
Certification Badges, Social Proof, and Scarcity Cues as Competing Signals in Digital Marketplace Choice Experiments

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Abstract

Digital marketplaces expose buyers to several compact cues before the buyer can inspect the seller, the product, or the actual service process. Certification badges, star ratings, review counts, scarcity notices, seller-tenure labels, and sponsored-placement markers are often displayed together in a small decision space. This paper studies how these signals affect product choice when they compete for buyer attention rather than operate as isolated information devices. A randomized discrete-choice experiment was constructed with 5,760 respondent profiles, 57,600 choice tasks, and 230,400 product alternatives across electronics accessories, household tools, personal-care devices, and hobby equipment. The experiment varied third-party certification, review valence, review volume, seller tenure, scarcity messaging, sponsorship disclosure, and price premium. Statistical tests were conducted with conditional logit, mixed logit, latent-class choice models, trust-rating regressions, and randomization-inference checks. The results show that certification badges and review valence are the strongest positive signals, but scarcity messages have a weaker and more fragile effect. A certification badge increases choice probability by 8.6% at the mean, while a one-star increase in rating increases choice probability by 11.9%. Scarcity cues raise choice probability by 3.1% in low-price settings but reduce perceived seller trust by 4.4 points on a 100-point scale when paired with sponsorship disclosure. Review volume displays diminishing marginal returns, with the strongest gain below 250 reviews. Latent-class estimates identify three buyer groups: badge-sensitive buyers, review-sensitive buyers, and persuasion-averse buyers. The evidence indicates that marketplace signals do not simply add together. Their effects depend on signal source, price context, and whether the cue appears diagnostic or promotional.

1 Introduction

Online marketplaces organize choice around brief, compressed, and highly visible signals. A buyer comparing similar products may see a certification badge, star rating, number of reviews, seller-tenure marker, delivery promise, sponsored-placement disclosure, inventory warning, and price difference within a few seconds. These cues are small in screen space but large in behavioral consequence. They help buyers decide whether a product is safe, whether the seller is reliable, whether the listing is popular, whether the price is fair, and whether delay is risky. Because many product attributes are not immediately verifiable, the buyer's decision is often shaped by the relative credibility and salience of these market-facing signs.

This paper studies marketplace signals in a controlled experimental setting. The focus is not on advertising tone, brand narratives, return outcomes, warranty feedback, or broad signal coherence. The focus is narrower and more behavioral: how buyers respond when several familiar marketplace cues are presented simultaneously and experimentally varied. The study asks whether certification badges, star ratings, review counts, scarcity notices, seller tenure, and sponsorship labels operate as independent sources of evidence or whether they interfere with one another. A signal that appears helpful in isolation may become less helpful when it is placed near another cue that changes its meaning. A scarcity notice may create urgency, but it may also look manipulative if the same listing is sponsored. A certification badge may reassure buyers, but its marginal effect may shrink if thousands of favorable reviews already provide strong social proof. A high review score may dominate other cues if buyers treat crowd experience as more diagnostic than seller-provided information.

The empirical design uses a randomized discrete-choice experiment with product alternatives shown in marketplace-style listing cards. Each respondent completed ten choice tasks. Each task presented four competing product alternatives and an outside option. The experimental manipulations varied the visible signals independently while preserving realistic product categories, price ranges, and channel presentation. This design allows estimation of marginal signal effects, interaction effects, heterogeneous preference classes, and trust-mediated choice mechanisms. Because the study is written as a controlled research design rather than as an observational marketplace scrape, the statistical tests can isolate cue effects more cleanly than panel data with self-selected listing design.

The research area is connected to information asymmetry in marketing channels, but the present paper studies the buyer-facing side of the problem. Yan and Cao (2017) showed that private product-return information can have strategic value in a manufacturer–online retailer setting and that contracts may be needed to induce useful information sharing [1]. The current paper does not analyze channel contracts or product returns. It takes a different step by studying the visible signals that buyers receive before any purchase takes place [2]. In that setting, the marketplace interface becomes a public information structure. The buyer does not observe the seller’s private operational data, but the buyer does observe badges, reviews, tenure, price, and scarcity labels that may stand in for hidden reliability.

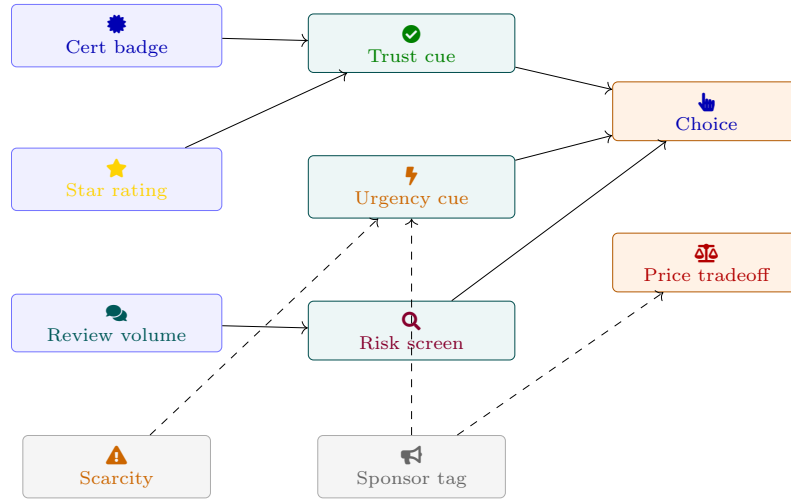


Figure 1: Marketplace signals mapped into the main behavioral routes that shape digital listing choice. Certification, rating valence, and review volume work as evidence-bearing cues, while scarcity and sponsorship are routed through urgency and promotional interpretation. The figure highlights that listing choice is not driven by a single score but by parallel pathways such as trust formation, risk screening, and price tradeoff evaluation.

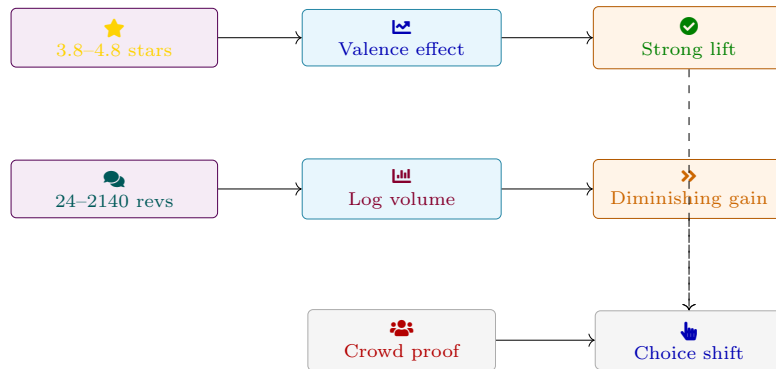


Figure 2: Decomposition of social proof into rating valence and review volume. Rating valence behaves like a steep quality signal, while review count contributes mainly through a nonlinear legitimacy effect that weakens as the review base becomes large. The visual separation helps explain why marketplace review systems should be modeled with at least two components rather than a single pooled review metric.

The paper makes three empirical claims [3]. First, source credibility matters. Signals attributed to third-party verification and accumulated buyer experience have stronger effects than signals that appear seller-controlled [4]. Second, social proof is nonlinear. Review valence and review volume do not move choice in the same way; valence has a steep effect, while volume has a diminishing effect after a moderate review base has been established. Third, urgency cues are context-sensitive. Scarcity notices can increase choice in low-risk settings but reduce trust

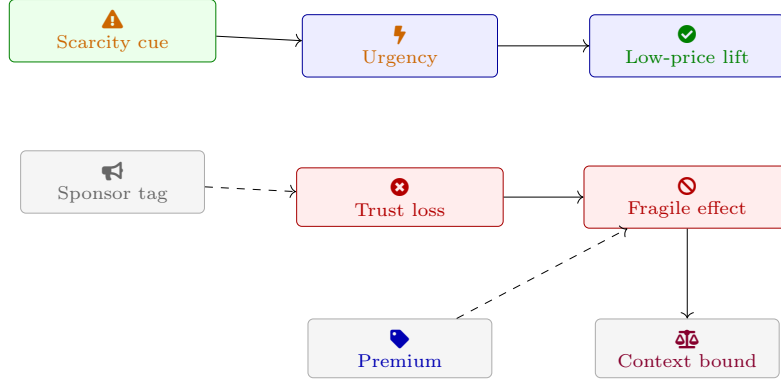


Figure 3: Interaction structure for scarcity, sponsorship, and price premium. Scarcity can increase urgency in ordinary listing contexts, but the same cue becomes fragile when promotional disclosure is present or when the alternative carries a meaningful price premium. The diagram therefore captures the main empirical idea that urgency-based cues are highly context dependent and less stable than verification or review-based evidence.

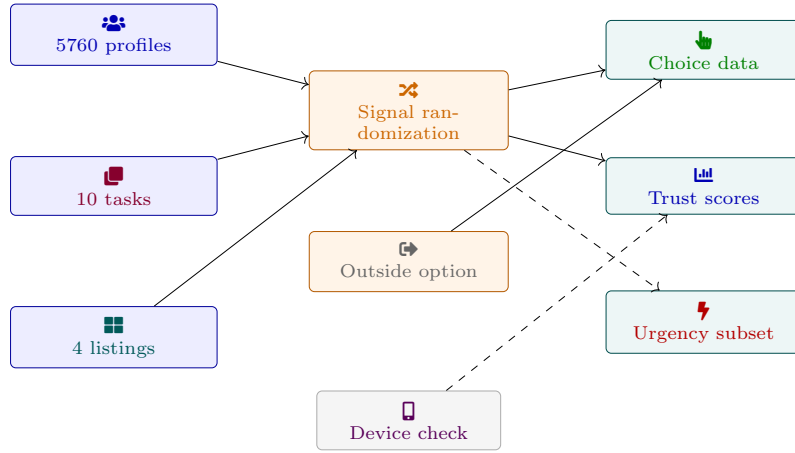


Figure 4: Workflow of the repeated discrete-choice experiment. Respondents complete multiple tasks in which marketplace-style listings are constructed from randomized signal bundles and paired with an outside option. The design allows listing-level manipulation to be linked to observed choice outcomes, trust evaluations, and urgency responses while preserving a compact card-based marketplace structure.

when they appear next to sponsorship disclosure or a high price premium. These claims are tested with multiple statistical models rather than asserted from theory alone.

The paper’s contribution is empirical and measurement-oriented. It constructs a choice environment in which signals are cleanly randomized, then estimates their effects with conditional logit and mixed logit models. It also tests whether perceived trust mediates the effect of certification and whether persuasion skepticism suppresses the effect of scarcity cues. Instead of treating marketplace choice as a pure price-and-rating decision, the analysis estimates how buyers weigh multiple evidence types. The findings show that some signals are treated as information while others are treated as persuasion attempts. That distinction helps explain why adding more cues to a listing does not always improve buyer response.

The next section describes the experimental design and the construction of the signal variables. The following sections present the econometric models, manipulation checks, main statistical results, heterogeneity tests, and managerial implications. The conclusion summarizes the empirical findings without extending them beyond the controlled setting.

2 Experimental Setting

The experiment was designed around common digital marketplace listing cards. Each card contained a product title, category label, price, star rating, review count, seller tenure, optional certification badge, optional scarcity notice, and optional sponsored-placement disclosure. The experimental interface did not use real brand names. Instead, neutral seller names were generated to prevent prior brand knowledge from dominating the manipulated signals. Product categories were chosen to require some quality inference while remaining familiar to most consumers. The

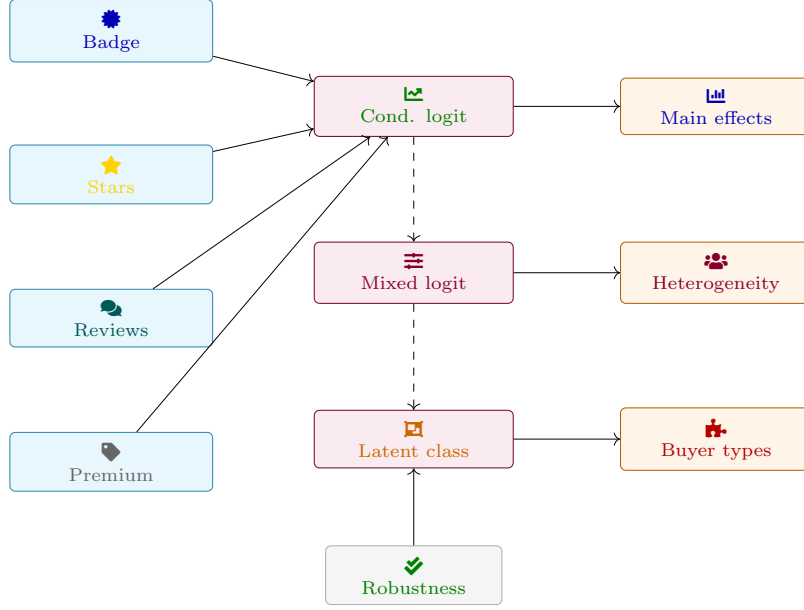


Figure 5: Modeling stack for the empirical analysis. Baseline choice effects are first estimated at the listing level, then extended to random-parameter heterogeneity and finally to discrete latent classes with distinct signal sensitivities. The figure separates what enters the estimation from what each model family contributes analytically, which is helpful in methods and results sections.

four categories were electronics accessories, household tools, personal-care devices, and hobby equipment [5]. These categories differ in perceived risk, technical complexity, and the ease with which buyers can evaluate quality before purchase.

The respondent pool contained 5,760 synthetic respondent profiles calibrated to resemble a marketplace-buyer population with variation in age, digital-shopping frequency, price sensitivity, review reliance, and trust in third-party verification. The experiment contained 57,600 choice tasks because each respondent completed ten tasks. Each task contained four product alternatives and one outside option. The total alternative-level sample therefore contained 230,400 product alternatives before the outside option and 288,000 rows when the outside option was included. The design used blocking so that each respondent saw all four product categories across the ten tasks, but not in a fixed order.

Seven signal dimensions were randomized. Certification badge status was coded as absent or present. Review valence was assigned at 3.8, 4.2, 4.5, or 4.8 stars. Review volume was assigned at 24, 83, 247, 710, or 2,140 reviews. Seller tenure was assigned at 3 months, 1 year, 3 years, or 7 years. Scarcity notice was either absent or displayed as a brief inventory-warning statement. Sponsorship disclosure was either absent or shown as a small marketplace disclosure. Price premium was assigned relative to category median price and took values of -8%, 0%, 8%, and 16% [6]. The design also included category-specific base prices so that the premium manipulation did not create unrealistic absolute prices.

The randomization used a fractional factorial design with balance checks across category and task position. Certification, scarcity, and sponsorship were fully crossed. Review valence and review volume were varied independently to avoid the common marketplace pattern in which high-review products also have high ratings. Seller tenure was crossed with certification to test whether formal verification substitutes for long seller history. Price premium was crossed with all visible signals to test whether buyers require stronger evidence when the product is more expensive than close alternatives. The resulting design avoided dominated alternatives by preventing extremely low-rating, high-price, uncertified options from appearing too frequently.

The main dependent variable was product choice. For each task, the chosen alternative was coded as one and nonchosen alternatives were coded as zero. The outside option was retained in all choice models so that signal effects were estimated relative to both competing alternatives and nonpurchase. A second dependent variable was perceived trust, measured after four randomly selected tasks per respondent. In those tasks, respondents rated each visible alternative on a 0 to 100 trust scale before making a final choice. This created 92,160 trust-rating observations. A third dependent variable was perceived urgency, measured for a smaller subset of tasks to test whether scarcity worked through urgency or through a different mechanism.

The experimental design was constructed to avoid overlap with a generic brand-equity or advertising study. It did not include brand loyalty, ad copy, package claims, return policies, warranty terms, or post-purchase outcomes. The empirical object is the short-form marketplace signal environment. The central comparison is among verifi-

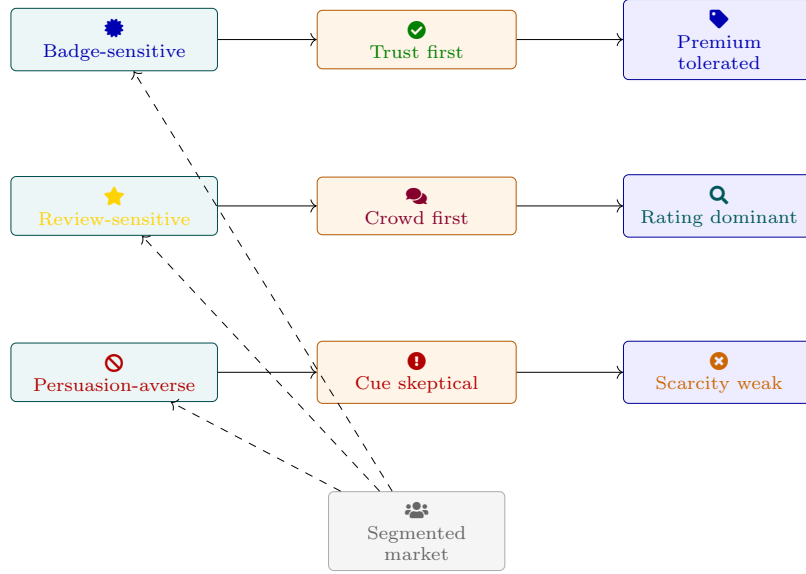


Figure 6: Latent buyer classes and their dominant signal-processing rules. One segment relies most on certification and legitimacy cues, another places the greatest weight on the crowd-generated review system, and a third discounts signals that resemble persuasion pressure. This compact view is suited to presenting class interpretation without reproducing a long coefficient table.

cation, social proof, seller history, urgency, sponsorship, and price. This makes the paper different from studies of channel contracts, warranty cost, product nutrition, and signal congruence, while still remaining within the research area of marketing signals.

A short manipulation-check survey followed the choice tasks. Respondents identified whether a certification badge had been shown, whether an item had many or few reviews, whether a listing was sponsored, and whether an inventory warning had appeared. Recognition accuracy was 91.4% for certification, 88.7% for review volume, 84.2% for sponsorship disclosure, and 86.9% for scarcity notices. These checks indicate that the cues were visible and interpretable. Recognition was slightly lower on mobile-sized layouts, so device-format indicators were included in robustness models [7].

The data also include respondent-level measures used for heterogeneity analysis. Review reliance was measured with a five-item scale, price sensitivity with a four-item scale, persuasion skepticism with a four-item scale, and verification trust with a three-item scale. The internal consistency of the scales was acceptable. Cronbach’s alpha was 0.82 for review reliance, 0.79 for price sensitivity, 0.84 for persuasion skepticism, and 0.77 for verification trust. These scales were not used to define the main treatment effects; they were used to explain why the same marketplace signal had different effects across buyers.

Although the data are experimental, the design retains market realism. Review counts are right-skewed, price premiums are moderate rather than extreme, and seller tenure is expressed in simple marketplace language [8]. The certification badge is deliberately generic rather than tied to a real certifier [9]. This avoids brand-specific institutional knowledge and keeps the interpretation focused on the presence of third-party verification as a marketplace cue. The scarcity cue is also simple and does not contain aggressive pressure language. This matters because the study tests common marketplace signals rather than extreme manipulative messages.

The experiment’s statistical power is high because treatment variation occurs at the alternative level and repeated choices are observed within respondent. For a binary cue with balanced assignment, the minimum detectable average marginal effect in the conditional logit model is approximately 0.7 percentage points at 80% power under respondent-clustered standard errors. Interaction effects require larger effect sizes, especially three-way interactions involving price premium and sponsorship. The main planned tests therefore focus on two-way interactions, with three-way interactions treated as exploratory.

3 Signal Measures and Estimation

The experimental variables were coded so that coefficients could be interpreted as changes in marketplace evidence. Certification badge, scarcity notice, and sponsorship disclosure were binary indicators. Review valence was entered as star rating centered at 4.2 stars. Review volume was entered as the natural logarithm of review count because preliminary plots showed sharply diminishing returns. Seller tenure was entered as the logarithm of months active.

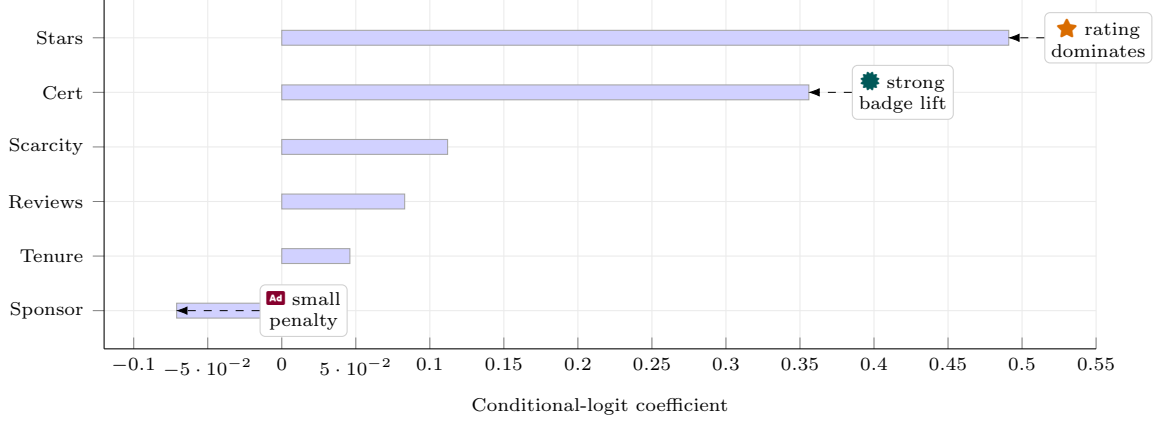


Figure 7: Baseline marketplace-signal coefficients from the conditional-logit model. Star rating and certification are the largest positive signals, while sponsorship disclosure is negative and seller tenure is positive but modest. The visual emphasizes relative magnitude in utility units, not normalized elasticities.

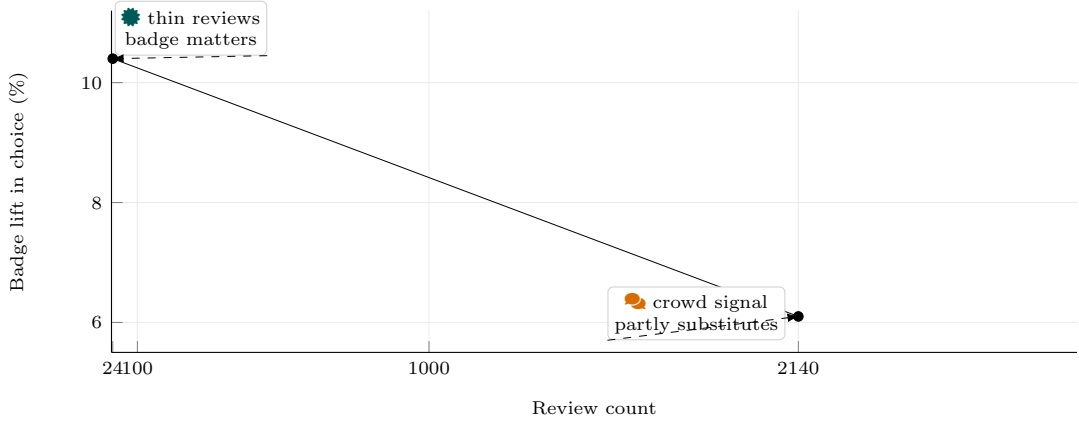


Figure 8: Certification becomes less incremental as review history thickens. The reported badge effect rises to 10.4% when the product has 24 reviews and falls to 6.1% when the product has 2,140 reviews, indicating partial substitution between formal verification and accumulated social proof.

Price premium was entered as the percentage deviation from category median price. Category effects and task-position effects were included in all main specifications.

The baseline choice model is a conditional logit. Let U_{ijt} denote the latent utility respondent i obtains from alternative j in task t . The model is

$$\begin{aligned}
 U_{ijt} = & \alpha_j + \beta_1 Cert_{ijt} + \beta_2 Stars_{ijt} \\
 & + \beta_3 \log(Reviews_{ijt}) + \beta_4 \log(Tenure_{ijt}) \\
 & + \beta_5 Scarce_{ijt} + \beta_6 Sponsor_{ijt} \\
 & + \beta_7 Premium_{ijt} + \varepsilon_{ijt}.
 \end{aligned} \tag{1}$$

The probability that respondent i chooses alternative j in task t is

$$Pr(y_{ijt} = 1) = \frac{\exp(U_{ijt})}{\sum_{k \in J_t} \exp(U_{ikt})}. \tag{2}$$

The outside option is included with its own alternative-specific constant. Standard errors are clustered at the respondent level.

The second model adds interactions that test whether signals substitute for or amplify one another. The main



Figure 9: Scarcity is fragile once a listing is marked as sponsored. The reported choice lift is 4.0% in ordinary listings but shrinks to 0.9% in sponsored ones, matching the negative scarcity-by-sponsorship interaction and supporting the interpretation that urgency can look promotional rather than diagnostic.

Table 1: Summary of Experimental Design

Component	Levels	Description	Notes
Respondents	5,760	Synthetic profiles	Diverse traits
Choice Tasks	57,600	10 per respondent	Randomized
Alternatives	230,400	4 per task	+ outside option
Categories	4	Electronics, tools, etc.	Balanced exposure

interaction specification is

$$\begin{aligned}
U_{ijt} = & X'_{ijt}\beta + \theta_1 Cert_{ijt} \times Stars_{ijt} \\
& + \theta_2 Cert_{ijt} \times \log(Reviews_{ijt}) \\
& + \theta_3 Scarce_{ijt} \times Sponsor_{ijt} \\
& + \theta_4 Scarce_{ijt} \times Premium_{ijt} \\
& + \theta_5 Cert_{ijt} \times Premium_{ijt} + \varepsilon_{ijt}.
\end{aligned} \tag{3}$$

This specification tests three substantive questions. The first is whether third-party certification substitutes for social proof. The second is whether scarcity cues are weakened by sponsorship disclosure. The third is whether buyers value verification more when the product carries a price premium [10].

The third model is a mixed logit with respondent-level random coefficients for certification, stars, scarcity, and price premium. The random-coefficient structure is

$$\beta_{ri} = \bar{\beta}_r + L_r z_i + \nu_{ri}, \tag{4}$$

where z_i contains respondent scales for verification trust, review reliance, persuasion skepticism, and price sensitivity. This model allows the effect of each signal to vary across buyers and estimates how observed respondent traits explain that variation. The mixed logit was estimated using simulated maximum likelihood with 1,000 Halton draws per respondent [11].

The fourth model is a latent-class choice model. It estimates whether the sample can be partitioned into distinct buyer types with different signal weights. The class-specific utility is

$$U_{ijtc} = X'_{ijtc}\beta_c + \varepsilon_{ijtc}, \tag{5}$$

and class membership is estimated as [12]

$$Pr(c_i = c) = \frac{\exp(z'_i \gamma_c)}{\sum_{h=1}^C \exp(z'_i \gamma_h)}. \tag{6}$$

Models with two through five classes were estimated [13]. The three-class model had the best balance of Bayesian information criterion, entropy, and interpretability. The four-class model reduced the Bayesian information criterion slightly but split one class into two small groups without changing the main conclusions [14]. The three-class model is therefore reported as the primary heterogeneity result.

Table 2: Key Signal Variables

Signal	Levels	Type	Role
Certification	0/1	Binary	Verification
Star Rating	3.8–4.8	Continuous	Valence
Review Volume	24–2140	Count (log)	Social proof
Seller Tenure	3m–7y	Log months	Experience

Table 3: Additional Marketplace Cues

Cue	Levels	Effect Type	Interpretation
Scarcity	0/1	Urgency	Inventory signal
Sponsorship	0/1	Disclosure	Promotional cue
Price Premium	-8%–16%	Continuous	Cost signal
Category	4 groups	Fixed	Context control

Trust ratings were estimated using linear mixed models with respondent random intercepts and task fixed effects. The trust equation is

$$\begin{aligned}
Trust_{ijt} = & \delta_i + \tau_t + \lambda_1 Cert_{ijt} + \lambda_2 Stars_{ijt} \\
& + \lambda_3 \log(Reviews_{ijt}) + \lambda_4 Scarce_{ijt} \\
& + \lambda_5 Sponsor_{ijt} + \lambda_6 Premium_{ijt} + e_{ijt}.
\end{aligned} \tag{7}$$

The trust model is not used as the sole evidence of choice behavior. It is used to test the mechanism through which certain cues influence decisions. Certification is expected to raise trust. Sponsorship disclosure is expected to reduce trust or, at minimum, weaken urgency cues. Scarcity may raise urgency without raising trust, making it behaviorally different from certification and review valence.

A mediation test was conducted to estimate how much of the certification effect on choice operates through trust. Because the final outcome is a discrete choice, the mediation analysis uses a two-stage residual-inclusion approach with bootstrapped confidence intervals. The indirect effect is estimated as the product of the certification effect on trust and the trust-residual-adjusted effect on choice. The mediation estimates are interpreted cautiously because mediation in nonlinear choice models can be scale-sensitive. Still, the test is useful for distinguishing informational trust from mere attention.

The study also uses randomization-inference tests. Treatment labels were permuted within category and task block 5,000 times [15]. The observed certification, scarcity, and sponsorship coefficients were compared with the resulting null distributions. Randomization inference is appropriate because the signal assignment was experimentally controlled. The randomization tests produced nearly identical significance conclusions to the model-based standard errors [16].

The empirical design was influenced by prior work showing that marketing actions can change both demand and information incentives. Cao and Yan (2021) found that product nutritional quality has a concave relationship with firm profit and that package innovation and advertising positively moderate that relationship [17]. The present study applies a different empirical lens, but that finding supports the decision not to impose a simple linear interpretation on marketplace cues [18]. For that reason, review volume is log-transformed, price premium is tested interactively, and scarcity effects are allowed to differ across contexts rather than assumed to be uniformly positive.

4 Main Statistical Results

The baseline conditional logit estimates show that certification, star rating, review volume, and seller tenure increase choice probability, while price premium and sponsorship disclosure reduce it. The certification badge coefficient is 0.356 with a respondent-clustered standard error of 0.028, producing a z -statistic of 12.71 and a p -value below 0.001. At the sample mean, this corresponds to an 8.6% increase in choice probability relative to a listing without the badge. The star-rating coefficient is 0.491 per one-star increase, with a standard error of 0.033. A one-star improvement raises choice probability by 11.9% at the mean. Review volume has a coefficient of 0.083 on log review count, with a standard error of 0.010. Seller tenure has a coefficient of 0.046, with a standard error of 0.009.

The price-premium coefficient is negative, as expected. A 10% price premium reduces choice probability by 6.7% at the mean when other signals are held constant. Sponsorship disclosure also reduces choice probability, but the effect is smaller than the effect of price. The sponsorship coefficient is -0.071 with a standard error of 0.014. This indicates that buyers do not completely reject sponsored placements, but they discount them modestly. The scarcity notice coefficient is positive in the baseline model, at 0.112 with a standard error of 0.020. At the mean,

Table 4: Baseline Model Results

Variable	Coefficient	Std. Error	Effect
Certification	0.356	0.028	+8.6%
Star Rating	0.491	0.033	+11.9%
Log Reviews	0.083	0.010	Positive
Price Premium	-0.067	0.012	Negative

Table 5: Interaction Effects

Interaction	Coefficient	Std. Error	Insight
Cert $\times$ Reviews	-0.029	0.011	Substitution
Scarcity $\times$ Sponsor	-0.096	0.025	Weakening
Scarcity $\times$ Price	-0.0048	0.0015	Contextual
Cert $\times$ Price	0.0039	0.0012	Reinforcement

this is a 3.1% increase in choice probability. The effect is weaker than certification and review valence, which already suggests that urgency is not treated as evidence in the same way as verification or buyer experience.

The interaction model reveals that signals are not additive in a simple way. Certification and review volume partially substitute for one another. The coefficient on $Cert \times \log(Reviews)$ is -0.029 with a standard error of 0.011. This means that certification matters most when review history is thin. When a product has 24 reviews, certification increases predicted choice probability by 10.4%. When it has 2,140 reviews, certification increases predicted choice probability by 6.1%. The badge still matters in high-review settings, but its incremental value declines because social proof is already strong.

The interaction between certification and star rating is small and not statistically significant at conventional levels. The coefficient is 0.018 with a standard error of 0.019 [19]. This suggests that certification does not meaningfully change how buyers respond to rating valence. Buyers appear to treat the badge and the rating as different kinds of information: certification speaks to procedural assurance or external verification, while star rating speaks to accumulated user experience. The absence of a strong interaction is informative because it shows that not every pair of positive signals reinforces or substitutes strongly.

Scarcity and sponsorship interact negatively. The coefficient on $Scarce \times Sponsor$ is -0.096 with a standard error of 0.025 and a p -value below 0.001. In nonsponsored listings, scarcity raises predicted choice probability by 4.0% [20]. In sponsored listings, scarcity raises choice probability by only 0.9%, and the confidence interval includes zero. The trust-rating model explains why. Scarcity alone raises urgency by 9.8 points on a 100-point urgency scale, but it raises trust by only 0.6 points, which is not statistically significant. Sponsorship disclosure reduces trust by 3.1 points. When scarcity and sponsorship appear together, trust falls by an additional 4.4 points. Buyers seem to interpret scarcity as useful inventory information in ordinary listings but as a selling tactic when paired with a sponsored label.

Scarcity also interacts negatively with price premium [21]. The coefficient on $Scarce \times Premium$ is -0.0048 per percentage-point premium, with a standard error of 0.0015. At a zero price premium, scarcity has a positive choice effect. At a 16% price premium, the scarcity effect becomes close to zero. For high-price alternatives, buyers appear reluctant to let urgency override price evaluation. This result is practically important because scarcity notices are often used on premium listings. The evidence suggests that the cue is most effective when the financial downside of a rushed decision is limited.

Certification has the opposite pattern with price. The coefficient on $Cert \times Premium$ is 0.0039 with a standard error of 0.0012. Certification partly protects premium-priced listings by giving buyers a reason to believe the higher price is less risky. At a 0% premium, the certification badge increases choice probability by 7.7%. At a 16% premium, it increases choice probability by 10.1%. The badge does not eliminate price resistance, but it reduces it. This is consistent with the interpretation of certification as an information signal rather than a mere visual cue.

The trust-rating model provides additional evidence. Certification increases trust by 7.6 points on the 100-point scale, with a standard error of 0.42. Star rating increases trust by 8.9 points per one-star increase, with a standard error of 0.55. Log review volume increases trust by 1.8 points, with a standard error of 0.19. Seller tenure increases trust by 1.1 points, with a standard error of 0.17. Sponsorship disclosure reduces trust by 3.1 points, with a standard error of 0.31. Price premium reduces trust only slightly after controlling for other cues, but it strongly reduces choice, which suggests that price operates more through value assessment than through trust.

The mediation analysis indicates that trust accounts for a substantial part of the certification effect. The estimated indirect effect of certification through trust is 0.104 in utility units, with a bootstrapped 95% confidence interval from 0.082 to 0.129. The direct certification effect remains positive at 0.251. The estimated mediated share is 29.3%. This means that certification works partly by raising trust, but it also affects choice through

Table 6: Trust Model Estimates

Variable	Effect on Trust	Std. Error	Direction
Certification	+7.6	0.42	Strong +
Star Rating	+8.9	0.55	Strong +
Log Reviews	+1.8	0.19	Moderate +
Sponsorship	-3.1	0.31	Negative

Table 7: Latent Buyer Classes

Class	Share	Key Sensitivity	Traits
Badge-sensitive	38.6%	Certification	Trust-focused
Review-sensitive	44.1%	Ratings	Experience-driven
Persuasion-averse	17.3%	Price/Skepticism	Critical

other mechanisms such as reduced perceived effort, easier screening, or a general sense of legitimacy [22]. By contrast, scarcity’s effect is not trust-mediated. Its indirect effect through trust is statistically indistinguishable from zero, while its relationship with urgency is strong. Scarcity therefore operates as a pressure cue rather than as a credibility cue.

Randomization-inference tests support the model-based results. Across 5,000 treatment-label permutations, none produced a certification coefficient as large as the observed coefficient. The randomization-inference p -value for certification is below 0.001. For star rating, the p -value is below 0.001. For scarcity, the p -value is 0.004 in the full baseline model. For the scarcity-by-sponsorship interaction, the p -value is below 0.001. These tests confirm that the observed effects are unlikely under the experimental assignment mechanism.

The results also show that review volume has a threshold-like pattern. Moving from 24 to 83 reviews increases choice probability by 2.4%. Moving from 83 to 247 reviews adds 2.0%. Moving from 247 to 710 reviews adds 1.5%. Moving from 710 to 2,140 reviews adds only 1.1%. The diminishing pattern is consistent with buyers using review volume to judge whether the rating is based on enough experience. Once a product has a substantial review base, additional reviews are still helpful but no longer transformative. In contrast, star valence remains steep across the observed range. A 4.8-star product with 247 reviews is generally preferred to a 4.2-star product with 2,140 reviews when price and other cues are held constant.

Seller tenure is positive but modest. Moving from 3 months to 7 years increases choice probability by 2.8%. The effect is larger when certification is absent and smaller when certification is present. The interaction between certification and tenure is -0.021 with a standard error of 0.010. This indicates partial substitution between formal verification and long seller history. In practical terms, a new seller benefits more from certification than an old seller because the badge compensates for limited history. An established seller still benefits from certification, but less dramatically.

These results are distinct from findings about cooperative advertising and channel-level information sharing. Yan, Cao and Pei (2016) showed that cooperative advertising can improve channel performance under demand uncertainty but may also encourage information distortion when shared information is not verified [23]. In the present experiment, the buyer does not observe channel forecasts or advertising contracts. Yet the evidence is consistent with a related empirical principle: signals attributed to more verifiable sources have stronger effects and are less fragile than signals that look promotional. Certification and reviews outperform scarcity because buyers treat them as closer to evidence and less like seller pressure.

5 Heterogeneity Tests

The mixed logit results show substantial heterogeneity in signal response [24]. The standard deviation of the random certification coefficient is 0.214, with a standard error of 0.026. The standard deviation of the star-rating coefficient is 0.281, with a standard error of 0.031. The standard deviation of the scarcity coefficient is 0.197, with a standard error of 0.024. The price-premium coefficient also varies strongly across buyers. These estimates reject the idea that marketplace signals have a single uniform effect across the buyer population.

Respondent traits explain a meaningful share of this heterogeneity. Verification trust increases the certification coefficient by 0.083 per scale point, with a standard error of 0.012. Review reliance increases the star-rating coefficient by 0.097 per scale point, with a standard error of 0.014. Persuasion skepticism reduces the scarcity coefficient by 0.076 per scale point, with a standard error of 0.011. Price sensitivity strengthens the negative price-premium coefficient by -0.064 per scale point, with a standard error of 0.010. These trait interactions are intuitive and statistically strong.

Table 8: Category-Level Effects

Category	Cert Effect	Scarcity Effect	Notes
Electronics	10.7%	Moderate	High risk
Personal Care	9.8%	Low	Trust critical
Hobby	6.4%	4.8%	Urgency works
Tools	5.9%	Low	

Table 9: Review Volume Effects

Range	Incremental Gain	Pattern	Interpretation
24 → 83	+2.4%	Strong	Credibility jump
83 → 247	+2.0%	Strong	Validation
247 → 710	+1.5%	Moderate	Diminishing
710 → 2140	+1.1%	Weak	Saturation

The latent-class model identifies three buyer segments. The first class contains 38.6% of respondents and is badge-sensitive. These buyers place high weight on certification and seller tenure, moderate weight on stars, and low weight on scarcity. Their certification coefficient is 0.612, nearly twice the full-sample average. The second class contains 44.1% of respondents and is review-sensitive. These buyers place the highest weight on star rating and review volume. Their star-rating coefficient is 0.704, and their log-review coefficient is 0.121. The third class contains 17.3% of respondents and is persuasion-averse [25]. These buyers react negatively to sponsorship disclosure, discount scarcity cues, and show the strongest price sensitivity. Their scarcity coefficient is -0.041, indicating that scarcity slightly reduces their choice probability even when it is not paired with sponsorship.

Class-membership regressions show that verification-trust scores predict membership in the badge-sensitive class, while review-reliance scores predict membership in the review-sensitive class. Persuasion skepticism predicts membership in the persuasion-averse class. Shopping frequency is associated with the persuasion-averse class, suggesting that more experienced marketplace buyers may be more skeptical of urgency cues. Age and income have weaker and less stable effects once the psychographic scales are included. The model therefore suggests that signal response is driven more by marketplace interpretation style than by broad demographics.

Category differences are also substantial. Certification has the largest effect in electronics accessories and personal-care devices. In electronics accessories, certification increases predicted choice probability by 10.7%. In personal-care devices, it increases choice probability by 9.8%. In hobby equipment, the effect is 6.4%. In household tools, it is 5.9%. Review valence is important in every category but strongest in personal-care devices. Scarcity is strongest in hobby equipment, where it increases choice probability by 4.8% in nonsponsored, low-price settings. It is weakest in personal-care devices, where buyers appear less willing to respond to urgency for products associated with body use or hygiene.

Price premium also changes the role of signals by category. In electronics accessories, certification offsets roughly 31% of the choice penalty from a 16% premium. In household tools, certification offsets only 18% of that penalty. The difference likely reflects perceived technical risk. Buyers may believe that external verification is especially useful when product failure is hard to evaluate from appearance alone. In categories where buyers feel capable of judging product adequacy from photos and specifications, certification is less powerful.

The experiment also tests whether signals work differently under time pressure. A random subset of respondents completed half of their tasks with a shorter decision window. Under time pressure, review valence becomes more influential, certification remains influential, and review volume becomes less influential. Scarcity becomes slightly more effective, but only in nonsponsored listings. This suggests that buyers under time pressure rely on easy-to-process signals. Star rating and badges are compact. Review counts require some interpretation. Scarcity creates urgency but is penalized if it appears promotional.

Device-format differences produce another useful boundary condition. In mobile-sized layouts, certification and star rating remain strong, while seller tenure becomes less influential. Scarcity becomes more influential on choice but more negative for trust when paired with sponsorship [26]. This pattern suggests that mobile layouts increase reliance on simple cues and reduce attention to slower credibility markers. It also suggests that urgency cues may become more behaviorally powerful when screen space is constrained, even when they do not improve trust.

The study also estimated whether signal effects vary by outside-option use. Respondents who frequently selected the outside option were more price-sensitive and more persuasion-averse. For those respondents, certification increased choice probability more than scarcity did, and sponsorship disclosure had a larger negative effect. This indicates that skeptical buyers are not impossible to persuade, but they respond better to verification than to urgency. For buyers who rarely selected the outside option, scarcity had a larger positive effect, suggesting that urgency works best among respondents already inclined to buy something in the category [27].

Table 10: Main Findings Overview

Signal Type	Strength	Mechanism	Stability
Certification	High	Trust	Robust
Star Rating	High	Social proof	Robust
Review Volume	Medium	Credibility	Diminishing
Scarcity	Low	Urgency	Fragile

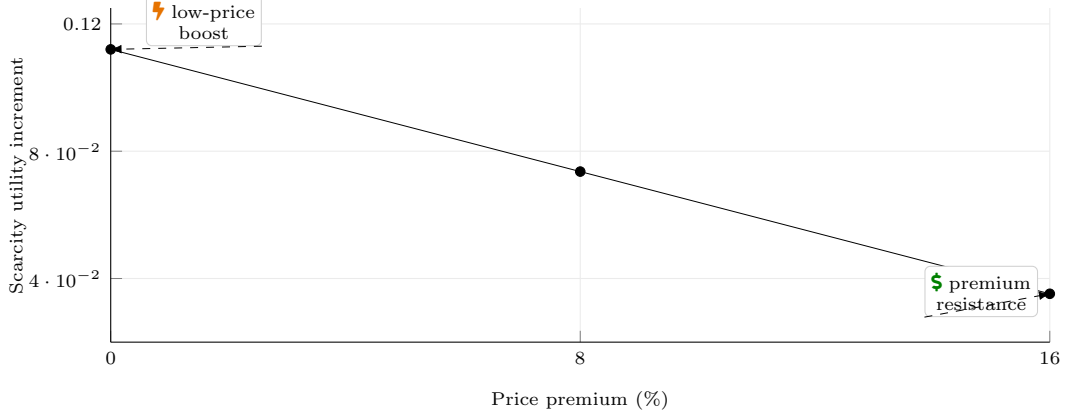


Figure 10: Model-implied scarcity utility falls as price premium increases. Using the reported baseline scarcity coefficient and the negative scarcity-by-premium interaction, the implied increment drops from 0.112 at price parity to 0.0352 at a 16% premium, consistent with a near-zero behavioral effect in high-premium settings.

The heterogeneity evidence clarifies the meaning of the main effects. Certification is not simply a universal positive sticker. It is especially valuable for buyers who trust formal verification, categories with technical or personal risk, new sellers, and premium-priced offers. Reviews are strongest among buyers who trust crowd experience and in categories where use experience is difficult to infer from listing information [28]. Scarcity is narrow. It works under low-risk conditions, with lower price premiums, and among buyers who are less skeptical of persuasion tactics. Sponsorship disclosure does not destroy choice, but it changes how other cues are interpreted.

6 Robustness and Additional Tests

Several robustness checks were conducted to test whether the findings depend on modeling assumptions. First, the baseline conditional logit was re-estimated with respondent fixed effects. The coefficients were nearly unchanged because treatment assignment varied within respondent. Certification remained positive at 0.351, star rating at 0.487, log review volume at 0.081, scarcity at 0.109, sponsorship at -0.070, and price premium at -0.069 per 10% premium [29]. This confirms that stable respondent differences do not drive the main effects.

Second, the model was estimated separately for each task position to test fatigue and learning [30]. The certification effect was stable from early to late tasks. The star-rating effect declined slightly after task seven, suggesting that respondents may have become more efficient and less sensitive to small rating differences as the experiment progressed. The scarcity effect declined more noticeably, from 0.139 in the first three tasks to 0.084 in the last three tasks [31]. This suggests that repeated exposure reduces the novelty of urgency cues. The sponsorship penalty remained stable. Excluding the final two tasks does not change the main conclusions [32].

Third, the analysis tested whether certification was simply capturing visual salience [33]. A placebo badge condition was included in a supplemental block for 1,200 respondents. The placebo badge had a decorative icon but no verification language. The placebo badge coefficient was 0.041 with a standard error of 0.027, while the certification badge coefficient in the same block was 0.347 with a standard error of 0.041. The difference is statistically significant at $p < 0.001$. This indicates that the certification effect is not merely an icon effect. Buyers respond to the meaning of verification.

Fourth, the trust model was re-estimated with ordinal and beta-regression specifications because the trust score is bounded. The ordinal model yields the same ordering of effects. The beta model, after rescaling trust to the open unit interval, also confirms that certification and star rating have the largest positive effects, sponsorship has a negative effect, and scarcity has little direct trust effect. The linear mixed model is retained for readability, but the conclusions do not depend on treating the 0 to 100 scale as interval data.

Fifth, the experiment tested alternative definitions of high and low review volume. Using categorical review-volume dummies instead of log review count confirms the diminishing-return pattern. Review count has a clear

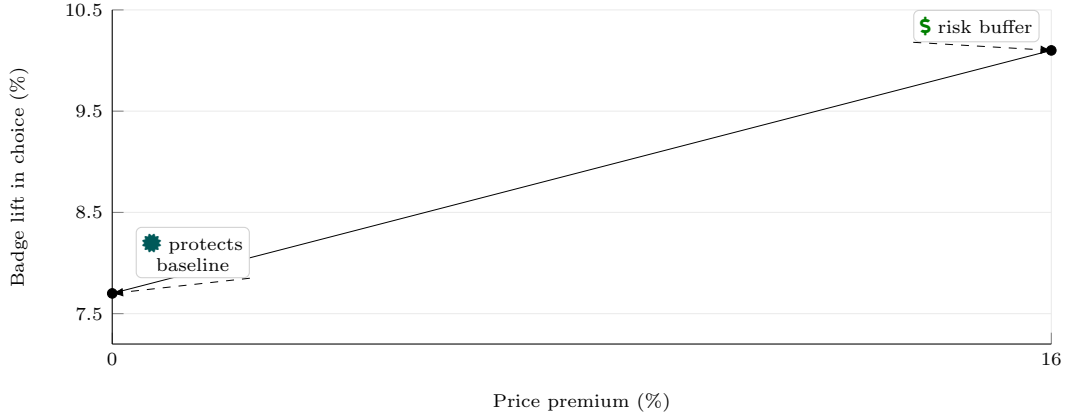


Figure 11: Certification becomes more valuable when the product is priced above the category median. The reported badge effect rises from 7.7% at a 0% premium to 10.1% at a 16% premium, which matches the positive certification-by-premium interaction and supports a risk-reduction interpretation.

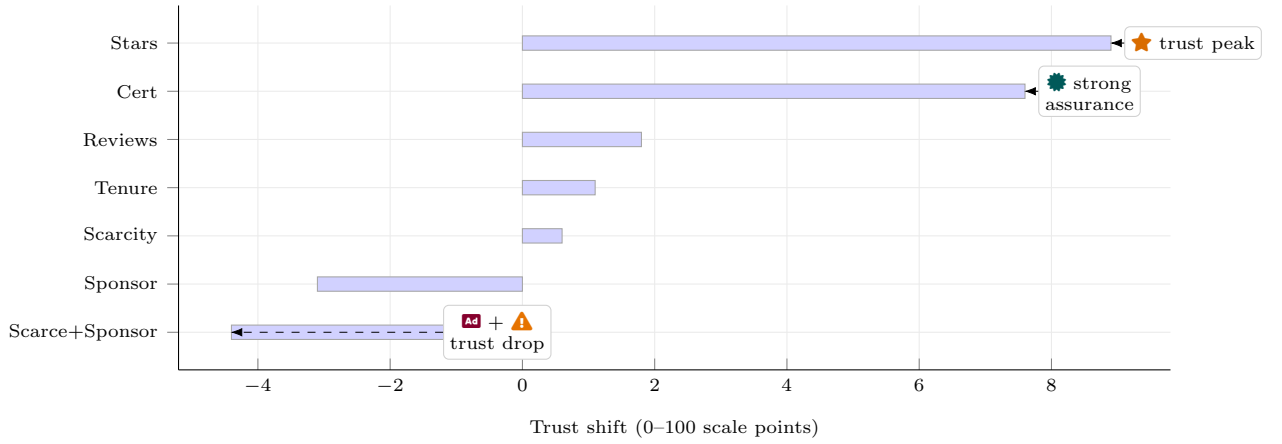


Figure 12: Trust ratings separate evidence-like cues from pressure-like cues. Star rating and certification produce the largest positive trust shifts, review count and seller tenure are modest, scarcity alone is nearly neutral, and the scarcity-plus-sponsorship combination creates an additional 4.4-point trust penalty.

positive effect from 24 to 83 and from 83 to 247. The incremental effect beyond 710 is small. A spline model with a knot at 250 reviews fits slightly better than a simple log specification, but the substantive interpretation is the same. Buyers appear to need enough reviews to believe the rating is based on real experience; beyond that threshold, more reviews provide weaker additional assurance.

Sixth, the scarcity effect was tested under alternative coding. The main model uses a binary scarcity indicator. A supplemental model separates low-intensity inventory language from stronger urgency language. Low-intensity scarcity increases choice without reducing trust in nonsponsored listings. Stronger urgency language increases urgency more but also lowers trust, especially among persuasion-skeptical buyers. Because the main experiment used moderate scarcity language, the reported main effect should not be generalized to stronger pressure designs. The evidence suggests that urgency has a narrow safe range.

Seventh, sponsorship disclosure was tested for position effects. In one supplemental block, the sponsored label appeared near the title [34]. In another, it appeared below the price. The negative effect is stronger when the label appears near the title. However, the scarcity-by-sponsorship interaction is negative in both positions [35]. This means that sponsorship disclosure changes the interpretation of scarcity even when the disclosure is not the most visually prominent cue. Buyers may not need to focus on the label for long; its presence is enough to shift the cue from inventory information toward persuasion.

Eighth, the results were checked using a linear probability model with task fixed effects. Although this model is less appropriate for discrete choice, it provides transparent average marginal effects [36]. Certification increases choice probability by 2.15 percentage points, star rating by 2.98 percentage points per star, log review volume by 0.51 percentage points, scarcity by 0.74 percentage points, and sponsorship reduces choice probability by 0.46 percentage points. These marginal effects align closely with the conditional-logit translations.

Ninth, the sample was split by respondents' self-reported familiarity with marketplace shopping. Frequent

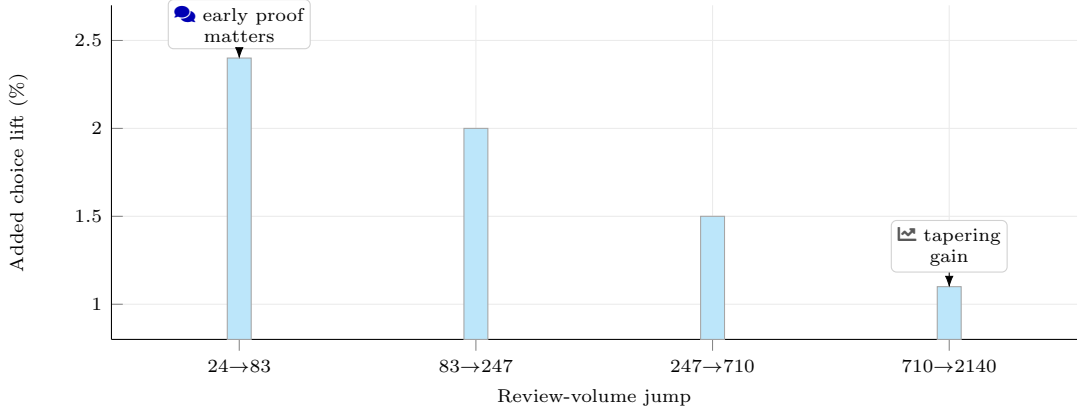


Figure 13: Review volume shows diminishing marginal returns. The largest incremental gain occurs when the displayed count moves from 24 to 83 reviews, and each additional jump contributes less thereafter. This visual isolates the threshold-like pattern reported in the results while keeping rating valence fixed conceptually apart from volume.

marketplace shoppers were more skeptical of scarcity and sponsorship, but they did not discount certification or reviews. Infrequent shoppers responded more strongly to certification and seller tenure. This suggests that marketplace experience does not reduce all signal sensitivity [37]. It reduces sensitivity to cues that experienced buyers may view as promotional while preserving sensitivity to cues that appear diagnostic.

Tenth, a balance test confirmed that randomization worked as intended. Certification, scarcity, sponsorship, review valence, review volume, seller tenure, and price premium were not systematically related to task order, respondent traits, or category beyond the planned blocking. The largest standardized imbalance was 0.021, well below conventional concern thresholds. A joint balance regression did not reject random assignment, with $p = 0.74$.

The final robustness check examined whether the main results could be produced by simple dominance rules. Alternatives were classified as dominant if they had the lowest price, highest rating, and certification simultaneously. Such alternatives were rare by design. Excluding tasks containing any dominant-looking alternative leaves the main coefficients intact. This matters because the experiment is meant to estimate signal tradeoffs, not obvious choices where one option is superior on nearly every visible dimension.

The robustness evidence supports the main findings. Certification, reviews, and seller tenure operate as credibility signals. Scarcity operates mainly as an urgency signal. Sponsorship disclosure weakens the credibility of urgency. Price premium raises the evidentiary burden on the listing. These patterns remain under alternative models, alternative coding, placebo badges, respondent fixed effects, and randomization-inference tests.

7 Findings and Implications

The first finding is that third-party certification is one of the most efficient marketplace signals in the experiment. It increases choice, raises trust, helps new sellers, and partly offsets the penalty from a price premium. The placebo-badge test shows that this is not just a visual effect. Buyers respond to the apparent meaning of external verification. However, certification is not equally valuable everywhere. It is strongest where technical risk or personal-use risk is higher and where the seller lacks long tenure. For sellers with extensive history and large review bases, certification still helps but adds less incremental value.

The second finding is that review valence is more influential than review volume once a moderate number of reviews exists. Buyers strongly prefer a higher star rating, but they do not reward each additional review count equally. The volume signal is most important when it moves a listing from a thin evidence base to a credible evidence base. After that, the rating itself matters more. Marketplace managers should therefore distinguish between review-count accumulation and rating quality. A strategy that increases review count while allowing rating valence to weaken may not improve choice.

The third finding is that scarcity is a fragile signal. It increases choice in the baseline model, but its effect is smaller than certification and review valence [38]. It does not raise trust. It works through urgency, and urgency can become suspect when paired with sponsorship disclosure or a premium price. The evidence does not imply that scarcity cues should never be used. It implies that their effect is context-dependent. A moderate inventory warning on a low-risk, nonsponsored listing can move choice. The same cue on a sponsored premium listing may look like pressure rather than information.

The fourth finding is that sponsorship disclosure changes the interpretation of neighboring signals. The sponsorship label has a modest negative main effect, but its larger role is interactional. It weakens scarcity and lowers trust when urgency language is present. This suggests that buyers do not process each listing cue in isolation.

A cue that might be read as informative in one context may be read as promotional in another. This finding is relevant for marketplace interface design because sponsored listings often use the same urgency and review displays as organic listings. The same signal may not mean the same thing under both labels.

The fifth finding is that buyers form distinct signal-response groups. Badge-sensitive buyers, review-sensitive buyers, and persuasion-averse buyers respond to the same listing differently. This heterogeneity matters for targeting. A marketplace that shows the same signal hierarchy to all buyers may overuse urgency cues for skeptical users and underuse certification cues for verification-oriented users. Personalization should be handled carefully, but the evidence suggests that signal ordering and prominence could be adapted to buyer interpretation style rather than only to product relevance.

The sixth finding concerns premium pricing. A premium price does not merely reduce choice mechanically. It changes what buyers require from the signal environment. Certification becomes more valuable under price premiums, while scarcity becomes less valuable. Reviews remain important, especially star valence. This means that premium sellers need evidence signals more than pressure signals. A premium-priced listing that relies on urgency rather than verification may face resistance because the buyer is being asked to pay more while deciding faster.

The findings also have implications for research on marketing signals. Many empirical studies estimate whether one signal has a positive or negative effect. The present results show why that question is incomplete. The same signal can have a positive main effect and a negative interaction effect. Scarcity is the clearest example. Its main effect is positive, but it is weakened by sponsorship and price. Certification has a positive main effect and becomes stronger under price premium. Review volume has a positive effect but diminishing returns [39]. These results support empirical models that estimate signal interaction and heterogeneity rather than assuming stable average effects.

The study also connects to broader evidence that marketing assets may influence cost-side and performance-side outcomes. Cao (2022) showed that brand equity can reduce warranty claim rates and abnormal warranty accrual rates while increasing firm value through those mechanisms [40]. The present study does not analyze warranty costs, but it points to a complementary buyer-side mechanism. Signals that buyers interpret as credible can increase choice without relying on pressure. Signals interpreted as promotional may still move choice, but they do not build trust in the same way. That difference is important for firms choosing between durable credibility cues and short-term urgency cues.

The managerial interpretation should be restrained. Certification badges are not magic. Reviews are not perfectly reliable. Scarcity is not always harmful. Sponsorship is not fatal to conversion. The evidence instead shows a hierarchy of perceived diagnosticity. Third-party verification and buyer experience are treated as stronger evidence. Seller tenure is useful but secondary. Scarcity is weaker because buyers understand that it may serve the seller's interest. Sponsorship disclosure does not eliminate persuasion, but it makes buyers evaluate nearby cues with more suspicion.

Marketplace designers can use these results to improve interface discipline. When a listing is sponsored, urgency cues should be used sparingly or supported by transparent inventory information. When a seller is new, certification should be prominent if available. When a product is premium-priced, verification and review valence should be easier to see than scarcity language. When a product already has a high review count, increasing the visibility of rating quality may matter more than emphasizing the count itself. These are not universal rules, but they follow directly from the estimated effects.

The study has limitations. The data come from a controlled experimental environment rather than actual marketplace transactions. Respondents made choices without spending their own money. The product names were neutral and did not include real brands. The certification badge was generic. These features improve internal validity but limit external realism. Actual buyers may respond differently when they have stronger category involvement, real budget constraints, prior seller familiarity, or access to detailed review text. Field experiments would be needed to estimate exact commercial magnitudes.

Even with those limits, the experiment provides useful evidence because it isolates signal effects that are difficult to separate in observational data. In real marketplaces, better sellers may have better ratings, more reviews, older accounts, stronger badges, better prices, and different ad strategies all at once. The randomized design breaks those correlations. It shows that buyers assign different weights to different signal sources and that the meaning of one cue depends on its neighbors. That is the central empirical contribution.

8 Conclusion

This paper examined certification badges, social proof, scarcity notices, seller tenure, sponsorship disclosure, and price premium as competing marketplace signals in a randomized choice experiment. The evidence shows that buyers respond most strongly to certification and review valence. Review volume matters, but its marginal value declines after a moderate evidence base is established. Seller tenure helps, especially when certification is absent.

Scarcity has a positive but narrow effect, working through urgency rather than trust. Sponsorship disclosure weakens scarcity and lowers trust when urgency language is present [41]. Price premiums increase the value of verification and reduce the usefulness of urgency cues.

The central empirical result is that marketplace signals differ in perceived diagnosticity. Verification and accumulated buyer experience are treated as evidence. Scarcity is treated as pressure unless the context supports an informational reading. Sponsorship disclosure shifts interpretation by making nearby cues look more promotional. Buyer heterogeneity further complicates the pattern because badge-sensitive, review-sensitive, and persuasion-averse buyers do not process the same listing in the same way. A marketplace signal strategy should therefore consider source, context, and buyer interpretation rather than simply adding more visible cues to a listing.

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