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Socio-Economic Evolution and Tobacco Products Sales in Spain: A Long-Term Analysis of the Tobacco Kuznets Curve

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ABSTRACT

This article examines the relationship between economic development and tobacco consumption in Spain, using the Kuznets Curve framework. Drawing on panel data from Spanish provinces (2002–2021), the findings confirm that GDP has a non-linear effect on cigarette consumption. A 1% increase in GDP initially is positively associated with an increase in cigarette sales by 2.31%, but at higher income levels, cigarettes sales decrease (−0.24%), reflecting changing consumption dynamics as economies develop, which corroborates the existence of the Tobacco Kuznets Curve (TKC). Beyond GDP, we examine the role of unemployment in shaping tobacco consumption patterns, focusing on product substitution effects. Unlike its negative impact on cigarette sales (−0.075%), unemployment has a positive effect on Roll-Your-Own (RYO), pipe tobacco, and cigars. A 1% increase in unemployment raises sales of these alternative products by 0.31%, 0.48% and 0.29%, respectively, suggesting that economic downturns push consumers toward cheaper substitutes, also perceived as less harmful, rather than leading to a complete reduction in tobacco use. The inclusion of real cigarette prices confirms that higher prices—often driven by taxation—are associated with reduced cigarette sales and a shift toward alternative tobacco products, supporting evidence of a substitution effect during periods of economic downturns. Additionally, factors such as life expectancy and demographic aging significantly influence consumption patterns across all tobacco products. These findings highlight the need for differentiated anti-smoking policies, as uniform regulations may fail to address product-specific shifts driven by economic cycles.

JEL Classification: I12, I18, H51, D12, E32, C23

1 | Introduction

Understanding the relationship between economic development and public health is crucial for creating effective policies, especially those focused on reducing the use of harmful substances such as tobacco. These policies may include strategies such as raising taxes and prices (Chaloupka 1999; Bader et al. 2011; Martín-Álvarez, Golpe, et al. 2020), implementing regulations for smoke-free workplaces (Fichtenberg and Glantz 2002; Pinilla et al. 2019; Del Arco-Osuna et al. 2023), conducting health education campaigns, and enforcing restrictions on advertising (Kasza et al. 2011; Almeida, Galiano, et al. 2021; Golpe et al. 2022). Beyond these policy measures, socioeconomic factors also play a significant role in shaping smoking behavior. For instance, individuals' economic status influences smoking habits (Hiscock et al. 2012), highlighting the need to examine how economic growth affects tobacco consumption. Understanding this relationship is crucial for policymakers, enabling them to design more effective interventions at various stages of economic development. To explore this dynamic, we apply the theoretical framework of the Kuznets Curve, which provides a valuable lens for analyzing the relationship between economic development and various social phenomena, including public health issues like tobacco consumption.

Originally introduced by Kuznets (1955) to describe the relationship between income inequality and economic growth, the Kuznets Curve has proven to be a versatile and adaptable tool. It suggests that inequality rises during the early stages of the economic grow and later decreases as economies mature. This concept has been extended to other relationships, such as economic development and environmental degradation. The empirical adaptation known as the "Environmental Kuznets curve" (EKC) was first applied by the World Bank (1992) and by Grossman and Krueger (1995). The core idea is that as economies advance, they contribute to atmospheric pollution, but as income levels rise, pollution tends to decrease (Congregado et al. 2016; Iglesias et al. 2013; Robalino-López et al. 2015). Similarly, the Kuznets Curve has been used to analyze the relationship between economic development and social issues such as gender inequality (Duflo 2012), crime rates (Fajnzylber et al. 2002), and access to education (Castello-Climent and Domenech 2014). These applications highlight the adaptability and versatility of the Kuznets Curve, inspiring policymakers across different domains to explore its potential for understanding how economic growth intersects with various dimensions of social progress and empowering them to make informed decisions.

Recent studies have extended this framework to include the consumption of goods that have significant public health implications, such as tobacco and alcohol (Grecu and Rotthoff 2015; Cantarero-Prieto et al. 2019, 2023). As income continues to rise and health becomes a normal good, people tend to shift their consumption toward healthier products. Deaton (2003) emphasized the importance of focusing on the role of income or related factors such as education, wealth, or social status in promoting health when reflecting on the relationship between health, inequality, and economic development. Additionally, the contemporary applications of the Kuznets curve to health remain valuable. For instance, Costa-Font et al. (2018) explored the existence of a Health Kuznets Curve, finding that income-related health inequalities increase with GDP per capita but eventually decline once a certain level of economic development is reached. A recent literature review by Patterson (2023) reveals a significant body of multidisciplinary research exploring the connection between economic growth and population health. The review notes that many researchers find that the growth-health relationship varies depending on several factors: (i) the specific aspect of "health" being examined, (ii) the nature of the relationship, whether it is positively linear or logarithmic, (iii) timing considerations include whether growth is observed over the short or long term, (iv) a focus on health inequalities versus overall population averages, and (v) multivariable relationships involving additional factors. The research indicates that employing multivariable approaches can lead to a more comprehensive understanding of the connection between economic growth and health. Therefore, it is suggested that simultaneously analyzing multiple factors could advance this field of research.

Current state-of-the-art research suggests a positive relationship between income and health both within and across countries (Marmot 1999), covering different age groups (Case et al. 2002) and mortality rates (Preston 1975). Additionally, Ruhm (2000) found that economic recessions might improve health outcomes. Ruhm examined the effects of economic downturns on the Kuznets curve by considering unemployment rates. However, in a subsequent study, he found that these results varied across different periods (Ruhm 2015).

In Spain, although a positive relationship is observed between income and tobacco sales, there is a strong asymmetry in periods of expansion and recession (Martín-Álvarez, Almeida, et al. 2020). "Asymmetry" in this context refers to the unequal impact of economic conditions on tobacco sales. Furthermore, while in expansion phases, tobacco sales are affected by income, in recessions, unemployment is the indicator that is linked to shifts falls in tobacco sales (Martín-Álvarez, Almeida, et al. 2020). Therefore, it seems essential to use GDP and unemployment as indicators of the economic cycle when analyzing the behavior of tobacco sales.

Several scholars have explored the connection between income and health using the Kuznets curve framework, leading to an extensive body of literature. For example, Marmot (1999) concluded that lower socio-economic status is associated with poorer health and vice versa. Case et al. (2002) demonstrated that household income plays a crucial role in children's health, showing a positive relationship. Grecu and Rotthoff (2015) examined the link between income and obesity through a Kuznets curve, referred to as the "Obesity Kuznets Curve". Furthermore, Fotourehchi and Çalışkan (2018) investigated the correlation between economic growth and health outcomes in 60 developing countries and found no specific Kuznets curve for health outcomes. This suggests that health policies need to be tailored to each health indicator. In this context, it seems that each health indicator can present heterogeneous behaviors, so analyzing the tobacco market only by using cigarette sales can provide biased results due to the heterogeneous behaviors across different types of tobacco products. A more nuanced analysis is necessary to capture the full complexity of tobacco consumption patterns.

Applying the Kuznets Curve (KC) framework to tobacco consumption—Tobacco Kuznets Curve (TKC), offers valuable insights into how economic development affects smoking behaviors and tobacco sales. In the early stages of economic growth, rising disposable income may lead to higher tobacco consumption, but as public health awareness grows, consumption may decline. This study aims to investigate whether tobacco sales in Spain follow this hypothesized inverted U-shaped pattern, examining how various socioeconomic factors—such as GDP and unemployment—affect consumption across different types of tobacco products, including cigarettes, roll-your-own (RYO), pipe, and cigars.

We hypothesize that tobacco sales increase with economic growth during the early stages of development, peak, and then decline as greater socioeconomic awareness is achieved.

Figure 1 illustrates the relationship between per capita GDP and cigarette sales in Spanish provinces from 2002 to 2021, showing a negative correlation during periods of economic expansion. This suggests that higher levels of socioeconomic awareness may reduce tobacco consumption. The figure also highlights differences in consumption patterns during economic expansions (black) and recessions (red), reinforcing the complex relationship between economic cycles and cigarette sales. The field of health economics is crucial for understanding these dynamics, as it examines the economic behaviors that underlie health outcomes, including consumption patterns and the effectiveness of public health interventions (Glied and Smith 2013). For example, as countries develop economically, increased disposable income may initially lead to higher consumption of harmful goods such as tobacco. However, over time, as socioeconomic status increases and public health initiatives become more prevalent, consumer behavior tends to shift, with individuals becoming more health-conscious and reducing their tobacco consumption. This economic perspective is essential for analyzing how different stages of economic development interact with public health measures to influence tobacco sales.

In previous research, Grecu and Rotthoff (2015) and Cantarero-Prieto et al. (2019), (2023) have shown similar patterns in alcohol or tobacco consumption, indicating that economic and social development have a significant impact on consumption behaviors. However, little attention has been given to applying the Kuznets Curve to tobacco consumption.

Traditionally used to analyze the relationship between economic development and income inequality, the Kuznets Curve approach provides a robust framework for understanding the complex interactions between economic variables and tobacco consumption. This study advances the literature by applying the Kuznets Curve framework tobacco products, using GDP as the primary economic determinant. The application of the Kuznets Curve methodology in this context is particularly significant and innovative. By distinguishing between two mechanisms, economic development (TKC) and the impact of economic downturn (substitution dynamics), this study provides an understanding of how economic fluctuations shape tobacco sales patterns. Our analysis offers a new perspective on how economic development influences different tobacco products, highlighting the nuanced effects of socioeconomic changes. This novel application not only enriches the existing literature but also offers practical insights for designing targeted tobacco control policies.

Previous studies have mostly relied on aggregate measures of tobacco consumption, which often mask significant differences

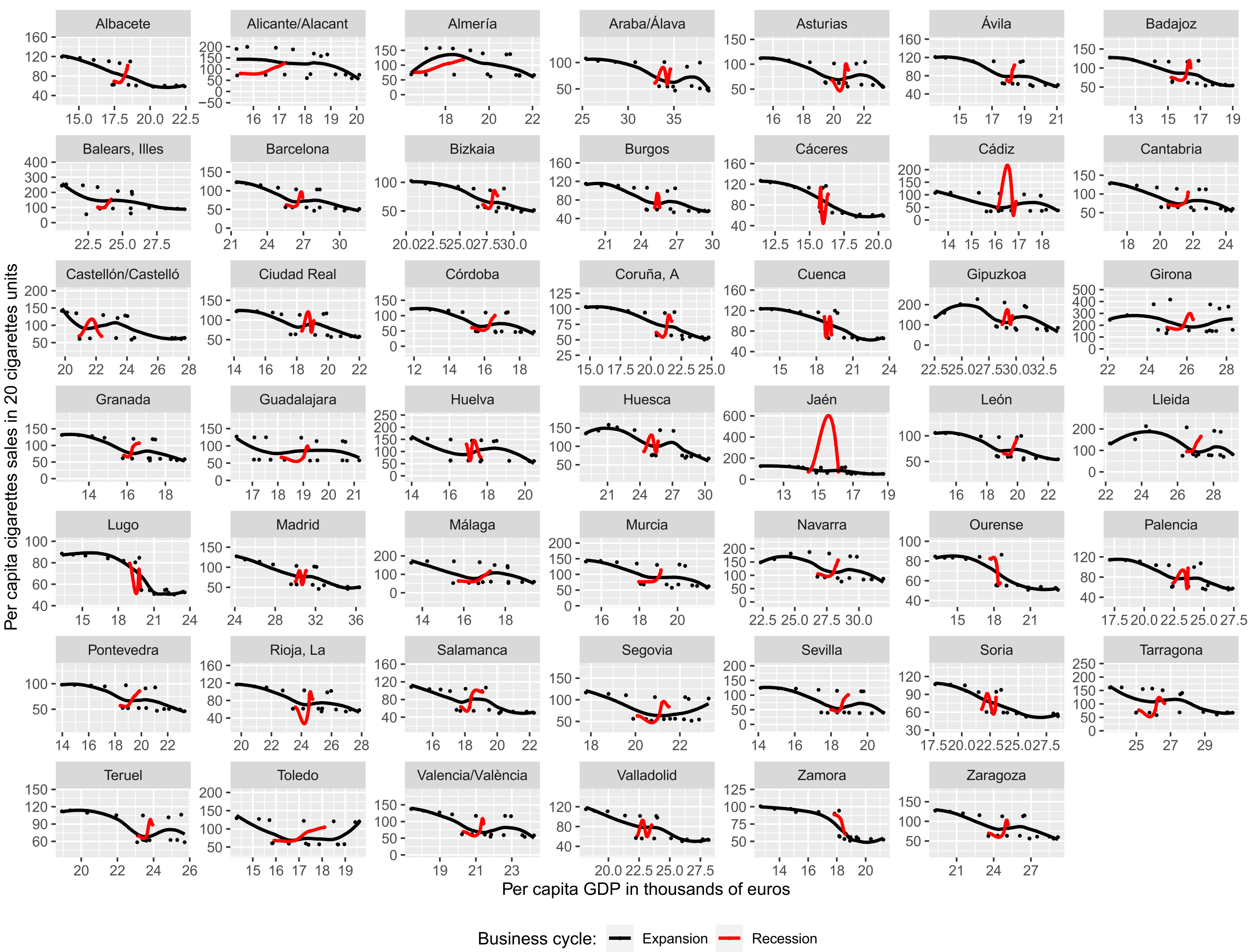

FIGURE 1 | Relationship between GDP and cigarette sales by province.

in how consumers react to income fluctuations or labor market shocks. Previous studies (Cantarero-Prieto et al. 2023) have applied the Tobacco Kuznets Curve (TKC) framework to tobacco consumption but, to the best of our knowledge, no previous study has disaggregated this analysis by product type. Analyzing different tobacco products in the context of economic cycles is essential because not all products respond equally to changes in economic conditions.

In addition, we are the first to empirically examine the substitution effect between tobacco products during economic downturns. Specifically, we show that rising unemployment is linked to a shift from more expensive products like manufactured cigarettes to lower-cost alternatives such as Roll-Your-Own (RYO), pipe tobacco, and cigars. This distinction is crucial for designing more targeted and effective tobacco control policies, as regulations focused solely on aggregate consumption may overlook these product-specific shifts in behavior triggered by economic stress.

Therefore, the contribution of our study lies in addressing a double gap in the literature. First, we apply the TKC framework specifically to cigarette consumption, capturing the non-linear effect of economic development on tobacco use. Second, we analyze how economic downturns, using unemployment rates, lead to a shift in consumption from one product to another, particularly from manufactured cigarettes to cheaper alternatives such as Roll-Your-Own (RYO), pipe tobacco, and cigars, using the real cigarettes prices as proxy of fiscal policy. This distinction is crucial for designing more targeted and effective tobacco control policies, as regulations focused solely on aggregate consumption may overlook important product-specific substitution effects that emerge during recessions. Moreover, we use panel data based on the Spanish provinces from 2002 to 2021, to account for time-varying and regional-specific characteristics.

That way we formulate the following hypotheses (H) and research questions (RQ), grounded in the gaps identified in the literature which focus on describing the heterogeneity of university enrollment responses to economic cycles:

i. H1: The relationship between GDP and cigarette consumption follows a non-linear relationship, where consumption initially is positively associated with economic growth but decreases at higher income levels, confirming the Tobacco Kuznets Curve (TKC).

ii. H2: Economic downturns (measures by increases in unemployment rate) and changes in fiscal policy (measures buy real price of cigarettes) lead to a decline in cigarette consumption but cause a shift toward alternative tobacco products (RYO, pipe tobacco, and cigars), increasing their consumption, but decreasing the cigarettes sales.

Therefor the research question we align with our empirical strategy are:

i. RQ1: Does the Tobacco Kuznets Curve hypothesis hold for the tobacco product using different types of tobacco?

ii. RQ2: Is there a shift in consumption from cigarettes to other tobacco products throughout the economic cycle?

This research will contribute to a deeper understanding of the socioeconomic drivers of tobacco consumption, providing insights that are valuable for both economic theory and public health policy. By shedding light on the conditions under which tobacco sales decline as economies grow, this study seeks to inform the design of more effective interventions aimed at reducing tobacco use and its associated health burdens.

2 | Data and Methods

The data on tobacco product sales come from the Ministry of Finance and Public Administration of Spain. In contrast, the data on the socioeconomic explanatory variables have been extracted from the National Institute of Statistics of Spain. The data were collected from the 48 provinces that make up the Spanish territory where tobacco was sold under the regulated market during the period 2002–2021 (960 observations).

It is important to note that heated tobacco products are included under the "pipe tobacco" category. However, their market share in Spain remains below 1% throughout the study period (Martín-Álvarez et al. 2023), and no official data on e-cigarette sales are available for consistent analysis.

All variables used in the estimation models are transformed into natural logarithms, allowing for the interpretation of estimated coefficients as elasticities (i.e., percentage changes). Table 1 shows the descriptive statistics of the variables in logarithms.

To address our research questions, we apply a structured panel data methodology to examine the relationship between economic and sociodemographic factors and tobacco product sales, inside the Kuznets Curve framework. The full empirical strategy is summarized in Table 2 and is designed to ensure the robustness and validity of the results.

In Step 1 and 2, before proceeding with model estimation, we assess the statistical behavior of the data to ensure the robustness of our results. Specifically, we test whether the variables are stable over time (stationarity) and whether they move together in the long term (cointegration). These checks are essential in panel data analysis to avoid drawing misleading conclusions based on trends that are unrelated but evolve similarly over time.

A stationary variable fluctuates around a consistent level, while a non-stationary one tends to drift due to long-term factors. Cointegration, on the other hand, indicates that even if variables evolve over time, they maintain a stable relationship, suggesting a meaningful long-run connection. These tests help determine whether our model is suitable for identifying genuine economic relationships rather than spurious ones.

For transparency, the technical details and formal definitions of the statistical tests applied (Cross-sectional Im-Pesaran-Shin and Pedroni) have been moved to the supplementary appendix (see Appendix 1 for technical details).

If the series are stationary or cointegrated, the next step is to choose the most suitable estimation method for panel data

TABLE 1 | Descriptive statistics.

Variable	Mean	SD	Min	Max	Q1	Q2	Q3
Cigarettes	90.0	43.0	33.6	416.0	59.3	76.9	111.0
RYO	0.0037	0.0022	0.0008	0.0166	0.0021	0.0033	0.0046
Pipe	0.0005	0.0002	0.0001	0.0019	0.0003	0.0004	0.0006
Cigars	0.2050	0.0889	0.0560	0.6120	0.1340	0.1950	0.2570
GDP	21.5	4.92	11.4	38.8	17.9	20.5	24.8
Unemployment rate	15.6	7.48	2.87	42.3	9.95	14.2	20.1
Real price cigarettes	1.146	0.416	0.367	1.609	0.762	1.342	1.505
Life expectancy	82.0	1.41	77.7	84.9	81.0	82.2	83.0
Aging ratio	1.51	0.563	0.718	3.40	1.10	1.35	1.82
Youth ratio	0.209	0.0274	0.143	0.267	0.189	0.211	0.230

TABLE 2 | Strategy of empirical research.

	Procedure	Hypotheses
Step 1	Pesaran CIPS test (Pesaran 2007)	Are the time series used stationary?
Step 2	Pedroni test (Pedroni 1999; Pedroni 2004)	Are there cointegration relationships between the time series used?
Step 3	Hausman test	Which model is appropriate for this dataset? (Pooled ordinary least squares, fixed effects, or random effects)
Step 4	Panel data model considering GDP and GDP-squared	Does the Tobacco Kuznets Curve hypothesis hold for the tobacco product considering different products? (RQ1)
Step 5	Panel data model considering unemployment rate	Is there a shift in consumption from cigarettes to other tobacco products throughout the economic cycle? (RQ2)

analysis: Pooled Ordinary Least Squares (POLS), Fixed Effects (FE), or Random Effects (RE). To make this decision, we use the Hausman test (Hausman 1978), which evaluates whether the RE or FE model is more appropriate. We compare Fixed Effects and Random Effects models using the Hausman test (Step 3), which guides the choice of the most appropriate estimation technique based on whether unobserved regional effects are correlated with the explanatory variables. (see Appendix 2 for details on Hausman test).

Estimating by panel data model we account for unobserved heterogeneity across regions and over time. This approach controls for regional-specific characteristics that are constant over time, such as structural economic differences, demographic profiles, or cultural attitudes toward tobacco use, that could otherwise bias the estimates.

In addition, by including year fixed effects, the model also captures common temporal shocks affecting all regions, such as economic crises or public health campaigns. This specification ensures that the estimated coefficients reflect the impact of within-regional variations in economic indicators (GDP, unemployment) on tobacco consumption, while netting out any influence from time-invariant regional factors or nationwide trends.

Next, Steps 4, drawing on previous studies in the Health Economics literature that examine the Alcohol or Tobacco Kuznets Curve (TKC) (e.g., Grecu and Rotthoff 2015; Cantarero-Prieto et al. 2019, 2023) focus on estimating the impact of income measured by GDP on tobacco sales, testing for a non-linear relationship by including both linear and quadratic terms for income (Equation 1):

$$\begin{aligned} \textit{Tobacco sales}_{st} = \beta_1 \cdot GDP_{st} + \beta_2 \cdot (GDP_{st})^2 + \phi \cdot \mathrm{RPC}_{st} \\ + X'\delta + \gamma_s + \tau_t + \mathcal{E}_{st} \end{aligned} \tag{1}$$

In this model (1), β_1 and β_2 capture the non-linear relationship between income (*GDP*) and cigarette consumption, in line with the Tobacco Kuznets Curve (TKC) hypothesis. A negative β_1 combined with a positive β_2 would support the existence of a U-shaped relationship, where tobacco consumption first decreases and later increases with income growth. The coefficient ϕ represents the effect of real prices of cigarettes and serves as a proxy to assess the impact of tobacco taxation policies. RPC denotes the real price of cigarettes, constructed by deflating the average national nominal price of a 20-cigarette pack—published annually by the Commission for Trade of Tobacco, using the national Consumer Price Index (CPI) with base year 2016. As tobacco taxation in Spain is centralized and uniform across all provinces, regional tax rates are not available and cannot be included in robustness checks. Following prior literature, such as Almeida, Galiano, et al. (2021), RPC serves as a proxy for fiscal pressure on tobacco consumption. A significantly negative ϕ would indicate that higher prices—often driven by taxation—lead to a reduction in cigarette consumption, reflecting the effectiveness of fiscal measures as a tobacco control tool. Including the price of cigarettes allows us to indirectly account for potential substitution effects between tobacco products, as an increase in cigarette prices may encourage consumers to switch to more affordable alternatives. This approach has been commonly adopted in the literature. For instance, Cornelsen and Normand (2014) and Vladisavljevic et al. (2022) use similar strategies to assess whether rising cigarette prices are associated with increased consumption of roll-your-own tobacco.

This part of the analysis corroborates the first hypotheses (RQ1) introduced in our research. Concretely, Step 4 test whether data supports the TKC hypothesis by confirming a non-linear relationship between GDP and cigarette sales. This hypothesis suggests that tobacco sales initially increase with GDP as economic development progresses but eventually decline as GDP continues to grow, reflecting a transition in consumption patterns.

In Step 5, we explore the substitution effect by including the unemployment rate as an explanatory variable and analyzing its impact on other tobacco products—RYO, pipe tobacco, and cigars (RQ2). Prior literature suggests that economic downturns may shift consumption toward cheaper alternatives. This step allows us to measure whether unemployment encourages substitution away from cigarettes and toward these products (Equation 2).

$$Tobacco\ sales_{st} = \beta_1\ unemp + \phi \cdot \mathrm{RPC}_{\mathrm{st}} + X'\delta + \gamma_s + \tau_t + \mathcal{E}_{st} \quad (2)$$

In the specification (2), the coefficient β captures the effect of economic downturns, proxied by the unemployment rate (*unemp*), on tobacco consumption. This allows us to assess whether rising unemployment is linked to a decline in cigarette sales, as would be expected during periods of reduced household income. However, for alternative tobacco products such as Roll-Your-Own (RYO), pipe tobacco, and cigars, a positive and significant β would indicate that consumers shift toward cheaper alternatives when economic conditions worsen. This would provide empirical evidence of a substitution effect in tobacco consumption during economic crises. The coefficient ϕ represents the impact of real price cigarettes (GPC) on tobacco products.

In both models (1) and (2) X' is a vector of time-varying socioeconomic factors of health outcomes. For controlling the differences in tobacco sales that are common to people in the same region, we include the regional fixed effects, γ_s. The time fixed effects, τ_t, absorb any time-varying in the tobacco sales, for example, changes in health policies (Del Arco-Osuna et al. 2023).

By estimating this model separately for each tobacco product, we test whether economic distress is positively associated with to a reallocation of consumption across product types, thus offering a more nuanced understanding of consumer behavior during economic downturns. By analyzing these relationships, we aim to clarify the dynamic interplay between economic conditions and tobacco use, offering valuable insights into how economic downturns and labor market fluctuations influence shifts in tobacco product preferences.

Finally, while concerns about potential endogeneity (e.g., reverse causality between tobacco consumption and macroeconomic variables) are valid, our empirical framework minimizes such risks. First, by focusing on short-term effects and using fixed effects models, we control for unobserved heterogeneity across provinces. Second, we performed Granger causality tests that consistently show the causal direction runs from economic conditions (GDP and unemployment) to tobacco sales, rather than the reverse (Appendix 3). The results indicate that reverse causality appears in a limited number of provinces, but it is not a systematic or widespread pattern across the sample (p-value associated to Granger causality test H0: no-causality). In addition to the provincial-level analysis, we also performed Granger causality tests on the full panel (global level) without disaggregating by province. The results show that the direction from economic variables (GDP and unemployment) to tobacco sales is consistently statistically significant across all tobacco products, confirming that macroeconomic conditions influence consumption patterns. In contrast, the reverse direction—from tobacco sales to GDP or unemployment—is not statistically significant in any case, which reinforces the assumption that tobacco consumption does not causally affect short-term changes in macroeconomic indicators. These results support the validity of our model specification, where GDP and unemployment are treated as exogenous variables influencing tobacco use. These findings reinforce our argument that the potential for reverse causality is limited within the short-term framework of this study (see Appendix Tables A1 and A2). Therefore, we consider endogeneity bias to be limited in our estimates.

3 | Results

Following the econometric strategy described above, in this section we present the results of the different test applied on our data set to confirm formally whether the variables have a particular characteristic: stationarity and cointegration. Particularly, Table 3 presents the results of the CPIS test to confirm formally whether the variables are stationary or not. Table 4 shows the results of the Pedroni's cointegration tests.

The results from Table 3, which presents the CIPS test for unit roots across various variables, indicate mixed stationarity properties. The variables RYO, Cigars, GDP, Life expectancy, Aging ratio, and "Youth ratio" fail to reject the null hypothesis of unit roots, suggesting they are stationary, despite p-values hovering around the 10% level. In contrast, "Cigarettes," "Pipe," and "Unemployment rate" are found to be non-stationary, given their significant p-values and test statistics. Table 4 presents the Pedroni's tests results, which consistently reject the null hypothesis across all tests at the 1%, 5%, and 10% significance levels. This strong rejection suggests the presence of multiple cointegrating relationships among the variables, indicating long-term equilibrium connections in the dataset. Taken together, the findings from both tables highlight short-term stationarity issues in some variables, while the cointegration test suggests robust long-term relationships.

In our analysis, each panel data model was estimated using both Random Effects (RE) and Fixed Effects (FE) approaches.

TABLE 3 | CIPS test results for unit roots across the used variables.

Variable	CIPS test statistic	*p*-value	Lag order	Conclusion
Cigarettes	−3.310	0.099	2	Non-stationary
RYO	−2.315	0.112	2	Stationary
Pipe	−2.617	0.064	2	Non-stationary
Cigars	−2.531	0.120	2	Stationary
GDP	−2.248	0.114	2	Stationary
Unemployment rate	−2.680	0.040	2	Non-stationary
Real price cigarettes	−2.894	0.056	2	Non-stationary
Life expectancy	−2.429	0.105	2	Stationary
Aging ratio	−1.022	0.114	2	Stationary
Youth ratio	−2.539	0.119	2	Stationary

TABLE 4 | Pedroni's cointegration tests results.

			Boostrap critical values			
Test	Empirical statistic	Standardized statistic	10%	5%	1%	Conclusion
Panel ν-statistic	591.42	31.67	−2.58	−1.96	−1.28	Reject H_0
Panel ρ-statistic	−0.89	16.43	−2.58	−1.96	−1.28	Reject H_0
Panel non-parametric *t*-statistic	1.57	12.67	−2.58	−1.96	−1.28	Reject H_0
Panel parametric *t*-statistic	0.19	30.42	−2.58	−1.96	−1.28	Reject H_0
Group ρ-statistic	−1.26	28.56	−2.58	−1.96	−1.28	Reject H_0
Group non-parametric *t*-statistic	0.25	22.43	−2.58	−1.96	−1.28	Reject H_0
Group parametric *t*-statistic	−0.50	21.90	−2.58	−1.96	−1.28	Reject H_0

Subsequently, the Hausman test was applied to determine the most appropriate model. The results of the Hausman test consistently indicated that the Fixed Effects model is the correct specification for our data. This outcome suggests that the Fixed Effects approach is preferable, as it accounts for the correlation between the individual-specific effects and the regressors, providing a more accurate representation of the underlying relationships. Therefore, all subsequent analyses are based on the Fixed Effects model, as it aligns with the test's recommendations and ensures the robustness of our findings.[1]

Once we have determined the structure of the variables in terms of stationarity and cointegration relationship and being proved that fixed effect estimation is the correct specification for our data, Table 5 shows the fixed effect (FE) estimation to measure the impact of economic and demographic factors on tobacco sales. The results from the fixed effects estimation show significant relationships between the independent variables and different types of tobacco consumption (Cigarettes, RYO, Pipe, and Cigars). All variables in the model are expressed in natural logarithms, allowing us to interpret the estimated coefficients as elasticities. That is, a 1% change in an independent variable is associated with a β% change in the dependent variable.

GDP has a significant non-linear relationship with tobacco sales except in the case of RYO, which confirm the Tobacco Kuznets Curve (TKC) hypothesis for the relationship between GDP and cigarette sales. As shown in Table 5, the coefficient for GDP is positive, while the coefficient for GDP squared is negative, both significant at 10%. This suggests that at lower levels of economic development, cigarette consumption is positively associated, but as GDP continues to grow, it declines. Concretely, a 1% increase in GDP initially is positively associated with cigarette sales increases, and estimated by 2.31%, but at higher income levels, cigarettes sales decrease (−0.24%), reflecting changing consumption dynamics as economies develop, which is consistent with the Tobacco Kuznets Curve (TKC).

The results indicate a negative relationship between unemployment and cigarette sales, but a positive relationship for alternative tobacco products, including RYO, pipe tobacco, and cigars. As shown in Table 5, the unemployment rate has a highly significant and positive effect on all tobacco types except cigarettes. For RYO, Pipe, and Cigars, the unemployment rate coefficient is positive and significant at 1%, suggesting that higher unemployment is associated with increased use of these forms of tobacco. Specifically, an increase of 1% in unemployment rate are correlated with raises sales of these alternative products by 0.31%, 0.48% and 0.29%, respectively. Across all models, the coefficient for the real price of cigarettes is statistically significant and consistent with theoretical expectations. It reduces cigarette sales (−0.835%), and it is associated with

TABLE 5 | Results of the fixed effects model to measure the impact of economic and demographic factors on tobacco sales.

Independent Variables	Dependent variable							
	Cigarettes		RYO		Pipe		Cigars	
GDP	2.311***		2.710		−14.643***		4.238***	
	(0.442)		(2.600)		(2.621)		(0.918)	
GDP^2	−0.244***		−0.480		2.001***		−0.917***	
	(0.073)		(0.429)		(0.432)		(0.151)	
Unemployment rate		−0.075***		0.311***		0.485***		0.299***
		(0.013)		(0.062)		(0.066)		(0.024)
Real price cigarettes	−0.835***	−0.692***	2.398***	2.161***	3.343***	2.651***	0.908***	0.599***
	(0.017)	(0.023)	(0.102)	(0.108)	(0.103)	(0.117)	(0.036)	(0.042)
Life expectancy	−0.054	0.130**	−0.280	−0.261	−0.598**	−1.135***	0.196**	−0.040
	(0.035)	(0.042)	(0.204)	(0.196)	(0.206)	(0.211)	(0.072)	(0.076)
Aging ratio	−1.500***	−1.716***	−3.308***	−2.113***	2.626***	4.496***	0.481**	1.412***
	(0.073)	(0.104)	(0.426)	(0.488)	(0.430)	(0.525)	(0.150)	(0.189)
Youth ratio	−0.510	−3.582***	−19.870***	−20.115***	−31.746***	−16.535***	−4.666***	−4.178***
	(0.455)	(0.436)	(2.676)	(2.035)	(2.697)	(2.193)	(0.945)	(0.788)
Observations	960	960	960	960	960	960	960	960
R^2	0.948	0.920	0.779	0.785	0.839	0.820	0.812	0.779

*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

increased consumption of substitutes (RYO, pipe, cigars), supporting the idea that taxation policies targeting cigarettes can unintentionally shift consumers toward untaxed or lower-taxed alternatives, unless those products are also regulated. These results imply that alternative products to cigarettes are utilized during economic recessions as substitutes.

This substitution behavior has important policy implications:

- Tobacco taxation strategies should account for the potential shift toward lower-cost alternatives rather than focusing solely on cigarettes.
- Public health campaigns need to address the misconception that RYO, Pipe or cigars are "less harmful" substitutes during economic downturns.
- Unemployment support programs could incorporate smoking cessation initiatives, particularly targeting those most vulnerable to economic shocks.

These findings underscore the complex link between economic cycles and tobacco consumption, reinforcing the need for differentiated regulatory approaches based on both product type and economic conditions.

Life expectancy consistently demonstrates a negative and highly significant effect on all types of tobacco consumption, indicating that longer life expectancy is associated with lower consumption across all categories. Similarly, the aging ratio is negatively associated with cigarette and RYO consumption, but positively associated with Pipe and cigar consumption, suggesting different patterns of tobacco use among older populations.

Finally, the youth ratio has a significant negative effect on cigarette and RYO consumption, but a significant positive effect on Pipe and Cigar use. This indicates that younger populations tend to consume less traditional forms of tobacco but more modern alternatives like RYO. The R^2, ranging from 0.78 to 0.95, suggests a good fit for the models, especially for Cigarettes and RYO.

In summary, our results guarantee that the Tobacco Kuznets Curve (TKC) hypothesis is observed in the case of cigarettes, which is in line with previous literature in which it is stated that GDP growth is positively associated with an "awareness effect" in the smoking population (Martín-Álvarez, Almeida, et al. 2020). This finding supports first hypothesis (RQ1), which posited that the relationship between GDP and cigarette consumption follows a non-linear pattern, with consumption initially increasing with economic growth but decreasing at higher income levels. On the other hand, the rest of the tobacco products are used by consumers as substitute products in phases of economic recession, in line with our second hypothesis (RQ2). This hypothesis suggested that economic downturns, measured by increases in the unemployment rate, lead to a decline in cigarette consumption but cause a shift toward alternative tobacco products (RYO, pipe tobacco, and cigars), increasing their consumption.

Our results align with previous studies indicating that during economic recessions, unemployment triggers a reduction in cigarette sales (Martín-Álvarez, Almeida, et al. 2020). In such periods, consumers tend to turn to cheaper alternatives with false "healthy" connotations (Martín-Álvarez et al. 2023).

3.1 | Policy Implications in Spain and Beyond

Our findings underscore the complex link between economic cycles and tobacco consumption, reinforcing the need for differentiated regulatory approaches based on both product type and economic conditions.

In Spain, cigarette taxation has been a key strategy to reduce consumption. However, our findings suggest that higher unemployment pushes consumers toward lower-cost alternatives such as RYO, cigars, and pipe tobacco. Policymakers should consider harmonizing excise taxes across all tobacco products to prevent substitution effects and ensure that tax policies discourage overall consumption rather than just shifting consumer preferences.

Misperceptions about harm reduction are particularly relevant in Spain, where the affordability of RYO and cigars makes them attractive substitutes during economic downturns. Anti-smoking campaigns should directly target these misconceptions, emphasizing that all tobacco products carry significant health risks.

Spain has existing public health programs for smoking cessation, but they are not specifically integrated with unemployment policies. Given our findings that unemployment influences tobacco consumption, policymakers should explore targeted cessation programs for unemployed individuals, particularly those in lower-income brackets.

Internationally, countries with similar economic structures could adjust tax policies dynamically based on business cycles, increasing taxation on alternative products during recessions to prevent shifts toward perceived cheaper options.

Beyond Spain, policymakers in other countries could design communication strategies tailored to economic conditions, ensuring that anti-smoking messages remain relevant during both economic expansion and recession.

For other countries, implementing health subsidies for cessation therapies or linking anti-smoking programs with social welfare initiatives could help mitigate the economic pressures that drive tobacco use during downturns.

Policymakers should recognize that economic downturns create shifts in tobacco consumption patterns, making it essential to adapt regulatory frameworks dynamically rather than applying static, one-size-fits-all approaches. This is particularly relevant for Spain and other EU countries, where economic cycles influence consumer behavior in regulated markets. Continuous monitoring of market responses to tax policies is necessary to adjust regulations accordingly and prevent unintended substitution effects.

4 | Conclusion

In recent years, there has been increasing interest from academics and policymakers in identifying economic measures to reduce tobacco consumption due to its substantial impact on public health and national budgets, including tax revenue and health costs. Understanding how economic factors such as GDP per capita and unemployment levels influence tobacco consumption is critical, yet empirical evidence has not reached a definitive conclusion on the relationship between economic cycles and tobacco use.

To address this gap, our study takes a novel approach by concurrently analyzing the effects of GDP, unemployment, and other socioeconomic factors on the sales of various tobacco products in Spain. This is a relatively unexplored area in the literature, and our findings offer new insights into the dynamics of tobacco consumption in response to economic conditions.

Our panel data analysis reveals that all tobacco products except pipes display an inverted U-shaped relationship with GDP, supporting the Tobacco Kuznets Curve hypothesis. Results are significative for cigarettes and cigars. This suggests that as GDP is correlated with increases, cigarette and cigars consumption initially rises but eventually declines as higher levels of socioeconomic development are reached.

Additionally, considering unemployment rate to examine the role of unemployment in shaping tobacco consumption patterns, focusing on product substitution effects considering alternative and cheaper products, such as RYO, Pipe, and Cigars, we observe significant and positive relationships with unemployment rates, confirming the substitution effect address by our second hypothesis and research question. We have proved the existence of this transition from cigarettes to other tobacco products by using real price of cigarettes as a proxy of the taxation policy. Both results indicate that through the economic cycle, consumers are likely to turn to these alternative tobacco products, which are cheaper and perceived as more affordable "safe havens" compared to cigarettes.

The implications of these findings are twofold. First, while higher socioeconomic awareness and development contribute to reduced cigarette consumption, this effect is partially counterbalanced by the increased use of RYO, Pipe, and Cigars. These products, perceived as cheaper and less harmful, continue to drive overall tobacco consumption, undermining the public health goals of reducing tobacco use. Second, the proliferation of alternative tobacco products highlights a potential gap in tobacco control policies, which may need to address not only cigarette consumption but also the rising use of other tobacco products.

Our study aligns with existing literature suggesting that economic downturns, as measured by unemployment, lead to increased tobacco use through cheaper alternatives. This finding underscores the need for nuanced public health strategies that consider the diverse effects of different tobacco products. Policymakers should consider the heterogeneous impacts of various tobacco products when developing and implementing tobacco control policies. A one-size-fits-all approach may inadvertently exacerbate tobacco consumption by pushing consumers toward alternative products.

While this study provides valuable insights into the relationship between economic conditions and tobacco consumption, it is important to acknowledge certain limitations related to the data used. First, the accuracy of sales data for alternative tobacco products (such as Roll-Your-Own, pipe tobacco, and cigars) may be lower than that of manufactured cigarettes, as these products are often subject to less consistent tracking and reporting mechanisms. Second, the analysis is based on aggregated provincial-level data, and thus lacks individual-level consumption information, such as age, gender, socioeconomic status, or health-related behaviors. This limits our ability to explore heterogeneous effects across population subgroups or assess the influence of personal characteristics on tobacco consumption decisions.

These limitations should be considered when interpreting the results and drawing broader policy conclusions. Future research could benefit from incorporating micro-level survey data or more detailed product-specific sales records to further refine the analysis.

Additionally, we address other limitations, notably the context of data collected during a severe economic recession. Future research could explore the influence of these findings on subsequent regulatory changes and their effectiveness in controlling tobacco use across different product categories. Further investigations could provide valuable insights into how economic conditions and tobacco product characteristics interact, helping to refine public health interventions and improve tobacco control strategies.

One limitation of this study is the potential endogeneity between tobacco consumption and economic indicators such as GDP and unemployment. Although our empirical strategy focuses on short-term effects and employs fixed effects models to control for unobserved heterogeneity, we acknowledge that endogeneity—particularly due to reverse causality or omitted variable bias, cannot be entirely ruled out. While Granger causality tests suggest that the predominant direction of influence runs from economic variables to tobacco consumption, future research could strengthen causal inference by exploring alternative identification strategies, such as instrumental variable (IV) approaches, when suitable instruments are available.

While our study uses a fixed effects panel model that accounts for unobserved heterogeneity across provinces and over time, future research could benefit from explicitly exploring geographic and temporal heterogeneity in the relationship between economic conditions and tobacco consumption. For example, it would be valuable to analyze whether the effects of GDP and unemployment on tobacco sales differ between urban and rural areas, where cultural norms, access to products, and price sensitivity may vary. Additionally, a pre- and post-crisis comparison—particularly around the 2008 financial crisis or the COVID-19 recession—could reveal important shifts in consumer behavior across economic cycles. Incorporating spatial econometric techniques or interacting economic indicators with regional characteristics could help uncover more localized or time-specific dynamics, offering even more nuanced insights for targeted policy interventions. This further research will attempt to follow the line of research initiate in this paper and in Andueza et al. (2023), Cadahia et al. (2022) and Almeida, Golpe, et al. (2021).

5 | Supplementary Material

The empirical analysis was carried out using the *R* statistical programming language, which provides a robust and flexible environment for panel data modeling and time series analysis. Specifically, we relied on a set of well-established packages to implement the different stages of the methodology. The plm package (Croissant and Millo 2008) was used for fixed effects and random effects estimation in panel data; the forecast package (Hyndman and Khandakar 2008) supported time series forecasting and diagnostics; the urca and tseries packages (Pfaff 2008; Trapletti and Hornik 2020) facilitated unit root and cointegration testing; and the tidyverse ecosystem (Wickham et al. 2019; Wickham and Bryan 2023) enabled efficient data manipulation and visualization. All computations were performed using R version 4.2.2 (R Core Team 2022).

Acknowledgments

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Endnotes

[1] Detailed results of the Hausman test and the estimates for both models are available upon request.

[2] A statistical test commonly used to verify the stationarity of a time series.

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Appendix 1: Technical Details of Stationarity and Cointegration Tests

This appendix provides the technical background and formal definitions of the statistical tests used to assess the properties of the panel data: the Cross-sectional Im-Pesaran-Shin (CIPS) test for stationarity and the Pedroni test for cointegration. These tests are essential to verify whether the time series data meet the assumptions required for valid econometric estimation. While a summary of their implications is included in the main text for accessibility, the following sections offer full methodological transparency for interested readers.

Consider a panel data model of the form:

$$y_{it} = \rho_i y_{it-1} + \sum_{j=1}^{p} \phi_{ij} \Delta y_{it-j} + \epsilon_{it}$$

where: y_{it} is the value of the variable for entity i at time t, ρ_i is the autoregressive coefficient, ϕ_{ij} are the coefficients of the lagged differences, ϵ_{it} is the error term, assumed to be i.i.d.

The Cross-sectional Im-Pesaran-Shin (CIPS) test statistic is computed by averaging the Cross-sectional Augmented Dickey-Fuller[2] (CADF) statistics for entity i:

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} CADF_i, \text{ where } CADF_i = \frac{y_{it} - \overline{y_t}}{\sigma_y}$$

The test evaluates whether all panels contain a unit root (indicating non-stationarity) or if at least one panel is stationary. If the CIPS statistic falls below the critical value, we reject the null hypothesis, confirming stationarity in at least one panel. Otherwise, we assume unit roots are present across all panels.

Even if variables fluctuate over time, they may still be linked by a long-term relationship. So the Step 2 account for it and using the Pedroni cointegration test determines whether there is a stable long-term relationship between the variables across regions. We check in this step checks whether certain economic variables move together over time in a predictable way.

The Pedroni test includes seven test statistics, divided into two categories: panel-based tests (which assume similar autoregressive behavior across units) and group-based tests (which allow for differences in unit dynamics). These tests evaluate residuals from the proposed cointegration relationship to determine whether a long-term link exists between variables.

The null hypothesis states that there is no cointegration, meaning no long-term relationship among the variables. The alternative hypothesis differs between categories:

i. Panel-based tests check whether all units are cointegrated.
ii. Group-based tests assess whether at least one-unit exhibits cointegration.

Each test statistic is compared to critical values from the standard normal distribution. If the test statistic significantly deviates from zero (typically at the 5% level, ± 1.96), we reject the null hypothesis and confirm cointegration.

This approach ensures a robust evaluation of long-term relationships in panel data, even when units display heterogeneity or cross-sectional dependence.

TABLE A1 | Granger causality tests at the provintial level.

Province	GDP to CGRTT	CGRTT to GDP	UNEM to CGRTT	CGRTT to UNEM	GDP to RYO	RYO to GDP	UNEM to RYO	RYO to UNEM	GDP to PIPE	PIPE to GDP	UNEM to PIPE	PIPE to UNEM	GDP to CIGAR	CIGAR to GDP	UNEM TO CIGAR	CIGAR to UNEM
Álava	0.04**	0.11	0.16	0.87	0.01**	0.38	0.33	0.13	0***	0.86	0.1*	0.56	0.73	0.1	0.01**	0.13
Albacete	0***	0.13	0.17	0.17	0.01***	0.13	0.08*	0.14	0.02**	0.7	0.09*	0.81	0.07*	0.17	0.05**	0.23
Alicante	0.04**	0.36	0.17	0.85	0.07*	0.17	0.45	0.16	0***	0.62	0.74	0.55	0.02**	0.13	0***	0.36
Almería	0.02**	0.69	0.08*	0.15	0.06*	0.15	0***	0.6	0***	0.71	0.91	0.81	0.04**	0.23	0.05**	0.08*
Ávila	0.19	0.19	0.04**	0.85	0.21	0.63	0.23	0.42	0.01**	0.99	0.83	0.35	0***	0.32	0.01**	0.43
Badajoz	0.05*	0.18	0.03**	0.34	0.26	0.32	0.05*	0.81	0.07*	0.87	0.28	0.89	0.7	0.06*	0.47	0.17
Baleares	0.86	0.1	0.76	0.86	0.13	0.34	0.51	0.36	0.04**	0.76	0.83	0.14	0.01**	0.33	0***	0.24
Barcelona	0.04**	0.14	0.09*	0.71	0.33	0.1	0.05**	0.91	0.06*	0.9	0.65	0.12	0***	0.05*	0.01***	0.06*
Burgos	0.56	0.4	0.27	0.66	0.2	0.35	0.61	0.71	0***	0.91	0.28	0.44	0.14	0.27	0.04**	0.39
Cáceres	0.03**	0.25	0.58	0.53	0.45	0.53	0***	0***	0.01**	0.75	0.02**	0.98	0.63	0.08*	0.01**	0.23
Cádiz	0.12	0.4	0.09*	0.33	0.01**	0.82	0.03**	0.79	0.22	0.61	0.18	0.79	0.01***	0.41	0.03**	0.51
Castellón	0.02**	0.69	0.02**	0.63	0.49	0.28	0.12	0.6	0.04**	0.41	0.67	0.16	0.61	0.1*	0.03**	0.34
Ciudad Real	0.4	0.18	0.08*	0.3	0.3	0.19	0.36	0.91	0***	0.63	0.77	0.13	0.21	0.2	0.2	0.19
Córdoba	0.15	0.18	0.02**	0.55	0.04**	0.79	0***	0.73	0***	0.95	0.98	0.41	0.14	0.06*	0.16	0.28
A Coruña	0.02**	0.12	0.22	0.31	0.12	0.18	0.12	0.4	0.13	0.76	0.31	0.78	0.37	0.13	0.11	0.49
Cuenca	0.24	0.21	0.07*	0.3	0.31	0.59	0.32	0.26	0.02**	0.93	0.92	0.18	0.15	0.41	0.22	0.19
Girona	0.01***	0.4	0.46	0.09*	0.03**	0.05**	0.01**	0.21	0.08*	0.32	0.9	0.32	0.13	0.34	0.14	0.6
Granada	0.09*	0.17	0.25	0.24	0.28	0.31	0.3	0.82	0.15	0.83	0.6	0.81	0.04**	0.31	0.06*	0.22
Guadalajara	0.24	0.11	0.04**	0.54	0.17	0.43	0.13	0.52	0.18	0.57	0.83	0.61	0.01***	0.05*	0.1*	0.22
Guipúzcoa	0.1	0.23	0.47	0.45	0.01***	0.13	0***	0.51	0.14	0.04**	0.25	0.22	0.36	0.25	0.15	0.55
Huelva	0.04**	0.62	0.21	0.15	0.14	0.31	0.26	0.44	0***	0.98	0.31	0.48	0.31	0.24	0.29	0.25
Huesca	0.24	0.6	0.61	0.62	0.27	0.19	0.09*	0.34	0***	0.99	0.54	0.48	0.3	0.15	0.09*	0.14
Jaén	0.07*	0.14	0.16	0.62	0.73	0.34	0.73	0.09*	0.15	0.69	0.11	0.67	0.02**	0.55	0.56	0.18
León	0.03**	0.02**	0.26	0.41	0.17	0.42	0.08*	0.33	0.07*	0.91	0.26	0.92	0.1	0.3	0.39	0.37
Lleida	0.47	0.67	0.25	0***	0.23	0.99	0.07*	0.11	0.22	0.7	0.82	0.85	0.21	0.32	0.01***	0.81
La rioja	0.26	0.43	0.11	0.6	0.14	0.33	0.67	0.31	0***	0.6	0.91	0.61	0.36	0.15	0.01***	0.29
Lugo	0.47	0.3	0.03**	0.31	0.27	0.26	0.08*	0.9	0.08*	0.71	0.09*	0.86	0.47	0.21	0.02**	0.78
Madrid	0.1*	0.09*	0.22	0.55	0.13	0.23	0.95	0.55	0.3	0.97	0.52	0.58	0***	0.07*	0.01***	0.16
Málaga	0.12	0.84	0.01***	0.24	0.69	0.28	0.02**	0.41	0.21	0.78	0.37	0.97	0.1	0.22	0.02**	0.26
Murcia	0.03**	0.08*	0.21	0.72	0.47	0.27	0.03**	0.13	0***	0.87	0.87	0.58	0.03**	0.13	0.02**	0.51
Navarra	0.02**	0.39	0.6	0***	0.01***	0.11	0***	0.16	0.08*	0.79	0.13	0.62	0.06*	0.26	0***	0.11

(Continues)

TABLE A1 | (Continued)

Province	GDP to CGRTT	CGRTT to GDP	UNEM to CGRTT	CGRTT to UNEM	GDP to RYO	RYO to GDP	UNEM to RYO	RYO to UNEM	GDP to PIPE	PIPE to GDP	UNEM to PIPE	PIPE to UNEM	GDP to CIGAR	CIGAR to GDP	UNEM TO CIGAR	CIGAR to UNEM
Ourense	0.01**	0.17	0.05**	0.42	0.14	0.36	0.23	0.32	0***	1	0.58	0.93	0.02**	0.18	0.18	0.5
Asturias	0.08*	0.12	0.28	0.28	0.14	0.4	0.02**	0.07*	0.14	0.93	0.24	0.98	0.17	0.12	0.29	0.53
Palencia	0.29	0.34	0.28	0.07*	0.01**	0.12	0.53	0.43	0.05**	0.91	0.9	0.86	0.05*	0.25	0.38	0.12
Pontevedra	0.01***	0.1*	0.24	0.47	0.12	0.31	0***	0.64	0.17	0.54	0.58	0.96	0.09*	0.23	0.01***	0.89
Salamanca	0.04**	0.25	0.46	0.05*	0***	0.13	0.52	0.07*	0***	0.58	0.55	0.95	0***	0.11	0***	0.24
Cantabria	0.05*	0.13	0.03**	0.69	0.2	0.41	0.09*	0.45	0***	0.98	0.39	0.62	0***	0.24	0.01**	0.25
Segovia	0.15	0.51	0.41	0.11	0.25	0.33	0.07*	0.14	0.18	0.99	0.03**	0.67	0.11	0.09*	0.23	0.15
Sevilla	0.27	0.11	0***	0.29	0.06*	0.48	0.1*	0.82	0.19	0.43	0.67	0.77	0.02**	0.26	0.21	0.06*
Soria	0.56	0.28	0.45	0.78	0.13	0.34	0.07*	0.47	0.02**	0.67	0.96	0.57	0***	0.15	0.04**	0.14
Tarragona	0.08*	0.04**	0.44	0.1	0.39	0.88	0.77	0.06*	0.11	0.78	0.32	0.87	0.15	0.12	0.04**	0.24
Teruel	0.04**	0.63	0.37	0.27	0.08*	0.78	0.79	0.34	0.02**	1	0.26	0.75	0***	0.83	0.26	0.67
Toledo	0.08*	0.74	0.03**	0.23	0.25	0.57	0.03**	0.8	0.01***	0.55	0.3	0.53	0.18	0.17	0.02**	0.86
Valencia	0.42	0.26	0.12	0.76	0.2	0.5	0.02**	0.33	0***	0.94	0.53	0.14	0.14	0.16	0.06*	0.33
Valladolid	0.5	0.29	0.27	0.4	0.32	0.19	0.36	0.47	0***	0.77	0.79	0.96	0.28	0.06*	0***	0.53
Vizcaya	0.26	0.32	0.4	0.57	0.06*	0.05*	0***	0.8	0.21	0.85	0.92	0.38	0.5	0.14	0***	0.13
Zamora	0.05*	0.27	0.8	0.28	0.22	0.58	0.15	0.36	0.07*	0.7	0.18	0.6	0.08*	0.39	0.03**	0.24
Zaragoza	0.14	0.27	0.01**	0.67	0.2	0.3	0.21	0.56	0***	0.94	0.62	0.42	0.32	0.12	0***	0.51

*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

Appendix 2: Technical Details on Hausman Test

This appendix provides the technical foundation and rationale behind the use of the Hausman test in our panel data analysis. The Hausman test is a standard econometric procedure used to determine whether a Fixed Effects (FE) or Random Effects (RE) model is more appropriate for a given dataset. Specifically, it tests whether the unobserved individual-specific effects are correlated with the explanatory variables. If such correlation exists, the RE estimator is inconsistent, and the FE model is preferred.

The following section outlines the statistical formulation of the test, its assumptions, and interpretation, in line with standard econometric practice. For clarity and accessibility, only the core logic is presented in the main text, while the full derivation and implementation details are provided here.

To conduct the Hausman test, we first estimate the Fixed Effects (FE) and Random Effects (RE) models. Then, we calculate the Hausman test statistic, which is given by:

$$H = (\hat{\beta}_{RE} - \hat{\beta}_{FE})'[Var(\hat{\beta}_{FE}) - Var(\hat{\beta}_{RE})] - 1(\hat{\beta}_{RE} - \hat{\beta}_{FE})$$

where R_{FE} and $\hat{\beta}_{FE}$ are the estimated coefficients from the Random Effects and Fixed Effects models, respectively, and $Var(\cdot)$ denotes the variance-covariance matrix of the estimators. The test checks whether random effects are correlated with the regressors.

Following the test statistics, which follows a chi-squared distribution with degrees of freedom equal to the number of regressors:

- If H is statistically significant, we reject the null hypothesis and choose the Fixed Effects model (FE).
- If H is not significant, we fail to reject the null hypothesis, meaning the Random Effects model (RE) is appropriate since it assumes no correlation between random effects and regressors.

TABLE A2 | Global granger causality tests.

	GDP to SALES	SALES to GDP	UNEM to SALES	SALES to UNEM
Cigarettes	0.02**	0.77	0.09*	0.40
RYO	0.018**	0.21	0.05**	0.36
Pipe	0.00***	0.47	0.00***	0.98
Cigars	0.06**	0.26	0.03**	0.26

*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

Appendix 3: Granger Causality Tests