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Hedonic pricing of wine attributes in Hungarian online retail: the Tokaj noble rot wines

Jeremiás Máté Balogh · Zalán Márk Maró

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Abstract

Tokaji Aszu (a botrytised noble rot wine) is one of Hungary's most renowned wine styles and an essential part of its viticultural heritage. This paper investigates the determinants of wine prices in the Hungarian online retail market, focusing on Tokaj wines. A hedonic pricing framework and a quantile regression approach are employed to analyse how the main wine attributes (e.g. origin or quality classifications) influence online retail prices across different market segments. The analysis is based on a cross-sectional dataset comprising 1,216 observations, including Hungarian and imported products. The findings indicate that vintage, import status, Tokaj-related characteristics, organic certification, and wine classification are significantly associated with observed retail prices, although the magnitude vary across quantiles. The negative vintage coefficient indicates that earlier vintages are associated with higher observed prices, implying higher premiums for aged wines. Wines produced in the Tokaj wine region and classified as Tokaj botrytised noble rot wine demonstrate positive price differentials, confirming the quality and terroir-driven reputation of this Hungarian appellation. Moreover, organic-certified and superior quality (Premier/Grand Cru) wines exhibit positive price associations, whereas Selection labels show less effects across specifications. The most pronounced price effects are concentrated in the upper quantiles, indicating that in high-end wines, exceptional value is placed on heritage, scarcity, and symbolic quality cues. The research provides new empirical evidence on wine price differentiation in the Hungarian online retail market. It highlights how historical reputation, sustainability, and quality signals jointly influence wine pricing, reflecting heterogeneity across conditional price distribution.

Introduction

In the past decades, the global wine market has undergone significant changes, driven by decreasing vineyards and production (Balogh and Maró, 2025; Depetris Chauvin et al., 2025; Nieto-Villegas et al., 2023), shifting consumer preferences, the rise of sustainability consciousness (Gastaldello et al., 2025; Lerro et al., 2021), and the digitalisation of retail channels (Bastard and Chaillet, 2023; Festa et al., 2023). As wine consumers gradually base their purchasing decisions on a combination of traditional quality indicators and modern cues (e.g. organic certification or geographic branding), the need for empirical analysis of these factors becomes more compelling (Lerro et al., 2021; Orth et al., 2005). One of the most informative tools for analysing wine markets is the hedonic pricing model (see e.g. Núñez et al., 2024), which estimates how product attributes, such as origin, vintage, or labelling, affect price formation.

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Recent investigations across various European wine regions have demonstrated the growing influence of region-specific indicators and consumer-oriented labels on perceived advantage (Castriota and Delmastro, 2015).

In this context, Hungary offers a unique case. The country has a long-standing viticultural tradition, with wine-making traditions dating back over a millennium. Among its many wine-producing regions, Tokaj-Hegyalja is known for producing Tokaji Aszu, a botrytised sweet wine with a historically embedded international reputation. This reputation, often associated with historical narratives such as the '*king of wines*' metaphor, reflects its cultural and symbolic importance (Balogh and Morgado, 2025; Szakál, 2018; Wine Folly, 2022b). The Tokaj region has maintained its reputation across centuries through a combination of distinctive geological features, favourable climatic conditions, and expert viticultural practices (Szepesi et al., 2017). However, the extent to which this historical prestige translates into measurable price premiums in contemporary markets remains an open empirical question. Thus, this research examines how three categories of wine attributes - intrinsic characteristics (e.g. vintage), extrinsic quality cues (e.g. geographical origin and organic certification) and institutional or symbolic quality signals (e.g. Premier/Grand Cru classifications and Selection labels) - are associated with wine prices in the Hungarian online retail market, considering Tokaj noble rot and imported fine wines. The online market in Hungary is an emerging distribution channel. The total Hungarian online retail market reached 4.87 billion EUR (1,948 billion HUF) in 2024 and 5.25 billion EUR (2,100 billion HUF) in 2025 (PwC, 2025). Recent market data indicate that online sales account for approximately 1–5% of total alcoholic beverage retail in Hungary, confirming that the online channel is relatively small in total market share. However, alcoholic beverages represent the largest category within Hungarian beverages e-commerce (76% of online revenue), highlighting the strategic relevance of online retail (Balogh and Mizik, 2022; ECDB, 2025).

The analysis applies a hedonic pricing framework and quantile regression to capture heterogeneity across price segments. The paper therefore aims to assess whether historical reputation, sustainability labels, and institutional quality classifications are reflected in observed retail prices. The hedonic pricing model provides a theoretical and empirical framework for quantifying how various attributes of a differentiated product influence its market price (Montero and Fernández-Avilés, 2014; Rosen, 1974). In wine economics, this approach decomposes observed prices into the implicit values of their constituent characteristics, such as vintage, appellation and producer reputation (Oczkowski, 2016). Hedonic pricing models have been applied across a broad range of wine markets, including France (Amédée-Manesme et al., 2020; Dubois and Nauges, 2010; Lecocq and Visser, 2006), Italy (Di Vita et al., 2015; Gastaldello et al., 2024), Portugal (Rebelo et al., 2019), Germany (Fedoseev et al., 2022), Australia (Horowitz and Lockshin, 2002; Oczkowski, 2001), and New Zealand (Bicknell and MacDonald, 2012), among others (Núñez et al., 2024). However, few studies have systematically examined Hungarian wine prices. While quantile regression allows for flexible modelling of price heterogeneity, alternative approaches such as finite mixture models have also been proposed to capture latent market segments (Masset, 2024). Against this broader international literature, the contribution of the present study lies not in introducing quantile regression to wine pricing, but in applying this approach to the Hungarian online retail market and examining Tokaj-related origin, sustainability certification, and institutional quality classifications in this context.

The investigation makes three main contributions. First, from a methodological perspective, it applies quantile regression to model the determinants of Hungarian online wine prices across different market segments, where empirical evidence remains limited. Second, it uses product-level online retail price data from two leading Hungarian wine market players, called Borháló and Bortársaság, rather than relying on crowd-sourced or auction-based price data. Most empirical studies emphasise export or global online platforms, neglecting domestic retail channels that shape national brand equity and local consumer behaviour (Outreville and Fur, 2020). Third, while environmental certifications have been explored in Western Europe (see e.g. Gastaldello et al., 2025), their price effects in post-socialist wine producer countries remain under-researched. The incorporation of new variables (e.g. organic-certified production, Premier/Grand Cru classification, and Selection labels) adds a novel dimension. Addressing these gaps is relevant for both research and practice. For policymakers, the results provide evidence on the economic value of geographical indications and certification schemes. For producers and consumers, they highlight which product attributes are most strongly associated with price premiums. To do so, following the Introduction, Section 'Literature review' presents a review of the relevant literature on hedonic wine pricing, quality signalling, and consumer

valuation. Section 'Data and methodology' details the data and methodology, including the construction of the dataset, and outlines the quantile regression specification. Section 'Results' reports the empirical results, while Section 'Discussion' discusses their implications for consumer behaviour, sustainability, and heritage branding. Finally, Section 6 concludes with the limitations and directions for future research.

Literature review

Theoretical background

The hedonic pricing model is rooted in the theory of consumer demand for differentiated products (Rosen, 1974). It posits that the price of a composite good reflects the implicit value of its individual attributes. This approach has become central to the analysis of heterogeneous products such as real estate (Malpezzi, 2003; Wei et al., 2022), automobiles (Baltas and Giakoumaki, 2021; Koç and Kostak, 2021), and wine (Oczkowski, 2016; Outreville and Fur, 2020). In wine economics, the hedonic pricing model decomposes observed prices into wine attributes such as geographical origin, vintage, alcohol content, expert ratings, grape variety, and production techniques. Each attribute contributes to the perceived and actual quality of wine, and therefore to its price. The conceptual strength of the hedonic pricing model lies in its ability to estimate implicit prices of individual attributes, meaning that product characteristics, rather than goods themselves, are priced in the market. In the wine sector, these characteristics involve intrinsic (objective) attributes (e.g. alcohol level, residual sugar, vintage) and extrinsic (or symbolic) cues (e.g. terroir, awards, organic-certification, classification systems) (Gastaldello et al., 2024; Oczkowski and Pawsey, 2019). Oczkowski and Pawsey (2019) note that hedonic price models enable researchers to estimate attribute-based willingness to pay, reflecting consumer preferences and information asymmetries in wine markets. Because wine is an experience good, its quality is not fully observable before consumption, and price acts as a signal and a proxy for quality (Combris et al., 2003). Over time, hedonic pricing models have evolved to incorporate nonlinear relationships, quantile effects, and market segmentation. Quantile regression (Koenker and Bassett, 1978) extends the classical model by allowing coefficients to vary along the price distribution, capturing differences between mass and fine wine markets. This technique has been applied in recent wine economics literature (e.g. Bazen et al., 2024; Costanigro et al., 2019) since it recognises that premium wines may be priced according to distinct determinants compared to mass-market ones.

The Hungarian wine sector

Hungary's winemaking heritage spans over a millennium, with historical records indicating grape cultivation dating back to as early as the 13th century. By the 17th and 18th centuries, Hungarian wines, especially dessert white varieties, were widely appreciated in European courts. However, a series of disruptions, including the phylloxera epidemic, historical conflicts, and decades of socialist collectivisation, severely affected vineyard structure, wine quality, and export competitiveness (Szepesi et al., 2017; Wine Folly, 2022a). Following the political transition of the 1990s, substantial private investment and international collaboration reinvigorated Hungarian viticulture, particularly in the Tokaj region. Today, Hungary's wine sector contributes approximately 1% to global wine production, with vineyards covering around 60,000 hectares distributed among six wine regions and twenty-two sub-districts (OIV, 2025). White varieties dominate the national production assortment, accounting for roughly 70% of the vineyard area. The Tokaj region, located in northeastern Hungary and extending towards southeastern Slovakia, covers approximately 6,000 hectares. Its microclimate, enriched by the confluence of the Tisza and Bodrog Rivers, and its volcanic soils and climate provide ideal conditions for the development of Botrytis cinerea, the "noble rot" fungus that defines Tokaji Aszu wines (Szepesi et al., 2017; Wines of Hungary, 2025). This unique natural phenomenon enables the concentration of sugars and aromas within the grape, producing a sweet yet complex wine whose quality attributes have been codified and protected under Hungarian and EU geographical indication systems (Török et al., 2020).

Although botrytised wines are also produced in other regions (e.g. Sauternes), Tokaji Aszu differs in its production methods, classification system, and historical role, which may contribute to its distinct market positioning.

Digital transformation has revolutionised the way wine prices and quality information are disseminated. Studies (Bazen et al., 2024; Gastaldello et al., 2024; Oczkowski and Pawsey, 2019) highlight how community ratings and user-generated reviews affect price perception. Over the past two decades, online retailers, e-commerce platforms and review sites have emerged as major intermediaries shaping consumer expectations in the Hungarian market as well (Balogh and Mizik, 2022; Hlédik and Harsányi, 2019). Specialised online retailers have become important in the dissemination of high-quality Hungarian wines to domestic and international consumers. Unlike larger Western European markets, Hungary's digital retail market is dominated by a few specialised distributors with hybrid offline–online models. The two retailers are Borháló, a nationwide wine franchise with a decentralised sourcing model (Borháló, 2025), and Bortársaság, a premium online and offline retailer specialising in curated selections (Bortársaság, 2025). E-commerce datasets from these established Hungarian retailers capture the realised retail pricing structure and can, therefore, provide a more accurate measure of market equilibrium. The inclusion of these sources in hedonic models aligns with recent methodological advances in applied wine economics, which increasingly rely on product-level online retail data to avoid the confounding effects of subjective ratings (Faye and Le Fur, 2019; Landazuri-Tveteraas et al., 2021). These online datasets allow the measurement of authentic consumer perception, filtered through professional curation and stable market mechanisms. Both retailers employ rigorous curation processes, effectively serving as quality gatekeepers. Their pricing data thus incorporates supply-side expertise and demand-side valuation, making them ideal for hedonic modelling. Obtaining data from these two platforms helps to capture the structural features of Hungary's commerce, where tradition and innovation coexist within digital retail ecosystems.

Determinants of wine prices: a review of core attributes

Drawing on the literature, the determinants of wine price can be classified into three main categories: intrinsic attributes (e.g. vintage, sweetness, alcohol content), extrinsic quality cues (such as appellation, awards, and certifications), institutional characteristics and symbolic signals (including cultural legacy, brand identity, and classification systems), all of which collectively form consumer perceptions and willingness to pay (see e.g. Lockshin and Corsi, 2012). These categories provide the conceptual basis for the selection of variables in the empirical model.

Vintage and age effects

Among the most examined factors in wine price formation is vintage, the year of harvest, which often represents the influence of climatic conditions and ageing potential. Lecocq and Visser (2006) and Oczkowski (2016) demonstrate that vintage acts as a proxy for weather variability, with better climatic conditions producing higher quality wines and, thus, higher prices. In markets where aged wines are valued as collectible assets, older vintages command price premiums due to scarcity and storage costs (Ashenfelter and Storchmann, 2016). More recent analyses using large-scale datasets confirm this pattern: older vintages systematically increase auction and retail prices (Bazen et al., 2024; Pugh and Ripley, 2025). This is consistent with the theory of experience goods and asset-like wine valuation, where aged wines accumulate consumption and investment value over time (Ashenfelter and Storchmann, 2016). In Hungary, where Tokaj noble rot wines can age gracefully for decades, the vintage effect intertwines with the historical identity of the product; older bottles can serve as consumption goods or as symbols of cultural continuity and rarity. The so-called "Puttonyos" classification (the number of baskets containing noble rot grapes) is usually used for the Tokaj noble rot wine category, with major revisions implemented in 2013 that raised quality standards. Today, only the 5 and 6 Puttonyos categories are allowed, while the 3 and 4 were abolished. All officially labelled Tokaj noble rot wines must now have a minimum of 120 g/L residual sugar (Ragyák et al., 2025). Therefore, the 5 and 6 Puttonyos categories can be handled as one product group.

H1. Older vintages are associated with higher retail prices, reflecting the effects of scarcity and storage costs in the Hungarian wine market.

Geographical origin and appellation systems

The appellation of origin is another dominant determinant in hedonic wine pricing studies. The principle of terroir (the interaction between soil, climate, and winemaker practice) is formalised through Protected Designations of Origin and Protected Geographical Indications under the European Union's wine regulation system (Török et al., 2020). Wines associated with prestigious appellations command higher prices than generic counterparts (Combris et al., 2003; Landon and Smith, 1998). In Hungary, the Tokaj region represents one of the oldest delimited wine appellations in the world, officially classified in 1737, predating even the Portuguese Douro Valley Appellation (1756) or Bordeaux's AOC classification (1855) system (Wine Folly, 2022b). Its inclusion as a variable in hedonic models thus captures geographical reputation and institutional legacy. Recent works have highlighted that region-of-origin effects persist even in the digital era. Consumers are willing to pay substantial premiums for wines labelled "Tokaji" compared to those from less recognised regions (Gál et al., 2025; Kárpáti and Szakál, 2009). More broadly, research on the Hungarian spirits market shows that geographical indications and product-related information are relevant to consumer awareness and purchasing behaviour (Maró, et al., 2023). The magnitude of this premium reflects the perceived quality and symbolic authenticity, key dimensions in heritage marketing.

H2. Wines from the Tokaj region and those labelled as Tokaj noble rot wines (Aszu) command significant price premiums due to terroir reputation and heritage value.

Production methods and organic certification

The rise of sustainable viticulture and organic certification has introduced new quality cues in wine markets. The literature has demonstrated that consumers increasingly associate 'bio', 'organic', and 'biodynamic' labels with environmental consciousness and authenticity (Delmas and Grant, 2014; Naspetti et al., 2019; Török et al., 2019). In hedonic frameworks, these attributes often explain measurable price premiums, particularly in mature markets such as Germany, France, and the United Kingdom (Lerro et al., 2021; Mauracher et al., 2019). In Central and Eastern European countries, however, empirical evidence is limited. The inclusion of an organic wine variable therefore bridges this gap by testing whether environmental certifications contribute to price differentiation in the Hungarian market. Given the increasing emphasis on sustainability among Hungarian consumers (Nagy Pető et al., 2023; Török et al., 2025), a positive coefficient for organic wines would align with global trends that link ecological awareness to the construction of hedonic value.

H3. Organic-certified wines yield positive price premiums, indicating growing consumer preference for environmentally sustainable production.

Institutional classification and quality labels

Institutional classification systems, such as Premier Cru and Grand Cru, serve as formal indicators of quality hierarchy and reputation. While originating in France, the logic of classification has been adopted in several European regions to stratify producers and vineyards according to quality and historical reputation (Carew and Florkowski, 2010; Garcia-Parpet, 2008). Grand Cru (Grosses Gewächs) Rieslings in Germany command premiums compared to unclassified wines (Green, 2025), while classified Bordeaux estates retain brand value independent of expert scores or vintage (Dubois and Nauges, 2010; Jones and Storchmann, 2001). Furthermore, classifications also reflect terroir differences and symbolic capital, strengthening perceived quality and investment appeal (Bentzen et al., 2002; Zhao, 2008). These classification systems reduce information asymmetry and provide credible signals of quality to consumers. In Hungary, although no national classification system formally mirrors France's Cru hierarchy, certain producers and distributors employ internal classifications (e.g. Selection, Superior, or Premium) to designate enhanced quality tiers. These internal labels may have similar signalling purposes within consumer markets, although

with potentially symbolic effects (Carew and Florkowski, 2010). The inclusion of the Premier or Grand Cru and Selection variables therefore captures how institutionalised quality signals are associated with wine prices.

H4. Wines classified as Premier or Grand Cru are associated with higher retail prices, reflecting institutional recognition and the quality hierarchy.

Selection-type designations, including terms such as Selection, Reserve, Superior, and Premium, are used across both domestic and imported wines to signal enhanced quality within producers' product portfolios. However, their regulatory meaning varies across countries and wine regions. In some cases, these designations are linked to formal production or ageing requirements, while in others they function primarily as producer-level marketing signals. Previous hedonic research suggests that reserve-type designations and multi-tier quality classifications may be associated with price premiums, although their effects can differ across market segments (Chen and McCluskey, 2018; Costanigro et al., 2019).

H5. Selection-type labels positively influence wine price although their price premium is expected to be smaller and less consistent than that associated with formal Premier or Grand Cru classifications.

Based on the reviewed literature, this study focuses on a set of key attributes capturing intrinsic characteristics (such as vintage), extrinsic signals (including geographical origin and organic certification), and institutional quality indicators (such as classification systems and labels). These factors have been identified as key determinants of wine prices and therefore constitute the core explanatory variables of the empirical analysis. Building on the methodological approaches discussed above, the study applies a hedonic pricing framework estimated using quantile regression. While ordinary least squares (OLS) regression captures only average effects, quantile regression allows the impact of these attributes to vary across the conditional distribution of prices. This is particularly relevant for wine markets, where price distributions are typically skewed and heterogeneous, and where attribute effects may differ substantially across market segments (Liao and Wang, 2012). In addition, as highlighted in the literature, quantile regression provides a more robust framework in the presence of heteroscedasticity, outliers, and unobserved heterogeneity (Koenker and Hallock, 2001). Thus, this approach offers an appropriate empirical strategy for examining price formation in the Hungarian wine market, as detailed in the following section.

Data and methodology

Data sources and collection

To analyse the determinants of wine prices in the Hungarian retail market, including those of Tokaji noble rot wines, data were obtained from two major domestic online wine retailers: Borháló and Bortársaság. These two platforms operate as major digital interfaces in the Hungarian wine economy, representing distinct segments of the market. These online retailers provide extensive product-level data, including information on vintage, grape variety, production methods, organic certifications, origin, and retail price. The use of real retail data from Borháló and Bortársaság offers an analytical advantage over crowd-sourced platforms (e.g. Vivino). While consumer review data capture subjective perception and social influence, retail datasets from established merchants reflect product-level pricing, professional curation, and a more transparent link between quality attributes and price formation. This distinction is critical for hedonic modelling, as it anchors price estimations to market fundamentals rather than reputation or network effects. Furthermore, these sources provide pricing patterns, covering middle and upper-class consumer segments.

The dataset was compiled on the 10th of October 2025 using an automated web scraping procedure, a data collection technique that programmatically retrieves information from public webpages (Khder, 2021). This approach is widely applied in market analytics and e-commerce research to obtain structured datasets from online sources (Krotov et al., 2020). The scraping process was implemented using a Python-based tool (Mitchell, 2018), which allowed for dynamic extraction of product-level information directly from the websites' HTML structures. Each retrieved observation contained detailed metadata, including (1) wine product name and vintage year; (2) producer

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Table 1 Variables used in the hedonic price model.

Variable	Description	Type	Expected sign	Rationale
ln_price	Natural logarithm of wine retail price per 0.75-liter bottle expressed in HUF	Dependent	-	Continuous variable representing wine value
Vintage	Year of harvest (continuous variable)	Continuous	Negative	Older vintages expected to command higher prices
Imported_wine	1 if wines are imported, 0 otherwise (for Hungarian domestic wines)	Dummy	Positive	Imported wines are often priced higher in premium retail market
Tokaj_region	1 if wines from Tokaj wine region or appellation, 0 otherwise (in the case of other Hungarian regions)	Dummy	Positive	Captures regional/historical reputation premium
Tokaj_noble_rot	1 if the wine is Tokaj noble rot (wine is made from botrytised noble rot wines, called Aszu), 0 otherwise (other wine types)	Dummy	Positive	Reflects product category prestige
Organic_wine	1 if wines have organic certification, 0 otherwise (non-certified wines)	Dummy	Positive	Represents sustainability and health perception premium
PGC	1 if the wine is labelled Premier Cru or Grand Cru (imported wines only), 0 otherwise	Dummy	Positive	Proxy for classification and institutional recognition
Selection	1 if wine labelled with “Selection” is a quality label used in specific wine regions to denote higher-quality single-vineyard wines in Europe (includes imported and domestic wines), 0 otherwise	Dummy	Positive	Captures producer-level quality segmentation

Table 2 Descriptive statistics of the variables.

Obtained full sample					
Variable	Observation	Mean	Std. dev.	Min	Max
price	1249	20.857	57087	900	880,000
price_per_bottle (converted into price per 0.75-liter bottle)	1249	19.622	61565	686	1,320,000
ln_price	1249	8.783	1.209	6.53	14.09
vintage	1216	2022	2.759	1987	2025
imported_wine	1249	0.227		0	1
Tokaj_region	1249	0.096		0	1
Tokaj_noble_rot	1249	0.018		0	1
organic_wine	1249	0.114		0	1
PGC	1249	0.021		0	1
Selection	1249	0.021		0	1
Data used for estimations					
ln_price	1216	8.796	1.209	6.531	14.093
vintage	1216	2022	2.759	1987	2025
imported_wine	1216	0.223		0	1
Tokaj_region	1216	0.099		0	1
Tokaj_noble_rot	1216	0.019		0	1
organic_wine	1216	0.116		0	1
PGC	1216	0.021		0	1
Selection	1216	0.021		0	1

ln stands for the natural logarithm, price denotes wine online retail price per bottle, expressed in HUF, PGC denotes Premier or Grand cru, which are top-tier French wine classifications from Burgundy, Champagne, and Bordeaux. For binary variables, the mean represents proportions; standard deviations are not interpretable. The original scrape produced 1249 listings, but 33 observations lacked vintage information. Since vintage is required for the hedonic model, these entries were removed, leaving 1216 usable observations. Therefore, descriptive statistics and econometric estimations are based on the 1216 cases.

and appellation (Tokaj or other Hungarian wine regions); (3) wine type (e.g. Tokaji Aszu, Szamorodni, dry Furmint, Muscat Blanc à Petits Grains/Hárslevelű, etc.); (4) bottle size; (5) certification status (organic or non-organic); (6) classification level (noble rot, Premier Cru, Grand Cru, Selection, or standard); (7) import status (domestic vs. imported wines); (8) retail price (expressed in Hungarian Forints, HUF).

Data were validated through random manual verification of 10% of entries to ensure consistency between the scraped values and the information displayed on the retailers' websites (Mitchell, 2018). The use of automated extraction ensured coverage of all listed wines within a given time frame, eliminating sampling bias that might arise from manual selection. The final dataset contained 1,216 unique wine listings, representing over 240 wineries and spanning 12 Hungarian wine regions and 11 foreign origins. Price data were converted to a logarithmic scale (natural log) to correct for skewness and enable elasticity interpretation in the regression analysis. The Vintage variable is coded as the calendar year of harvest rather than as wine age. Thus, a negative coefficient indicates that wines from earlier vintage years, that is, older wines, are associated with higher retail prices. Table 1 summarises the main variables included in the econometric model, their operational definitions, and expected signs based on theoretical and empirical literature. The combination of traditional attributes (e.g. vintage, origin, wine type) with indicators (e.g. organic certification, classification tiers) enables a holistic exploration of historical reputation and contemporary consumer values.

The dataset covers wines listed on 10 October 2025 and retrieved from the websites of Borháló (44%) and Bortársaság (56%), covering both domestic and imported wine products. Retail prices per 0.75-liter bottle range from 686 HUF (1.7 EUR) to 1,320,000 HUF (3300 EUR) in Hungary, with a mean of 19,622 HUF (49 EUR) and standard deviation of 61,565 HUF (154 EUR). Of the total sample, 78% of the wines are domestically produced, while 22.7% are imported (mean 0.227). In the domestic category, Tokaji noble rot (Aszu) wines account for a share of 1.8% of

Table 3 Pearson correlation coefficients between variables.

	ln_price	vintage	imported_wine	Tokaj_region	Tokaj_noble_rot	organic_wine	PGC	Selection
ln_price	1							
vintage	-0.550*	1						
imported_wine	0.549*	−0.231*	1					
Tokaj_region	0.177*	−0.126*	−0.176*	1				
Tokaj_noble_rot	0.211*	−0.239*	−0.074*	0.420	1			
organic_wine	0.154*	0.019	0.107*	0.071*	−0.030	1		
PGC	0.324*	−0.021	0.269*	−0.047	−0.020	0.089*	1	
Selection	0.009	−0.006	−0.065*	−0.028	−0.020	0.001	−0.021	1

*$p < 0.05$; ln stands for the natural logarithm, price denotes wine retail price per bottle (converted into 0.75 l) expressed in HUF, PGC is Premier or Grand cru, a top-tier French wine classifications from Burgundy, Champagne, and Bordeaux.

listings, other wines from the Tokaj region for 9.6%. In terms of classification, Premier or Grand Cru labels appear on 2% of wines available in the online store, while Selection designations are also present in about 2.1% of the sample. Organic-certified wines comprise approximately 11.4% of the sample (mean 0.114), a relatively small yet rapidly expanding category in Hungary's wine retail market. The average vintage year is 2022, with a range from 1987 to 2025, encompassing collectible and current-release wines (Table 2).

Regarding wine types, Cuvée (14%) was the most frequent, followed by Furmint (4.82%), Chardonnay (4.16%), Olaszrizling (4.16%), and Kékfrankos (Blaufrankish) with 4.06%. Among the top 10 most frequent varieties, the shares of Sauvignon Blanc, Rosé, Cabernet Sauvignon, and Cabernet Franc were below 4%. Considering wineries, Sauska has the highest share (3.04%) in the sample, followed by Mészáros Borház (2.24%), Takler (2.16%), and others (e.g. Szepsy, Vylyan, Dubicz, Bock, Cezar, Günzer wineries) with shares below 1%. The most frequent vintages were 2021 (11%), 2022 (16%), 2023 (17%), and 2024 (32%).

Pearson correlations confirm the expected associations. Tokaj noble rot wine status and Premier/Grand Cru classification show strong positive correlations with price ($r = 0.32$ and $r = 0.21$, respectively), while vintage year is negatively correlated ($r = -0.55$), consistent with the hypothesis that older vintages command higher premiums (Table 3). For dummy variables, pairwise associations were calculated using the pwcorr command in Stata. Pearson correlation coefficients are mathematically equivalent to the Phi coefficient.

Methodological framework and model specification

The hedonic pricing model posits that the observable market price of a differentiated good can be expressed as a function of its measurable attributes (Rosen, 1974). Traditional OLS estimation provides a single average effect for each explanatory variable, potentially obscuring differences across market segments. Quantile regression, developed by Koenker and Bassett (1978), addresses this limitation by estimating conditional quantiles of the dependent variable. In line with Gonçalves et al. (2021), quantile regression can reveal the heterogeneous relationships that OLS may miss. Quantile regression estimates are often statistically different across different quantiles compared to OLS. These differences arise when the data exhibit heteroskedasticity or non-normal distributions, in which OLS fails to capture how a predictor's effect varies across the conditional distribution of the outcome.

In wine economics, quantile regression allows researchers to examine whether specific attributes exert higher effects among high-priced wines than among low-priced ones. The use of quantile regression is particularly relevant for Tokaj noble rot (Aszu) wines due to their skewed price distribution and concentration in the higher quantiles. For instance, while entry-level wines in Borháló average 3000–5000 HUF (7.5–12.5 EUR), Tokaj noble rot (Aszu) and Grand Cru wines listed on Bortársaság may exceed 100,000 HUF (250 EUR) per bottle. Hence, quantile regression allows for a deeper analysis of how prestige and rarity influence price elasticity differently across consumer segments. Based on the variables and theoretical considerations above, the estimated hedonic price function is expressed as:

Table 4 Quantile regression estimates for determinants of Hungarian wine prices.

	(1)	(2)	(3)	(4)	(5)	(6)
	Model 1			Model 2		
		ln_price			ln_price	
VARIABLES	q10	q50	q90	q10	q50	q90
vintage	−0.143***	−0.220***	−0.310***	−0.145***	−0.222***	−0.318***
	(0.018)	(0.021)	(0.025)	(0.0210)	(0.019)	(0.032)
imported_wine	1.052***	1.020***	1.482***	0.996***	0.986***	1.346***
	(0.058)	(0.084)	(0.182)	(0.064)	(0.082)	(0.152)
Tokaj_region	0.572***	0.721***	0.905***			
	(0.133)	(0.157)	(0.129)			
Tokaj_noble_rot				1.380***	1.085***	1.754***
				(0.174)	(0.296)	(0.599)
organic_wine	0.496***	0.332***	0.415***	0.721***	0.401***	0.317***
	(0.142)	(0.072)	(0.124)	(0.134)	(0.071)	(0.056)
PGC	1.442***	1.901***	2.239***	1.249***	1.944***	2.234***
	(0.182)	(0.144)	(0.417)	(0.383)	(0.173)	(0.315)
Selection	0.478***	0.309*	0.363**	0.661***	0.271**	0.230
	(0.184)	(0.162)	(0.185)	(0.181)	(0.113)	(0.208)
Constant	297.4***	453.4***	636.2***	301.3***	457.1***	651.5***
	(35.60)	(41.39)	(51.13)	(42.39)	(38.14)	(64.34)
Pseudo R squared	0.265	0.361	0.494	0.256	0.352	0.462
Observations	1216	1216	1216	1216	1216	1216

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

PGC Premier or Grand cru

Model 1 (Tokaj regional effect)

$$Q_\tau(\ln price_i|X_{ki}) = \beta_0(\tau) + \beta_1(\tau)vintagei + \beta_2(\tau)imported_wine_i + \beta_3(\tau)Tokaj_region_i + \beta_4(\tau)organic_i_wine_i + \beta_5(\tau)PGC_i + \beta_6(\tau)Selection_i + \varepsilon_i$$

Model 2 (product-specific Tokaj noble rot effect)

$$Q_\tau(\ln price_i|X_{ki}) = \beta_0(\tau) + \beta_1(\tau)vintage_i + \beta_2(\tau)imported_wine_i + \beta_3(\tau)Tokaj_noble_rot_i + \beta_4(\tau)organic_i_wine_i + \beta_5(\tau)PGC_i + \beta_6(\tau)Selection_i + \varepsilon_i$$

where $Q\tau(\ln_price_i|X_{ki})$ denotes the conditional quantile function of ln_price, and β_k (τ) are quantile-specific coefficients capturing heterogeneous effects across the price distribution. X_{ki} denote the k-th explanatory variable for observation i, where $k=1,2,\ldots,K$ captures the different wine attributes (vintage, region, organic certification, etc.), and i indexes the individual wine observations.

The variables Tokaj_region and Tokaj_noble_rot were not included simultaneously in the same specification. Although their correlation is moderate ($r = 0.420$), the two attributes capture overlapping dimensions of Tokaj-related wine reputation: geographical origin and product-specific prestige. Including both variables in a single model would reduce interpretation by conflating terroir-based effects with the price premium associated with botrytized noble rot wines. To avoid this overlap and multicollinearity, we estimate two separate model specifications: one focusing on regional origin effects (Model 1) and another isolating the price premium associated with Tokaj noble rot wines (Model 2).

Quantile regressions were estimated for the 10th (q10), 50th (q50), and 90th (q90) quantiles, providing evidence on how the marginal effects of these variables differ across the lower, median, and upper price spectrum. The analysis

was conducted using the Stata 19 statistical package, applying the sqreg command for simultaneous quantile estimation (Fröolich and Melly, 2010; Muñoz and Siravegna, 2021). Robust standard errors were employed to correct for heteroskedasticity. Coefficients were evaluated at the 1%, 5%, and 10% significance levels. The models achieved R^2 values ranging from 0.26 to 0.49, consistent with the explanatory power typically reported in hedonic wine price literature (Oczkowski and Pawsey, 2019). OLS regression results and Kernel density function are presented in the Appendix for comparison.

Results

The quantile regression estimations reveal a consistent and statistically significant relationship between wine attributes and retail prices across quantiles. Table 4 summarises the estimated coefficients for the 10th (q10), 50th (q50), and 90th (q90) percentiles of the price distribution for two model specifications. Model 1 includes the Tokaj region as a geographical indicator, and Model 2 includes Tokaj noble rot wine as a product-specific variable. The pseudo R^2 values range between 0.26 (q10) and 0.49 (q90), which should be interpreted cautiously as quantile-specific, loss-based fit measures. The results confirm the heterogeneous influence of wine attributes across the price spectrum, highlighting that factors determining observed market prices differ markedly between lower-priced and premium wines.

The vintage coefficient is significantly negative across all quantiles, with increasing magnitude toward the upper tail (from −0.143 at q10 to −0.310 at q90). This pattern indicates that older vintages command higher retail prices, reflecting the premium placed on ageing potential, rarity, and collectability. The increasing magnitude of the coefficient also implies that premium consumers are sensitive to vintage year. The variable of imported wine exhibits large, positive, and highly significant coefficients across all quantiles (ranging from +0.98 to +1.48), underscoring the price premium attached to imported wines in Hungary's domestic market. However, the persistence of high coefficients even after controlling for Tokaj noble rot and Premier Cru indicators indicates that imported wines dominate the upper market segment. Furthermore, the magnitude of the coefficients for Tokaj noble rot wine and the Tokaj region demonstrates that certain domestic wines successfully rival imported competitors in price performance.

The variable of the Tokaj region captures the geographical indication effect independent of product type. The coefficient for Tokaj region is positive and statistically significant at all three quantiles at the 1% level, increasing from 0.572 at q10 to 0.721 at q50 and 0.905 at q90. This pattern indicates that the estimated association between Tokaj origin and observed retail price is larger at higher conditional price levels. Replacing the regional indicator with the variable of Tokaj noble rot wine in Model 2 yields higher coefficients (1.38 (q10), 1.09 (q50), and 1.75 (q90)), demonstrating that product type-specific prestige exceeds the regional effect. The positive and statistically significant coefficient for Tokaj noble rot wine suggests a substantial price association across all three quantiles. The estimated coefficient (1.380 at q10, 1.085 at q50, and 1.754 at q90) indicate that Tokaj noble rot wines are associated with considerably higher observed retail prices, particularly at the upper end of the conditional price distribution. Furthermore, the coefficient at the upper quantile (q90) nearly doubles relative to the median, indicating that the association between Tokaj noble rot status and price is larger in magnitude at q90 than at q50.

The variable of organic wine demonstrates statistically significant positive coefficients across all quantiles in both models, though of moderate magnitude (ranging from 0.317 to 0.721). The highest coefficient appears at the lower quantile (q10) in Model 2 (0.721), suggesting that sustainability cues play a decisive role among mid-range and value-conscious consumers seeking ethical consumption options. The smaller magnitude of coefficients at the upper quantiles indicates that luxury consumers prioritise heritage and classification over eco-certification. In addition, the variable Premier or Grand Cru yields the most significant coefficients in models, ranging from 1.44 at q10 to 2.24 at q90, all of which are significant at the 1% level. The progressive increase in coefficient magnitude toward higher quantiles suggests that such classifications are especially influential for premium wines, where symbolic and institutional validation drive consumer confidence. The Selection variable also shows positive effects (ranging from 0.23 to 0.66). The effect is statistically significant at q10 and q50 in both models and at q90 in Model 1, but it is not statistically significant at q90 in Model 2. Moreover, the magnitude of the coefficients does not increase

Table 5 Marginal effects of wine attributes regarding Hungarian wine prices.

Model 1: Tokaj_region included			
VARIABLES	q10 ME (%)	q50 ME (%)	q90 ME (%)
Vintage	–13.3	–19.8	–26.6
Imported_wine	186.3	171.9	339.0
Tokaj_region	77.3	105.6	147.1
Organic_wine	64.2	39.4	51.4
PGC	323	565	839
Selection	61.6	36.2	43.7
Model 2: Tokaji_noble_rot included			
VARIABLES	q10 ME (%)	q50 ME (%)	q90 ME (%)
Vintage	–13.5	–19.9	–27.2
Imported_wine	171	168	287
Tokaji_noble_rot	295	195.9	480
Organic_wine	105.6	49.3	37.3
PGC	249	598	833
Selection	93.6	31.2	25.9

Marginal effects (ME) computed using the Halvorsen and Palmquist (1980) semi-logarithm transformation: $ME_k = (e^{\beta k} - 1) \times 100$. Effects represent percentage changes in the conditional quantile of price (Q10, Q50, Q90) with the presence of attribute *k*. Vintage is interpreted as the percentage change in price associated with a 1-year increase in vintage.

systematically toward the upper quantiles. These findings suggest that Selection-type labels are associated with moderate price premiums, particularly in the lower and middle price segments, but their effect is less consistent than that of formal Premier or Grand Cru classifications.

The marginal effects reported in Table 5 indicate substantial differences in the estimated associations between wine attributes and conditional price levels across the lower (q10), median (q50), and upper (q90) quantiles.. Vintage is measured as the calendar year of harvest. The negative coefficient indicates that wines with earlier vintages are associated with higher observed retail prices (a one-year increase in more recent vintages reduces prices by 13–27% across quantiles), conditional on the other variables included in the model. The magnitude of the coefficient increases toward the upper quantile, indicating a larger estimated association between vintage year and price at higher conditional price levels. This pattern indicates that older wines command higher market prices (premiums). However, the cross-sectional design does not allow for the separate identification of scarcity, storage costs, or perceived aging quality.

Imported wines display a large positive marginal effect, ranging from 171% at q10 to 339% at q90, confirming higher observed retail prices across all market segments. Quality signals related to Tokaj also exhibit noticeable effects. Wines from the Tokaj region increase in price by 77% (q10), 106% (q50), and 147% (q90), while Tokaj noble rot wines show higher premiums (295% to 480%), underscoring the exceptional market positioning of botrytized (Aszú) wines. Organic wines increase prices by 39% to 106%, with the largest effects observed in the lower quantile, suggesting that mid-range buyers are responsive to environmental attributes. Formal classification labels generate the largest premiums in the dataset: Premier/Grand Cru wines increase prices by 249% to 839%, reflecting the substantial symbolic and institutional value embedded in these categories. Finally, the Selection label is also positively associated with price, although its statistical significance is not consistent across all quantiles (e.g. q90 in Model 2) (26% to 94%), in line with its role as a mid-tier quality signal rather than a top-tier classification.

Table 6 Summary of hypotheses and empirical results.

Hypothesis	Description	Empirical result	Decision
H1	Older vintages are associated with higher retail prices, reflecting the effects of scarcity and storage costs.	Negative coefficient for *Vintage Year* ($p < 0.01$), larger coefficients at high quantiles indicate that older wines are priced higher.	Supported
H2	Wines from the Tokaj region and those labelled as Tokaj noble rot (Aszu) command significant price premiums due to terroir reputation and heritage value.	Positive and highly significant across all quantiles.	Supported
H3	Organic-certified wines yield positive price premiums, indicating growing consumer preference for environmentally sustainable production	Positive and significant; indicates smaller magnitude, greater in upper quantiles.	Supported
H4	Wines classified as Premier or Grand Cru attain higher price coefficients, reflecting institutional recognition and quality pyramid.	Positive and significant; with the largest effects observed among high-end wines.	Supported
H5	Selection-type labels positively influence wine price although their price premium is expected to be smaller and less consistent.	Positive coefficients across all quantiles; significant at q10 and q50 in both models and at q90 in Model 1, but not significant at q90 in Model 2. The effect does not systematically increase toward the upper quantiles.	Partially supported

Discussion

The results of the quantile regression analysis provide empirical support for the hypothesised relationships between wine characteristics and retail prices in the Hungarian online market. Each hypothesis is discussed below in the light of prior literature. In the Hungarian market, older vintage wines are associated with a price premium, supporting Hypothesis 1 (Table 6). This finding is consistent with the standard hedonic pricing framework, in which the year of vintage inversely relates to wine age, so a lower year value corresponds to greater maturity. Older vintages are valued for their maturity and rarity and are associated with higher storage costs (Bazen et al., 2024; Pugh and Ripley, 2025), and are often perceived as indicators of quality improvement through aging (Combris et al., 2003; Oczkowski, 2022). The larger effects observed in the upper quantiles suggest that price premiums for aged wines are concentrated among high-end bottles, aligning with Oczkowski (2016) and Cardebat et al. (2014), who also found that aged premiums are nonlinear and market-segment specific.

The coefficient for Tokaj noble rot (Aszu) wine is positive and highly significant across all quantiles, confirming H2. These findings are consistent with previous research suggesting that geographical origin, appellation, and product-specific quality signals can contribute to wine price differentiation (Casolani et al., 2024; Tarabashkina et al., 2024). Furthermore, these results are in line with Lecocq and Visser (2006), who demonstrated similar terroir-related premiums for Bordeaux, and with Gál et al. (2025), who found that Hungarian consumers identify Tokaj as having superior authenticity and a premium. Tokaj's reputation has the strongest effect among premium-priced wines, reflecting its universal prestige as a dessert wine with long-lasting historic and cultural heritage. This supports the idea that geographical indications and terroir-based branding continue to be a differentiator in the alcoholic beverage market (Maró et al., 2023; Török et al., 2020), even in the domestic e-commerce market. In other countries, botrytised wines universally command a super-premium segment of the market (Cardebat et al., 2014). The noble rot (Aszu) effect also suggests that Louis XIV's proverb: "*Vinum regnum, rex vinorum*" remains economically relevant in modern retail market, as the king of wines and the wine of kings.

The positive and significant coefficient for organic status of wines confirms H3. The results are consistent with the possibility that organic certification is associated with higher-priced wines in the sampled online market. These findings are in line with studies demonstrating price premium for environmentally certified wines (Delmas and Grant, 2014; Mauracher et al., 2019). However, the magnitude of this effect is smaller than that of regional or classification attributes, suggesting that while sustainability certifications add value (Nieto-Villegas et al., 2026), they are not yet a dominant driver in the Hungarian market. Eco-label premiums are more relevant in the premium wine segment in Hungary, where consumers are more quality- and ethics-oriented. Similar patterns have been reported in other European countries (see e.g. Lerro et al., 2021), where organic labels are accessible markers of quality for middle-

income buyers. In addition, in line with H4, high-quality classifications (Premier Cru or Grand Cru) are associated with higher retail prices across all quantiles, confirming the long-established relationship between formal quality hierarchies and market valuation (Garcia-Parpet, 2008; Jones and Storchmann, 2001). The pattern across quantiles (e.g. moderate at the median and more vigorous toward the 90th percentile) suggests that classification mainly drives prices in the upper-tier market, similarly to Bordeaux, consistent with findings of Cardebat et al. (2014). The imported-wine variable also exhibits positive and statistically significant coefficients across all quantiles. This result indicates that imported wines are positioned at higher price levels in the Hungarian online retail market, even after controlling for formal classifications and other observed attributes. The premium may reflect differences in reputation, product positioning, distribution structures, and import-related costs.

H5 is partially supported. Selection-type labels have positive coefficients across all quantiles, suggesting that these designations are generally associated with higher retail prices. However, the effect is not fully consistent across model specifications. Moreover, the magnitude of the coefficients does not increase systematically toward the upper quantiles. These findings suggest that Selection-type labels function as moderate quality signals, particularly in the lower and middle price segments, but their price effect is less robust than that of formal Premier Cru and Grand Cru classifications. These findings demonstrate that wine attributes are associated with prices differently across the conditional price distribution. Organic certification and Selection-type labels appear to be relatively more relevant in the lower and middle price segments, whereas vintage, Tokaji origin, Tokaji noble rot status, and formal Premier Cru or Grand Cru classifications exhibit particularly strong associations with prices in the upper segment. These results point to heterogeneous pricing mechanisms within the Hungarian online wine market. Moderate quality and sustainability signals contribute to price differentiation in lower and middle segments, while heritage, scarcity, geographical reputation, and formal classification are more strongly associated with premium wine prices.

Policy and managerial implications

Regarding policy implications, the findings highlight the effectiveness of geographical indications and wine classification systems in signalling quality and maintaining price differentiation in Hungarian domestic markets. The price premium for Tokaj and classified wines confirms that official appellations serve as credible tools for protecting producers' value creation and for promoting rural regions through reputation-based strategies. Policymakers should therefore maintain and strengthen the institutional framework supporting protected designations of origin and quality certification programmes. The moderate premium associated with organic wines suggests that sustainability-oriented labelling schemes are recognised but not yet fully capitalised upon. Public bodies can reinforce awareness and trust in eco-certification by maintaining consistent communication and implementing stricter control over wine labelling practices, thus facilitating the transition toward more sustainable viticulture.

For wineries and retailers, the results offer opportunities for pricing and product positioning. Producers of Tokaj and other regionally recognised wines can leverage origin and classification information in marketing communication, especially in online retail environments where information asymmetry is high. The larger price effects observed in upper quantiles indicate that signalling strategies, such as appellation, classification, and vintage, are particularly relevant in premium segments. At the same time, the positive though smaller premium for organic certification indicates a growing (niche) consumer segment that values sustainability. Wineries seeking to differentiate themselves within mid- and high-end price tiers can benefit from combining traditional quality signals (e.g. vintage and classification) with messages of eco-friendly production. Considering importers and distributors, the consistent price advantage of imported wines highlights the potential for strategic decisions in assortment.

Finally, the results contribute to the broader hedonic pricing literature by demonstrating that attribute valuation in wine markets is quantile dependent. The larger coefficients in magnitude at the upper quantiles confirm that the estimated price association of some emblematic attributes varies across the conditional price distribution. This supports the theoretical view of market segmentation and the hedonic framework, where luxury and premium product category, buyers are more responsive to reputation-based signals than to functional or sensory characteristics. In

addition, the persistence of region- and classification-based premiums in online retail settings suggests that traditional signals of authenticity remain relevant in digital markets.

Conclusions

The paper presents a new quantitative analysis of real retail wine pricing in Hungary, utilising a hedonic pricing framework combined with quantile regression. The results confirm that intrinsic characteristics (e.g. vintage, organic certification, and classification) and extrinsic signals (e.g. region, import status) significantly influence wine retail prices, but with varying intensity across quantiles. The most apparent impacts are observed for hight quality-related attributes (Tokaj origin, classification, and vintage), particularly among fine wines. From a methodological perspective, the application of quantile regression demonstrated that hedonic prices vary across market segments, confirming the presence of heterogeneous pricing mechanisms. In addition, the findings contribute to the limited empirical literature on Hungarian wine pricing by applying quantile regression to product-level online wine retail data analysis (retrieved from Borháló and Bortársaság). The analysis also provides evidence on the price associations of Tokaj-related characteristics and organic certification in a Central and Eastern European wine market. Finally, the inclusion of sustainability-related and institutional classification variables highlights the relevance of geographical indications and quality labels, while also identifying opportunities for sustainability-oriented differentiation. In sum, the results indicate that the Hungarian wine market exhibits a dual structure, with a commercial wine segment driven by price and sustainability considerations, and a premium segment shaped by heritage, classification, and reputation-based signals. These findings have implications for policymakers at national and international. They provide evidence on the economic value of geographical indications and certification schemes, supporting EU-level quality and sustainability policies. Also, it helps identify which product attributes are most associated with price premiums and which market positioning strategies are most suitable for wine producers and retailers in domestic and international wine markets.

Despite the robustness of the quantile regression results, several limitations should be acknowledged. First, the analysis relies on wine price data scraped from two major Hungarian online wine retailers at a given moment in time. Consequently, the sample may not represent the broader Hungarian wine market, including supermarkets, restaurants, direct-to-consumer sales, or offline retailers. While the online wine market in Hungary represents a relevant distribution channel, the overall market share is limited. Despite its modest scale, the online channel is expanding rapidly, driven by e-commerce and increasing digital adoption. Thus, observed price premiums may reflect retail markups rather than consumer willingness to pay. Second, the cross-sectional nature of the data prevents causal inference; the identified relationships reflect equilibrium market conditions rather than temporal dynamics. Future research could employ panel data or time-series price tracking to assess how attribute premiums evolve in response to changes in demand, supply, or macroeconomic conditions. Third, some quality-related factors, such as expert ratings, alcohol content, or producer reputation, were not included in the analysis due to data scarcity. Adding these characteristics could improve model accuracy and disentangle the role of intrinsic versus extrinsic cues. Finally, extending the analysis beyond Hungary would allow for cross-country comparison, clarifying whether the observed quantile-specific effects are dedicated to emerging online wine markets or hold more generally across other European markets.

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Declarations

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Authors and Affiliations

Jeremiás Máté Balogh [1] · **Zalán Márk Maró** [1]

[1] Department of Agricultural Economics, Corvinus University of Budapest, Budapest, Hungary