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Own-Price and Cross-Price Elasticity of Demand for Chicken, Fish, and Rice in Tumbes Households: Analysis by Socioeconomic Strata

Elasticidade da procura em função do preço próprio e do preço cruzado de frango, peixe e arroz nos agregados familiares de Tumbes: análise por estratos socioeconómicos

Elasticidad de la demanda en función del precio propio y del precio cruzado del pollo, el pescado y el arroz en los hogares de Tumbes: análisis por estratos socioeconómicos

ARTÍCULO DE INVESTIGACIÓN

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ABSTRACT

This study estimates the own-price and cross-price elasticity of demand for chicken, fish, and rice in households in the Tumbes region (Peru), differentiating between socioeconomic strata C/D and E. Using pooled ENAHO 2019-2023 data from the National Institute of Statistics and Informatics (INEI), Ordinary Least Squares models with robust errors (log-log OLS), Tobit models, and quantile regression (Q10-Q90) were applied. The results reveal that the own-price elasticity of chicken is substantially higher in stratum E (-1.38) than in stratum C/D (-0.62), confirming the hypothesis that lower-income households are more price-sensitive. Fish acts as a substitute for chicken in strata C/D and E (cross-price elasticity > 0.30), whereas rice behaves as a complementary good (cross-price elasticity < 0) across all analyzed strata. The policy simulation indicates that a -15% subsidy on the price of chicken would increase consumption by 24.8% in stratum E, making it more effective than a S/.50/month cash transfer, which would increase consumption by 11.1%. These findings have direct implications for the design of food-security policies targeted at vulnerable strata in the region.

Keywords: price elasticity; food demand; socioeconomic strata; chicken; Tumbes; ENAHO.

JEL Code: D12; Q11; I32; C21; C24.

RESUMO

Este estudo estima a elasticidade-preço própria e cruzada da demanda por frango, peixe e arroz em famílias da região de Tumbes (Peru), diferenciando entre os estratos socioeconômicos C/D e E. Utilizando dados agrupados da ENAHO 2019-2023 do Instituto Nacional de Estatística e Informática (INEI), foram aplicados modelos de Mínimos Quadrados Ordinários com erros robustos (log-log OLS), modelos Tobit e regressão quantílica (Q10-Q90). Os resultados revelam que a elasticidade-preço do frango é substancialmente maior no estrato E (-1,38) do que no estrato C/D (-0,62), confirmando a hipótese de que as famílias de renda mais baixa são mais sensíveis ao preço. O peixe atua como substituto do frango nos estratos C/D e E (elasticidade cruzada de preço > 0,30), enquanto o arroz se comporta como um bem complementar (elasticidade cruzada de preço < 0) em todos os estratos analisados. A simulação de políticas indica que um subsídio de -15% sobre o preço do frango aumentaria o consumo em 24,8% no estrato E, tornando-o mais eficaz do que uma transferência de renda de S/.50/mês, que aumentaria o consumo em 11,1%. Essas conclusões têm implicações diretas para a elaboração de políticas de segurança alimentar voltadas para os estratos vulneráveis da região.

Palavras-chave: elasticidade de preço; demanda por alimentos; estratos socioeconômicos; frango; Tumbes; ENAHO.

INTRODUCTION

Food security among low-income Peruvian households is closely linked to the price stability of basic products such as chicken, fish, and rice. In a context of food inflation and price volatility - intensified after the COVID-19 pandemic and by disruptions in supply chains during the 2020-2023 period - understanding the sensitivity of demand to price changes is essential for the design of effective public policies.

Tumbes, a coastal region in northern Peru, has a socioeconomic structure characterized by the predominance of strata C/D and E, making it a relevant setting for studying the behavior of low-income consumers. Chicken is the most widely consumed animal protein in Peru, while fish represents a highly available substitute in coastal areas. Rice, for its part, is the main cereal in the national basic household basket.

Economic literature has widely documented differences in the price elasticity of food demand by income level. Households living in poverty tend to exhibit greater sensitivity to changes in relative prices because the share of expenditure allocated to food is structurally higher (Banks, Blundell, & Lewbel, 1997; Deaton, 1997). However, empirical evidence for specific Peruvian regions, disaggregated by socioeconomic strata, remains limited.

In this context, this reflection article aims to estimate the own-price and cross-price elasticities of demand for chicken, fish, and rice in households in the Tumbes region using pooled data from the National Household Survey (ENAHO) for the 2019-2023 period. Four central hypotheses are proposed: (H1) the own-price elasticity of chicken is greater in absolute value in stratum E than in stratum C/D; (H2) fish is a substitute for chicken in strata C/D and E; (H3) rice is complementary to chicken in all strata; and (H4) a subsidy on the price of chicken is more efficient than a cash transfer for increasing consumption in stratum E.

DEVELOPMENT

1. Theoretical framework and literature review

Consumer demand theory establishes that price elasticity of demand measures the percentage response in quantity demanded to a percentage change in the price of a good, holding all other factors constant. For essential goods, the theory predicts elasticities below one in absolute value for middle- and high-income households, but potentially higher elasticities for low-income households where the income effect is more pronounced (Varian, 2010).

Cross-price elasticity captures the relationship between substitute goods (positive sign) and complementary goods (negative sign). For the chicken-fish pair in Latin American coastal contexts, previous studies have found evidence of moderate substitution, with cross-price elasticities ranging from 0.15 to 0.45 (Abdulai & Aubert, 2004; Cembalo et al., 2019). The chicken-rice relationship, given the complementarity observed in Peruvian consumption patterns, tends to exhibit negative cross-price elasticities.

In econometric methodology, the log-log model is widely used to estimate elasticities directly as regression coefficients. The Tobit model corrects selection bias when there is censoring at zero - households that did not purchase the good during the reference period - and is especially relevant in consumption surveys (Amemiya, 1984). Quantile regression (Koenker & Bassett, 1978) makes it possible to study the heterogeneity of effects across the consumption distribution, revealing whether elasticity differs between frequent and occasional consumers.

2. Data and methodology

The database used corresponds to a five-year pool from the National Household Survey (ENAHO 2019-2023) of Peru's National Institute of Statistics and Informatics (INEI), restricted to households in the Tumbes region (department code 24). ENAHO is a multipurpose survey with a probabilistic, stratified, and multistage design, representative at the departmental level.

From Module 601 (Food expenditures), purchase data were extracted for chicken (code 0901), fish (codes 2000, 2001, 2003, 2004, 2005, 2009), regular and superior rice (codes 0301, 0302), and beef (codes 0800, 0802-0805). Unit prices were calculated as the ratio of reported expenditure to the quantity purchased (implicit price). Monthly per capita consumption was obtained by dividing quantities by the number of household members and the months of the year. Outliers were treated through winsorization at the 99th percentile, and missing prices were imputed with the median by ubigeo using the imputeoutlog command.

The socioeconomic stratification variable (estrsocial) comes from the Sumaria file and follows the INEI/APEIM classification, recoded into three categories: A/B (strata 1-2), C/D (strata 3-4), and E (strata 5-6). In the Tumbes region, no observations for stratum A/B were recorded during the analyzed period; therefore, the analysis focuses on strata C/D and E.

The main econometric model is specified as follows:

ln(q_chicken_pc)it = alpha + beta1 ln(p_chicken)it + beta2 ln(p_fish)it + beta3 ln(p_rice)it + beta4 ln(p_beef)it + beta5 ln(expenditure_pc)it + beta6 household_members + beta7 education + sum delta_t dt + epsilon_it.

Where q_chicken_pc is monthly per capita chicken consumption in kilograms; p_j denotes the prices of chicken, fish, rice, and beef, respectively (implicit prices in S/./kg); expenditure_pc is total monthly per capita household expenditure; household_members is the number of people in the household; education is the education level of the household head; and dt are year dummies that capture temporal effects. The coefficients beta1 and beta2 directly represent the own-price and chicken-fish cross-price elasticities. All models were estimated using sampling weights (factor07) and robust standard errors for heteroscedasticity.

3. Descriptive statistics

The descriptive analysis of the pooled ENAHO 2019-2023 data for Tumbes reveals differentiated patterns by socioeconomic stratum. The average price of chicken is S/.9.82/kg in stratum C/D and S/.9.14/kg in stratum E; this difference is statistically significant ($F = 8.7$, $p < 0.01$), reflecting the

fact that lower-income households access lower-value cuts and lower-price stores. Monthly per capita chicken consumption is 1.23 kg in C/D and 0.87 kg in E, indicating a protein-access gap of approximately 29% between strata.

The price of fish has a mean of S/.8.45/kg for the full sample, with seasonal variability associated with biological fishing bans. Per capita fish consumption is relatively homogeneous across strata (0.94 kg/month in C/D versus 0.91 kg/month in E), consistent with its role as a lower relative-price substitute during periods of rising chicken prices. Rice, with an average price of S/.2.78/kg, shows the highest per capita consumption (4.12 kg/month in C/D and 4.38 kg/month in E), reflecting its character as an inferior good with expected negative income elasticity.

4. Results of the econometric models

The results of the log-log OLS model with robust errors are presented for the whole sample and by socioeconomic stratum. The global model explains 47.3% of the variance in the logarithm of per capita chicken consumption (adjusted R2 = 0.473), with all price regressors statistically significant at the 1% level.

Table 1.
Estimated elasticities by model and socioeconomic stratum

Variable	OLS Global	OLS C/D	OLS E	Tobit Global
ln(p_chicken) - Own-price elasticity	-0.847*** (0.098)	-0.621*** (0.112)	-1.382*** (0.143)	-0.913*** (0.104)
ln(p_fish) - Cross-price elasticity	0.312*** (0.087)	0.274** (0.109)	0.418*** (0.127)	0.341*** (0.092)
ln(p_rice) - Cross-price elasticity	-0.183*** (0.063)	-0.154** (0.074)	-0.247*** (0.091)	-0.196*** (0.068)
ln(p_beef) - Cross-price elasticity	0.091 (0.071)	0.083 (0.089)	0.112 (0.104)	0.097 (0.076)
ln(expenditure_pc) - Expenditure elasticity	0.634*** (0.075)	0.589*** (0.094)	0.712*** (0.108)	0.681*** (0.079)
Household members	-0.071*** (0.018)	-0.063*** (0.022)	-0.085*** (0.027)	-0.076*** (0.019)
Education of household head	0.048** (0.021)	0.044* (0.025)	0.057** (0.031)	0.052** (0.022)
Observations	2,847	1,623	1,224	2,847
Adjusted R2	0.473	0.441	0.502	-

Note. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. Models include year dummies (2020-2023). Sampling weights factor07.

The results in Table 1 make it possible to contrast the four proposed hypotheses. First, the own-price elasticity of chicken differs markedly across strata: -0.621 in C/D versus -1.382 in E, both statistically significant at the 1% level. This difference fully confirms H1, showing that households in stratum E are more than twice as sensitive to the price of chicken as households in stratum C/D. The unit-elasticity threshold (|epsilon| = 1) is exceeded only in stratum E, implying that chicken demand is elastic

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among lower-income households, with direct implications for total expenditure on this protein.

Regarding H2, the chicken-fish cross-price elasticity is positive and significant in all models, with values of 0.274 in C/D and 0.418 in E. These results confirm the substitution relationship between the two proteins, which is stronger in stratum E. This finding is consistent with the coastal geography of Tumbes, where access to fresh fish is relatively easier for lower-income households, who use it as a protein alternative when chicken prices rise.

H3 is also confirmed: the chicken-rice cross-price elasticity is negative and significant (-0.154 in C/D and -0.247 in E), evidencing complementarity between both goods in the region's food basket. This result is consistent with culinary patterns on Peru's northern coast, where rice is the most common accompaniment to chicken in main meals.

5. Quantile regression: distributional heterogeneity

Quantile regression reveals that the own-price elasticity of chicken is not uniform across the consumption distribution. For the full sample, elasticity varies from -0.513 at quantile Q10 to -1.241 at Q90, indicating that large chicken consumers show greater price sensitivity, possibly because they have greater substitution capacity. This pattern is amplified in stratum E, where elasticity at Q90 reaches -1.587.

Table 2.
Elasticities by chicken-consumption quantile - Quantile regression

Elasticity / Quantile	Q10	Q25	Q50	Q75	Q90	OLS
Own-price elasticity (Global)	-0.513***	-0.671***	-0.847***	-1.034***	-1.241***	-0.847***
Own-price elasticity (Stratum E)	-0.784***	-1.021***	-1.262***	-1.412***	-1.587***	-1.382***
Fish cross-price elasticity (Global)	0.197**	0.241***	0.312***	0.371***	0.428***	0.312***
Rice cross-price elasticity (Global)	-0.092*	-0.134**	-0.183***	-0.221***	-0.267***	-0.183***

Note. *** p<0.01, ** p<0.05, * p<0.10. Estimates with qreg2 (robust bootstrap errors, 500 replications).

6. Policy simulation (H4)

The evaluation of H4 compares two food policy instruments targeted at stratum E: (a) a -15% subsidy on the price of chicken and (b) a direct cash transfer of S/.50 per month. For stratum E, where the median total monthly per capita expenditure is S/.312.40, calculations based on the estimated OLS coefficients are as follows:

A -15% subsidy on the price of chicken: Delta ln(q) = beta_ln_p_chicken x ln(0.85) = (-1.382) x (-0.1625) = 0.2245. This implies a percentage increase in consumption of exp(0.2245) - 1 = 24.8%. Thus, a 15% reduction in the price of chicken would raise monthly per capita consumption from 0.87 kg to 1.09 kg in stratum E.

Cash transfer of S/.50/month: Delta ln(expenditure_pc) = ln(1 + 50/312.40) = ln(1.1601) = 0.1484. Therefore, Delta ln(q) = beta_ln_expenditure_pc x 0.1484 = (0.712) x (0.1484) = 0.1057. The increase in consumption is exp(0.1057) - 1 = 11.1%, bringing consumption to 0.97 kg per capita per month.

The comparison shows that a direct subsidy on the price of chicken generates a 24.8% increase in protein consumption, compared with 11.1% for the cash transfer. The price subsidy is therefore more than twice as effective in terms of its impact on consumption of this protein. This confirms H4 and has implications for designing food-security programs in the region, although it should be noted that a price subsidy has a higher fiscal cost and may generate unintended substitution effects.

CONCLUSION

This study estimates the own-price and cross-price elasticity of food demand in Tumbes households using a five-year ENAHO pool (2019-2023). The results confirm the four proposed hypotheses and allow relevant policy implications to be derived.

The own-price elasticity of chicken is significantly higher in stratum E (-1.38) than in stratum C/D (-0.62), confirming that lower-income households are the most vulnerable to fluctuations in the price of this protein. This result has direct implications for social policy: when chicken prices rise, households in stratum E reduce their protein consumption by a greater proportion, which deteriorates the nutritional quality of their diet.

Fish acts as a substitute for chicken in strata C/D and E, with cross-price elasticities of 0.27 and 0.42, respectively. In Tumbes, given the availability of fresh fish due to its coastal condition, this substitution represents a relevant adjustment mechanism for lower-income households during periods of rising chicken prices. Rice, by contrast, is complementary to chicken across all strata, with negative and statistically significant cross-price elasticities.

Quantile regression adds an important dimension of heterogeneity: own-price elasticity increases in absolute value across consumption quantiles, meaning that households that consume more chicken are those that reduce their demand the most in response to price increases. In stratum E, elasticity at Q90 reaches -1.587, reinforcing the vulnerability of these households.

Finally, the policy simulation indicates that a -15% subsidy on the price of chicken increases consumption in stratum E by 24.8%, more than twice the effect of a S/.50/month cash transfer (11.1% increase). This evidence suggests that direct interventions on the price of animal proteins are more efficient than cash transfers for improving protein access among the most vulnerable households in the region.

Among the study's limitations are the use of implicit prices as a proxy for market prices, the possible endogeneity between prices and quantities in the OLS model, and the absence of stratum A/B observations in Tumbes, which prevents comparisons with the top of the income distribution. Future research could estimate complete demand systems (AIDS or QUAIDS) and extend the analysis to other Peruvian regions in order to evaluate the geographic heterogeneity of elasticities.

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