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What drives organic certification? Practices, capabilities, and governance in the wine sector

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ABSTRACT

Despite being a central instrument of European agri-food sustainability policy, organic certification uptake remains uneven even among producers that implement environmental practices. This paper examines the factors associated with organic certification in the wine sector, focusing on environmental practices, organizational capabilities, and relational governance. We conceptualize certification as an institutional outcome that formalizes accumulated sustainability engagement rather than as a direct proxy for practice adoption. Using cross-sectional survey data from 232 Hungarian wineries, we estimate logit models in a context characterized by heterogeneous production structures and dense relational networks. The results show that green field practices and green technological practices are strongly associated with certification: a one-standard-deviation increase in these variables is associated with 11.6 and 9.4 percentage point higher probabilities of certification, respectively. Absorptive capacity—the ability to identify, integrate, and apply external knowledge—is also positively associated with certification, corresponding to an 11.0 percentage point higher probability. By contrast, relational quality with business partners is associated with a 12.9 percentage point lower probability of certification. This finding is consistent with the interpretation that trust-based relationships may reduce reliance on formal certification as a credibility mechanism. Interaction analysis indicates that relational quality does not significantly moderate the association between green field practices and certification; rather, it is associated with lower certification probabilities across different levels of green practice engagement. These findings suggest that certification-based sustainability policies may need to address organizational learning constraints and the governance contexts in which producers establish credibility. Because the data are cross-sectional, the results should be interpreted as associations rather than causal effects.

1. Introduction

Organic certification is a central instrument of European agri-food sustainability policy. By codifying production standards and enabling third-party verification, certification schemes seek to align private production decisions with public environmental objectives, while also allowing producers to signal quality, sustainability, and regulatory compliance to market actors. In the wine sector, organic certification is particularly relevant because viticulture is closely linked to land use, soil quality, biodiversity, chemical input use, and climate-related production risks. Certification schemes are therefore expected to support the diffusion of environmentally beneficial practices and strengthen the credibility of sustainability claims in wine markets [1–3].

Yet certification uptake remains uneven, including among wineries that already implement environmentally oriented production practices. Many producers reduce chemical inputs, adopt soil conservation measures, invest in cleaner technologies, or engage in broader sustainability-oriented innovation without necessarily pursuing formal organic certification [4,5]. This pattern suggests that the adoption of environmental practices and the decision to formalize those practices through certification are related but analytically distinct processes. If certification is treated simply as a proxy for sustainable production, important differences between actual environmental engagement and formal institutional recognition may be overlooked.

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This paper examines the factors associated with organic certification among wineries, focusing on environmental practices, organizational capabilities, and relational governance structures. The central question is: under what conditions are environmentally engaged wineries more likely to formalize their practices through organic certification? We conceptualize certification as an institutional outcome that reflects the formalization and external validation of accumulated sustainability engagement, rather than as a direct measure of practice adoption itself. This perspective allows us to examine why some wineries that are active in environmental practices may nevertheless remain uncertified.

Existing research has examined several aspects of organic and sustainable wine production, including consumer demand, price premiums, environmental motivations, and the adoption of specific production practices [6–8,3]. However, less attention has been paid to the organizational and relational conditions that shape the transition from practice adoption to formal certification. The resulting gap is not simply that certification determinants remain underexplored, but that the literature has paid limited attention to whether, and under what conditions, already environmentally engaged producers convert practice engagement into formal certification. In particular, certification may require capabilities that go beyond environmental motivation, including the ability to interpret standards, absorb external knowledge, manage documentation, and interact with certifying bodies. At the same time, wineries embedded in strong trust-based business relationships may perceive less additional value in formal certification if credibility and quality assurance are already supported through repeated exchange, reputation, and direct communication with partners.

The novelty of this study lies in analytically separating environmental practice engagement from the formalization of such engagement through organic certification, and in examining how learning capabilities and relational governance are associated with that formalization process.

The empirical setting is the Hungarian wine sector. This context is theoretically informative because it combines heterogeneous winery structures, varying levels of organizational capability, and strong relational networks characteristic of post-transition agri-food systems. These features make it possible to examine whether certification is associated not only with environmental practices, but also with the organizational and governance conditions under which such practices are formalized. At the same time, the Hungarian setting is institutionally specific, and the mechanisms examined here may operate differently in countries where organic certification is more widespread or where relational governance and formal certification have developed in parallel over longer periods.

Using original cross-sectional survey data from 232 Hungarian wineries, we estimate logit models of organic certification. Because the outcome of interest is binary—whether a winery holds organic certification or not—the empirical analysis estimates how environmental practices, organizational capabilities, relational quality, and control variables are associated with the probability of certification. The models are therefore used to examine patterns of association rather than causal effects. This distinction is important because the data do not allow us to establish the timing or sequencing of practice adoption, capability development, relational embeddedness, and certification. Evidence from French winegrowers identifies organic certification among the factors associated with the adoption of soil carbon sequestration practices, illustrating why the direction of the practice–certification relationship cannot be inferred from our cross-sectional data [9].

The paper is organized as follows. Section 2 develops the theoretical framework and hypotheses, drawing on research on organic certification, environmental practices, organizational capabilities, and relational governance. Section 3 describes the data, variables, measurement strategy, and empirical specification. Section 4 presents the logit results, marginal effects, interaction analysis, and robustness checks. Section 5 discusses the theoretical and empirical implications of the findings, including the boundary conditions of the Hungarian context. Section 6 concludes by summarizing the main contributions, limitations, and directions for future research.

2. Literature review

2.1. Organic certification as an institutional outcome

Organic certification in the wine sector can be understood as an institutional outcome that formalizes and externally validates a winery's engagement with environmentally oriented production practices. Unlike the adoption of a single technological or agronomic innovation, certification involves compliance with externally defined standards, recurrent third-party verification, documentation requirements, and interaction with certifying bodies. It therefore reflects not only the technical implementation of organic or environmentally friendly practices, but also the organizational capacity to translate such practices into a formally recognized institutional status [10,11].

This distinction between practice adoption and certification is important. A substantial body of research shows that wineries adopt environmentally oriented practices for heterogeneous reasons, including environmental stewardship, soil quality, climate adaptation, input reduction, market differentiation, and access to premium segments [6–8]. However, not all producers that engage in such practices pursue formal certification. Evidence from German wineries likewise shows that producers' decisions to convert to organic production reflect diverse motivations and that communication along the wine value chain can be a barrier [12]. Some wineries may adopt sustainable viticulture techniques, reduce chemical inputs, or invest in environmental protection without entering a formal certification scheme [5,13]. This suggests that certification represents an additional institutional threshold rather than the starting point of sustainability engagement.

From this perspective, certification should not be treated simply as a proxy for environmental behavior. Rather, it can be viewed as the institutionalization of prior or accumulated sustainability engagement. Certification enables wineries to codify environmental practices, communicate them credibly to external stakeholders, and align internal routines with formal standards. Yet the decision to certify is likely to depend on factors beyond practice adoption itself, including learning capabilities, access to technical knowledge, administrative capacity, and the governance structures through which credibility is established with buyers and other partners.

2.2. Environmental practices and certification

Environmental practices provide the technical foundation for organic certification. Green field practices—such as reduced chemical input use, soil conservation, biodiversity-oriented vineyard management, and more sustainable pest and disease control—overlap closely with the core requirements of organic production standards. Wineries that have already adopted such practices may face lower adjustment costs when pursuing certification because their production routines are already closer to certified organic requirements [2,14].

Green technological practices may also be associated with certification, although their relationship to organic standards is less direct. Investments in energy efficiency, renewable technologies, waste reduction, water management, and cleaner cellar processes signal broader organizational engagement with sustainability and process upgrading [15,16]. These practices may not always be mandatory for organic certification, but they indicate managerial attention to environmental performance and a willingness to invest in sustainability-related improvements. They may therefore complement field-level practices by strengthening the overall organizational basis for certification.

Previous studies on organic and sustainable wine production show that producers often adopt environmental practices before pursuing certification, and that certification may serve to formalize,

communicate, or appropriate reputational benefits from these practices [17,4]. At the same time, practice adoption does not automatically imply certification. Producers may rely on informal communication, territorial reputation, direct buyer relationships, or local embeddedness to signal sustainability without formal certification. This implies that environmental practices are expected to be positively associated with certification, but they may not be sufficient to explain certification decisions on their own.

Hypothesis 1. Environmental field practices are positively associated with organic certification.

Hypothesis 2. Environmental technological practices are positively associated with organic certification.

2.3. Organizational capabilities as enablers of certification

Beyond observable environmental practices, certification depends on organizational capabilities that allow wineries to engage with complex institutional requirements. Certification is not only a technical production decision; it is also an administrative and knowledge-intensive process involving the interpretation of standards, record keeping, compliance monitoring, communication with certifying bodies, and the coordination of production routines across vineyard and cellar activities.

Managerial environmental orientation may influence early engagement with sustainability, especially by motivating experimentation with environmentally friendly practices. Prior research on organic adoption and sustainable farming emphasizes the role of values, attitudes, and environmental concern in shaping producers' intentions and behavior [18,7]. However, the role of environmental orientation in explaining certification is theoretically more ambiguous. Certification requires more than pro-environmental values; it also requires organizational readiness, technical understanding, and the ability to manage formal procedures. Once actual practices and organizational capabilities are considered, managerial values may therefore have a weaker independent association with certification.

Absorptive capacity is likely to be especially important. Following Cohen and Levinthal [19], absorptive capacity refers to the ability to recognize the value of external knowledge, assimilate it, and apply it to organizational routines. Organic certification depends heavily on such knowledge-processing capacity. Wineries must understand regulatory requirements, interpret technical guidelines, learn from advisors or inspectors, adapt internal procedures, and maintain documentation over time. Firms with stronger absorptive capacity should be better able to reduce informational and compliance costs associated with certification (Gerini et al., 2019; Madau et al., 2021).

Recent work on organic advisory systems strengthens this argument by highlighting the supply side of knowledge transfer. Milardo and Bertazzoli [20] show that advisors and inspectors play a key role in the development of organic agriculture by supporting farmers' decision-making, improving understanding of production techniques, and facilitating communication with control bodies. Their study also shows that the effectiveness of these professionals depends on working conditions, workload, autonomy, job satisfaction, and the broader functioning of the Agricultural Knowledge and Innovation System. This is directly relevant for certification, because wineries' ability to absorb and apply external knowledge depends not only on their internal capabilities but also on the availability and effectiveness of advisors, inspectors, and support services.

The AKIS perspective therefore helps clarify why absorptive capacity may be unevenly distributed across producers. Wineries with stronger internal learning routines and better access to advisory networks are likely to be better positioned to navigate certification requirements. Conversely, limited access to reliable advice, high administrative complexity, or weak knowledge-transfer infrastructures may increase the perceived costs of certification, even for producers that are already environmentally engaged.

Adaptive capacity is related but conceptually distinct. Whereas absorptive capacity concerns the acquisition, interpretation, and application of external knowledge, adaptive capacity refers to the ability to reconfigure routines in response to changing environmental, market, or regulatory conditions. Adaptive capacity may help wineries respond to climate shocks, market volatility, changing consumer expectations, or evolving production risks. However, its relationship with certification may be weaker than that of absorptive capacity. Certification is a discrete institutional status that requires specific knowledge, documentation, and compliance procedures. General flexibility may help firms adjust production routines, but it may not necessarily translate into the formal decision to certify once environmental practices and certification-specific learning capabilities are taken into account.

Innovative problem-solving orientation may also matter, but its expected role is ambiguous. Managers who are confident in solving complex problems may be better able to deal with certification requirements. At the same time, they may also develop informal or alternative ways of demonstrating sustainability to partners, thereby reducing reliance on formal certification. For this reason, innovative orientation may support sustainability engagement without necessarily increasing certification uptake.

Taken together, these arguments suggest that learning-oriented organizational capabilities, especially absorptive capacity, should be more closely associated with certification than general environmental orientation, adaptive flexibility, or individual problem-solving orientation.

Hypothesis 3. Absorptive capacity is positively associated with organic certification.

2.4. Relational governance and alternative credibility mechanisms

Wineries operate within relational and network-based governance structures that shape how quality, sustainability, and credibility are communicated. Relational governance refers to coordination based on trust, repeated interaction, mutual adjustment, communication quality, reciprocity, and long-term business relationships. In agri-food systems, such relationships can reduce information asymmetry and create reputational constraints that support credible exchange even in the absence of formal third-party certification [21–23].

From an institutional perspective, certification and relational governance can both function as credibility mechanisms. Certification provides external validation through codified standards and third-party verification. Consumer evidence from the wine market also indicates that information about certification standards can affect how organic labels are valued [24]. Relational governance, by contrast, provides credibility through direct knowledge, repeated transactions, personal trust, and reputational embeddedness. When buyers, distributors, or other partners already possess reliable information about a winery's practices, formal certification may provide less additional signaling value. In such settings, strong relational quality may be negatively associated with certification because trust-based relationships partly reduce the perceived need for formal verification.

Recent research on organic innovation adoption helps situate this argument within a broader framework of facilitating conditions. Righi and Viganò [25] apply a revised UTAUT framework to organic farmers' adoption of digital innovation and emphasize the role of facilitating conditions such as consortia, cooperatives, producer organizations, enterprise networks, supply-chain contracts, and consulting services. Their findings underline that adoption decisions are not shaped only by individual motivation or perceived usefulness, but also by organizational and support structures that enable producers to implement innovations. This insight maps closely onto certification decisions: wineries may be more or less likely to formalize their environmental practices depending on the networks, advisory structures, and governance arrangements in

which they are embedded. Evidence on territorial sustainability certification in Italy similarly points to the role of wine consortia in coordinating producers and disseminating knowledge [26].

However, the relationship between relational governance and certification may differ across institutional contexts. In contexts where certification is widespread and strongly demanded by retailers or export markets, relational governance and formal certification may coexist and reinforce one another. In more relationally embedded or post-transition settings, where informal exchange and direct partner relationships remain especially important, relational governance may operate more as an alternative credibility channel. The negative association between relational quality and certification should therefore be interpreted cautiously as suggesting that relational governance may provide an alternative credibility channel in this context, rather than as proof that it replaces formal certification.

The moderating role of relational governance is also theoretically ambiguous. Strong relationships may facilitate knowledge exchange and therefore help producers understand certification requirements. At the same time, trust-based relationships may reduce the need to use certification as a formal signal. If relational governance operates mainly as an alternative credibility mechanism, it should lower the baseline likelihood of certification rather than weaken the association between environmental practices and certification. In other words, green practices may remain positively associated with certification, while high relational quality may shift certification probabilities downward across different levels of practice engagement.

Hypothesis 4. High-quality relational governance with business partners is negatively associated with organic certification.

Hypothesis 5. Relational quality does not significantly moderate the association between green field practices and organic certification; rather, it is expected to be negatively associated with certification across different levels of green practice engagement.

2.5. Synthesis and testable implications

The preceding discussion conceptualizes organic certification as the formal institutionalization of sustainability engagement. Environmental practices provide the technical foundation for certification, but certification also requires organizational capabilities and is shaped by governance arrangements. Green field and technological practices are expected to be positively associated with certification because they indicate accumulated environmental engagement. Absorptive capacity is expected to be positively associated with certification because it enables wineries to interpret standards, process external knowledge, interact with advisors and certifying bodies, and manage compliance requirements. Adaptive capacity, while important for broader organizational flexibility, may be less directly related to certification because it does not necessarily provide the specific knowledge-processing capacity required for formal compliance.

Relational governance introduces a further institutional mechanism. Trust-based relationships with business partners may provide alternative ways of establishing credibility, quality assurance, and sustainability reputation. Accordingly, relational quality is expected to be negatively associated with certification, especially where business relationships are dense and informal governance remains important. This does not imply that relational governance reduces the relevance of environmental practices themselves. Rather, it suggests that relational governance may reduce the incremental value of formal certification as a credibility signal.

This framework yields empirically testable expectations that map directly onto the binary-choice models estimated below. Certification is expected to be positively associated with green practices and absorptive capacity, while relational quality is expected to be negatively associated with certification. The interaction analysis evaluates whether relational governance changes the strength of the association between green field practices and certification or instead operates mainly as a level-shifting factor in certification probabilities.

3. Data and methodology

3.1. Data collection and sample

The empirical analysis is based on a cross-sectional survey of Hungarian wineries conducted in 2022 as part of a broader research program on sustainability-oriented innovation, managerial capabilities, and environmental practices in the Hungarian wine sector. The survey targeted owner-managers and senior decision-makers, as these respondents are directly involved in strategic choices concerning production practices, technological upgrading, environmental management, partner relationships, and certification decisions.

The sampling frame was constructed using official winery registries, regional producer associations, and professional networks, with the aim of capturing heterogeneity in winery size, production structure, and geographical location. Surveys were distributed across the major Hungarian wine regions through industry associations and direct contact. The questionnaire was pre-tested with industry experts to ensure clarity, relevance, and consistency with the sectoral context.

The survey yielded 234 completed questionnaires. Two observations contained missing values on variables used in the multivariate regression models. The final analytical sample used in the logit estimations therefore consists of 232 wineries. The larger sample of 234 observations is used where possible for measurement validation and descriptive analysis. Because some questionnaires were distributed indirectly through professional networks and associations, a precise response rate cannot be calculated. However, the sample captures substantial variation in winery size, production volume, organizational characteristics, and certification status.

The dependent variable is organic certification, coded one if the winery holds organic certification and zero otherwise. The explanatory variables capture environmental practices, managerial orientation, organizational capabilities, relational governance, and structural controls.

3.2. Variable construction and measurement

All survey-based constructs were derived from questionnaire items designed to capture distinct dimensions of environmental practice adoption, managerial orientation, organizational capabilities, and network relationships. Managerial, capability, and relational-governance items were measured on five-point Likert-type scales, with higher values indicating stronger agreement or greater intensity of the underlying construct. The seven process-innovation items used to construct the green-practice dimensions were an exception: they were recorded on three-category ordinal response scales coded from 1 to 3. Full item wording and response scales are reported in Appendix A.

Table 1 summarizes the main variables used in the empirical analysis, their item composition, measurement approach, and reliability statistics.

Environmental orientation is measured using a single item capturing whether the respondent gives higher priority to environmental protection and employee welfare than to profitability. This item captures a normative managerial orientation and is treated as a single-item proxy for environmental values.

Innovative problem-solving orientation is constructed from two items: whether the respondent has many original ideas and whether the respondent usually has several solutions to a problem. Although the reliability of this two-item scale is acceptable, its limited item base restricts its psychometric richness. We therefore interpret it as a parsimonious indicator of managerial cognitive orientation and acknowledge this as a measurement limitation.

Table 1
Variable construction, scale origin, measurement, and reliability.

Variable	Description	Measurement	Scale source / origin	Reliability
Organic certification	Whether the winery holds organic certification	Binary variable (1 = certified, 0 = not certified)	Original survey item	Not applicable
Green field practices	Resource-saving and vineyard-level environmental practices	Factor score derived from process-innovation items (Appendix A; Table 2)	Original survey items; factor-analytic construct	See Table 2
Green technological practices	Technology-intensive environmental practices in production and cellar operations	Factor score derived from process-innovation items (Appendix A; Table 2)	Original survey items; factor-analytic construct	See Table 2
Environmental orientation	Priority assigned to environmental and employee-related objectives relative to profitability	Single-item measure	Original survey item	Not applicable
Innovative problem-solving orientation	Managerial originality and ability to generate alternative solutions	Two-item composite scale (Appendix A)	Original survey items	Cronbach's $\alpha = 0.737$
Absorptive capacity	Ability to acquire and use external knowledge	Three-item composite scale (Appendix A)	Adapted from Cohen and Levinthal [19]	Cronbach's $\alpha = 0.818$
Adaptive capacity	Ability to modify routines and respond to environmental changes	Three-item composite scale (Appendix A)	Informed by adaptive-capacity/ dynamic-capabilities literature	Cronbach's $\alpha = 0.680$
Relational quality	Quality of relationships with business partners based on trust, flexibility, and mutual support	Four-item composite scale (Appendix A)	Adapted from relational-governance literature (e.g., [27])	Cronbach's $\alpha = 0.829$
Vineyard land	Vineyard area operated by the winery	Hectares	Original survey measure	Not applicable
Production volume	Annual wine production	Hectolitres	Original survey measure	Not applicable
Managerial age	Age of respondent	Years	Original survey measure	Not applicable
Education	Highest educational attainment of respondent	Ordinal measure	Original survey measure	Not applicable

Notes: Detailed item wording is reported in Appendix A. Reliability statistics for multi-item constructs are reported in Appendix B. Green field practices and green technological practices are factor scores derived from principal-component factor analysis with varimax rotation; rotated factor loadings are reported in Table 2. Multi-item composite scales were constructed by averaging standardized constituent items and subsequently standardizing the resulting scale to mean zero and unit variance.

Absorptive capacity is measured using three items capturing whether the winery can identify valuable external knowledge, integrate newly acquired knowledge with existing knowledge, and use integrated knowledge for product, technological, and process development. Adaptive capacity is measured using three items capturing whether employees question existing routines and whether the winery can adapt quickly to market and business-environment changes. This distinction is central to the empirical analysis: absorptive capacity captures knowledge acquisition and use, whereas adaptive capacity captures organizational flexibility.

Relational quality is measured using four items capturing whether the winery regularly consults with partners about mutual support, builds good personal relationships with partners, deals flexibly with partners, and solves problems constructively with partners. These items capture the quality of exchange relationships with key business partners and are used to assess whether relational governance is associated with organic certification.

A distinction is made between descriptive comparison and regression scaling. Table 3 reports the green-practice variables, organizational-capability constructs, and relational-quality measure in their standardized analytical form, with a full-sample mean of zero and standard deviation of one. The green-practice variables are standardized regression-based factor scores obtained from the principal-component factor model described in Section 3.3. Structural variables are reported in their original units in Table 3 but are standardized before inclusion in the regression models.

For the regression analysis, all continuous explanatory variables are standardized to mean zero and unit variance before estimation. This includes the multi-item constructs, factor scores, and continuous controls. Standardization allows logit coefficients and average marginal effects to be interpreted as changes associated with a one-standard-deviation increase in each explanatory variable, facilitating comparison across variables measured on different scales. Thus, descriptive statistics and regression estimates serve different purposes: the former describe the sample in meaningful measurement units, while the latter provide comparable estimates of association.

For the green-practice variables, Table 3 and the regression models use the same regression-based factor scores. These scores are standardized to a full-sample mean of zero and standard deviation of one; consequently, the group means in Table 3 indicate the relative positions of certified and non-certified wineries within the sample rather than original-scale levels of practice adoption.

3.3. Factor analysis of green practices

Green-practice variables were constructed from seven three-category process-innovation items referring to integrated viticulture, agrochemical reduction, material-, energy-, and water-saving practices, greenhouse-gas reduction, renewable-energy use, and green vineyard- and cellar-level solutions. The items were measured on three-category ordinal scales coded as 1 = not implemented, 2 = implemented in cooperation with a partner, and 3 = implemented independently by the winery.

We estimated a principal-component factor model from the Pearson correlation matrix of these seven items and retained two factors, which were subsequently rotated using orthogonal varimax rotation. The suitability of the items for factor analysis is supported by Bartlett's test of sphericity, $\chi^2(21) = 297.429$, $p < 0.001$, and a Kaiser–Meyer–Olkin measure of sampling adequacy of 0.728. The retained factors explain 55.0% of the total variance. All KMO and Bartlett diagnostics, rotated loadings, and factor scores reported in Table 2 and Appendix B were generated from this same specification.

The rotated factor loadings are reported in Table 2.

The first factor loads primarily on agrochemical reduction, resource-saving practices, and vineyard-level green solutions. We interpret this factor as green field practices. The second factor loads on integrated viticulture, greenhouse-gas reduction, renewable energy use, and cellar-level green solutions. We interpret this factor as green technological

Table 2
Rotated factor loadings for green practice variables.

Item	Description	Factor 1	Factor 2
process2	Introduction of integrated viticulture		0.468
process3	Reduction of agrochemical use	0.800	
process5	Material-, energy-, and water-saving solutions	0.763	
process6	Reduction of greenhouse-gas emissions		0.464
process7	Use of renewable energy		0.650
process8	Green vineyard-level solutions	0.792	
process9	Green cellar-level solutions		0.853

Notes: Principal-component factor analysis with varimax rotation. Blanks indicate absolute loadings below 0.40.

practices. Two items, integrated viticulture and greenhouse-gas reduction, have moderate loadings slightly above 0.40, indicating that the distinction between the two dimensions is empirically meaningful but not perfectly sharp. For this reason, the factor loadings are reported explicitly and the interpretation of the two factors remains cautious.

Regression-based factor scores were predicted from the rotated solution and then standardized to mean zero and unit variance before inclusion in the regression models.

3.4. Reliability, validity, and multicollinearity diagnostics

Reliability diagnostics support the use of the main multi-item constructs. Absorptive capacity and relational quality show good internal consistency, with Cronbach's alpha values of 0.818 and 0.829, respectively. Innovative problem-solving orientation has acceptable reliability, with $\alpha = 0.737$, but it is based on only two items and is therefore interpreted cautiously. Adaptive capacity has $\alpha = 0.680$, slightly below the conventional 0.70 threshold, but close enough to be retained as an exploratory organizational capability measure.

To assess whether the capability constructs overlap excessively, we examined pairwise correlations and variance inflation factors. The VIF diagnostics were calculated using the same set of explanatory variables as in the full logit model. The highest VIF is 1.69 for absorptive capacity and the mean VIF is 1.31. These values are well below conventional thresholds and suggest that multicollinearity does not drive the observed changes in coefficient size or significance across nested model specifications.

3.5. Empirical specification

The empirical analysis estimates the probability that winery *i* holds organic certification. Because the dependent variable is binary, we use logit regression as the main specification. The logit model is appropriate because it estimates the probability of certification as a function of environmental practices, managerial orientation, organizational capabilities, relational quality, and structural controls. It also allows direct computation of average marginal effects and predicted probabilities, which are used to interpret the substantive magnitude of the estimated associations.

The baseline empirical model is:

$$Pr(Organic_i = 1) = \Lambda\big(\beta_0 + \beta_1 GreenField_i + \beta_2 GreenTech_i + \beta_3 EO_i + \beta_4 INO_i + \beta_5 Absorb_i + \beta_6 Adapt_i + \beta_7 RelQual_i + X_i'\gamma\big),$$

where $\Lambda(\cdot)$ denotes the logistic cumulative distribution function. $Organic_i$ is a binary indicator equal to one if winery i holds organic certification. $GreenField_i$ and $GreenTech_i$ are standardized factor scores capturing green field practices and green technological practices. EO_i denotes environmental orientation, INO_i denotes innovative problem-solving orientation, $Absorb_i$ denotes absorptive capacity, $Adapt_i$ denotes adaptive capacity, and $RelQual_i$ denotes relational quality with business partners. X_i is a vector of standardized control variables including vineyard land, production volume, managerial age, and education.

The models are estimated sequentially. The first model includes environmental orientation and controls. The second model adds green field and green technological practices. The third model adds absorptive and adaptive capacity. The fourth model adds innovative problem-solving orientation and relational quality. This stepwise structure allows us to assess whether environmental orientation remains associated with certification once realized practices, organizational capabilities, and relational governance are included.

Robust standard errors are reported throughout. Average marginal effects are reported for the fully specified logit model to translate coefficient estimates into changes in certification probability. These marginal effects are treated as the primary quantitative estimates for interpreting substantive magnitude.

To assess whether relational quality moderates the association between green field practices and organic certification, we estimate an extended model including the interaction term $GreenField_i \times RelQual_i$:

$$Pr(Organic_i = 1) = \Lambda\big(\beta_0 + \beta_1 GreenField_i + \beta_2 RelQual_i + \beta_3 GreenField_i \times RelQual_i + Z_i'\delta\big),$$

where Z_i includes the remaining explanatory variables and controls. Because interaction coefficients in nonlinear models cannot be interpreted directly as moderation effects, we evaluate the interaction using predicted probabilities and marginal effects of green field practices at low, average, and high levels of relational quality. This approach allows us to assess whether relational quality changes the slope of the association between green practices and certification or instead shifts certification probabilities downward across different levels of green practice engagement.

As a robustness check, we also compare the main logit estimates with a semi-nonparametric binary-choice model reported in Appendix D. The SNP estimator allows the latent error distribution to deviate from the logistic specification and therefore provides a check on whether the main results are sensitive to distributional assumptions. The main results are reported using logit models for parsimony, interpretability, and consistency with the binary certification outcome.

The cross-sectional nature of the data limits causal interpretation. The analysis therefore identifies associations between practices, capabilities, relational governance, and certification status, rather than causal effects. Although the theoretical framework conceptualizes certification as the formalization of accumulated sustainability engagement, the data do not allow us to establish the timing or sequencing of practice adoption, capability development, and certification. The results should therefore be interpreted as evidence on the correlates and institutional mechanisms associated with certification decisions among Hungarian wineries.

4. Results

This section presents the empirical results on the association between environmental practices, organizational capabilities, relational governance, and organic certification among Hungarian wineries. The analysis proceeds in four steps. First, we summarize the descriptive patterns by certification status. Second, we present the baseline logit models. Third, we report average marginal effects from the fully specified model. Finally, we examine whether relational quality moderates the association between green field practices and certification using interaction models and predicted probabilities.

4.1. Descriptive patterns

Table 3 reports a descriptive comparison of the main variables by organic certification status. Because the empirical analysis combines different types of variables, the table reports each variable in the metric most relevant for comparing certified and non-certified wineries. Green-practice, organizational-capability, and relational-quality variables are reported in their standardized analytical form, while structural variables such as vineyard land, production volume, managerial age, and education are reported in their original units.

The purpose of the table is therefore not to compare magnitudes across variables, but to compare certified and non-certified wineries within each variable. For standardized and factor-based variables, group means should be interpreted as relative positions within the sample rather than as original-scale levels. For land, production volume, age, and education, the reported values retain their original substantive units.

Certified wineries have higher average scores on both green practice dimensions. The differences are statistically significant, suggesting that

Table 3
Descriptive comparison of analytical variables by organic certification status.

Variable	Non-certified	Certified	Total	*p*-value
N	158 (67.5%)	76 (32.5%)	234 (100.0%)	
Green field practices	−0.184 (1.036)	0.384 (0.799)	0.000 (1.000)	<0.001
Green technological practices	−0.170 (0.912)	0.353 (1.087)	0.000 (1.000)	<0.001
Environmental orientation	−0.106 (0.972)	0.221 (1.027)	0.000 (1.000)	0.019
Innovative problem-solving orientation	−0.043 (0.969)	0.089 (1.062)	0.000 (1.000)	0.348
Absorptive capacity	−0.121 (1.031)	0.252 (0.886)	0.000 (1.000)	0.007
Adaptive capacity	−0.058 (1.013)	0.121 (0.967)	0.000 (1.000)	0.198
Relational quality	0.061 (0.988)	−0.127 (1.019)	0.000 (1.000)	0.179
Vineyard land (ha)	21.4 (48.6)	27.5 (41.8)	23.4 (46.5)	0.352
Production volume (hl)	2,715.3 (16,707.2)	5,859.5 (34,795.3)	3,731.8 (24,052.5)	0.353
Managerial age (years)	48.5 (12.4)	45.6 (13.1)	47.6 (12.6)	0.095
Education	2.7 (1.1)	2.8 (0.9)	2.7 (1.1)	0.230

Notes: Means are reported with standard deviations in parentheses. Green field practices, green technological practices, environmental orientation, innovative problem-solving orientation, absorptive capacity, adaptive capacity, and relational quality are reported in their standardized analytical form, with a full-sample mean of zero and standard deviation of one. The two green-practice variables are standardized regression-based factor scores obtained from the principal-component factor model reported in Table 2. Vineyard land, production volume, managerial age, and education are reported in their original units. The last column reports *p*-values from two-sample mean-comparison tests.

certified wineries are more strongly characterized by environmental practice engagement. Because these variables are constructed analytical measures, the absolute values should not be interpreted as original-scale practice levels; rather, the relevant information is the difference between certified and non-certified wineries.

Certified wineries also have higher average standardized scores for environmental orientation and absorptive capacity. These differences indicate that certified wineries occupy a higher relative position within the sample on these constructs, especially on the ability to identify, integrate, and apply external knowledge. This descriptive pattern is consistent with the argument that certification is associated not only with environmental practice engagement, but also with knowledge-processing capabilities.

By contrast, certified and non-certified wineries do not differ significantly in innovative problem-solving orientation, adaptive capacity, or relational quality in the bivariate comparison. This suggests that the role of these variables cannot be inferred from group means alone and needs to be assessed in the multivariate models. This is particularly relevant for relational quality, which is not significantly different across groups descriptively but becomes negatively associated with certification once green practices, organizational capabilities, and controls are considered jointly.

The same applies to structural controls. Certified wineries have somewhat larger vineyard areas and higher production volumes on average, but these differences are not statistically significant. Managerial age is lower among certified wineries, with a marginally significant difference, while education does not differ meaningfully across groups.

Overall, the descriptive comparison suggests that certification is most clearly associated with green practice engagement, environmental orientation, and absorptive capacity. However, these bivariate comparisons do not account for overlap among practices, capabilities, governance relationships, and winery characteristics. The following logit models therefore assess whether these associations persist when all explanatory variables are considered jointly.

4.2. Baseline logit models

Table 4 reports four nested logit models for the probability that a winery holds organic certification. All continuous explanatory variables are standardized, so the coefficients refer to changes associated with a one-standard-deviation increase in the corresponding variable. Robust standard errors are reported in parentheses.

The results provide strong evidence that green practices are positively associated with organic certification. Green field practices and green technological practices are positive and statistically significant in all models in which they are included. Their coefficients remain stable across specifications, indicating that the association between environmental practice engagement and certification is not sensitive to the inclusion of organizational capabilities or relational quality. This supports Hypotheses 1 and 2.

Environmental orientation is positive and statistically significant only in Model 1. Once green practices are added in Model 2, the coefficient becomes smaller and statistically insignificant. This pattern suggests that managerial environmental values are associated with

Table 4
Determinants of organic certification: logit models with robust standard errors.

Variable	(1) Values only	(2) + Practices	(3) + Capabilities	(4) Full model
Environmental orientation	0.332**	0.237	0.217	0.275
	(0.157)	(0.165)	(0.173)	(0.188)
Green field practices		0.643***	0.609***	0.692***
		(0.159)	(0.162)	(0.176)
Green technological practices		0.569***	0.555***	0.560***
		(0.165)	(0.164)	(0.166)
Absorptive capacity			0.299	0.657***
			(0.202)	(0.254)
Adaptive capacity			-0.138	-0.011
			(0.205)	(0.236)
Innovative problem-solving orientation				0.040
				(0.208)
Relational quality				-0.766***
				(0.232)
Vineyard land, standardized	0.023	-0.073	-0.049	-0.003
	(0.155)	(0.147)	(0.151)	(0.153)
Production volume, standardized	0.128	0.163	0.152	0.158
	(0.135)	(0.127)	(0.126)	(0.122)
Managerial age, standardized	-0.274*	-0.279*	-0.290*	-0.370**
	(0.151)	(0.155)	(0.159)	(0.163)
Education, standardized	0.142	0.187	0.192	0.169
	(0.142)	(0.168)	(0.167)	(0.176)
Constant	-0.777***	-0.894***	-0.906***	-0.979***
	(0.147)	(0.160)	(0.161)	(0.166)
Observations	232	232	232	232
Pseudo-R^2	0.035	0.137	0.145	0.197
AIC	293.66	268.11	269.70	258.53

Notes: Dependent variable: organic certification, coded 1 if the winery holds organic certification and 0 otherwise. Robust standard errors are reported in parentheses. All continuous explanatory variables are standardized. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

certification mainly through their relationship with realized environmental practices. In other words, values alone do not explain certification once the model accounts for what wineries actually do in terms of field-level and technological green practices.

Absorptive capacity becomes positive and statistically significant in the full model. This supports Hypothesis 3 and suggests that certification is associated not only with environmental practice engagement, but also with the organizational ability to identify, integrate, and use external knowledge. The increase in the absorptive-capacity coefficient after including relational quality does not appear to be driven by multicollinearity. Variance inflation factor diagnostics show a maximum VIF of 1.69 and a mean VIF of 1.31, well below conventional thresholds. The change across models is therefore more plausibly interpreted as reflecting the distinct roles of learning capability and relational governance rather than unstable estimation caused by collinearity.

Adaptive capacity is not statistically significant in either Model 3 or Model 4. This pattern is consistent with the theoretical distinction between general organizational flexibility and the more certification-specific knowledge-processing role of absorptive capacity. However, the insignificant coefficient should not be interpreted as decisive evidence that adaptive capacity is unrelated to certification. The scale has slightly below-threshold internal consistency ($\alpha = 0.680$), and one item has a comparatively weak one-factor loading (0.451), compared with loadings of 0.919 and 0.928 for the other two items. Measurement attenuation is therefore a plausible competing explanation for the insignificant logit result. Moreover, the negative and weakly significant estimate in the full SNP model indicates some sensitivity to the assumed latent-error distribution.

Innovative problem-solving orientation is also statistically insignificant in the full model. This indicates that managerial creativity and problem-solving confidence do not independently explain certification once environmental practices, absorptive capacity, and relational quality are included. This result is consistent with the interpretation that certification depends less on general individual problem-solving orientation than on practice engagement and certification-relevant organizational learning.

Relational quality is negative and statistically significant in the full model. This finding is consistent with Hypothesis 4. However, the result should be interpreted cautiously. The negative coefficient indicates that wineries with stronger trust-based partner relationships are less likely to hold organic certification, conditional on their environmental practices and capabilities. This is consistent with an alternative credibility-channel interpretation, but the coefficient should not be read as evidence that trust-based relationships causally replace formal certification.

Among the controls, managerial age is negative and statistically significant in the full model, indicating that younger decision-makers are more likely to be associated with certification. Vineyard land, production volume, and education are not statistically significant. Because these variables are standardized in the revised models, the near-zero coefficient problem associated with original measurement units is avoided. The results indicate that the absence of scale effects is substantive rather than merely an artifact of hectares or hectoliters being measured in large or uneven units.

4.3. Average marginal effects

Table 5 reports average marginal effects from the fully specified logit model. These estimates translate logit coefficients into changes in predicted certification probability and provide the main quantitative interpretation of the results.

The marginal effects confirm the substantive importance of green practices. A one-standard-deviation increase in green field practices is associated with an 11.6 percentage point higher probability of organic certification. A one-standard-deviation increase in green technological practices is associated with a 9.4 percentage point higher probability of certification. These estimates should be used as the paper's primary quantitative claims.

Table 5
Average marginal effects from the full logit model.

Variable	Average marginal effect	Robust SE
Environmental orientation	0.046	0.031
Green field practices	0.116***	0.028
Green technological practices	0.094***	0.026
Innovative problem-solving orientation	0.007	0.035
Absorptive capacity	0.110***	0.041
Adaptive capacity	-0.002	0.040
Relational quality	-0.129***	0.035
Vineyard land, standardized	-0.001	0.026
Production volume, standardized	0.027	0.020
Managerial age, standardized	-0.062**	0.026
Education, standardized	0.028	0.029
Observations	232	

Notes: Average marginal effects from the full logit model. Robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Absorptive capacity has a similarly large association with certification. A one-standard-deviation increase in absorptive capacity is associated with an 11.0 percentage point higher probability of certification. This reinforces the argument that certification is not merely a reflection of environmental practice adoption, but also depends on the ability to process and apply external knowledge relevant to certification requirements.

Relational quality has a negative marginal effect. A one-standard-deviation increase in relational quality is associated with a 12.9 percentage point lower probability of certification. This result is consistent with the idea that strong partner relationships may reduce the perceived need for formal certification, but the interpretation remains associational. The analysis shows a lower certification probability among wineries with stronger relational quality; it does not directly observe whether or how producers use partner relationships instead of certification when establishing credibility.

The marginal effect of adaptive capacity is close to zero and statistically insignificant. This supports the interpretation that general organizational flexibility is not sufficient for certification when certification requires more specific knowledge-processing and compliance capabilities. The marginal effects for environmental orientation and innovative problem-solving orientation are also small and statistically insignificant. Among the controls, managerial age has a negative and statistically significant marginal effect, while land, production volume, and education remain statistically insignificant.

4.4. Relational quality and the green practice-certification association

Hypothesis 5 concerns whether relational quality moderates the association between green field practices and organic certification. Because interaction effects in nonlinear models cannot be evaluated from the coefficient alone, we report both the logit interaction model and marginal effects of green field practices at low, average, and high levels of relational quality. (Table 6)

The interaction between green field practices and relational quality is not statistically significant. However, this coefficient alone is not sufficient to evaluate moderation in a nonlinear model. We therefore estimate the marginal effect of green field practices at three levels of relational quality: low (-1 SD), average, and high (+1 SD). The marginal effect of green field practices remains positive and statistically significant at all three levels: 10.9 percentage points at low relational quality, 11.5 percentage points at average relational quality, and 10.6 percentage points at high relational quality. (Table 7)

These results indicate that relational quality does not materially alter the strength of the association between green field practices and certification. The effect of green field practices remains similar across low, average, and high levels of relational quality. The evidence therefore

Table 6
Interaction models.

Variable	(1) Green field × Relational quality	(2) Green field × Absorptive capacity
Green field practices	0.698***	0.714***
	(0.179)	(0.179)
Relational quality	-0.771***	-0.770***
	(0.228)	(0.236)
Absorptive capacity	0.664***	0.692***
	(0.256)	(0.252)
Green field × Relational quality	0.104	
	(0.173)	
Green field × Absorptive capacity		-0.152
		(0.190)
Green technological practices	0.558***	0.564***
	(0.167)	(0.165)
Environmental orientation	0.287	0.280
	(0.191)	(0.187)
Innovative problem-solving orientation	0.032	0.029
	(0.206)	(0.208)
Adaptive capacity	-0.030	-0.009
	(0.237)	(0.237)
Vineyard land, standardized	0.000	-0.007
	(0.152)	(0.152)
Production volume, standardized	0.157	0.157
	(0.121)	(0.122)
Managerial age, standardized	-0.392**	-0.360**
	(0.168)	(0.162)
Education, standardized	0.176	0.158
	(0.176)	(0.175)
Constant	-1.003***	-0.976***
	(0.172)	(0.168)
Observations	232	232
Pseudo-R^2	0.198	0.199

Notes: Dependent variable: organic certification. Robust standard errors in parentheses. Continuous variables are standardized. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 7
Marginal effect of green field practices at different levels of relational quality.

Relational quality	Marginal effect of green field practices	Robust SE	*p*-value
Low relational quality (-1 SD)	0.109	0.038	0.004
Mean relational quality	0.115	0.028	<0.001
High relational quality (+1 SD)	0.106	0.035	0.003

does not support a moderation interpretation.

Figure 1 presents predicted probabilities from the interaction model. The predicted probability of certification increases with green field practices at both low and high levels of relational quality. However, the predicted probability curve for wineries with high relational quality lies below the curve for wineries with low relational quality across most of the observed range of green field practices. This pattern is consistent with a level effect: stronger relational quality is associated with a lower baseline probability of certification, while the positive association between green field practices and certification remains broadly similar.

Taken together, the interaction results are consistent with Hypothesis 5. Relational quality does not significantly moderate the association between green field practices and certification. Instead, it is negatively associated with certification probabilities across different levels of green practice engagement. This finding is consistent with the interpretation that trust-based partner relationships may provide an alternative credibility channel, but the evidence should be interpreted as an associational level effect rather than as direct evidence of substitution.

The additional interaction between green field practices and absorptive capacity is also statistically insignificant. This suggests that absorptive capacity is directly associated with certification rather than operating primarily by strengthening the green practice-certification relationship. In substantive terms, green practices and absorptive capacity appear to contribute independently to certification: practices capture accumulated environmental engagement, while absorptive capacity captures the organizational ability to understand and manage certification-relevant knowledge.

4.5. Robustness and interpretation

The main results are robust across the nested logit specifications. Green field practices, green technological practices, absorptive capacity, and relational quality retain their signs and substantive relevance in the full model. The stepwise structure also clarifies why some coefficients change across models. Environmental orientation is significant only before green practices are included, suggesting that environmental values are reflected in practice adoption rather than independently associated with certification. Absorptive capacity becomes significant in the full model, indicating that learning capability has an independent association with certification once relational quality is accounted for. Adaptive capacity remains insignificant throughout, suggesting that general organizational flexibility is not equivalent to the knowledge-processing capabilities required for certification.

The multicollinearity diagnostics support this interpretation. The highest VIF is 1.69 and the mean VIF is 1.31, indicating that coefficient changes across nested models are not driven by problematic multicollinearity. The results therefore point to conceptually distinct roles for environmental practices, absorptive capacity, and relational quality.

The SNP estimates reproduce the main findings for green field practices, green technological practices, absorptive capacity, and relational quality. In the full SNP specification, however, innovative problem-solving orientation becomes negative and statistically significant (-0.323, $p < 0.05$), while adaptive capacity becomes negative and weakly significant (-0.255, $p < 0.10$); both variables are statistically insignificant in the main logit model. These sign and significance shifts indicate that conclusions concerning these two constructs are sensitive to the assumed latent-error distribution or to unobserved heterogeneity captured by the more flexible SNP specification. We therefore regard the evidence for innovative problem-solving orientation and adaptive capacity as specification-sensitive. The central results for green practices, absorptive capacity, and relational quality remain stable across specifications.

Overall, the robustness checks support the core findings for green practices, absorptive capacity, and relational quality. The interpretation of these findings is developed in the following discussion.

5. Discussion

This study examined organic certification among Hungarian wineries through a capability- and governance-based perspective. The findings support the argument that certification should be understood as an institutional outcome rather than as a direct proxy for environmental practice adoption. Certification is associated with accumulated environmental engagement, but the results also show that practices alone do not fully explain why some wineries formalize their sustainability activities through certification while others remain uncertified. Organizational learning capabilities and relational governance structures also matter.

The positive association between green practices and certification is consistent with the idea that certification usually builds on an existing

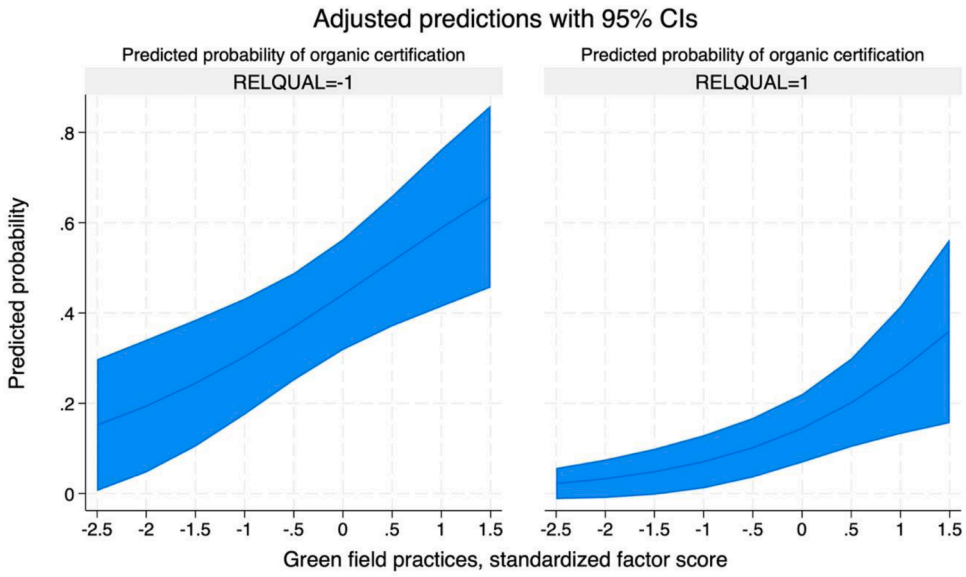


Figure 1. Predicted probability of organic certification by green field practices and relational quality.

base of sustainability-oriented production routines. Wineries that have already adopted field-level and technological environmental practices are better positioned to comply with certification requirements and to benefit from formal recognition. This finding helps clarify the relationship between environmental practice adoption and certification. Certification does not necessarily initiate sustainability engagement; rather, it appears to formalize and externally validate practices that are already partly embedded in the organization. This distinction is important because policy and empirical research often use certification as an observable indicator of sustainability, even though uncertified producers may also engage in substantial environmental practices.

The results also highlight the importance of absorptive capacity. Certification requires wineries to interpret standards, process external knowledge, manage documentation, and interact with certifying bodies. These tasks are knowledge-intensive and administratively demanding. The positive role of absorptive capacity therefore suggests that certification is facilitated by the ability to identify, integrate, and apply external knowledge. This extends capability-based perspectives on sustainability by showing that organizational learning matters not only for innovation or practice adoption, but also for the formal institutionalization of sustainability engagement.

This interpretation is reinforced by recent work on organic advisory and inspection systems. Milardo and Bertazzoli [20] show that advisors and inspectors play an important role in supporting organic agriculture by helping producers understand production techniques, certification procedures, and communication with control bodies. Their findings also point to the workload, competencies, and working conditions of these professionals as important features of the broader knowledge infrastructure around organic farming. In this light, absorptive capacity should not be viewed only as an internal firm attribute. It is also connected to the availability, quality, and accessibility of external advisory and certification-related knowledge. Wineries can benefit from such support structures only if they have the internal capacity to recognize and use the knowledge provided.

The logit results provide no robust evidence that adaptive capacity is associated with certification. This pattern is consistent with the possibility that general organizational flexibility is less directly relevant to certification than the acquisition and application of external knowledge captured by absorptive capacity. Nevertheless, this interpretation remains tentative. The adaptive-capacity scale has modest reliability and an uneven loading structure, which may attenuate its estimated association, while the full SNP specification produces a negative and weakly significant coefficient. The results therefore distinguish the robust positive association of absorptive capacity from the specification-sensitive evidence concerning adaptive capacity, but they do not establish that adaptive capacity has no role in certification.

The findings also refine the role of managerial environmental orientation. Environmental values may encourage wineries to engage in sustainability-oriented practices, but they do not independently explain certification once realized practices and organizational capabilities are included. This suggests that certification is less a direct expression of managerial values than a formal organizational decision shaped by routines, capabilities, and institutional requirements. Values may matter at earlier stages of sustainability engagement, while certification depends more strongly on whether environmental practices and organizational learning capabilities have already developed.

The negative association between relational quality and certification is one of the most theoretically interesting findings. It suggests that wineries embedded in high-quality, trust-based business relationships may rely less on formal certification as a credibility mechanism. Relational governance can provide credibility through repeated exchange, mutual knowledge, reputation, and direct communication with partners. In such settings, formal certification may offer less additional signaling value. However, this interpretation should remain cautious. The evidence shows that relational quality is negatively associated with certification; it does not directly demonstrate that wineries deliberately use partner relationships in place of certification, nor that relational governance causally reduces certification uptake.

The interaction analysis further qualifies this interpretation. Relational quality does not appear to weaken the association between green practices and certification. Instead, it is associated with lower certification probabilities across different levels of green practice engagement. This pattern is more consistent with a level effect than with moderation. In substantive terms, environmentally active wineries remain more likely to be certified, but those embedded in stronger partner relationships are less likely to rely on certification than otherwise similar wineries. This supports the interpretation that relational governance may operate as an alternative credibility channel, while leaving the practice-certification association largely intact.

Righi and Viganò's [25] analysis of innovation adoption in organic farming helps place this result in a broader institutional context. Their work emphasizes the importance of facilitating conditions such as cooperatives, consortia, producer organizations, advisory services, business networks, and supply-chain relationships. These structures can

support innovation and knowledge transfer, but they also shape how producers coordinate with partners and establish credibility. The present findings suggest that such governance environments may influence not only whether producers adopt sustainability-related practices, but also whether they choose to formalize them through certification.

The Hungarian wine sector provides an important boundary condition for interpreting these results. The sector combines heterogeneous winery structures, relatively strong relational networks, and post-transition institutional legacies in which informal governance and direct business relationships remain important. These features may make the negative association between relational quality and certification more visible than in contexts where certification is more deeply institutionalized. In higher-certification countries such as France, Italy, or Austria, relational governance and formal certification may have developed together and may operate more as complements than as alternatives. In such settings, trusted relationships with buyers, cooperatives, or territorial organizations may support certification rather than reduce its perceived value.

The boundary condition is therefore mechanistic rather than merely national. Relational governance may be associated with lower reliance on certification where informal credibility mechanisms are strong and formal certification is less embedded in market exchange. By contrast, relational governance may reinforce certification where formal standards are already expected by retailers, export markets, or producer organizations. Comparative research across institutional settings is needed to determine when relational governance functions as an alternative credibility channel and when it facilitates certification.

The findings also suggest that winery scale and formal education are less central than expected once practices, capabilities, and relational quality are taken into account. Certification in this sample is not primarily explained by vineyard size or production volume. This implies that organizational and governance conditions may be more relevant than simple structural size differences. The negative association between managerial age and certification may point to generational differences in openness to formal sustainability standards, although this interpretation should remain tentative.

Overall, the results point to a broader understanding of certification within sustainability governance. Organic certification is not simply a market label, a policy target, or a direct indicator of environmental behavior. It is shaped by the interaction between practice engagement, organizational learning, and the governance context through which credibility is established. Recognizing this broader institutional setting helps explain why certification uptake may remain uneven even among producers already engaged in environmental practices.

6. Conclusions

This paper examined organic certification among Hungarian wineries as an institutional outcome associated with environmental practices, organizational capabilities, and relational governance. Rather than treating certification as a direct proxy for sustainable production, the study distinguished between the adoption of sustainability-oriented practices and the formal recognition of those practices through certification. This distinction is important because many producers may engage in environmentally beneficial practices without necessarily entering formal certification schemes.

The analysis contributes to the literature in three main ways. First, it shows that organic certification should be analyzed separately from environmental practice adoption. Green field and technological practices are strongly associated with certification, but they do not fully explain why some environmentally active wineries certify while others do not. Second, the study highlights the role of organizational learning. Absorptive capacity is positively associated with certification, suggesting that the ability to identify, integrate, and apply external knowledge matters for navigating certification requirements. Third, the study shows that governance relationships are relevant for understanding certification behavior. Relational quality with business partners is negatively associated with certification, which is consistent with the interpretation that trust-based relationships may reduce the perceived additional value of formal certification as a credibility signal. However, this should be interpreted as an associational level effect rather than as evidence that relational governance replaces certification.

The findings have implications for sustainability policy, but these implications should be stated cautiously. The results suggest that policies aimed at increasing certification uptake may need to address informational, organizational, and administrative barriers, not only financial costs. Advisory services, technical assistance, peer-learning platforms, and clearer certification procedures may help wineries with weaker absorptive capacity engage more effectively with certification systems. At the same time, the analysis does not directly test the effectiveness of certification subsidies, advisory programs, or other policy instruments. Therefore, the results should be understood as indicating where potential barriers may lie, rather than as evidence that one policy tool is superior to another.

The findings also suggest that certification-based sustainability policies may operate differently across governance contexts. In relationally embedded production systems, formal certification may not be the only mechanism through which producers establish credibility with buyers and partners. Where trust-based relationships, repeated exchange, and local reputation are strong, some producers may perceive less additional value from certification. This does not imply that certification is unimportant, but it does suggest that policy frameworks should recognize the coexistence of formal and informal credibility mechanisms in agri-food systems.

Several limitations should be acknowledged. The cross-sectional design prevents causal interpretation and does not allow us to establish the timing of environmental practice adoption, capability development, relational embeddedness, and certification. The study is also based on a single national context. The Hungarian wine sector has specific post-transition institutional features, including strong relational networks and relatively limited historical reliance on formal certification. The observed association between relational quality and certification may therefore differ in countries such as France, Italy, or Austria, where certification is more established and may coexist more closely with relational governance. In addition, certification is measured as a binary outcome, which does not capture variation in certification intensity, compliance costs, duration of certification, or engagement with alternative sustainability schemes.

Future research could address these limitations in several ways. Longitudinal data would make it possible to examine whether environmental practices and capabilities precede certification or whether certification itself stimulates organizational learning and further practice adoption. Comparative studies across countries and certification regimes could clarify when relational governance complements certification and when it functions as an alternative credibility mechanism. Further work could also link certification decisions to economic outcomes such as price premiums, export access, contract stability, consumer recognition, or resilience to market and environmental shocks.

Overall, the paper shows that organic certification is best understood as one element within a broader sustainability governance landscape. Certification reflects not only environmental practice engagement, but also the organizational capacity to work with external knowledge and the governance context through which credibility is established. Recognizing this broader institutional setting can help researchers and policymakers better understand why certification uptake remains uneven, even among producers already engaged in sustainability-oriented practices.

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Declaration of competing interest

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A Survey items and variable construction

Unless otherwise indicated, managerial, capability, and relational-governance items were measured on five-point Likert-type scales. The process-innovation items used in the green-practice factor analysis were measured on three-category ordinal scales coded as 1 = not implemented, 2 = implemented in cooperation with a partner, and 3 = implemented independently by the winery. Green-practice variables are reported in Table 3 as standardized regression-based factor scores obtained from the principal-component factor model described in Section 3.3. Organizational-capability constructs and relational quality are likewise reported in their standardized analytical form, whereas structural variables are shown in their original units. Thus, the group means of the standardized variables indicate the relative positions of certified and non-certified wineries within the sample rather than levels expressed in the original measurement units. (Table A1)

Table A1
Managerial orientation items.

Construct	Item code	Survey item	Use in analysis	Construction
Environmental orientation	manager1 / MEO-env	Environmental protection and employee welfare are prioritized relative to profitability.	Environmental orientation	Single standardized item
Risk tolerance	manager2 / MEO-risk	I am willing to take risks in financial and business decisions.	Not included in main model	Single standardized item
Managerial self-confidence	manager3 / MEO-trust	My colleagues trust my abilities.	Not included in main model	Single standardized item
Independence	manager4 / MEO-indep	I feel independent in my work and decisions.	Not included in main model	Single standardized item
Work ethic	manager5 / MEO-dilig	Success requires hard work.	Not included in main model	Single standardized item
Innovative orientation	manager6 / MEO-innov	I have many original ideas.	Innovative problem-solving orientation	Averaged with manager7
Creative problem solving	manager7 / MEO-creat	I usually have several solutions to a problem.	Innovative problem-solving orientation	Averaged with manager6

Notes: Environmental orientation is retained as a single-item construct because it captures the core managerial trade-off relevant to the paper. Innovative problem-solving orientation is a two-item construct; because of its limited item base, it is interpreted cautiously and acknowledged as a measurement limitation.

(Table A2)

Table A2
Organizational capability items.

Construct	Item code	Survey item	Use in analysis	Construction
Adaptive capacity	adaptive1 / ADAC1	Employees question or improve existing procedures.	Adaptive capacity	Averaged with adaptive2 and adaptive3
Adaptive capacity	adaptive2 / ADAC2	The winery can adapt quickly to market changes.	Adaptive capacity	Averaged with adaptive1 and adaptive3
Adaptive capacity	adaptive3 / ADAC3	The winery can adapt to changes in the business environment.	Adaptive capacity	Averaged with adaptive1 and adaptive2
Absorptive capacity	absorb1 / ABSOC1	The winery can identify valuable external knowledge.	Absorptive capacity	Averaged with absorb2 and absorb3
Absorptive capacity	absorb2 / ABSOC2	The winery can integrate newly acquired external knowledge with existing knowledge.	Absorptive capacity	Averaged with absorb1 and absorb3
Absorptive capacity	absorb3 / ABSOC3	The winery can use integrated knowledge for developing products, technologies, and processes.	Absorptive capacity	Averaged with absorb1 and absorb2

Notes: Absorptive capacity captures knowledge identification, integration, and use. Adaptive capacity captures flexibility and adjustment to market and business-environment changes.

(Table A3)

Table A3
Network capability and relational governance items.

Construct	Item code	Survey item	Use in analysis	Construction
Coordination and partner knowledge	network1 / NETCAP1	We plan what we want to achieve with each partner.	Not included in main model	Used in supplementary coordination scale
Coordination and partner knowledge	network2 / NETCAP2	We develop relationships based on partners' contribution.	Not included in main model	Used in supplementary coordination scale

(*continued on next page*)

Table A3 (*continued*)

Construct	Item code	Survey item	Use in analysis	Construction
Relational quality	network3 / NETCAP3	We regularly consult with partners about how we can support each other.	Relational quality	Averaged with network4-network6
Relational quality	network4 / NETCAP4	We are able to build good personal relationships with business partners.	Relational quality	Averaged with network3, network5, network6
Relational quality	network5 / NETCAP5	We deal flexibly with partners.	Relational quality	Averaged with network3, network4, network6
Relational quality	network6 / NETCAP6	We solve problems constructively with partners.	Relational quality	Averaged with network3-network5
Coordination and partner knowledge	network7 / NETCAP7	We know our partners' markets.	Not included in main model	Used in supplementary coordination scale
Coordination and partner knowledge	network8 / NETCAP8	We know our partners' products and production methods.	Not included in main model	Used in supplementary coordination scale
Coordination and partner knowledge	network9 / NETCAP9	We know our partners' strengths and weaknesses.	Not included in main model	Used in supplementary coordination scale
Coordination and partner knowledge	network10 / NETCAP10	We hold regular project meetings.	Not included in main model	Used in supplementary coordination scale
Internal informal relations	network11 / NETCAP11	Employees maintain informal relationships.	Not included in main model	Descriptive / supplementary item
Internal feedback	network12 / NETCAP12	Managers and employees provide regular feedback to each other.	Not included in main model	Descriptive / supplementary item

Notes: The main relational-governance variable is restricted to network3-network6 because these items directly capture trust-based, flexible, and constructive exchange relationships with external business partners.

(Table A4)

Table A4
Knowledge-source items.

Construct	Item code	Survey item	Use in analysis	Construction
Market / supplier knowledge	knowledge1 / Inter1	Innovation with input and technology suppliers.	Supplementary knowledge scale	Supplementary standardized item / construct validation only
Market / industry knowledge	knowledge2 / Intra1	Innovation with other wineries and competitors.	Supplementary knowledge scale	Supplementary standardized item / construct validation only
Scientific knowledge	knowledge3 / Scien1	Innovation with universities and research institutes.	Supplementary knowledge scale	Supplementary standardized item / construct validation only
Market / consumer knowledge	knowledge4 / Intra2	Innovation with buyers and consumers.	Supplementary knowledge scale	Supplementary standardized item / construct validation only
Institutional knowledge	knowledge5 / Intra3	Innovation with sectoral and professional associations.	Supplementary knowledge scale	Supplementary standardized item / construct validation only
Advisory knowledge	knowledge6 / Inter2	Innovation with consultants and knowledge-intensive business services.	Supplementary knowledge scale	Supplementary standardized item / construct validation only
Scientific knowledge	knowledge7 / Scien2	Knowledge from scientific and professional journals.	Supplementary knowledge scale	Supplementary standardized item / construct validation only
Professional-event knowledge	knowledge8 / Scien3	Knowledge from exhibitions, fairs, conferences, and organized contacts.	Supplementary knowledge scale	Supplementary standardized item / construct validation only

Notes: Knowledge-source variables are not included in the main certification models because absorptive capacity captures the broader ability to identify, integrate, and apply external knowledge. These items are retained for supplementary diagnostics and construct validation.

(Table A5)

Table A5
Process innovation and green practice items.

Construct	Item code	Survey item	Use in analysis	Construction
Process innovation	process1 / PROCIN1	IT use in viticulture, monitoring, precision viticulture, or site-specific viticulture.	Not included in green-practice factor model	Descriptive / supplementary item
Green practice	process2 / PROCIN2	Introduction of integrated viticulture.	Green technological practices	Contributes to factor-based practice score
Green practice	process3 / PROCIN3	Reduction of agrochemical use.	Green field practices	Contributes to factor-based practice score
Process innovation	process4 / PROCIN4	Recycling, use of prunings/manure, or wastewater treatment.	Not included in green-practice factor model	Descriptive / supplementary item
Green practice	process5 / PROCIN5	Material-, energy-, and water-saving solutions.	Green field practices	Contributes to factor-based practice score
Green practice	process6 / PROCIN6	Reduction of greenhouse-gas emissions.	Green technological practices	Contributes to factor-based practice score
Green practice	process7 / PROCIN7	Use of renewable energy.	Green technological practices	Contributes to factor-based practice score

(*continued on next page*)

Table A5 (*continued*)

Construct	Item code	Survey item	Use in analysis	Construction
Green practice	process8 / PROCIN8	Green vineyard-level solutions.	Green field practices	Contributes to factor-based practice score
Green practice	process9 / PROCIN9	Green cellar-level solutions.	Green technological practices	Contributes to factor-based practice score

Notes: Green field and green technological practices are constructed from process2, process3, and process5-process9 using principal-component factor analysis with varimax rotation. Process1 and process4 are not included in the retained green-practice factor solution because the final model focuses on the environmentally oriented practice items that produced the two-factor structure used in the empirical analysis.

(Table A6)

Table A6
Control variables.

Variable	Description	Measurement	Use in analysis
Vineyard land	Vineyard area operated by the winery	Hectares	Standardized in regression models
Production volume	Annual production volume	Hectolitres	Standardized in regression models
Managerial age	Age of respondent / decision-maker	Years	Standardized in regression models
Education	Highest educational level of respondent	Ordinal scale	Standardized in regression models

Notes: Vineyard land and production volume are reported in original units in descriptive statistics, but standardized in regression models to improve interpretability and avoid coefficients appearing close to zero because of measurement units.

Appendix B Measurement diagnostics

B1. Factor analysis of green practice variables

Green practice variables were constructed using principal-component factor analysis with varimax rotation. The suitability of the process innovation items for factor analysis was supported by Bartlett's test of sphericity and the Kaiser–Meyer–Olkin measure of sampling adequacy (Tables B1 and B2).

Table B1
Factor-analysis diagnostics for green practice items.

Diagnostic	Value
Number of observations	234
Bartlett test of sphericity	$\chi^2(21) = 297.429$
Bartlett test *p*-value	< 0.001
KMO measure of sampling adequacy	0.728
Retained factors	2
Variance explained by Factor 1	31.8%
Variance explained by Factor 2	23.2%
Total variance explained	55.0%

Table B2
Rotated factor loadings for green practice variables.

Item	Description	Factor 1: Green field practices	Factor 2: Green technological practices	Uniqueness
process2	Introduction of integrated viticulture		0.468	0.623
process3	Reduction of agrochemical use	0.800		0.357
process5	Material-, energy-, and water-saving solutions	0.763		0.385
process6	Reduction of greenhouse-gas emissions		0.464	0.628
process7	Use of renewable energy		0.650	0.520
process8	Green vineyard-level solutions	0.792		0.369
process9	Green cellar-level solutions		0.853	0.266

Notes: Principal-component factor analysis with orthogonal varimax rotation. Loadings below 0.40 are suppressed. Regression-based factor scores were predicted from the rotated solution and standardized before inclusion in the regression models.

The first factor loads primarily on agrochemical reduction, resource-saving practices, and vineyard-level green solutions. It is therefore interpreted as green field practices. The second factor loads primarily on integrated viticulture, greenhouse-gas reduction, renewable energy use, and cellar-level green solutions. It is interpreted as green technological practices. Two items, process2 and process6, have moderate loadings slightly above 0.40; for this reason, the distinction between the two practice dimensions is treated as theoretically meaningful but not perfectly sharp.

B2. Reliability of multi-item constructs (Table B3)

Table B3
Reliability diagnostics.

Construct	Items	Number of items	Cronbach's alpha, raw	Cronbach's alpha, standardized
Innovative problem-solving orientation	manager6, manager7	2	0.736	0.737
Adaptive capacity	adaptive1, adaptive2, adaptive3	3	0.663	0.680
Absorptive capacity	absorb1, absorb2, absorb3	3	0.812	0.818
Relational quality	network3, network4, network5, network6	4	0.812	0.829
Coordination and partner knowledge	network1, network2, network7, network8, network9, network10	6	0.868	0.874
Science and institutional knowledge depth	knowledge3, knowledge5, knowledge7, knowledge8	4	0.636	0.637
Market-based knowledge depth	knowledge1, knowledge2, knowledge4, knowledge6	4	0.629	0.635

Notes: The main empirical models use innovative problem-solving orientation, adaptive capacity, absorptive capacity, and relational quality. Coordination and knowledge-depth scales are reported for transparency but are not part of the main specification.

Absorptive capacity and relational quality show good internal consistency. Innovative problem-solving orientation has acceptable reliability, but because it consists of only two items, it is interpreted as a parsimonious indicator and acknowledged as a measurement limitation. Adaptive capacity is slightly below the conventional 0.70 threshold, and therefore the results involving this construct should be interpreted cautiously.

B3. One-factor checks for capability and governance constructs (Table B4)

Table B4
One-factor diagnostic loadings for selected constructs.

Construct	Item	Factor loading
Adaptive capacity	adaptive1	0.451
Adaptive capacity	adaptive2	0.919
Adaptive capacity	adaptive3	0.928
Absorptive capacity	absorb1	0.861
Absorptive capacity	absorb2	0.899
Absorptive capacity	absorb3	0.808
Relational quality	network3	0.661
Relational quality	network4	0.853
Relational quality	network5	0.874
Relational quality	network6	0.857

Notes: The Stata output confirms strong one-factor structure for absorptive capacity. Adaptive capacity is more uneven because adaptive1 loads more weakly than adaptive2 and adaptive3. This supports retaining adaptive capacity as an exploratory construct but interpreting its null result cautiously.

B4. Multicollinearity diagnostics

Variance inflation factors were calculated using the same right-hand-side variables as the full logit model (Table B5).

Table B5
Variance inflation factors.

Variable	VIF	1/VIF
Absorptive capacity	1.69	0.592
Vineyard land, standardized	1.52	0.659
Adaptive capacity	1.50	0.666
Relational quality	1.47	0.681
Production volume, standardized	1.46	0.685
Innovative problem-solving orientation	1.40	0.712
Environmental orientation	1.16	0.863
Green field practices	1.07	0.933
Green technological practices	1.06	0.948
Managerial age, standardized	1.03	0.968
Education, standardized	1.03	0.973
Mean VIF	1.31	

Notes: All VIF values are well below conventional thresholds, indicating that multicollinearity does not drive the coefficient changes across nested model specifications.

Appendix C Additional model diagnostics and interaction checks

This appendix reports additional diagnostics supporting the interpretation of the nonlinear interaction models. Because interaction coefficients in

nonlinear models cannot be interpreted directly as moderation effects, the main text reports marginal effects and predicted probabilities. (Table C1)

Table C1
Marginal effect of green field practices at different levels of relational quality.

Relational quality	Marginal effect of green field practices	Standard error	*p*-value	95% confidence interval
Low relational quality (-1 SD)	0.109	0.038	0.004	[0.035, 0.183]
Mean relational quality	0.115	0.028	<0.001	[0.060, 0.170]
High relational quality (+1 SD)	0.106	0.035	0.003	[0.037, 0.175]

Notes: Marginal effects are calculated from the logit model including the interaction between green field practices and relational quality. The results indicate that green field practices are positively associated with certification at low, average, and high levels of relational quality. The similarity of the marginal effects indicates that relational quality does not materially moderate the association between green field practices and certification.

(Table C2)

Table C2
Marginal effect of green field practices at different levels of absorptive capacity.

Absorptive capacity	Marginal effect of green field practices	Standard error	*p*-value	95% confidence interval
Low absorptive capacity (-1 SD)	0.115	0.039	0.003	[0.038, 0.192]
Mean absorptive capacity	0.120	0.029	<0.001	[0.064, 0.176]
High absorptive capacity (+1 SD)	0.110	0.044	0.012	[0.024, 0.196]

Notes: The interaction between green field practices and absorptive capacity is not statistically significant in the logit model. The marginal effects indicate that the association between green field practices and certification remains positive across different levels of absorptive capacity. This supports the interpretation that absorptive capacity is directly associated with certification rather than primarily strengthening the effect of green practices.

C1. Interpretation of nonlinear interaction checks

The interaction diagnostics support two conclusions. First, relational quality does not significantly alter the marginal association between green field practices and certification. Instead, wineries with stronger relational quality show lower predicted certification probabilities across the observed range of green field practices. Second, absorptive capacity does not significantly moderate the relationship between green field practices and certification. Rather, absorptive capacity appears to have an independent positive association with certification.

These results reinforce the interpretation that environmental practices, absorptive capacity, and relational quality operate through distinct mechanisms. Green practices capture accumulated environmental engagement; absorptive capacity captures the organizational ability to identify, integrate, and apply external knowledge; and relational quality captures the governance context through which credibility may be established with business partners.

Appendix D Robustness to distributional assumptions

To assess whether the main results are sensitive to distributional assumptions, we estimated semi-nonparametric binary-choice models as robustness checks. The SNP estimator allows the latent error distribution to deviate from the standard logistic specification by approximating the distribution using higher-order polynomial terms. This provides a robustness check against distributional misspecification. (Table D1)

Table D1
Semi-nonparametric binary-choice robustness checks.

Variable	(1) Parsimonious model	(2) Full model
Environmental orientation	0.290	0.256*
	(0.271)	(0.149)
Green field practices	1.030***	1.285***
	(0.338)	(0.123)
Green technological practices	0.869***	0.936***
	(0.188)	(0.105)
Vineyard land, standardized	0.055	-0.147
	(0.123)	(0.112)
Production volume, standardized	0.220**	0.011
	(0.104)	(0.042)
Managerial age, standardized	-0.466**	-0.640***
	(0.200)	(0.126)
Education, standardized	0.335	0.219
	(0.231)	(0.144)
Innovative problem-solving orientation		-0.323**
		(0.165)
Absorptive capacity		0.806***
		(0.217)
Adaptive capacity		-0.255*
		(0.145)
Relational quality		-0.664***
		(0.143)
Observations	232	232
Log likelihood	-123.871	-112.311

(*continued on next page*)

Table D1 (*continued*)

Variable	(1) Parsimonious model	(2) Full model
AIC	267.742	252.622
BIC	302.209	300.876

Notes: Dependent variable: organic certification, coded one if the winery holds organic certification and zero otherwise. The table reports semi-nonparametric binary-choice estimates. Standard errors are reported in parentheses. All continuous explanatory variables are standardized. The semi-nonparametric distributional parameters are estimated but not reported to preserve readability. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Data availability

Data will be made available on request.

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