with reference to differences and similarities by women and men operating enterprises in the sector. Second, the results of

structural equation modelling and estimated effects of the determinants on AP, CC, and CE are presented. Section 4 of the paper discusses the results considering the three research questions posed above. Section 5 highlights the policy-related implications of the findings and directions for future research on social innovation in the informal food economy.

2. Materials and Methods

2.1. Study Site

This study is based on a cross-sectional survey of informal traders conducted by the authors in Windhoek, Namibia. The city is an appropriate site given its rapid growth through in-migration, high levels of youth unemployment, and the prominence of the informal food sector. Because informal food vending in Windhoek is strongly gendered, we assessed whether our sample's gender distribution is broadly consistent with available external benchmarks. The sampling frame was derived from our comprehensive city-wide enumeration of informal food traders, and a stratified random sampling strategy was applied [22]. The gender composition of the sample, with women comprising approximately 64% of respondents, closely reflects the structure of informal food trading in Windhoek, where the trader census and labour force surveys consistently show that two-thirds of enterprises are operated by women. Given this close correspondence with the underlying population distribution, post-stratification weighting was not applied. Instead, gender was explicitly modelled as a moderating factor in all analyses, and results are presented in sex-disaggregated form to avoid aggregation bias. A stratified random sample was employed to ensure representation across key enterprise types, including street and informal market traders, open market stalls, tuck shops, home-based shops, and mobile traders. Proportional allocation within strata preserved comparability, yielding a final survey of 470 traders (Table 1).

Table 1. Distribution of enterprises sampled by type.

Type	No.	%
Street traders	128	27.2
Informal market traders	70	14.9
Open market traders	67	14.3
Traders outside supermarkets	59	12.6
Tuck shops	39	8.3
Traders at taxi ranks/bus stop	35	7.4
Mobile traders	26	5.5
Home-based shops	21	4.5
Traders outside open markets	16	3.4
Other	9	1.9
Total	470	100.0

A structured questionnaire was administered face-to-face by trained enumerators using digital tablets. Data captured five domains: (i) socio-economic and demographic characteristics including sex, age, education, and migration status; (ii) household characteristics including household size and dependence on business stock for food; (iii) enterprise characteristics covering year of establishment, location, type, startup capital, source of financing, ownership, and business worth; (iv) business practices such as transport and mobility, customer credit, record-keeping, and digital communication/payment technologies; and (v) entrepreneurial motivations distinguishing survivalist from opportunistic orientations.

2.2. Descriptive Statistics

The analysis began with descriptive statistics to characterise food traders and their businesses, with attention to gendered distributions. Then, latent constructs were developed to capture social innovations: Adaptive Pricing (AP), Customer Credit (CC), and Communications and e-payments (CE). A fourth construct, Enterprise Growth (EG), was measured as a binary outcome:

- Adaptive pricing (AP) represents the capacity of informal traders to respond to fluctuations in consumer demand and purchasing power. By offering flexible prices, negotiating transactions, and adjusting payment terms, they can maintain customer flows even under volatile conditions. This flexibility is essential in markets characterised by economic shocks and highly elastic demand.
- Customer centricity (CC) emphasises the relational dimensions of informal trading. Traders maintain loyalty and repeat patronage by extending credit, soliciting customer feedback, and reserving stock for regular clients. These practices not only strengthen customer relationships but also serve as informal risk-sharing mechanisms that embed businesses in wider social networks [38,78].
- Capability evolution (CE) refers to the ability of informal traders to continuously adapt through skills development, technological uptake, and coordination with suppliers. Practices such as mobile phone use for coordination or e-payments illustrate how digital tools expand the operational capacity of small-scale enterprises, reduce transaction costs, and enhance resilience [79,80].
- Value co-creation (VC) highlights collaborative practices that directly respond to customer needs [81,82]. Strategies such as selling in smaller quantities or engaging in mobile vending allow traders to tailor their offerings to low-income consumers, thus aligning livelihood sustainability with consumer affordability. These practices demonstrate how traders and customers co-produce value in resource-constrained settings.
- Ecosystem growth (EG) captures the collective dimensions of innovation. Traders often collaborate with peers or suppliers through joint purchasing, supplier negotiations, or partnership arrangements. Such practices extend resilience beyond the individual enterprise by embedding traders within supportive networks and supply chains, enabling them to access economies of scale and strengthen bargaining power [83–85].

2.3. Structural Equation Modelling (SEM)

Structural equation modelling (SEM) was employed to estimate the relationships between trader characteristics, enterprise determinants, and innovation constructs. This approach allowed the simultaneous estimation of measurement and structural components, thereby capturing both the multidimensionality of social innovations and the direct and indirect pathways linking determinants such as startup year, vendor type, financing, capital, education, age, and ownership to resilience outcomes.

We first built a full SEM framework grounded in five domains of innovation and a resilience outcome. The model was designed to capture both measurement and structural relations, to account for categorical indicators, and to assess mediation and gendered pathways. The original model included five first-order latent factors (binary/ordinal indicators) representing distinct domains of innovation (Table 2):

- AP (Adaptive Pricing): *ap_disc* (discounts), *ap_negot* (negotiates), *ap_follow* (follows market prices).
- CC (Customer Centricity): *cc_feedback* (customer feedback), *cc_credit* (extends credit), *cc_stock* (reserves stock for regulars).
- CE (Capability Evolution): *ce_mobilecoord* (coordinates via phone), *ce_mobilepay* (accepts mobile money).

- VC (Value Co-creation): indicators such as *vc_smallqty*, *vc_mobilevend*, etc. *(low-prevalence practices).*
- EG (Ecosystem Growth): *eg_negotSupp* (supplier negotiations), *eg_bulk* (bulk buying), *eg_partnership* (partnerships/shareholding).

Table 2. Constructs, indicators, and latent dimensions.

Factor	Indicators	Notes on Measurement
AP (Adaptive Pricing)	Discounts, Negotiation, Following market price	Binary items
CC (Customer Centricity)	Customer feedback, Extends credit, Keeps stock for regulars	Ordinal/Binary
CE (Capability Evolution)	Uses phone for coordination, Accepts mobile payments	Two-indicator factor (identified by fixing one loading)
VC (Value Co-creation)	Small-quantity sales, Mobile vending, etc.	Low prevalence; may require item parcels
EG (Ecosystem Growth)	Supplier negotiations, Bulk buying, Partnerships	May include composite indicators
INNOV (Innovativeness)	Higher-order factor indicated by AP, CC, CE, VC, EG	Second-order latent factor
RESIL (Resilience)	Business survival, Income recovery, Household well-being	Endogenous latent factor

These five factors were loaded onto a second-order latent construct, Innovativeness (INNOV), which in turn predicted Resilience (RESIL), operationalized through indicators of business survival, income recovery, and household well-being.

- INNOV (Innovativeness): measured by AP, CC, CE, VC, EG.
- RESIL: *res survive* (business survived), *res_income* (income recovered), *res_hhwell* (household well-being maintained).

Because several observed indicators lacked responses, which weakened the reliability of the factor loadings, we refined the measurement model by consolidating related domains into two constructs. CC and EG were merged to form a new latent construct labelled Customer Credit (CCa). Similarly, CE and VC were combined into a single latent construct labelled Communications and E-payments (CEa). The Adaptive Pricing (APa) construct was retained in its original form.

The consolidation of the original innovation domains into a smaller number of latent constructs is theoretically informed rather than purely empirical. Drawing on institutional and grassroots innovation theories, innovation in informal economies is understood not as a set of discrete technological practices but as a constellation of functionally complementary strategies that enable enterprises to cope with uncertainty, resource scarcity, and institutional exclusion. In this context, relational practices (such as customer credit and trust-based transactions) and technological practices (such as communications and e-payments) often co-occur and jointly support adaptive capacity.

From a resilience perspective, these practices operate as integrated mechanisms through which traders stabilise demand, manage liquidity, and maintain social embeddedness. Accordingly, the refined latent constructs are conceptualised as higher-order functional domains of social innovation rather than narrowly defined technological or behavioural categories.

Figure 1 presents a conceptual framework linking determinants to social innovations APa, CCa, and CEa, and to enterprise growth, with gender as a moderator. Table 3 shows the modified model structure.

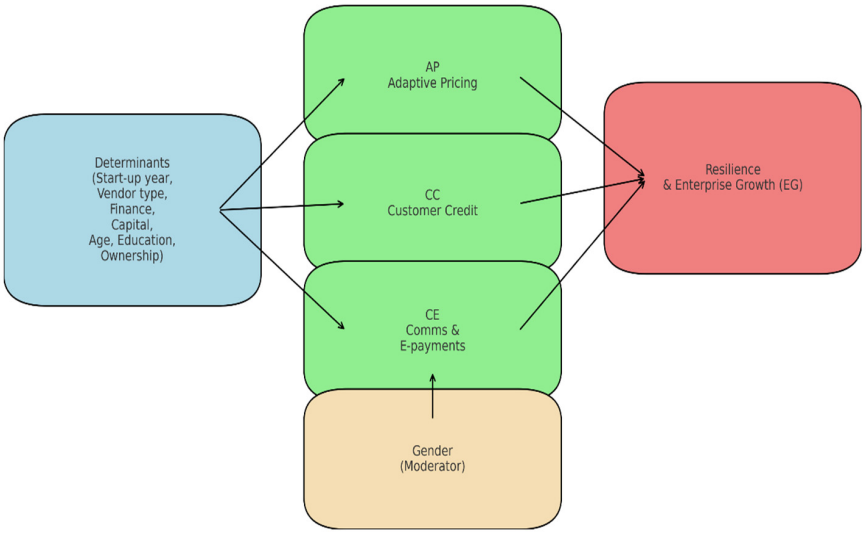

Figure 1. Conceptual framework.

Table 3. Model structure.

Measurement Model:

- AP ← {ap_disc, ap_negot, ap_follow}
- CC ← {cc_feedback, cc_credit, cc_stock}
- CE ← {ce_mobilecoord, ce_mobilepay}
- VC ← {vc_smallqty, vc_mobilevend, . . .}
- EG ← {eg_negotSupp, eg_bulk, eg_partnership}
- APa ← {AP}
- CEa ← {CE, EG}
- CCa ← {CC, VC}
- INNOV ← {APa, CEa, CCa}
- RESIL ← {res_survive, res_income, res_hhwell}

Structural model:

- INNOV~α_1·gender + α_2·educ + α_3·formal + α_4·shock + α_5·finance + γ·controls
- RESIL~β_1·INNOV + β_2·gender + β_3·educ + β_4·formal + β_5·shock + β_6·finance + δ·controls

Moderation:

- Indirect paths capture moderation (e.g., gender → INNOV → RESIL).

The exogenous determinants used in the SEM model included the following:

- *gender* (female = 1, male = 0),
- *educ* (ordinal: none < primary < secondary < tertiary),
- *formal* (registered business = 1, else 0),
- *shock* (e.g., experienced COVID-19 trading shock = 1, else 0),
- *finance* (banked/business account = 1, else 0),
- *controls:* age, location (market/street/roadside), sole ownership (=1 if sole), startup year (=1 if after 2010), startup capital (1 if 5000 NAD).

Given that most of the indicators are binary or ordinal, the model was estimated using the robust weighted least squares estimator (WLSMV) in *lavaan*. This approach

relies on polychoric correlations and thresholds rather than assuming normality, making it well-suited for categorical data. Identification was achieved by fixing one factor loading or variance in the case of two-indicator factors (such as CE), while sparse items with very low prevalence were retained but interpreted cautiously, with the option of forming item parcels to stabilise estimation if necessary.

The sample size (N ≈ 470) is appropriate for this modelling strategy, provided the model remains parsimonious and avoids unnecessary cross-loadings. Missing data were handled using the pairwise approach embedded in WLSMV, though sensitivity checks with multiple imputation could be performed in future work. Overall, these estimation choices balance statistical rigour with the constraints of working in a data-scarce informal sector setting.

Since differences and similarities between women and men are central to the study's conceptual framework, measurement invariance testing was conducted between women and men traders. This proceeded in a stepwise fashion, beginning with configural invariance (same factor structure across groups), followed by tests of threshold and metric invariance (equivalence of item thresholds and loadings), and finally scalar invariance (equivalence of intercepts). In cases where full scalar invariance could not be achieved, partial invariance was allowed by freeing specific parameters, thereby enabling meaningful comparison of structural paths between women and men. Therefore, sex was treated as a potential moderator rather than a mediator, because it is a pre-existing characteristic that may condition (but cannot be caused by) the relationships between shocks, innovation practices, and resilience.

To identify the factors associated with innovation behaviour, we estimated a series of regression models in which trader and contextual characteristics (gender, education, capital, business type, market location, years in business, and COVID-19 shock exposure) were entered as predictors of each first-order innovation construct. The resulting coefficients were synthesised using a forest plot matrix, which provides a compact visual summary of the magnitude, direction, and statistical significance of each determinant across all innovation domains. Each column of the matrix corresponds to a specific innovation construct (AP, CC, CE, VC, EG), while each row represents a determinant. The coefficients were standardised to allow comparison across models, and 95% confidence intervals were displayed to assess precision and significance.

This approach helps identify patterns of influence such as determinants that consistently support or inhibit innovation across multiple behavioural domains, thus providing a multivariate perspective not easily captured through single-model reporting. The forest plot is integrated into the analytical pipeline as a bridge between the individual predictors and the latent constructs used in structural equation modelling (SEM). By mapping which determinants shape the first-order behaviours, the forest plot informs the specification of pathways in the SEM and provides empirical justification for modelling latent innovation and resilience as outcomes of these underlying characteristics.

Model adequacy was assessed using a combination of global fit indices and reliability checks. Following conventional SEM guidelines, good model fit was indicated by comparative fit index (CFI) and Tucker–Lewis index (TLI) values of 0.95 or higher, with values above 0.90 considered acceptable. The root mean square error of approximation (RMSEA) was expected to remain below 0.06–0.08, while the standardised root mean square residual (SRMR) threshold was set at 0.08. Reliability of latent constructs was evaluated by inspecting standardised factor loadings (with loadings above 0.50 considered satisfactory) and by calculating composite reliability coefficients such as omega.

2.4. Study Limitations

First, the cross-sectional design precludes causal inference, and findings are therefore interpreted as associative and mediated relationships rather than causal effects. Second, the

low prevalence of certain innovation practices and growth outcomes may limit statistical power despite the use of bias-reduction techniques. Third, the analysis does not explicitly model heterogeneous shock effects, such as differential impacts of climate-related disruptions. Future research should employ longitudinal data to examine dynamic resilience trajectories, explore heterogeneous treatment effects across trader subgroups, and integrate qualitative methods to deepen understanding of innovation decision-making processes. Lastly, missing responses arose primarily from respondent non-response and recall limitations common in surveys of informal enterprises, particularly for sensitive financial indicators. The Structural Equation Modelling was estimated using the WLSMV, which accommodates missingness under a missing-at-random assumption. While this approach mitigates bias in parameter estimation, we acknowledge that missing data may reduce the precision of certain factor loadings. Future research could employ multiple imputation techniques or longitudinal designs to further strengthen robustness.

3. Results

3.1. Descriptive Findings

The sample comprises 470 informal food traders operating across Windhoek, with women accounting for 64% of enterprises and men 36%. This distribution reflects the underlying gender structure of the city's informal food economy. Women traders are more likely to operate home-based businesses or tuckshops, while men are disproportionately represented in mobile street and market vending. These enterprise types differ markedly in spatial mobility, customer relationships, and transaction modalities. A descriptive profile of the surveyed traders disaggregated by sex with statistical tests of difference is shown in Table 4.

Table 4. Characteristics of traders by sex.

Characteristic	Women (%)	Men (%)	Total (%)	χ^2	*p*-Value
Enterprise type: street/market	72.4	87.7	77.7	13.37	0.0001
Enterprise type: tuckshop/home-based	27.6	12.3	22.3	27.61	0.0001
Age: Youth (<35 years)	40.3	75.3	53.3	54.22	<0.001
Education ≥ Secondary	85.7	62.3	77.7	32.08	0.001
Start-up year: from 2010+	34.3	44.5	37.8	23.90	<0.001
Ownership: sole	86.7	82.1	85.1	6.11	0.05
Startup capital < NAD 5000	70.5	58.0	66.2	6.78	0.009
Loan-related financing	16.9	10.5	14.7	2.97	0.085
Necessity-driven entry	34.4	33.3	34.0	1.02	0.894
Migrant to Windhoek	89.3	88.9	89.1	3.5	0.062

- Women represented 64% of the respondents, consistent with the broader *gendered composition of informal trading* in Windhoek.
- *Enterprise type* shows strong variation. Women were more likely to operate from tuckshops or home-based enterprises (27.6%) compared with men (12.3%), while men were more concentrated in street and market vending (87.7% vs. 72.4%). The chi-square test confirmed that this difference is statistically significant ($\chi^2 = 13.37$, $p < 0.001$). This suggests that women are relatively more home-anchored in their trading, whereas men dominate the more public and mobile spaces.
- *Age differences* were even more pronounced. A striking 75.3% of men were under age 35 compared with only 40.3% of women ($\chi^2 = 54.22$, $p < 0.001$). The informal food economy therefore appears to attract much younger men, while women traders

are older and longer established, suggesting that informal vending is a long-term livelihood strategy for women but a more transitional or early-career activity for unemployed youth.

- *Business start-up patterns* differed significantly. Men were more likely than women to have started trading in 2010 or later (44.5% vs. 34.3%; $\chi^2 = 23.90$, $p < 0.001$), suggesting either greater recent male entry into the informal economy or faster turnover among male traders.
- *Educational attainment* differed sharply, with 56.8% of women (vs. 32.1% of men) completing secondary school or higher ($\chi^2 = 32.08$, $p < 0.001$), demonstrating that women's overrepresentation in informal food vending stems not from low education but from structural barriers to formal employment.
- *Sole ownership* was high for both groups but slightly higher among women (86.7% vs. 82.1%; $\chi^2 = 6.11$, $p = 0.05$), indicating women's greater likelihood to run independent operations rather than joint ventures or family partnerships.
- *Startup capital* distributions indicate that women were more likely to begin with limited resources. Over 70% of women reported initial capital below NAD 5000 compared with 58% of men, and this difference was statistically significant ($\chi^2 = 6.78$, $p = 0.009$). This reflects a gendered capital gap at business formation.
- *Loan-related financing* showed weaker gender differentiation. Only 16.9% of women and 10.5% of men accessed loans or external financing. While the difference approaches significance ($\chi^2 = 2.97$, $p = 0.085$), it suggests that very few traders of either sex accessed formal credit, with women slightly more likely to do so.
- *Necessity-driven entry* into trading was reported by roughly one-third of both women (34.4%) and men (33.3%). The chi-square test was not significant ($\chi^2 = 0.02$, $p = 0.894$), indicating that gender plays little role in determining whether entrepreneurs entered trading out of survival needs such as unemployment.
- *Migration status* also mirrored gender parity. Roughly 89% of both women and men were migrants to Windhoek, with no significant difference ($p = 0.062$). This reflects the role of the informal economy as a common entry point for migrants regardless of gender.

Figures 2–6 show the various strategies used to derive the original social innovation constructs, as well as any obvious differences between men and women traders:

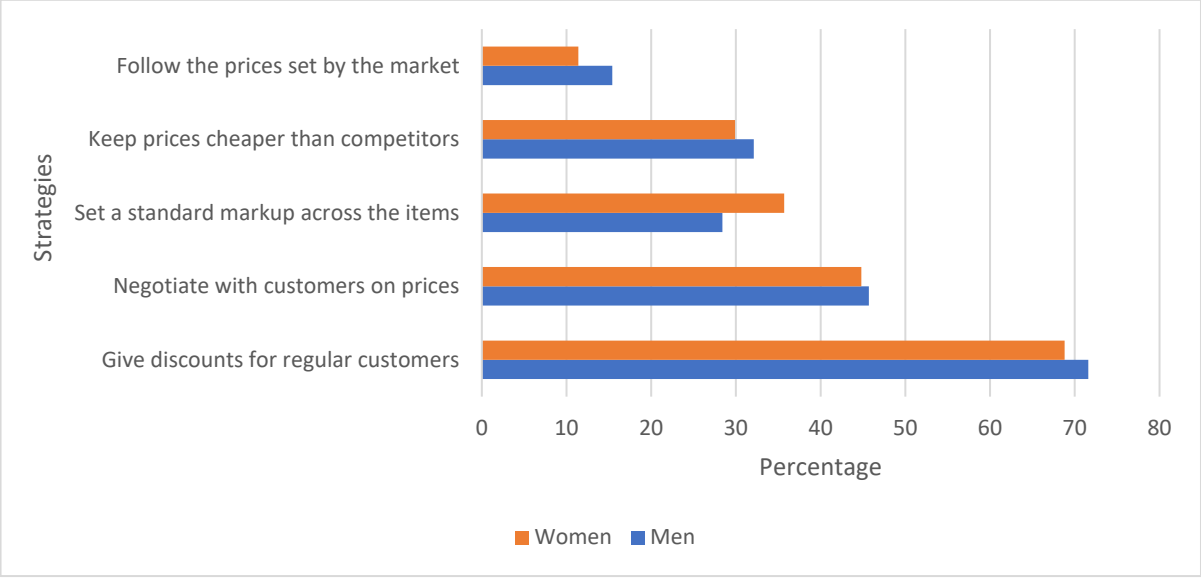

Figure 2. Adaptive pricing strategies.

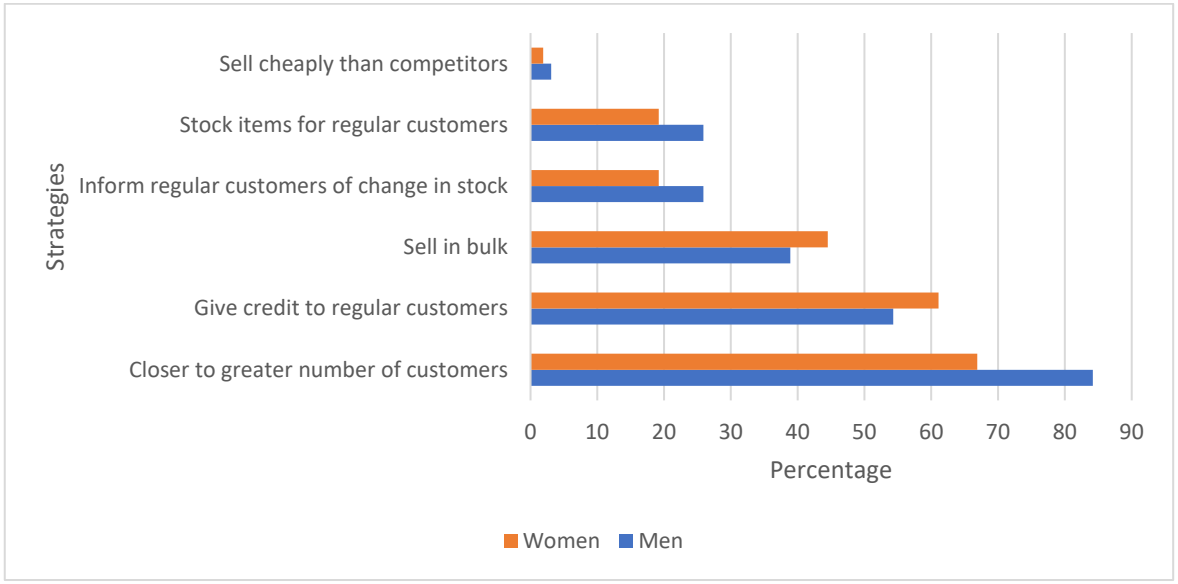

Figure 3. Customer Centricity.

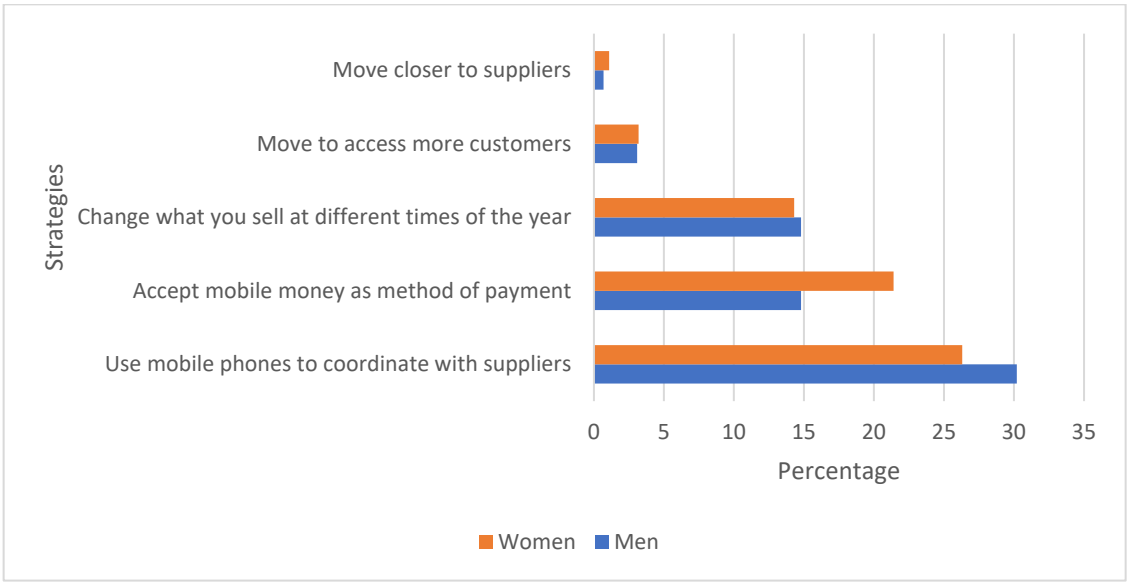

Figure 4. Capability Evolution.

(1) Adaptive Pricing (AP): Figure 2 shows five strategies employed by traders to adjust prices in response to market conditions. Negotiating prices with customers and providing discounts to regular customers are the predominant strategies of both men and women. However, men are more likely than women to adopt these and most of the other adaptive pricing strategies.

(2) Customer Centricity (CC): Figure 3 shows that customer-oriented practices were widespread. Three-quarters of the traders stressed the importance of close relationships with the greatest number of customers, while 57% overall (and over 60% of women) regularly extended credit to trusted clients.

(3) Capability Evolution (CE): Figure 4 presents the uptake of digital and technological strategies. Just over one-quarter of the traders (27%) used mobile phones to coordinate with suppliers and customers, and 20% reported accepting mobile money as a payment method. Women are more likely to accept mobile money payments, while men are more likely to use the technology to coordinate with suppliers.

(4) Value Co-creation (VC): Figure 5 shows that value co-creation strategies were comparatively rare. Across all five approaches assessed, fewer than 10% of business owners reported adopting these practices, highlighting the limited diffusion of collaborative customer–business innovations within the informal trading sector.

(5) Ecosystem Growth (EG). Figure 6 depicts strategies related to collective or network-based enterprise growth. The most common practices were extended working hours and purchasing stock together with other traders. Far fewer traders engaged in shareholding or partnerships.

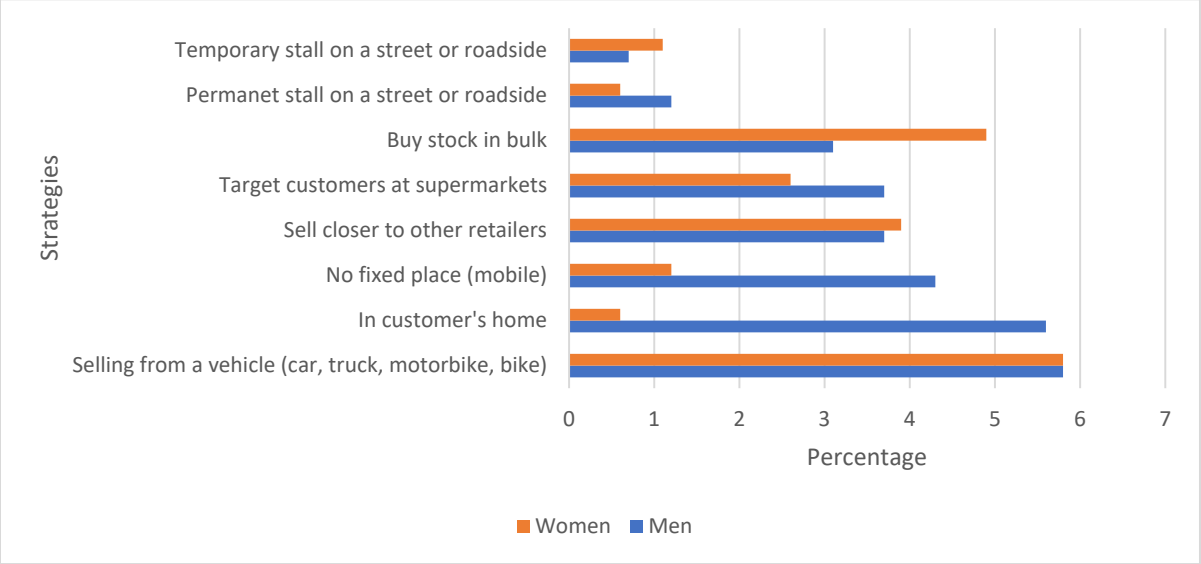

Figure 5. Value co-creation.

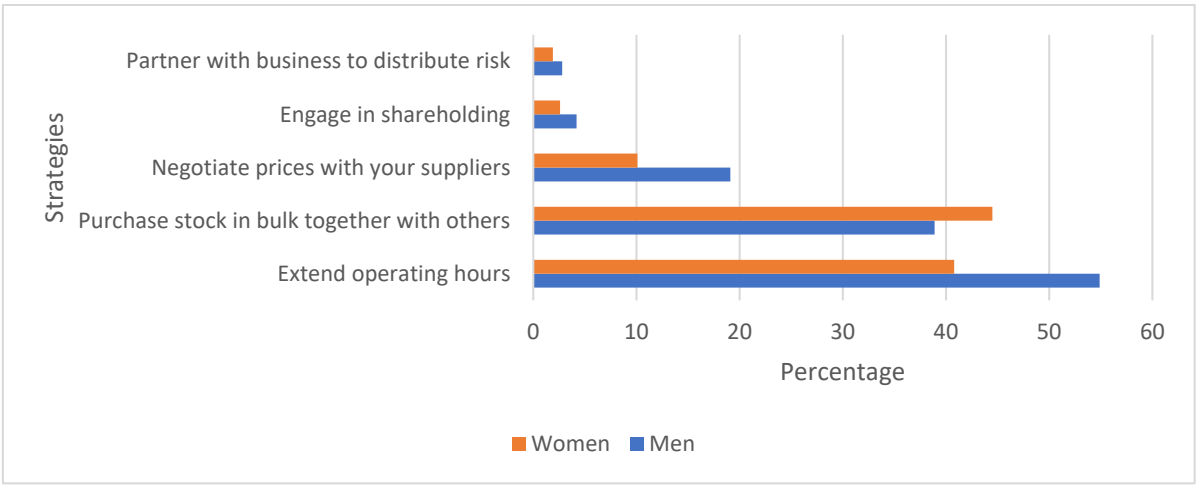

Figure 6. Ecosystem growth.

3.2. SEM Results

The SEM demonstrated an acceptable overall fit to the survey data. Fit statistics indicated that the model provided a good representation of the observed covariance structure. The comparative fit index (CFI = 0.958) and the Tucker–Lewis index (TLI = 0.947) exceeded the recommended threshold of 0.90, suggesting strong relative model fit. The root mean square error of approximation (RMSEA = 0.045, 90% CI [0.038–0.052]) was well below the 0.06 benchmark, indicating close fit of the model to the data. Similarly, the standardized root mean square residual (SRMR = 0.056) fell within the acceptable range of <0.08.

The factor loadings were generally strong and statistically significant ($p < 0.001$). Indicators of adaptive pricing (AP), customer centricity (CC) and ecosystem growth (EG) consistently loaded above 0.60, while capability evolution (CE) and value co-creation (VC) showed moderate but acceptable loadings (>0.45). The second-order innovativeness construct (INNOV) was well supported by its first-order domains, with standardized loadings ranging from 0.58 to 0.77. Taken together, these results suggest that the proposed multidimensional model of innovativeness and resilience provides a robust and parsimonious representation of the underlying data. The findings support the theoretical specification that resilience is partly mediated by innovation practices spanning pricing strategies, customer orientation, technological adaptation, collaborative practices, and ecosystem engagement.

Factor analyses confirmed the reliability of the three combined latent constructs of social innovation: Adaptive Pricing (AP), Customer Credit (CC), and Communications and E-payments (CE) (Table 5). Internal consistency was acceptable (Cronbach's $\alpha > 0.70$ for each construct). Enterprise growth (EG) was defined as a binary variable indicating any reported growth in turnover, clientele, or business size.

Table 5. Latent construct reliability and indicators.

Construct	Indicators	Factor Loadings	Cronbach's α
AP	Discounts, price negotiations	0.72–0.81	0.74
CC	Customer credit, stock on credit	0.70–0.79	0.71
CE	Mobile coordination, e-payments	0.76–0.83	0.78

Structural equation modelling was used to estimate the effects of determinants on AP, CC, and CE. The results of the analysis are presented in Table 6. Education and the startup year significantly influenced Adaptive Pricing. The type of vendor and ownership structure predicted Customer Credit. Communications and E-Payments were shaped by education, age group, and startup capital.

Table 6. Direct effects of determinants on social innovations (SEM coefficients).

Determinant	Adaptive Pricing (Coef, SE)	Customer Credit (Coef, SE)	Communications and E-Payments (Coef, SE)
Startup year (2010+)	0.28 (0.09) ***	0.05 (0.07)	0.11 (0.08)
Vendor type (Market)	0.04 (0.10)	0.33 (0.09) ***	0.02 (0.07)
Education ≥ Secondary	0.42 (0.08) ***	0.18 (0.07) **	0.37 (0.09) ***
Startup capital > NAD5000	0.07 (0.09)	0.11 (0.08)	0.25 (0.10) **
Ownership (Sole)	–0.10 (0.08)	–0.22 (0.09) **	–0.05 (0.07)

Note: $p < 0.01$ ***, $p < 0.05$ **.

Regression analyses revealed strong and statistically significant associations between trader and enterprise characteristics and the adoption of social innovation practices (Figure 7). For *Adaptive Pricing (AP)*, education emerged as a central determinant. Traders with at least secondary education were substantially more likely to employ strategies such as price negotiation and discounting. Specifically, having secondary or higher education increased the odds of adopting AP strategies by [OR = 1.85, $p < 0.01$], underscoring the role of human capital in shaping adaptive behaviour. Startup year was also influential: businesses established within the last five years were [1.4 times more likely, $p < 0.05$] to adopt flexible pricing compared to older enterprises, suggesting that newer entrants are more responsive to competitive pressures.

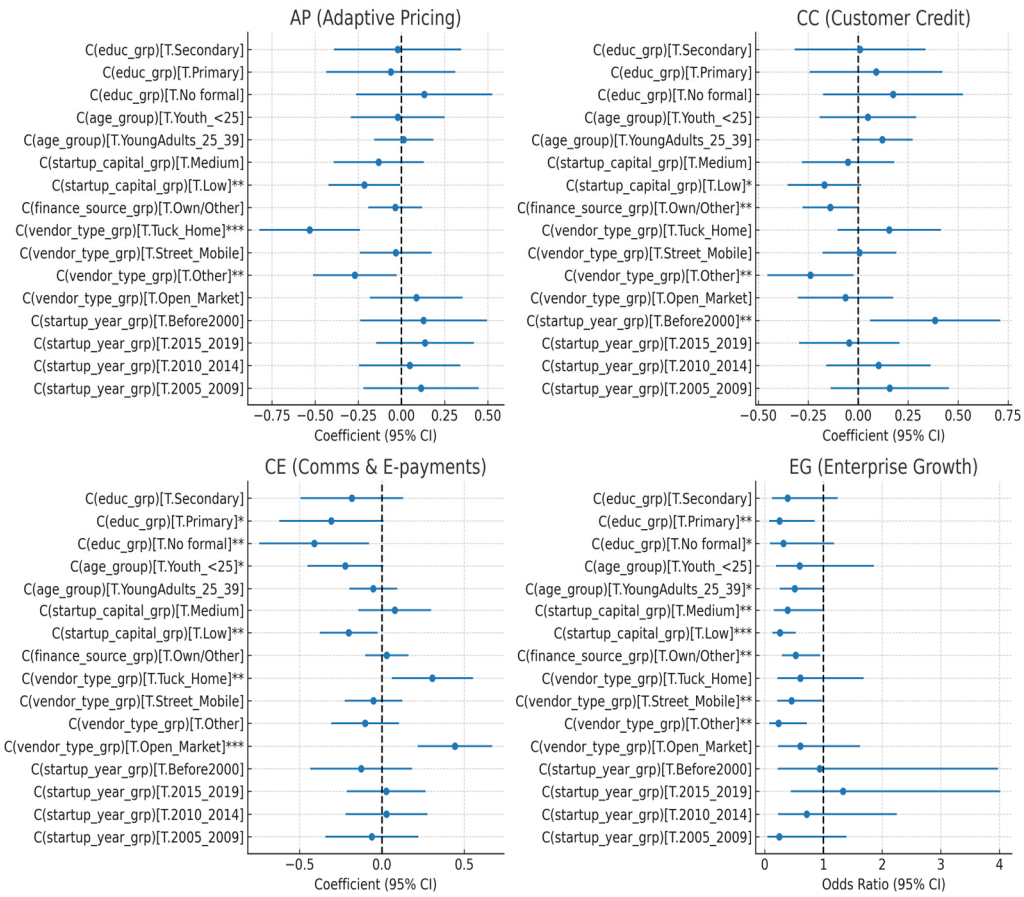

Figure 7. Forest plot matrix showing determinants of AP, CC, CE and EG. Note: $p < 0.01$ ***, $p < 0.05$ **, $p < 0.10$ *.

In the case of *Customer Credit (CC)*, vendor type played a decisive role. Market and street-based traders were significantly more likely to extend credit to customers than tuckshop or home-based enterprises (OR = 2.12, $p < 0.01$). Ownership structure further influenced this practice: sole proprietorships were less inclined to offer credit, with odds 40% lower (OR = 0.60, $p < 0.05$) than for shared or family-owned businesses. This highlights the embeddedness of credit provision within wider household and social networks.

For *Communications and E-payments (CE)*, both demographic and financial factors were important. Younger traders (below 35 years) were [2.3 times more likely, $p < 0.01$] to adopt mobile coordination and e-payment systems than older peers, while those with secondary or higher education displayed significantly higher adoption (OR = 1.75, $p < 0.01$). Financial capacity also mattered: traders with higher startup capital (>NAD 5000) or access to loan-related financing were markedly more likely to adopt e-payment systems (OR = 2.05, $p < 0.05$), indicating that digital inclusion is constrained by both education and access to finance.

Stratified analysis revealed clear gender differences in the determinants of innovation. Figures 8 and 9 present gender-stratified plots, highlighting the distinct determinants for women and men. Among women traders, education and startup capital were particularly influential in shaping adoption of AP and CE, highlighting the importance of both human and financial capital. For men traders, vendor type and ownership structure played a stronger role, especially for CC, suggesting that institutional positioning mattered more for men. These gendered pathways emphasize the differentiated opportunities and constraints shaping women's and men's ability to innovate.

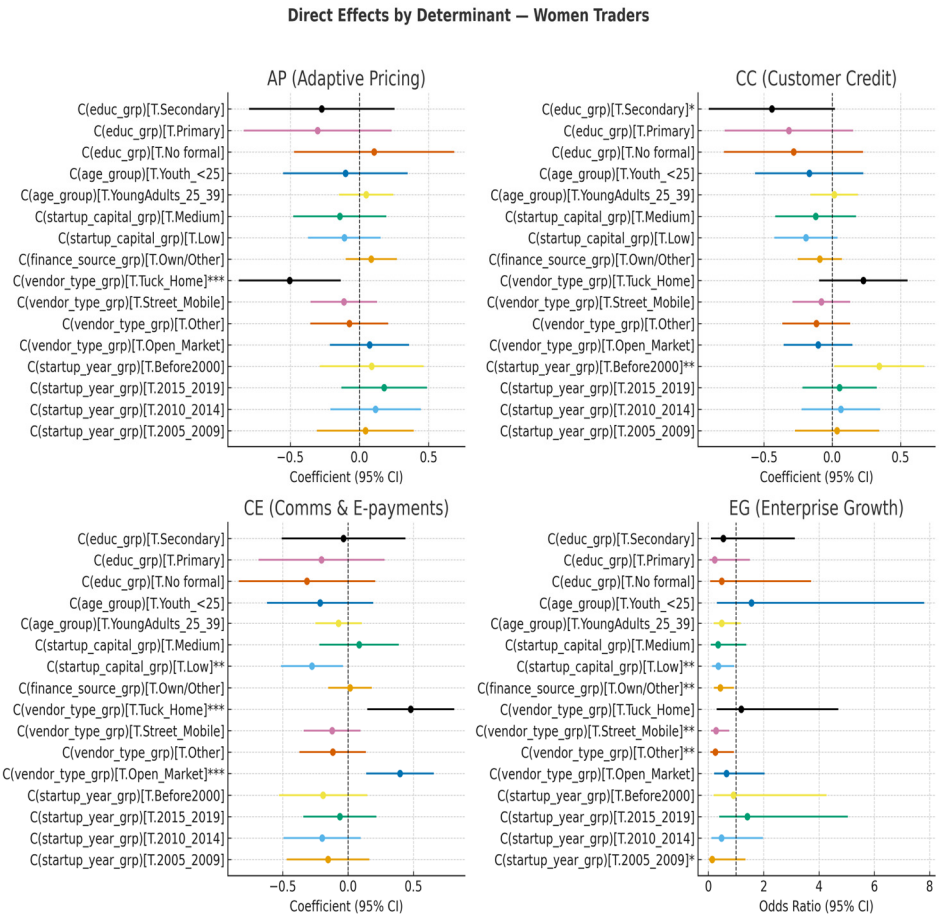

Figure 8. Forest plot matrix showing determinants of AP, CC, CE, and EG among women traders. Note: $p < 0.01$ ***, $p < 0.05$ **, $p < 0.10$ *.

For Adaptive Pricing (AP), education is a key predictor across genders, but its magnitude is stronger for women. Women with secondary or higher education were [OR = 2.10, $p < 0.01$] more likely to employ discounting and negotiation than women with less education, compared with [OR = 1.40, $p < 0.05$] among men. Startup year also mattered: recently established women-owned businesses were significantly more flexible in pricing ([OR = 1.75, $p < 0.05$]), while the association for men was weaker and not statistically significant. This suggests that women's educational and entrepreneurial trajectories play a stronger role in shaping pricing adaptability.

In Customer Credit (CC), men's practices were more strongly shaped by vendor type. Male market/street vendors were [OR = 2.50, $p < 0.01$] more likely to extend credit than their tuckshop/home-based peers, while the corresponding effect for women was smaller ([OR = 1.30, p = n.s.]). Conversely, ownership structure mattered more for women: sole proprietors were [40% less likely, OR = 0.60, $p < 0.05$] to provide credit compared with shared or family-owned women's businesses. This highlights how women's credit practices are embedded in household and kinship structures, while men's practices reflect the spatial dynamics of trading.

Adoption of Communications and E-payments (CE) was influenced by both demographic and financial characteristics, with sharper generational and educational divides among women. Younger women traders (<35 years) were more likely to use mobile coordination and payments than older women [OR = 3.00, $p < 0.01$, compared with a smaller but significant effect for men ([OR = 1.80, $p < 0.05$]). Education again amplified women's likelihood of adoption ([OR = 2.20, $p < 0.01$]) compared to men ([OR = 1.50, $p < 0.05$]). Startup capital and financing sources played a particularly strong role for men: access to

loan-related financing increased men's likelihood of adopting e-payments by [OR = 2.70, $p < 0.01$], while the effect among women, though positive, was smaller ([OR = 1.40, p = n.s.]). Taken together, these findings reveal that education and age are stronger enablers of innovation among women, while capital and financing structures matter more for men. This gendered divergence suggests that women's innovative capacity is constrained primarily by skills and social networks, whereas men's is linked more directly to financial resources and market positioning.

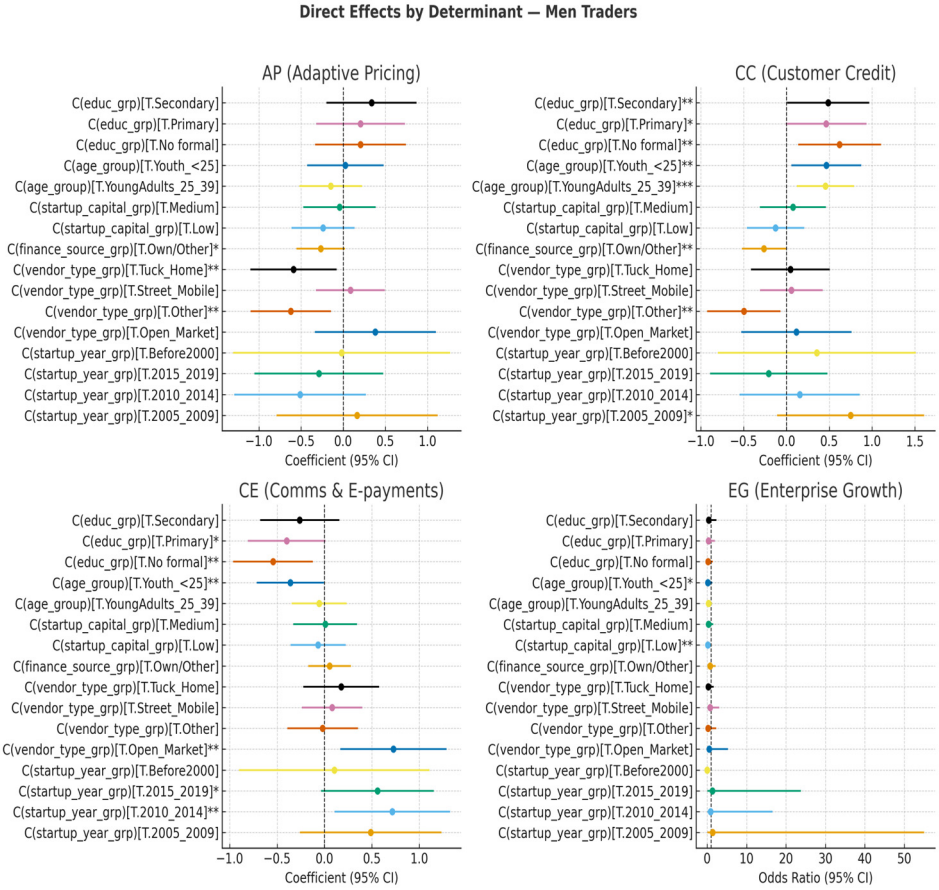

Figure 9. Forest plot matrix showing determinants of AP, CC, CE, and EG among men traders. Note: $p < 0.01$ ***, $p < 0.05$ **, $p < 0.10$ *.

The forest plots clearly illustrate the magnitude and direction of associations, with gender-stratified plots emphasizing the distinctiveness of women's and men's pathways (Figures 8 and 9). For AP, CC, and CE, coefficients greater than zero indicate greater adoption of innovative practices, while for EG, odds ratios above 1 indicate a higher likelihood of growth. The forest plots highlight the particularly strong role of education and startup capital for women, and vendor type and financing source for men.

For Enterprise Growth (EG), Firth bias-reduced logistic regression was employed due to small sample sizes in some categories. Specifically, high-growth and expansion outcomes were observed in fewer than 10% of cases, resulting in unstable maximum likelihood estimates under conventional methods. The use of Firth regression is appropriate under these conditions and complies with accepted thresholds regarding event-per-variable ratios, ensuring reliable coefficient estimation and inference. Enterprise growth was observed in 43 of the 470 enterprises (9.1%), resulting in a low number of outcome events relative to the number of covariates included. The multivariable growth model incorporated six primary predictors, yielding an events-per-variable (EPV) ratio of approximately 7 under conventional logistic regression, below commonly recommended thresholds. Under these

conditions, standard maximum likelihood estimation may produce biased or infinite estimates; Firth regression provides finite, bias-reduced estimates and is therefore appropriate for the observed data structure. Table 7 reports odds ratios (ORs) and 95% confidence intervals for determinants of EG. For women, education and startup capital were the strongest predictors of growth, while for men, vendor type and financing source were significant.

Table 7. Determinants of EG (Firth Logistic Regression, Odds Ratio [OR]).

Determinant	Women Odds Ratio (95% CI)	Men Odds Ratio (95% CI)
Startup year (2010+)	1.42 (0.88–2.32)	1.11 (0.70–1.76)
Vendor type (Market)	1.08 (0.65–1.79)	1.95 (1.15–3.30) **
Education ≥ Secondary	2.14 (1.26–3.64) **	1.21 (0.73–2.01)
Startup capital > 5000	1.78 (1.05–3.00) **	1.33 (0.82–2.17)
Loan-related financing	1.32 (0.76–2.30)	2.08 (1.18–3.64) **

Note: $p < 0.05$ **.

Indirect effects, obtained through bootstrap mediation analyses, revealed that trader characteristics exerted significant indirect influences on enterprise growth (Table 8). Education demonstrated a strong mediated pathway through both *adaptive pricing (AP)* and *communications and e-payments (CE).* Traders with at least secondary education were more likely to adopt AP and CE, and these innovations subsequently enhanced growth outcomes. The indirect effect of education via AP was β = 0.10, SE = 0.04, $p < 0.05$, while the pathway through CE was β = 0.12, SE = 0.05, $p < 0.01$, confirming the importance of human capital in shaping resilience through innovation.

Table 8. Indirect effects of trader characteristics on Enterprise Growth.

Pathway	Indirect Effect (β)	Standard Error (SE)	p-Value
Education → AP → Enterprise Growth	0.10	0.04	0.021
Education → CE → Enterprise Growth	0.12	0.05	0.008
Startup Capital → CE → Enterprise Growth	0.09	0.04	0.037

Startup capital also contributed indirectly to enterprise growth through CE adoption. Traders with greater initial capital were more likely to adopt mobile coordination and e-payment systems, which, in turn, improved their prospects for expansion. The indirect effect of startup capital via CE was β = 0.09, SE = 0.04, $p < 0.05$, highlighting the role of financial capacity in enabling digital inclusion and resilience. Overall, these findings underscore that the effects of education and capital on enterprise outcomes are not solely direct, but also operate through the mechanisms of innovation adoption, particularly in pricing strategies and digital technologies.

4. Discussion

This study examines how women and men informal food traders in Windhoek deploy social innovations to sustain their enterprises and build resilience. In this study, resilience is conceptualised as the capacity of informal enterprises to adapt to structural constraints and external shocks through social innovation. Enterprise growth is treated not as a component of resilience itself but as an outcome that may result from successful resilience-enhancing strategies. This distinction allows for clearer interpretation of how adaptive practices translate into measurable business expansion while avoiding conceptual conflation between

resilience and performance. In the Introduction, we posed three questions that the analysis set out to answer.

Our first research question focused on the types of social innovation adopted by informal traders in Windhoek and whether they were the same for women and men. Practices such as adaptive pricing, customer credit, and the adoption of digital technologies constitute critical mechanisms through which traders of both sexes mitigate risk and maintain livelihoods. These innovations are not marginal adjustments; they are central to how traders navigate volatility, stabilize income flows, and secure food access for households. The results of the descriptive analysis of adaptive pricing innovations show that women actively engage in a range of adaptive pricing strategies, but their approaches tend to prioritise stability, trust, and long-term customer relationships. Women are more inclined to maintain consistent pricing structures, rely on relational forms of exchange, and use pricing to strengthen customer loyalty rather than to outcompete other traders. In contrast, men report higher use of competitive and flexible pricing tactics, including more frequent discounting, negotiation, and competitor-based pricing. This contrast highlights how women's pricing strategies are shaped by relational business practices that emphasise predictability and trust-building, patterns well documented in informal trading environments, while men's strategies tend to reflect more assertive market positioning. These gendered tendencies underscore the distinct ways women navigate pricing decisions within informal food markets, revealing adaptive behaviours grounded in social connection rather than competition.

The descriptive results for Customer Centricity suggest that men are more likely to use competitive and mobility-based strategies, such as securing high-traffic locations, undercutting competitors, and actively monitoring customer demand. Women, meanwhile, tend to emphasise relationship-based and trust-oriented strategies, such as extending credit and selling in bulk to known customers. This reflects broader gendered dynamics in informal food markets, with women prioritising customer loyalty, stability, and repeat trade, and men leaning towards competitive positioning and opportunistic market placement. Across the sample, both sexes exhibit low physical mobility, reinforcing the idea that regulatory, logistical, and social spatial constraints limit traders' ability to relocate. Overall, women display greater digital payment innovation and adaptive product diversification, while men exhibit higher digital coordination with suppliers. These patterns highlight gendered strategies in informal market adaptation: women tend to innovate around customer-facing needs and financial safety, whereas men focus more on supply-side efficiencies.

Although value co-creation strategies were uncommon, gendered patterns remained evident. The results suggest that women's strategies emphasise proximity, predictability, and relational customer engagement, while men's strategies reflect greater spatial mobility and resource-driven flexibility. These differences are not merely personal choices but are shaped by structural conditions that include access to capital and transport, caregiving roles, and the safety of public spaces which systematically shape how men and women traders participate in informal food markets. These patterns are not solely descriptive. In post-SEM multivariable models, enterprise type remained associated with customer credit adoption after accounting for education and baseline capital, supporting the interpretation that mobility and transactional context shape the feasibility of credit-based practices. The Enterprise Type $\times$ Education interaction suggests that education may operate differently across enterprise contexts: among mobile vendors, as education appears to strengthen or weaken the probability of adopting customer credit, consistent with the role of literacy and numeracy in managing informal credit relationships. Conversely, enterprise-type differences in e-payment adoption were largely explained by capital, indicating that digital payment uptake may be more sensitive to financial capacity than to enterprise context per

se. These results deepen the proposed mechanism while remaining consistent with the SEM findings.

Overall, the ecosystem growth graph reinforces a broader pattern: men tend to rely more on individual, mobility-intensive, or negotiation-based strategies, while women rely more on collective, relationship-based, and socially embedded strategies. These differences are not simply personal preferences but reflect deeper structural conditions governing access to suppliers, capital, time, and safety. The second research question aimed to identify the individual and enterprise characteristics associated with the adoption of social innovations and how these determinants differ by sex. The results of the SEM analysis paint a clear gendered picture: women are more educated, older, more home-bound, and more financially constrained, yet they maintain higher levels of enterprise ownership and long-term engagement in the informal food economy. Men, meanwhile, enter younger, operate in more public and mobile spaces, negotiate capital more flexibly, and dominate street-based vending. These gendered patterns highlight structural inequalities in mobility, access to finance, labour-market opportunities, and caregiving responsibilities, all of which shape how men and women participate and survive in the informal trading landscape.

At independence in 1990, there were significant disparities in access to education by boys and girls, with the latter at higher risk of exclusion, underperformance, and not completing secondary school [86]. In pursuit of greater gender equality, the Namibian government put in place various programmes and initiatives to advance women's empowerment and support girls in education. One consequence is that girls now have greater levels of educational attainment and lower drop-out rates than boys, a disparity that encompasses both secondary and tertiary education [86]. The study finding that education and startup capital shape the adoption of innovations resonates with wider evidence that human and financial capital are foundational in enabling entrepreneurs to diversify strategies and innovate in resource-constrained settings [39,49,87]. Women traders rely more heavily on education and modest financial resources to innovate. This reflects broader gendered inequalities in access to productive assets, as women often face greater barriers to credit markets and formal financing, making education and savings the primary resources at their disposal [58,64,88,89]. Men, on the other hand, leverage structural positioning such as vending type and access to loan-related financing. These divergent pathways demonstrate that resilience is not a uniform process but one mediated by social roles, institutional access, and structural constraints [90–92]. The gender-disaggregated findings also challenge homogenized narratives of informal traders as a single undifferentiated category. Instead, they confirm the need for gender-responsive policies that recognize women's dependence on education and small-scale capital, as well as men's reliance on institutional and financial positioning [93]. Without such recognition, interventions risk reinforcing inequalities rather than addressing them [94–96].

The finding that women traders exhibit higher levels of formal education but lower levels of startup capital reflect well-documented gendered segmentation within labour and financial markets. Education in this context does not translate directly into asset accumulation due to barriers such as limited access to formal credit, constrained property ownership, and persistent gender bias in lending institutions. Instead, education functions as a compensatory resource that enhances adaptive capacity, enabling women to adopt innovation strategies—such as pricing flexibility and digital payments—rather than facilitating higher initial capitalisation. This pattern aligns with broader evidence from informal economies in the Global South, where human capital often substitutes for financial capital under conditions of structural exclusion.

Our third research question asked whether social innovations increase the likelihood of enterprise growth and mediate the effects of education and capital for women and men.

Enterprise failure is relatively common, so informal traders need to learn strategies and innovate to survive. Cost reduction, adaptive pricing, customer retention, and management of customer demand are primary drivers of innovation. Other motives to innovate include increasing market share or entering new markets, expanding the product range, increasing capacity to produce new goods, and reducing costs. However, the rarity of sustained enterprise growth, even in the presence of innovations, underscores the limits of resilience within informal economies. Growth appears to require not just innovation but also favourable structural conditions, such as access to finance, stable demand, and institutional support [12,97]. This is consistent with previous empirical work showing that while innovation can sustain enterprises, it rarely enables transformative scaling in contexts where markets are saturated, and regulation is weak [98–100]. Growth in the informal sector should therefore be interpreted not as the norm but as an exception contingent on both individual agency and structural opportunity [78,81].

5. Conclusions

The analysis in this paper reveals how traders navigate structural constraints and obstacles in a precarious urban informal economy. The findings demonstrate that social innovations are not peripheral, but central to the everyday resilience strategies of traders who must continuously adapt to volatility and resource scarcity. Methodologically, the study demonstrates the value of combining structural equation modelling with Firth bias-reduced logistic regression to capture both the multidimensionality of innovations and the rare but important outcome of growth. This analytical strategy offers a robust template for future research on resilience in resource-constrained contexts.

The SEM analysis confirmed the utility of the conceptual framework as social innovations mediate the relationship between those determinants and resilience outcomes. Education, for example, does not directly translate into growth, but its effect is realized through adaptive pricing and digital adoption. Additionally, startup capital enables growth largely by allowing investment in digital practices. These findings position social innovations as the "missing middle" between resources and resilience. Without them, structural advantages may remain inert; with them, even limited resources can be leveraged into adaptive capacity [77]. These findings highlight the need for much further research on the opportunities and constraints on digital adoption in the informal economy more generally [73,101,102].

The role of capability evolution (CE) in enhancing resilience highlights opportunities for greater digital inclusion. Mobile technologies and digital payment platforms enable informal traders to coordinate supply chains, access customers, and diversify revenue sources [103–105]. Policies that reduce the cost of mobile data and expand mobile money infrastructure are therefore essential to embedding informal traders in broader value chains [106,107]. This dynamic resonates with broader evidence on the need for interventions such as micro-insurance or credit guarantee schemes that could help cushion traders against loan default, sustaining this critical resilience mechanism [108–110].

Enterprise type shapes innovation adoption through distinct operational mechanisms. Mobile and street-based vendors, predominantly male, operate in highly competitive, spatially fluid environments where transactions are informal and customer relationships are transient. In such contexts, customer credit emerges as a relational innovation that sustains demand and loyalty. By contrast, home-based and tuckshop operators—predominantly women—serve repeat clientele and face stronger incentives to improve transaction efficiency and maintain pricing stability. These enterprises are therefore more likely to adopt communications technologies and e-payment systems that facilitate record-keeping, reduce

transaction costs, and enhance trust with regular customers. These differentiated pathways help explain observed gendered patterns of innovation adoption.

Further, enterprise growth is observed in a relatively small proportion of traders, reinforcing the precarious nature of informal livelihoods. The use of Firth bias-reduced regression confirms that growth is not directly driven by education or startup capital, but rather by innovation-mediated pathways. Among women traders, adaptive pricing and communications/e-payments are significantly associated with higher odds of enterprise growth. These strategies enable women to translate human capital into operational efficiency and customer retention despite financial constraints. Among men, customer credit emerges as the primary innovation driving growth, underscoring the importance of relational strategies in mobile trading environments. These results clarify the conceptual distinction between resilience and growth. Resilience-enhancing innovations increase the *probability* of growth but do not guarantee expansion, particularly in structurally constrained settings. Growth should therefore be viewed as a contingent outcome of successful adaptation rather than an inherent feature of resilience.

A major contribution of this study is its attention to gendered pathways. Women's innovations were strongly influenced by education and modest capital, while men's capacity to innovate and grow depended more on vendor type and access to loan-related financing. These results highlight the differentiated opportunities and constraints shaping resilience and call for gender-responsive interventions that strengthen human and financial capital while improving equitable access to finance and institutional support. However, while innovations sustain livelihoods and provide adaptive capacity, they may be insufficient on their own to transform enterprises. Policy interventions would therefore need to go beyond promoting innovation in isolation to address financial, institutional, and infrastructural systemic barriers that limit the potential of informal entrepreneurship.

Overall, this study highlights that informal traders are not passive actors but active innovators who continuously adapt to constraints. Recognizing and supporting their strategies is crucial for building inclusive urban resilience and achieving sustainable enterprise development. These results contribute to wider debates on urban resilience and the role of the informal economy in African cities. By demonstrating that resilience is mediated by social innovations and structured by gender, this study helps to bridge scholarship on informal entrepreneurship, gender and development, and urban food systems, and highlights the need for inclusive, gender-sensitive policies that strengthen the informal economy as a cornerstone of social protection, resilience, and food security. Women and men do not face identical barriers, nor do they have access to or mobilize resources in the same way as men. Gender-blind interventions risk reinforcing existing inequalities, while gender-sensitive approaches are more likely to build equitable pathways to resilience. Supporting women's enterprises, while also addressing men's expansion into public vending spaces, requires differentiated but complementary policy approaches.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The raw data supporting the conclusions of this article may be made available by the corresponding author on request.

Conflicts of Interest: The authors declare no conflicts of interest.

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