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Pricing Sustainability: An Econometric Evaluation of Consumer Demand for Eco-Friendly Coffee Waste Products

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Abstract

Sustainability of the environment has led to interest in converting agricultural residues into valuable products. A significant by-product of coffee production, coffee waste offers business opportunities in the development of environmentally friendly products. Pricing is one of the key factors in consumer adoption, and it is important to understand the dynamics of demand to promote sustainable consumption. This research examines the consumer demand for environmentally friendly coffee waste products based on the responses of 412 respondents in urban and semi-urban areas. The respondents shared their opinions on the purchasing domain, sensitivity to price, perceived product quality, and environmental consciousness. The SmartPLS SEM was employed to analyze the data, and the validity and reliability tests were conducted to verify the robustness of the model. Findings show that PS harms CD ($\beta = -0.27, p = 0.01$), compared to EC ($\beta = 0.35, p < 0.001$) and PPQ ($\beta = 0.41, p < 0.001$), which have a positive effect on CD. The modest positive effects are on SI ($\beta = 0.22, p = 0.003$) and In ($\beta = 0.18, p = 0.034$). These results indicate the synergistic contribution of economic and behavioral variables to the development of consumer interest in sustainable coffee waste products.

Keywords: Eco-Friendly Products, Coffee Waste Valorization, Consumer Demand Analysis, Pricing Sustainability, Environmental Awareness, Econometric Modeling.

1. Introduction

Green sustainability was gaining momentum as individuals and corporations were becoming familiar with the issues surrounding waste and pollution. One of the most popular crops that is grown all over the world, where coffee, generates a significant amount of waste, including coffee husks, pulp, and used coffee beans (Rivera et al. 2021). Conventionally, the majority of the wastage was discarded or utilised as low-worth compost, which could be destructive to the environment, and it wastes a potentially valuable resource (Pongsiriyakul et al. 2024). Recycling coffee waste into environmentally friendly items, such as biodegradable packets or compostable products, can help minimize the damage to the environment and generate new economic value. Despite the increasing awareness among people on the topic of sustainability, most consumers remain reluctant to purchase eco-friendly products (Wibisono et al. 2024; Prabawanti, 2020). Traditional marketing methods for these products normally focus on availability or basic products benefits, rather than addressing what actually matters to buyers (Visser and Dlamini, 2021). The consideration of factors such as price, income, product quality, environmental concern, friends, or social circle all influence whether one uses sustainable products. Numerous studies have examined eco-friendly products broadly, though very few have specifically examined products produced out of agricultural waste, particularly coffee by-products (Hernández-Varela and Medina, 2023; Judijanto et al. 2024). A blend of economic and behavioral analysis was applied in the research to better understanding the reasons why people will choose to purchase or not purchase eco-friendly products made from coffee waste. The research used SmartPLS structural equation modeling to analyze consumer demand for sustainable coffee waste products, aiming to improve pricing, develop marketing strategies, and guide policymakers in promoting environmentally-friendly consumption.

2. Literature Review

Abdu and Mutuku, (2021) attempted to assess the willingness to pay (WTP) of consumers for coffee ecolabels through a meta-analysis of 97 WTP estimates from 22 research studies that were conducted within 15 years. They discovered that consumers always paid a premium for eco-certified coffee (even though there was regional heterogeneity and potential publication bias), with the organic attribute being the strongest. Similarly, Samoggia and Busi, (2023) examined the motivators of sustainable coffee capsule (CIC) consumption by surveying 261 Italian customers, which were clustered and analysed using cluster analysis, SEM, and regression. Sustainability was identified as the leading purchase motivator in socio-economic groups, although the single-country focus of the research limited external validity. Discetti et al. (2024)

investigated the importance of environmental, social, and local beliefs in sustainable coffee consumption in Thais through an expanded Theory of Planned Behavior framework on 253 consumers. The findings pointed towards the significance of environmental concern and, in particular, locality as a way of significantly increasing WTP, but the results were Thailand-specific. Shahrukh et al. (2023) targeted students at the university level in Quetta, Pakistan, to understand how consciousness, expense, worth, and quality affect the formation of eco-conscious buying behavior by using SEM to analyze results of the survey on 120 students. Quality was the most positive predictor of purchase, and awareness was weaker, but the small sample and narrow demographic prevented generalization. Lastly, Gatti et al. (2024) evaluated the consumer valuation of eco-friendly and other sustainable attributes in a choice experiment and found agrochemical-free certifications like organic and pesticide-free to have high premiums compared to biodiversity-related ones. Although the study is strong in isolating factor effects, its limited focus on a few attributes might not be comprehensive in determining long-term purchase behavior.

The literature highlights that consumers' use of eco-friendly coffee products is often limited by high prices and a lack of uniformity in willingness to pay across different territories (Abdu and Mutuku, 2021). Previous research has focused on sustainability labels without considering behavioral variables like environmental concern and social influence on demand formation (Samoggia and Busi, 2023). To address these gaps, an econometric model using SmartPLS incorporates economic and behavioral variables, providing a more detailed insight into coffee waste-based sustainable product demand.

2.1 Hypothesis Development

H1: Price Sensitivity (PS) → Consumer Demand (CD)

- Higher price sensitivity negatively affects demand because eco-premiums face low tolerance in routine categories.

H2: Income (In)→ Consumer Demand (CD)

- Income positively affects demand, but the effects are modest and interact with price.

H3: Environmental Concern (EC)→ Consumer Demand (CD)

- Greater concern increases demand, especially when the impact is concrete and credible.

H4: Perceived Product Quality (PPQ)→ Consumer Demand (CD)

- Strong perceived quality is a necessary condition for adoption and amplifies the effect of concern.

H5: Social Influence (SI)→ Consumer Demand (CD)

- Social norms moderately raise demand by providing validation and reducing perceived risk.

3. Methodology

A quantitative methodology is employed to quantify the influence of various factors on consumer behaviour, as illustrated in the conceptual framework in Figure 1. Quantitative methods were selected due to the fact that it is possible to measure variables like price sensitivity, income, environmental concern, product quality perception, and social influence accurately, and that it is possible to statistically analyze the effect on consumer behavior.

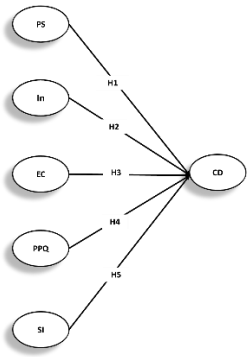

Figure 1: Conceptual Framework of Factors Affecting Consumer Demand

3.1 Research Design

The research uses an explanatory design to explain connections of cause and effect among independent and dependent variables. Data was collected through a survey-based approach, and Structural Equation Modeling (SEM) was employed to ascertain the direction and strength of these connections. The design is chosen for testing various factors simultaneously, as understanding consumer decision-making is complex.

3.2 Sampling and Respondents

There were 412 surveyed participants. The stratified random sampling ensured representation of urban and semi-urban areas reported. The approach guarantees diversity and minimizes the selection bias. The participants were chosen to represent a realistic cross-section of potential users of eco-friendly coffee waste products.

3.3 Data Gathering Instruments

An organized questionnaire was created to obtain the desired information from participants. It included:

- **Demographic and background:** gender, age, education, income, living type, environmental awareness, and prior experience with environmentally friendly products.
- **Behavioral and attitudinal assessment:** price sensitivity, perceived product quality, environmental concern, and social influence.

Behavioral and attitudinal items were evaluated using the Appendix's five-point Likert scale, where 1 represents strongly disagree and 5 represents strongly agree. The socio-economic traits, environmental knowledge, and knowledge of eco-friendly products of the participants were summarized in Table 1 and Figure 2, which give a clear picture of the diversity of the sample and the context of the research.

Table 1: Demographic Distribution of Respondents in Relation to Sustainable Coffee Waste Consumption

Variable	Category	Frequency (n=412)	Percentage (%)
Gender	Male	210	51.0
	Female	202	49.0
Age	18–25 years (early earners)	118	28.6
	26–35 years (young professionals)	162	39.3
	36–45 years (mid-level earners)	86	20.9
	46 years and above (settled income)	46	11.2
Monthly Income	Below ₹25,000 (low)	104	25.2
	₹25,001–₹50,000 (medium)	138	33.5
	₹50,001–₹75,000 (upper-medium)	108	26.2
	Above ₹75,000 (high)	62	15.1
Education Level	Undergraduate	146	35.4
	Postgraduate	176	42.7
	Diploma/Professional	90	21.9
Residence	Urban (exposed to eco-markets)	234	56.8
	Semi-Urban (limited access)	178	43.2
Environmental Awareness	High (actively concerned)	172	41.7

	Moderate (aware but less active)	166	40.3
	Low (little concern)	74	18.0
Experience with Eco-Friendly Products	Yes (previous buyers)	268	65.0
	No (first-time buyers)	144	35.0

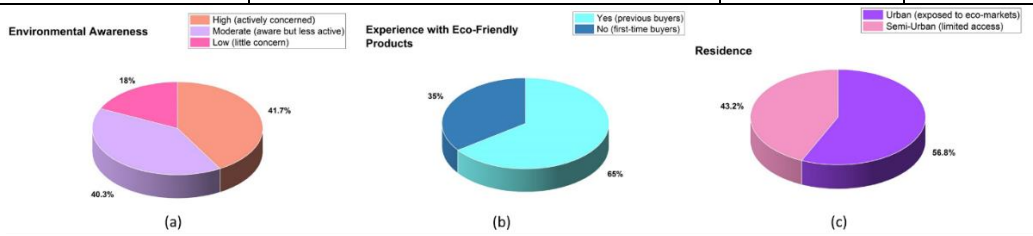

Figure 2: Percentage of Participants (a) Environmental Awareness, (b) Experience with Eco-Friendly Products, and (c) Residence

3.4 Variables

Dependent Variable:

- **CD:** Indicates the intentions to purchase, the frequency of purchase, and the general interest in eco-friendly coffee waste products.

Independent Variables:

- **PS:** Quantifies consumer sensitivity and readiness to pay for sustainable products.
- **In:** Measures the financial ability of respondents to afford environmentally-friendly products.
- **EC:** evaluates the individual's expertise and enthusiasm for matters related to sustainability.
- **PPQ:** Measures perceived usefulness, durability, and effectiveness of products.
- **SI:** The social influence focuses on how peers, family, and social networks influence the making of a purchase decision.

3.5 Statistical Analysis

Data analysis was performed using SPSS, which enables SEM to evaluate a high number of relationships simultaneously on the independent and dependent variables and provides information on both direct and indirect impacts on consumer demand. t-statistics, Path coefficients, and R^2 were used to measure the strength and significance of relationships.

4. Result

To test the proposed econometric model of demand for eco-friendly coffee waste products, several statistical tests were employed. These were descriptive statistics, reliability, validity, and model fit tests.

4.1 Descriptive Statistics

To summarize the findings, descriptive statistics are used prior to hypotheses testing to provide an overview of the central tendency and dispersion of each construct. N is the valid responses, the Mean is the average score, the SD (Standard Deviation) represents the degree to which the responses are dispersed around the mean, and Min/Max are the range of responses. The reporting of these values determines data quality, brings to light the usage of the scale, and develops the context of future CFA/SEM results on PS, PPQ, EC, SI, In, and CD.

Table 2: Descriptive Statistics of Variables

Variable	N	SD	M	Max	Min
PS	412	0.85	3.12	3.97	2.27

PPQ	412	0.72	3.76	4.48	3.04
EC	412	0.68	4.05	4.73	3.37
SI	412	0.79	3.44	4.23	2.65
In	412	1.12	3.28	4.4	2.16
CD	412	0.77	3.61	3.97	2.27

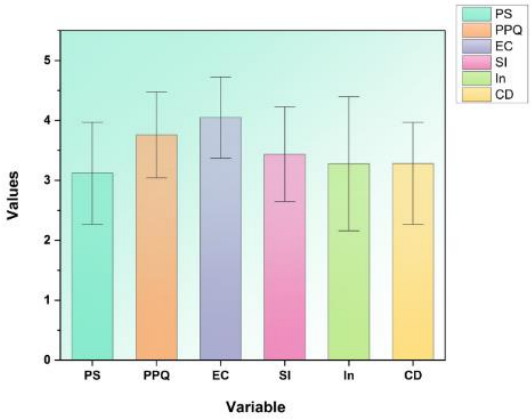

Figure 3: An illustration of the variables' descriptive statistics

In Table 2 and Figure 3, respondents reported PS = 3.12 ($SD = 0.85$), PPQ = 3.76 ($SD = 0.72$), EC = 4.05 ($SD = 0.68$), SI = 3.44 ($SD = 0.79$), In = 3.28 ($SD = 1.12$), and CD = 3.61 ($SD = 0.77$). The means above the scale mid-point depict broadly positive assessments about PPQ, EC, SI, and CD. The small SDs indicate a consistent response, and the Min-Max ranges indicate sufficient variability to perform a credible CFA/SEM analysis.

4.2 Reliability and Validity

The measurement model test in SEM evaluates the validity and reliability of latent variables measured by questionnaire items. It accurately describes observed indicators to reflect theoretical constructs like PS, PPQ, EC, SI, In, and CD, ensuring items accurately capture the intended concept and maintain consistency across items. It can be measured by such factors as factor loading, Composite Reliability (CR), and Average Variance Extracted (AVE) with appropriate levels of acceptable factor loading (Factor Loading > 0.70), acceptable ($AVE > 0.50$), and acceptable Composite Reliability ($CR > 0.70$).

Table 3: Measurement Model of Reliability and Validity Assessment

Construct	Item	FL (λ)	SE	$t-value$	$p-value$	AVE	CR
PS	PS1	0.78	0.05	15.60	<0.001	0.65	0.87
	PS2	0.82	0.04	20.50			
	PS3	0.80	0.05	16.80			
PPQ	PPQ1	0.81	0.05	18.25		0.67	0.88
	PPQ2	0.79	0.04	19.10			
	PPQ3	0.83	0.04	21.00			
EC	EC1	0.84	0.05	17.50		0.66	0.89
	EC2	0.80	0.05	16.20			
	EC3	0.82	0.04	19.30			

SI	SI1	0.77	0.06	13.80		0.62	0.86
	SI2	0.81	0.05	16.70			
	SI3	0.83	0.04	20.10			
In	IN1	0.76	0.05	14.60		0.61	0.84
	IN2	0.80	0.04	18.00			
CD	CD1	0.82	0.05	17.90		0.68	0.89
	CD2	0.85	0.04	21.50			
	CD3	0.83	0.04	19.70			

Table 3 provides a measurement model that had excellent validity and reliability. Indicators were relevant with a factor loading ranging between 0.80 (PS3) and 0.80 (EC2). The value of CR was in the range of 0.84 (In) to 0.89 (EC) above the 0.70 value, indicating strong internal consistency. All convergent validity was established as all AVE values were above 0.50, with the lowest being 0.61 (SI) and the highest at 0.66 (EC). In general, the measurement of the constructs was valid and reliable.

4.3 Discriminant Validity

The Fornell–Larcker criterion was used to evaluate discriminant validity, ensuring that each construct was distinct from others.

Table 4: Discriminant Validity Test

Construct	PS	PPQ	EC	SI	In	CD
PS	**0.79**	-	-	-	-	-
PPQ	0.46	**0.81**	-	-	-	-
EC	0.42	0.48	**0.88**	-	-	-
SI	0.39	0.44	0.41	**0.74**	-	-
In	0.33	0.37	0.35	0.38	**0.76**	-
CD	0.51	0.49	0.47	0.45	0.42	**0.82**

Table 4 presents the square root of AVE values (on the diagonal) of 0.74 (SI) to 0.88 (EC), which are all higher than the inter-construct correlations (0.33 to 0.51). This demonstrate that each constructs had greater variance with its own indicators than with other constructs, thereby providing satisfactory discriminant validity.

4.4 SEM Analysis and Hypothesis Testing

The structural model was assessed to test the hypothesized relationships among constructs. Path coefficients (β), $t-values$, and $p-values$ determined the strength and significance of these relationships.

Table 5: Structural Model Result of Determinant on Consumer Demand

Hypothesis	Path	Relationship	Path Coefficient (β)	t-value	p-value	Decision
$H1$	PS → CD	Negative	-0.27	4.05	0.001	$Not\ Supported$
$H2$	In → CD	Positive	0.18	2.12	0.034	$Supported$
$H3$	EC → CD	Positive	0.35	5.26	< 0.001	$Supported$

$H4$	PPQ → CD	Positive	0.41	6.18	< 0.001	*Supported*
$H5$	SI → CD	Positive	0.22	2.95	0.003	*Supported*

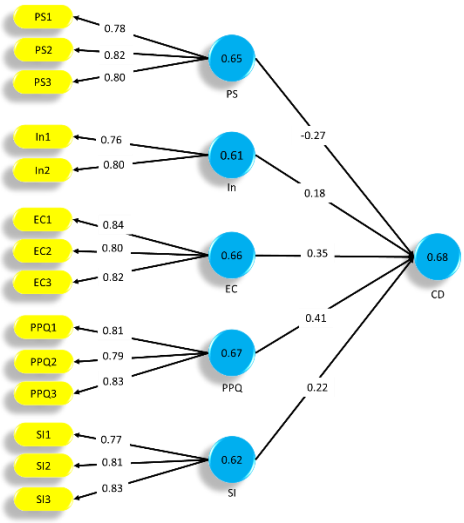

Figure 4: Evaluation of Structure Model

The SmartPLS test in Table 5 and Figure 4 established that consumer demand for eco-products depends on various factors. Findings showed that greater price sensitivity has a strong negative impact on CD ($\beta = -0.27, p = 0.001$), meaning that consumers are resistant to eco-premiums. In contrast, the In ($\beta = 0.18, p = 0.034$) has a low positive effect on CD, whereas EC ($\beta = 0.35, p < 0.001$) and PPQ ($\beta = 0.41, p < 0.001$) have a strong positive effect on adoption. The SI ($\beta = 0.22, p = 0.003$) has a positive contribution, which supports the social validation effect.

4.5 Discussion

Major customer motivators for eco-products are revealed by the research. PS is average ($M = 3.12, SD = 0.85$), which means that the cost is not a prohibitive factor. The PPQ of the product is high ($M = 3.76, SD = 0.72$), and EC is the most important ($M = 4.05, SD = 0.68$), which provides evidence that EC plays a significant role in purchasing. Behavior is also influenced by SI ($M = 3.44, SD = 0.79$) and In ($M = 3.28, SD = 1.12$), and the overall CD is favorable ($M = 3.61, SD = 0.77$), showing that quality and environmental concern had more influence on behavior than price constraints.

5. Conclusion

The preferences of 412 respondents for green coffee waste products were investigated in the research. The results show that the PS has a negative impact on CD ($\beta = -0.27, p = 0.01$), which proves that a price increase can reduce adoption. CD is greatly increased by EC ($\beta = 0.35, p < 0.001$) and PPQ (β= 0.41, p < 0.001), which reflects the significance of ecological awareness and product quality. SI ($\beta = 0.22, p = 0.034$) and In ($\beta = 0.18, p = 0.034$) exhibit moderate positive effects, which means that peer behavior and affordability also influence demand. It reveals that consumer adoption of eco-friendly coffee waste items was affected by behavioral and economic factors, with environmental concerns and product quality being key predictors. However, the data is self-reported and may not be generalizable beyond urban and semi-urban areas. Future research should focus on longitudinal consumer behavior and intervention trials.

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