Sustainable Development

WILEY

Sustainable Development

RESEARCH ARTICLE OPEN ACCESS

Same Practices, Different Outcomes: Gender Gaps in Organic Certification

Imre Fertő[1,2,3] | Valéria Lekics[4]

[1]ELTE Centre for Economic and Regional Studies, Budapest, Hungary | [2]Corvinus University of Budapest, Budapest, Hungary | [3]Czech University of Life Sciences, Prague, Czech Republic | [4]Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

Correspondence: Imre Fertő (ferto.imre@krtk.elte.hu)

Received: 24 February 2026 | **Revised:** 29 June 2026 | **Accepted:** 7 July 2026

Keywords: eco-innovation | gender | Hungary | nonlinear decomposition | organic certification | relational governance | sustainability | wineries

ABSTRACT

This paper examines gender differences in organic certification among Hungarian wineries and asks whether they reflect observable differences in sustainability engagement, organizational capabilities, and structural characteristics, or differences in how similar profiles translate into certified status. Using a 2022 cross-sectional survey, we estimate binary-response models and apply nonlinear Blinder–Oaxaca decomposition to separate the female–male certification gap into characteristics and coefficient/residual components. Female-managed wineries are more likely to hold organic certification than male-managed wineries, despite broadly similar reported green-practice adoption, managerial orientation, absorptive capacity, relational governance, education, and firm age. Observable characteristics explain little of the gap. Instead, the difference is concentrated in the coefficient/residual component, indicating a reduced-form residual difference in certification probabilities among wineries with similar observed profiles, rather than identifying its mechanism. Robustness checks using alternative link functions, land transformations, principal-component indices, and linear decomposition support this descriptive pattern. The findings highlight the need to distinguish reported sustainability practices from formal certification, especially in high-value agri-food sectors where certification also functions as a market signal. The results should be interpreted cautiously: the cross-sectional design, small female-managed subsample, and self-reported practice measures preclude causal identification. The paper therefore identifies an unexplained certification-pattern difference and points to the need for longitudinal, process-level, and externally validated data on certification histories, advisory support, market channels, documentation practices, inspection experiences, and pathways through which sustainability practices become formally recognized.

1 | Introduction

Organic certification is increasingly used to promote environmentally responsible production and to signal sustainability attributes in agri-food markets. Yet adoption remains uneven across producers, and the role of gender in certification decisions is still poorly understood. Reviews of organic farming and sustainable innovation adoption identify gender as a potentially relevant characteristic, but they also emphasize that the direction and magnitude of gender effects vary substantially across contexts, technologies, and institutional settings (Sapbamrer and Thammachai 2021; Rizzo et al. 2024; Karipidis and Karypidou 2021). A recurrent finding is that women may place relatively greater weight on environmental and health-related motivations, whereas men may more often emphasize productivity, scale, and market returns. However, these patterns are not stable across empirical settings and often weaken once socioeconomic characteristics, farm structure, and local

institutional conditions are taken into account (Sapbamrer and Thammachai 2021; Rizzo et al. 2024; Fertő and Bojnec 2025; Eti 2025).

A central reason for this ambiguity is that much of the existing evidence concerns the adoption of organic-compatible or environmentally friendly practices rather than certified organic status. Practice adoption and certification are related but analytically distinct outcomes. Organic-compatible practices can be adopted incrementally and informally, whereas certification requires producers to translate such practices into a formalized system of documentation, inspection, and third-party verification. Certification therefore involves not only production choices but also administrative capacity, market positioning, organizational routines, and expectations about the benefits of formal recognition (Karipidis and Karypidou 2021; Sapbamrer and Thammachai 2021). These requirements may interact with resources, networks, advisory support, and labor availability, all of which can be gendered in agriculture (Ume et al. 2023; Ruzzante et al. 2021; Awoke et al. 2025). At the same time, the nature and direction of such interactions cannot be assumed to be uniform across sectors. In high-value agri-food sectors, gender differences in certification may reflect not only constraints but also selection into management roles, differences in market channels, or unobserved managerial strategies.

The Hungarian wine sector provides a useful setting for examining these issues because organic certification functions both as a production standard and as a market signal. Wineries may adopt environmentally friendly vineyard and cellar practices without pursuing certification, especially where quality, sustainability, or reputation are communicated through established buyer relationships, local reputation, tourism, or direct sales. Conversely, certification may be more valuable where wineries seek to communicate sustainability attributes to less familiar buyers, intermediaries, or export-oriented market segments. This means that certification should not be treated simply as a direct measure of environmental engagement. Rather, it is a formal recognition outcome that may depend on how sustainability-related practices, managerial capabilities, and market incentives combine within a particular sectoral context.

This distinction is especially important for gender analysis. General agricultural research often emphasizes women's disadvantages in land, capital, training, and organizational participation, and these factors may constrain access to complex certification schemes (Ruzzante et al. 2021; Ume et al. 2023; Tufa et al. 2022). However, female-managed wineries may not necessarily mirror the patterns observed among female-headed farms in broader agricultural settings. Women who occupy senior management positions in wineries may represent a selected group of decision-makers operating in relatively established or commercially oriented firms. Consequently, gender differences in certification in this sector may arise not only from observable resource gaps but also from differences in market orientation, certification strategies, advisory connections, family-firm organization, or other unobserved factors. This makes the wine sector a relevant context for asking whether similar observed sustainability profiles are associated with similar certification outcomes across gender groups.

This paper examines gender differences in organic certification among Hungarian wineries. The empirical question is whether female- and male-managed wineries differ in certified organic status because they differ in observable sustainability engagement, capabilities, and structural characteristics, or because similar observed profiles are associated with different certification outcomes. We use a 2022 cross-sectional survey of 234 Hungarian wineries, including 41 female-managed and 193 male-managed wineries. The analysis estimates binary choice models and applies nonlinear Blinder–Oaxaca decomposition to separate the raw gender difference in certification into a component associated with observable characteristics and a residual component associated with differences in estimated coefficients (Blinder 1973; Oaxaca 1973; Bauer and Sinning 2008).

The decomposition framework is useful because it distinguishes between two empirically different possibilities. If certification gaps are mainly explained by observable characteristics, then differences in resources, capabilities, or practice adoption would account for most of the observed gap. If, instead, the coefficient component dominates, then wineries with similar observed characteristics are associated with different predicted certification outcomes across gender groups. Importantly, the latter pattern should not be interpreted as direct evidence of discrimination, structural barriers, or unequal treatment. In a cross-sectional decomposition, the coefficient component is a reduced-form residual. It may reflect omitted variables, measurement error, sample selection, unobserved preferences, differences in market positioning, or certification-process factors that are not directly observed in the data.

The results show that female-managed wineries have a higher probability of holding organic certification than male-managed wineries. Observable differences in managerial orientation, green-practice adoption, relational governance, absorptive capacity, land, education, and firm age explain little of this gap. Instead, the difference is concentrated in the coefficient/residual component, indicating that the observed covariates do not account for the certification gap. This should be interpreted as a reduced-form residual pattern, not as evidence that the underlying certification process differs structurally by gender. This finding should be read as descriptive and exploratory rather than causal. It identifies a pattern in the certification–practice relationship that requires further explanation, rather than establishing the mechanism that produces it.

The paper contributes to research on gender and sustainability transitions in two ways. Substantively, it shows that gender differences in formal certification cannot be inferred directly from differences in reported sustainability practices or managerial orientation. This matters because certification is often used as an indicator of sustainability engagement, even though producers with similar reported practice profiles may differ in whether they formalize those practices through certification. Methodologically, the paper applies nonlinear decomposition to a certification outcome, thereby distinguishing compositional differences from differences in estimated associations. This distinction is relevant for future research because it points to the need for more detailed data on conversion histories, certification costs, advisory support, inspection experiences, market channels, and the intensity and quality of environmental practices. The contribution is

therefore deliberately descriptive. The analysis identifies whether the observed covariates available in the survey account for the certification gap, but it does not adjudicate among the unobserved mechanisms that may generate the coefficient/residual component.

The remainder of the paper proceeds as follows. Section 2 reviews prior evidence on organic adoption, certification, gendered constraints, and sector-specific mechanisms that may shape certification outcomes. Section 3 presents the data, variables, and empirical strategy. Section 4 reports the decomposition results and robustness checks. Section 5 discusses the findings, their limitations, and implications for future research and policy. Section 6 concludes.

2 | Literature Review

Research on organic certification adoption rarely centers on gender explicitly. Nevertheless, work on organic farming, quality certification, sustainable innovation adoption, and agri-environmental measures provides useful guidance for understanding why certification may differ across producer groups. This literature points to two broad insights. First, certification is related to, but not identical with, the adoption of environmentally friendly practices. Second, gender differences in certification may arise not only from differences in observed resources or sustainability orientation, but also from differences in market positioning, organizational routines, advisory connections, and unobserved managerial strategies.

This section reviews four strands of research. Section 2.1 discusses determinants of organic certification and emphasizes the distinction between practice adoption and formal recognition. Section 2.2 reviews gender differences in organic and sustainable practice adoption. Section 2.3 discusses potential mechanisms that may shape the translation of sustainability engagement into certification. Section 2.4 connects these mechanisms to the Hungarian wine sector and clarifies the research gap addressed by the present study.

2.1 | Organic Certification as a Formalization and Market-Signaling Process

Organic adoption and certification are typically explained by expected returns, risk, and capacity constraints. Systematic reviews of organic farming adoption and organic conversion decisions identify education, age or experience, farm size, off-farm income, and institutional conditions as important correlates of adoption decisions (Sapbamrer and Thammachai 2021; Karipidis and Karypidou 2021). Broader reviews and meta-analyses of sustainable agricultural technology adoption similarly highlight land size and tenure security, credit access, extension services, and organizational participation as recurring predictors across contexts and technologies (Rizzo et al. 2024; Ruzzante et al. 2021; Ume et al. 2023).

These findings suggest that certification is not only a production decision. It is also an organizational and administrative process. Producers must not only adopt practices compatible with organic standards but also document those practices, undergo inspection, maintain compliance routines, and evaluate whether the expected market benefits justify the costs of certification. Certification-focused studies reinforce this point. Evidence from Taiwan shows that age, education, experience, labor and facilities, and especially organizational participation are associated with the adoption of different agricultural certification types (Kuan et al. 2021). Research on agro-food quality certification in China likewise stresses the role of cooperatives and producer organizations in facilitating certification adoption and improving performance (Dong and Liang 2023). At the same time, perceived barriers and concerns over economic sustainability may discourage organic implementation even when environmental motivations are present (Eti 2025).

A key implication is that practice adoption and certification should be treated as analytically distinct outcomes. Organic-compatible practices may be adopted incrementally, informally, or selectively, while certification requires these practices to be translated into a formally recognized and externally verified status. This distinction is especially relevant in high-value agri-food sectors, where certification can serve as a market signal to buyers, retailers, tourists, or export markets. In such settings, producers may adopt environmentally friendly practices without certifying if they rely on local reputation, repeated buyer relationships, or direct sales. Conversely, certification may be more attractive where producers seek to communicate sustainability attributes to less familiar buyers or more standardized market channels.

The literature therefore suggests that certification reflects both sustainability engagement and the perceived value of formal recognition. This distinction motivates the present study's focus on whether female- and male-managed wineries differ in certification because of observable differences in practices, capabilities, and resources, or because similar observed profiles are associated with different certification outcomes.

2.2 | Gender and Organic or Sustainable Practice Adoption

The literature on gender and sustainable agricultural adoption is mixed. Reviews of organic farming and sustainable innovation adoption identify gender as a potentially relevant characteristic, but also show that its direction and magnitude vary across technologies, regions, and institutional settings (Sapbamrer and Thammachai 2021; Rizzo et al. 2024; Karipidis and Karypidou 2021). Many studies suggest that women place relatively greater weight on environmental, health, and household welfare motivations, whereas men may emphasize productivity, scale, and market returns (Sapbamrer and Thammachai 2021; Rizzo et al. 2024; Fertő and Bojnec 2025). However, these differences often weaken or disappear once socioeconomic characteristics, farm assets, and local institutional conditions are controlled for (Eti 2025; Kuan et al. 2021).

Much of this evidence concerns the adoption of practices rather than certified organic status. This matters because a producer may use organic-compatible techniques without entering or completing a formal certification process. In the limited number of studies explicitly testing gender differences in organic adoption,

women are often found to be more likely to adopt organic farming, but their organic plots may be smaller and more closely linked to household livelihood strategies or off-farm income (Sapbamrer and Thammachai 2021). Evidence from northern Ghana shows that female-headed households were more likely to adopt organic fertilizer, but that adoption increased women's labor burden substantially (Daadi and Latacz-Lohmann 2021). Similar findings appear in research on climate-smart agriculture: women's lower access to land, credit, training, and hired labor can reduce adoption, while additional labor demands often fall disproportionately on women (Awoke et al. 2025).

These studies reveal an important tension. Women may display strong environmental motivations and may adopt sustainable practices when they control production decisions, but formal certification can require resources and routines that differ from those required for practice adoption alone. Certification introduces documentation, inspection, and compliance tasks that may interact with labor availability, administrative capacity, and advisory support. Therefore, gender differences in certification cannot be inferred directly from gender differences in environmental attitudes or practice adoption.

Evidence from agri-environmental and climate schemes provides complementary insights. European studies suggest that women may be more inclined toward environmentally oriented measures, but apparent gender differences can diminish once scale and assets are accounted for (Fertő and Bojnec 2025). Evidence from Hungary similarly indicates that adoption intensity can be comparable across male- and female-headed farms after controlling for farm size and assets (Fertő and Bojnec 2025). This reinforces the view that observed gender differences in green engagement are often mediated by farm structure and resources rather than by stable preference differences alone.

2.3 | Mechanisms Linking Sustainability Engagement to Certification

Prior research points to several mechanisms through which sustainability engagement may or may not translate into certification. These mechanisms should be understood as possible channels rather than as mechanisms identified directly in the present study.

First, resources and organizational participation may shape the certification process. Reviews and meta-analyses consistently identify education, land size, tenure, credit access, extension, and farmer organization membership as important predictors of organic and sustainable technology adoption (Ruzzante et al. 2021; Rizzo et al. 2024; Ume et al. 2023; Karipidis and Karypidou 2021). Certification studies further show that producer organizations and cooperatives can reduce information costs, facilitate compliance, and improve market access for certified producers (Kuan et al. 2021; Dong and Liang 2023). Because women in agriculture often face disadvantages in land access, credit, training, and organizational participation, these channels may constrain their ability to enter complex certification schemes even when they are willing to adopt sustainable practices (Sapbamrer and Thammachai 2021; Ume et al. 2023; Awoke et al. 2025; Tufa et al. 2022).

However, this resource-constraint argument cannot be applied mechanically to all sectors. In high-value sectors such as wine, women who occupy senior management positions may represent a selected group. They may manage older, larger, family-owned, or more commercially oriented firms rather than reflecting the average resource position of women in agriculture. This possibility is important for the present study because female-managed wineries in the sample do not appear to have lower land endowments than male-managed wineries. Therefore, the literature on gendered resource constraints provides an important background, but the empirical analysis must also allow for sector-specific selection into winery management.

Second, labor and time demands may affect certification. Organic and climate-smart practices can increase labor requirements, and additional labor is often disproportionately supplied by women (Daadi and Latacz-Lohmann 2021; Awoke et al. 2025). Certification may add further time demands through recordkeeping, inspections, and compliance routines. Nevertheless, the available data do not directly measure household labor allocation, unpaid care responsibilities, or time spent on certification administration. For this reason, labor burden should be treated as a plausible explanation that future research should test, rather than as an established mechanism in the present study.

Third, networks and advisory channels may influence whether producers move from practice adoption to certification. Adoption decisions are shaped not only by individual resources but also by peer effects, perceived norms, local institutions, and access to trusted information (Tran-Nam and Tiet 2022; Xia et al. 2023). A mixed-method study of participatory guarantee system certification in Vietnam shows that local institutional arrangements and social influence can shape adoption, and that gendered roles in cultivation and marketing can condition who drives decisions (Tennhardt et al. 2025). In certification contexts, advisory contacts, certifier interactions, and producer organizations may affect how easily producers understand requirements, prepare documentation, and evaluate expected benefits.

Fourth, market channels and relational governance may condition the value of certification. Certification is a third-party signal. Its value may be greatest when producers sell to distant, less familiar, or more standardized markets where buyers cannot easily observe production practices. By contrast, in local or relationship-based markets, reputation, repeated transactions, and trust may partly substitute for formal certification. This logic is particularly relevant for wine, where producers may rely on direct sales, tourism, local reputation, restaurants, specialized retailers, or export channels. Therefore, the relationship between relational governance and certification may be ambiguous. Strong buyer relationships may support learning and coordination, but they may also reduce the perceived need for third-party verification if sustainability and quality are already communicated through repeated interaction.

These mechanisms indicate several possible channels through which certification status may differ across producer groups, although the present study cannot observe or identify these channels directly. Any residual certification difference may therefore reflect unobserved variation in resources, market orientation, organizational embeddedness, advisory support, family-firm

roles, buyer relationships, certification histories, or managerial strategies. Importantly, a decomposition analysis cannot distinguish among these channels unless they are measured directly. The coefficient component in a Blinder–Oaxaca decomposition should therefore be interpreted as a reduced-form residual that may capture omitted variables, measurement error, sample selection, or unobserved strategy differences, not as direct evidence of discrimination or institutional barriers.

2.4 | Hungarian Wine Sector and the Certification–Practice Relationship

The Hungarian wine sector offers a useful setting for studying these issues because organic certification combines production, regulatory, market-signaling, and territorial-reputation dimensions. Recent wine-sector research increasingly treats sustainability not only as a farm-level environmental practice but also as a value-chain and governance issue involving standards, measurement systems, consumer communication, and territorial coordination (Rugani and Lamastra 2022; Brito et al. 2024). Studies of winery sustainability certification similarly stress that certification can function as a collective reputational device and as a tool for knowledge diffusion and coordination among producers, not only as a private production decision (Ceccacci et al. 2024). In this setting, wineries may adopt environmentally friendly vineyard and cellar practices for agronomic, reputational, or personal reasons without necessarily pursuing certification. Certification may be attractive when wineries expect benefits from formal recognition, access to particular buyers, export opportunities, or differentiation in competitive markets. It may be less attractive when producers rely on local reputation, established buyer relationships, direct sales, tourism, or other informal signals of quality and sustainability.

Recent Central European evidence reinforces the market-signaling interpretation. A large survey in the DACH region shows that wine knowledge and environmental awareness are associated with a higher likelihood of purchasing organic or sustainably certified wines, while more knowledgeable consumers show greater willingness to pay for such wines (Stockl et al. 2024). For Hungarian wines, recent evidence on international competition awards also suggests that external recognition can shape price positioning, market access, and international visibility, especially for regions such as Tokaj, Eger, Villány, and Szekszrd (Szilágyi and Nagy 2024). Although awards and organic certification are different forms of recognition, both illustrate that formal signals can matter in wine markets where quality, origin, and credibility are difficult for buyers to evaluate directly. This supports the interpretation of certification as a formal recognition outcome rather than as a direct measure of environmental engagement alone.

The Hungarian context also highlights the importance of market channels and organizational capabilities. A recent study of sustainability innovation in the Hungarian wine sector, based on a survey of wineries across the country's historical wine regions, finds that wineries differ more in adaptive, absorptive, innovation, and cooperation capabilities than in simple demographic characteristics (Lekics 2023). Evidence from the Mór wine region likewise emphasizes the continuing importance of personal sales relationships, the limited effectiveness of online sales for many wineries, and weaknesses in cooperation among producers (Kismarjai et al. 2024). These findings are relevant because they suggest that the value of certification may vary according to wineries' capabilities, cooperation networks, and routes to market. Producers embedded in direct sales, tourism, or repeated customer relationships may be able to communicate sustainability informally, whereas producers targeting more distant or standardized markets may have stronger incentives to formalize sustainability claims through certification.

This sectoral context complicates standard assumptions about gendered resource constraints. The broader agricultural literature often emphasizes women's lower access to land, capital, credit, and organizations. These constraints are highly relevant in many agricultural settings, but they may not describe female-managed wineries in the same way. Female managers in the wine sector may represent a selected group of decision-makers with access to established land, family assets, professionalized firms, or market-oriented strategies. Consequently, a finding that female-managed wineries have similar or even higher average land endowments than male-managed wineries should not be treated as a contradiction to the broader literature. Instead, it suggests that gender dynamics in winery management may differ from gender dynamics in smallholder agriculture or general farm household settings. In such a context, gender differences in certification may reflect not only resource constraints but also selection into management roles, differences in market positioning, advisory access, family-firm organization, or unobserved certification strategies.

The sector also makes it important to distinguish between the breadth of environmental practices and certified organic status. Recent research on sustainability indicators in wine stresses that wine-sector sustainability programs often differ in their metrics and that many systems still lack an integrated quantitative framework for assessing and communicating sustainability performance (Rugani and Lamastra 2022). Product Environmental Footprint evidence from Italian wines further shows that environmental performance depends on multiple hotspots, including vineyard establishment, winery energy use, and packaging, rather than on the simple presence or absence of individual practices (Frasnetti et al. 2024). Therefore, a winery may report several environmentally friendly practices but remain uncertified because certification costs, documentation requirements, or expected market returns do not justify formalization. Conversely, certification may reflect not only environmental engagement but also strategic positioning in markets where formal recognition is valuable. The certification–practice relationship is therefore likely to depend on both internal capabilities and external market conditions.

This reasoning leads to the central research gap addressed in this paper. Existing studies show that gender may matter for sustainable practice adoption, but findings are context-dependent and often weaken after controlling for socioeconomic characteristics. Certification-specific studies identify resources, organizations, standards, and market incentives as important, while recent wine-sector research emphasizes territorial certification, consumer recognition, sustainability indicators, and market channels. However, this literature rarely

examines gender-disaggregated certification outcomes in wineries. Moreover, few studies ask whether similar observed sustainability profiles translate into certification in the same way across gender groups.

The present study addresses this gap by examining organic certification among Hungarian wineries. Rather than assuming that certification gaps reflect either resource deprivation or gendered barriers, the analysis separates observable compositional differences from differences in estimated associations between characteristics and certification. This approach is exploratory and descriptive. It allows us to assess whether female- and male-managed wineries differ mainly in their observed sustainability engagement, capabilities, and structural characteristics, or whether similar observed profiles are associated with different certification outcomes. The latter pattern would not identify a specific mechanism, but it would indicate that certification is shaped by factors not fully captured by observed practice breadth, managerial orientation, organizational capabilities, land, education, and firm age.

3 | Data and Methodology

3.1 | Data, Sample, and Variables

The empirical analysis draws on a cross-sectional survey of Hungarian wineries conducted between June 2022 and January 2023 as part of a broader research program on sustainability-oriented innovation in the wine sector. The survey targeted owner-managers and senior decision-makers, as these actors are directly involved in strategic decisions concerning production practices, environmental management, technological upgrading, market positioning, and certification. The sampling frame was assembled from official winery registries, regional producer associations, industry sources, and professional networks. The survey covered wineries operating across Hungary's historical wine regions and was designed to capture heterogeneity in winery size, production structure, ownership form, and market orientation.

The questionnaire was pre-tested with industry experts to ensure clarity and sectoral relevance. Participation was voluntary and responses were anonymized to reduce social desirability and self-reporting bias. The full descriptive sample consists of 234 wineries. After excluding observations with missing values in the baseline model, the complete-case estimation sample consists of 233 wineries, of which 41 are female-managed and 192 are male-managed. Female-managed wineries therefore account for approximately 17.6% of the baseline estimation sample. This small subsample is an important limitation of the empirical analysis and motivates the sensitivity checks described below.

The dependent variable is a binary indicator equal to one if the winery held organic certification at the time of the survey and zero otherwise. Organic certification is defined as compliance with the EU organic regulatory framework. The survey does not distinguish between specific certifying bodies, but certified wineries operate under the same general regulatory regime. The dependent variable therefore captures certified organic status rather than the intensity, quality, duration, or environmental effectiveness of organic-compatible practices.

The main explanatory variable of interest is manager gender, coded as one for female-managed wineries and zero for male-managed wineries. The purpose of the analysis is not to estimate a causal effect of manager gender. Rather, the aim is to examine whether differences in organic certification are associated with differences in observable characteristics or with differences in the estimated relationship between those characteristics and certification.

The explanatory variables are organized around four dimensions emphasized in the literature: managerial orientation, eco-innovation practices, organizational capabilities and governance, and structural characteristics. The wording of the underlying survey items is reported in Table A1.

Managerial orientation captures three aspects of strategic decision-making that may be relevant for certification: environmental priority, perceived managerial agency, and creativity. The index is constructed from three five-point Likert-scale survey items. The first item states that "environmental protection and the well-being of workers are more important goals than profitability." The second item states that "how my life goes depends on me." The third item states that "I see myself as someone who is always original and comes up with new ideas." These items correspond to the variables manager1, manager2, and manager3 in the survey. Each item is standardized, and the index is calculated as the row mean of the standardized items. Because the reliability of this index is modest, it is interpreted as a parsimonious composite of related managerial attributes rather than as a strongly unidimensional latent construct.

Eco-innovation practices are measured using a count of nine binary indicators. Each indicator equals one if the winery reports adopting the relevant environmentally oriented practice and zero otherwise. The nine practices are: applying informatics in cultivation; introducing integrated cultivation; reducing agrochemical use; reusing stems and branches; applying energy- and water-saving measures; decreasing greenhouse gas emissions; utilizing renewable energy; introducing novel green solutions on plantations; and introducing novel green solutions in cellars. The resulting variable ranges from zero to nine and measures the breadth of reported environmental practice adoption. In robustness checks, we also use a normalized practice-share variable, defined as the practice count divided by nine. This measure captures the number of practices adopted, but it does not capture their intensity, duration, quality, compliance with organic standards, or environmental performance.

Absorptive capacity captures the winery's ability to recognize, assimilate, and apply external knowledge. It is measured using three five-point Likert-scale items: the winery is able to recognize and understand new external knowledge; the winery is able to combine newly acquired knowledge with existing knowledge successfully; and the winery is able to use the newly combined knowledge for new products and to improve the production process. These items correspond to absorb1, absorb2, and absorb3. The baseline analysis uses the existing absorptive-capacity variable in the dataset, ABSORB. As a consistency check, we

reconstructed the index as the row mean of the three standardized items. The reconstructed index is almost perfectly correlated with the original variable. Reliability and dimensionality checks support the use of this construct.

Relational governance captures the quality of cooperative and trust-based relationships that may shape learning, coordination, and the perceived value of third-party certification. It is constructed from three five-point Likert-scale items. The first states that the winery is able to build good personal relationships with its business partners. The second states that the winery almost always solves problems constructively with its partners. The third states that managers and employees often give feedback to each other. These items correspond to network1, network2, and network3. Each item is standardized, and the index is calculated as the row mean of the standardized items. The construct therefore captures both external relational quality with business partners and internal feedback routines that support coordination.

Structural controls include land area under cultivation, manager education, and firm age. Land area, measured in hectares, proxies for scale and the ability to absorb fixed certification costs, although its distribution is highly skewed. For this reason, robustness checks replace land area with log-transformed land and winsorized land. Education is an ordinal measure of the manager's formal educational attainment, with higher values denoting higher education. Firm age measures the number of years since establishment and captures accumulated organizational experience with production routines, compliance, and market participation. Manager age and production volume are excluded from the baseline specification to avoid redundancy and overfitting, as they are closely related to firm age and land area, respectively.

We treat land size as an empirical issue rather than as an assumed gender constraint. The broader agricultural literature often emphasizes women's weaker access to land, but this assumption may not apply directly to female-managed wineries. Female managers in the wine sector may represent a selected group of decision-makers operating in relatively established or commercially oriented firms. The descriptive analysis therefore reports both mean and median land area by gender, and the robustness analysis checks whether the results are sensitive to land transformation or extreme values.

3.2 | Empirical Strategy

The empirical objective is to examine whether the gender difference in organic certification reflects differences in observable characteristics or differences in the estimated association between these characteristics and certification. Because the dependent variable is binary, the baseline model is a logit specification of the following form:

$$P\left(\text{bio}_i = 1 | X_i, g_i\right) = F\left(X_i \beta_g\right)$$

where bio_i indicates whether winery i holds organic certification, X_i is the vector of explanatory variables, g_i denotes manager gender, and $F(\cdot)$ is the logistic cumulative distribution function. Probit specifications are estimated as robustness checks.

To decompose the certification gap between female- and male-managed wineries, we use nonlinear Blinder–Oaxaca decomposition for binary outcomes. The Blinder–Oaxaca decomposition was originally developed to analyze wage differentials between groups (Blinder 1973; Oaxaca 1973). Later contributions refined the interpretation of decomposition components and the choice of reference structure (Reimers 1983; Cotton 1988; Neumark 1988; Oaxaca and Ransom 1994), while Bauer and Sinning (2008) extended the framework to nonlinear models such as logit and probit.

The decomposition partitions the observed difference in mean certification probabilities into a component associated with differences in observable characteristics and a component associated with differences in estimated coefficients. In the threefold version, an additional interaction term captures the joint contribution of differences in characteristics and coefficients. We report results under alternative reference structures, including $\Omega = 1$, $\Omega = 0$, and pooled weighting schemes.

Throughout the paper, we refer to the coefficient component as a coefficient/residual component to avoid implying that it identifies structural barriers, discrimination, or differential treatment. This terminology is important. In a cross-sectional decomposition, the coefficient component captures differences in estimated associations between covariates and certification. It may reflect omitted variables, measurement error, unobserved preferences, market positioning, family-firm selection, advisory access, certification-process differences, or other unmeasured factors. It should therefore not be interpreted as evidence of discrimination, unequal treatment, institutional barriers, or any specific certification-process mechanism unless such mechanisms are directly measured.

Inference for the nonlinear decomposition is based on bootstrap standard errors with 2000 replications. Bootstrapping is used because decomposition components are nonlinear functions of estimated parameters. However, the small number of female-managed wineries means that inference should still be interpreted cautiously. Bootstrap inference can quantify sampling uncertainty, but it cannot fully eliminate concerns related to small-sample instability, sparse group-specific estimation, or omitted-variable bias.

3.3 | Sensitivity Checks

Several sensitivity checks are conducted to address the main methodological concerns.

First, we assess functional-form sensitivity by estimating logit, probit, and linear probability models. In addition to the nonlinear decomposition, we estimate a linear Oaxaca–Blinder decomposition as a transparent robustness check. Although the linear probability model is less appropriate for bounded binary outcomes, it provides a useful comparison because it is less dependent on nonlinear functional-form assumptions.

Second, we examine whether the results are sensitive to the construction of key covariates. For the three composite constructs—managerial orientation, absorptive

capacity, and relational governance—we report item counts, Cronbach's alpha, principal-component eigenvalues, and factor loadings. We also reestimate the decomposition using first-principal-component scores instead of row-mean indices. This check is particularly important because measurement error in the indices could contribute to the coefficient/residual component.

Third, we assess the role of land size. Because land is highly skewed and female-managed wineries do not appear land-disadvantaged in the sample, we report mean, median, interquartile range, and nonparametric comparisons by gender. We also reestimate the baseline models using log-transformed land and winsorized land.

Fourth, we address the small female subsample by estimating gender-specific regressions only as descriptive diagnostics. Standard group-specific logit models are complemented by penalized logit estimates where feasible, and leave-one-female-out diagnostics are used to assess whether the female-specific estimates are driven by individual observations. These checks are not intended to establish stable gender-specific mechanisms; rather, they indicate how sensitive the descriptive patterns are to sparse subgroup estimation.

Fifth, we examine covariate overlap between female- and male-managed wineries. A propensity-score overlap check is estimated using the baseline covariates to predict female management. This diagnostic assesses whether the decomposition compares wineries with broadly similar observed characteristics or whether the results are driven by lack of common support.

Finally, we examine the certification–practice relationship descriptively by comparing certification rates across green-practice tertiles by gender. This check helps assess whether the certification gap is concentrated only among wineries with low or high practice breadth. Because the practice count is self-reported and measures breadth rather than intensity or environmental performance, these results are interpreted as descriptive evidence on the relationship between reported practices and certification, not as evidence on actual environmental outcomes.

In sum, the empirical strategy is designed to distinguish observed compositional differences from residual differences in certification associations, while explicitly recognizing the limits of cross-sectional data, small subgroup size, and imperfect measurement. The analysis is therefore descriptive and exploratory. It identifies whether observable sustainability engagement, capabilities, governance, and structural characteristics account for the gender difference in organic certification, but it does not identify the causal mechanisms behind any remaining coefficient/residual component.

4 | Results

4.1 | Descriptive Patterns and Raw Gender Differences

Table 1 reports descriptive statistics for the main variables used in the baseline analysis, separately for male- and female-managed wineries. The complete-case estimation sample consists of 233 wineries: 192 male-managed and 41 female-managed wineries. One male-managed winery from the full survey sample is excluded from the baseline models because of missing covariate information.

Two patterns are central. First, female- and male-managed wineries are broadly similar across most sustainability-related and organizational characteristics. Mean differences in managerial orientation, the number of green practices adopted, relational governance quality, absorptive capacity, education, and firm age are small and statistically insignificant. The average number of green practices adopted is almost identical across groups: 5.28 among male-managed wineries and 5.15 among female-managed wineries. This suggests that female-managed wineries do not have higher certification rates simply because they report a greater breadth of environmental practice adoption.

Second, organic certification differs substantially by manager gender. Female-managed wineries have a certification rate of 46.3%, compared with 29.2% among male-managed wineries. The raw female–male difference is therefore 17.2 percentage points

TABLE 1 | Descriptive statistics by manager gender.

	Gender			
	Male	**Female**	**Total**	***t* test (*p*)**
N	192 (82.5%)	41 (17.5%)	234 (100.0%)	
Organic certificate	0.295 (0.457)	0.463 (0.505)	0.325 (0.469)	0.037
Managerial orientation (env priority, agency, creativity)	−0.011 (0.729)	0.053 (0.622)	0.000 (0.710)	0.602
Number of green practices adopted (0–9)	5.290 (2.462)	5.146 (2.308)	5.265 (2.432)	0.732
Relational governance quality (trust, problem solving, feedback)	−0.001 (0.779)	0.004 (0.910)	−0.000 (0.801)	0.972
Absorptive capacity (standardized)	0.035 (0.976)	−0.163 (1.104)	−0.000 (1.000)	0.253
Land (ha)	21.148 (41.350)	34.078 (65.235)	23.414 (46.516)	0.106
Education (1–4)	2.736 (1.035)	2.805 (1.209)	2.748 (1.065)	0.707
Firm age (years)	19.562 (10.441)	22.854 (9.342)	20.142 (10.314)	0.064

Note: Managerial orientation, relational governance, and absorptive capacity are standardized indices.

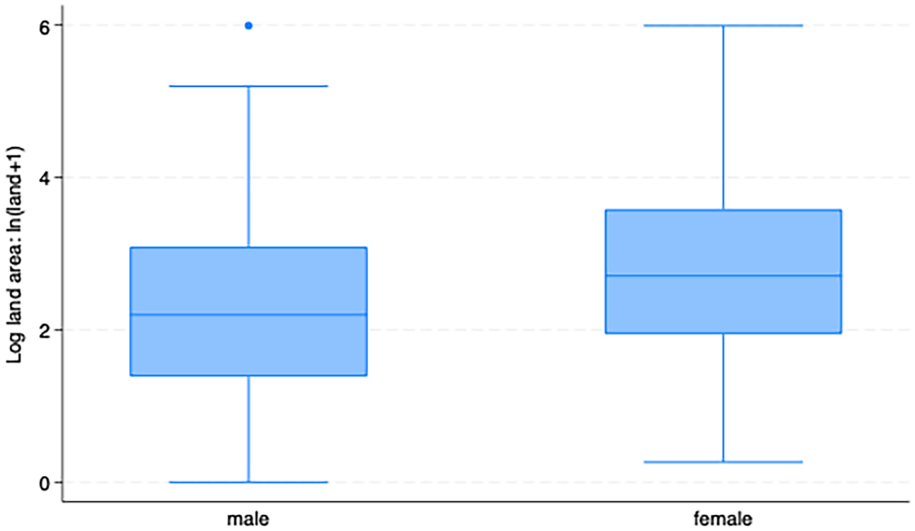

FIGURE 1 | Boxplot of log land area by manager gender.

and is statistically significant at conventional levels. This gap motivates the decomposition analysis below.

A further descriptive finding concerns land endowment. Contrary to the pattern often emphasized in the broader agricultural gender literature, female-managed wineries in this sample do not appear land-constrained. Their mean land area is higher than that of male-managed wineries, although the mean comparison is affected by the skewed distribution of land. The median difference is also notable: female-managed wineries have a median land area of 14 ha, compared with 8 ha among male-managed wineries. The Wilcoxon rank-sum test for land is statistically significant ($p = 0.037$), and the difference in log land area is also significant ($p = 0.038$). Figure 1 illustrates this distributional difference using log-transformed land.

This pattern is important for interpretation. It suggests that female managers in the Hungarian wine sector may represent a selected group of decision-makers operating in relatively established or commercially oriented wineries. The results should therefore not be interpreted through a conventional land-resource deprivation lens. Instead, the analysis asks whether observed sustainability engagement, capabilities, governance, and structural characteristics account for the certification difference.

Because the analysis relies on three composite indices, we examined whether the results are sensitive to the construction of these measures. Table A2 reports item counts, Cronbach's alpha, first-principal-component eigenvalues, explained variance, and first-component loadings for managerial orientation, absorptive capacity, and relational governance; the corresponding scree plots are shown in Figure A1. The diagnostics support the use of absorptive capacity and relational governance as internally consistent constructs. Absorptive capacity has strong internal consistency, with Cronbach's alpha of 0.818, and its first principal component explains 73.5% of the variance. Relational governance also shows acceptable internal consistency, with Cronbach's alpha of 0.721, and its first principal component explains 64.5% of the variance.

Managerial orientation is weaker psychometrically. Its Cronbach's alpha is 0.509, and the first principal component explains 50.5% of the variance. This suggests that the three items capture related but not fully interchangeable aspects of managerial orientation: environmental priority, managerial agency, and creativity. For this reason, the index should be interpreted as a parsimonious composite of related managerial attributes rather than as a strongly unidimensional latent scale.

To assess whether measurement construction affects the decomposition results, we reestimated the nonlinear decomposition using first-principal-component scores instead of row-mean indices for the three composite constructs. The results are substantively unchanged. The raw certification gap remains 0.172, the explained component remains close to zero and statistically insignificant, and the coefficient/residual component remains positive and statistically significant. This indicates that the main decomposition result is not driven by the use of row-mean indices rather than principal-component scores. The PC1-based decomposition results are reported in Table A3.

4.2 | Adjusted Gender Differences in Certification

Before turning to the decomposition, Table 2 reports pooled binary-response models of organic certification. These models are descriptive and should not be interpreted causally. They assess whether the female certification advantage remains after controlling for managerial orientation, green-practice breadth, relational governance, absorptive capacity, land, education, and firm age.

The adjusted gender difference remains stable across model specifications. In the baseline logit model, the average marginal effect of female management is 0.182 ($p = 0.013$). The corresponding probit estimate is 0.180 ($p = 0.013$), and the linear probability model estimate is 0.185 ($p = 0.016$). Thus, after adjustment for the observed covariates, female-managed wineries are approximately 18 percentage points more likely to hold organic certification.

TABLE 2 | Adjusted gender differences in organic certification.

Specification	Predicted Pr(certified), male	Predicted Pr(certified), female	Female–male difference	*p*
Logit AME	0.290	0.471	0.182	0.013
Probit AME	0.290	0.470	0.180	0.013
Linear probability model	0.289	0.474	0.185	0.016

Note: All models control for managerial orientation, green-practice count, relational governance, absorptive capacity, land, education, and firm age. Robust standard errors are used in the pooled models.

TABLE 3 | Nonlinear Blinder–Oaxaca decomposition of organic certification.

Component	Coefficient	Std. error	*p*
Raw gap	0.172	0.087	0.049
Explained/characteristics, $\Omega = 1$	−0.002	0.042	0.963
Coefficient/residual, $\Omega = 1$	0.207	0.093	0.027
Interaction, $\Omega = 1$	−0.033	0.072	0.649

Note: Gender = 1 denotes female-managed wineries and gender = 0 male-managed wineries. The raw gap is computed as female minus male. Bootstrap standard errors are based on 2000 replications.

The covariate patterns are also consistent across models. Managerial orientation, green-practice breadth, and absorptive capacity are positively associated with certification, while relational governance is negatively associated with certification. Land, education, and firm age are not statistically significant in the pooled models. The negative association of relational governance is consistent with the possibility that trust-based relationships may partly substitute for third-party certification in some market settings, although this interpretation remains descriptive and cannot be tested directly with the present data.

4.3 | Nonlinear Blinder–Oaxaca Decomposition

Table 3 reports the nonlinear Blinder–Oaxaca decomposition of the female–male certification gap using a logit model. The decomposition separates the raw difference in certification probabilities into a component associated with observable characteristics and a coefficient/residual component associated with differences in estimated coefficients.

The raw certification gap is 0.172 and statistically significant ($p = 0.049$). The explained component is close to zero and statistically insignificant. Under the $\Omega = 1$ reference structure, the characteristics component is −0.002 ($p = 0.963$). Under the alternative $\Omega = 0$ reference structure, it is −0.035 ($p = 0.658$). Thus, observable differences in managerial orientation, green-practice breadth, relational governance, absorptive capacity, land, education, and firm age account for little of the observed certification gap.

By contrast, the coefficient/residual component is positive and statistically significant. Under $\Omega = 1$, it is 0.207 ($p = 0.027$); under $\Omega = 0$, it is 0.174 ($p = 0.037$). The interaction component in the threefold decomposition is small and statistically insignificant. These results indicate that the observed certification difference is not driven primarily by compositional differences in the included covariates.

This decomposition result should be read as a descriptive partition of the observed certification gap. The coefficient/residual component does not show why the remaining difference arises and should not be interpreted as direct evidence of discrimination, institutional barriers, unequal treatment, or any specific certification-process mechanism. Rather, it captures differences in estimated associations that may reflect omitted covariates, measurement error, unobserved certification histories, advisory contacts, buyer channels, inspection experiences, family-firm selection, market positioning, or other unmeasured factors. The decomposition therefore narrows the empirical question: the observed sustainability engagement, capabilities, governance, and structural characteristics included in the model do not account for the certification gap, but the analysis does not identify the causal mechanism behind the remaining difference.

4.4 | Group-Specific Regressions and Small-Sample Diagnostics

Table 4 reports gender-specific logit estimates. These models are included only as descriptive diagnostics because the female subsample is small. The standard logit estimates show similar signs across gender groups. Managerial orientation and green-practice breadth are positively associated with certification, while relational governance is negatively associated with certification. Absorptive capacity is positive in both groups, though imprecisely estimated in the female subsample.

The female-specific point estimates are generally larger in magnitude than the male-specific estimates, but they are also much less precisely estimated. For example, the female-specific coefficient for green-practice count is 0.485 in the standard logit model, compared with 0.358 among male-managed wineries. However, the female estimate is based on only 41 observations.

Penalized/Firth logit estimates attenuate the female-specific coefficients. In the female subsample, the Firth estimates are 0.930 for managerial orientation, 0.366 for green-practice count, −0.854 for relational governance, and 0.849 for absorptive capacity. Among these, green-practice count is only marginally significant ($p = 0.079$), while the other estimates are not statistically significant. This reinforces the need to avoid strong claims about gender-specific mechanisms.

Leave-one-female-out diagnostics provide additional reassurance but also confirm small-sample sensitivity. All 41 leave-one-out female models converged. The green-practice coefficient is relatively stable across these models, ranging from approximately 0.40 to 0.63. Managerial orientation remains positive, relational

TABLE 4 | Group-specific certification models.

Variable	Male logit	Female logit	Male Firth logit	Female Firth logit
Managerial orientation	0.760**	1.258*	0.718**	0.930
Green-practice count	0.358***	0.485**	0.338***	0.366*
Relational governance	−0.750***	−1.153*	−0.709**	−0.854
Absorptive capacity	0.415*	1.144	0.391*	0.849
Land	0.002	−0.009	0.002	−0.006
Education	0.115	0.040	0.106	0.056
Firm age	0.004	−0.004	0.003	−0.002
Observations	192	41	192	41

Note: Entries are coefficients. Significance levels: ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$. Group-specific models are descriptive and should not be interpreted as stable estimates of gender-specific mechanisms.

TABLE 5 | Robustness checks for decomposition results.

Specification	Raw gap	Explained/characteristics	Coefficient/residual	Interaction
Baseline logit	0.172**	−0.002	0.207**	−0.033
Probit	0.173**	−0.004	0.208**	−0.031
Log land	0.172**	−0.001	0.194**	−0.022
Winsorized land	0.172*	−0.001	0.199**	−0.026
Practice share	0.172**	−0.002	0.207**	−0.033
PC1 indices	0.172**	−0.003	0.206**	−0.031
LPM Oaxaca-style	0.172**	−0.007	0.179**	—

Note: Entries are decomposition components. Bootstrap standard errors are based on 2000 replications. For nonlinear decompositions, the table reports the $\Omega = 1$ reference structure. The LPM decomposition uses a pooled-coefficient reference. Significance levels: **$p < 0.05$, *$p < 0.10$.

governance remains negative, and absorptive capacity remains positive in the leave-one-out estimates, but the magnitudes vary across omitted observations. These diagnostics support the broad descriptive pattern but also confirm that the female-specific regressions should be interpreted cautiously.

4.5 | Robustness Checks

Table 5 summarizes robustness checks for the decomposition results. The baseline conclusion is stable across alternative link functions, land transformations, measurement choices, and decomposition approaches.

The probit decomposition yields almost identical results to the logit decomposition. The raw gap is 0.173 ($p = 0.036$), the explained component remains close to zero and insignificant, and the coefficient/residual component remains positive and significant. Replacing land with log-transformed land produces a coefficient/residual component of 0.194 ($p = 0.041$), while using winsorized land gives 0.199 ($p = 0.033$). The result is also unchanged when the green-practice count is replaced by the normalized practice-share variable.

Measurement robustness checks using first-principal-component scores instead of row-mean indices also support the baseline conclusion. The coefficient/residual component remains positive and statistically significant, while the explained component remains insignificant. Finally, a linear probability Oaxaca-style decomposition gives the same substantive result: the total gap is 0.172 ($p = 0.044$), the explained component is −0.007 ($p = 0.852$), and the unexplained/residual component is 0.179 ($p = 0.013$).

A common-support diagnostic further indicates that the decomposition is not driven by a lack of covariate overlap. A logit model predicting female management from the baseline covariates has low explanatory power (pseudo $R^2 = 0.034$; Wald $p = 0.384$). Only six observations fall outside the common support region of the predicted probability of female management: five male-managed wineries and one female-managed winery. Figure A2 shows the overlap in predicted female-management probabilities by gender.

4.6 | Certification and Green-Practice Breadth

The final descriptive check examines whether the certification gap is concentrated at particular levels of green-practice breadth, as reported in Table 6. Certification rates increase with the number of green practices adopted for both gender groups. However, within each green-practice tertile, female-managed wineries have higher certification rates than male-managed wineries.

This pattern is consistent with the main result that observed practice breadth does not fully account for certification differences. However, it should be interpreted descriptively because the female cell counts are small.

Figure 2 plots predicted certification probabilities by green-practice count and gender. Certification probability increases with green-practice breadth for both groups. Female-managed wineries have higher predicted certification probabilities across the practice-count range, although confidence intervals are wide, especially at low practice counts. Importantly, the gender-by-practice-count interaction is not statistically significant ($p = 0.983$). Thus, the evidence does not indicate that the marginal association between practice breadth and certification differs by gender. Rather, the pattern is closer to a level difference: female-managed wineries have higher predicted certification probabilities at similar levels of reported practice breadth.

Overall, the results are consistent with the "same practices, different outcomes" framing in a descriptive sense. Female- and male-managed wineries report similar levels of sustainability-oriented practices and capabilities in the observed survey measures, while female-managed wineries are more likely to hold organic certification. The decomposition and robustness checks show that this difference is not accounted for by the observed covariates included in the analysis. At the same time, the residual nature of the coefficient component, the small female subsample, and the self-reported nature of the practice measure mean that the findings should be interpreted as evidence of an unexplained certification-pattern difference rather than as evidence of a specific institutional or causal mechanism.

TABLE 6 | Certification rates by green-practice breadth tertile and gender.

Green-practice tertile	Male-managed	Female-managed
Low	0.137	0.333
Medium	0.281	0.385
High	0.484	0.692

5 | Discussion and Policy Implications

This study examined whether the observed gender difference in organic certification among Hungarian wineries is accounted for by observable sustainability engagement, organizational capabilities, and structural characteristics. The results show a clear descriptive pattern. Female-managed wineries are more likely to hold organic certification than male-managed wineries, while the two groups are broadly similar in the survey-based measures of green-practice breadth, managerial orientation, absorptive capacity, relational governance, education, and firm age. The nonlinear decomposition shows that the observed covariates explain little of the certification gap. The remaining difference is concentrated in the coefficient/residual component, which should be interpreted as a reduced-form residual difference rather than as evidence of a specific institutional, structural, or causal mechanism.

This finding contributes to the literature by reinforcing the distinction between sustainable practice adoption and formal certification. Prior research shows that organic and sustainable technology adoption are shaped by resources, institutional conditions, market incentives, and organizational participation (Sapbamrer and Thammachai 2021; Karipidis and Karypidou 2021; Rizzo et al. 2024; Ruzzante et al. 2021; Ume et al. 2023). Certification, however, is not simply the final stage of practice adoption. It also requires documentation, inspection, compliance routines, and an expectation that formal recognition will generate sufficient market or reputational benefits. Studies of agricultural certification similarly emphasize the importance of farmer organizations, cooperatives, advisory support, and market access in facilitating certification (Kuan et al. 2021; Dong and Liang 2023). Our results are consistent with this broader view: observed practice breadth and managerial capabilities are associated with certification, but they do not fully account for certified status.

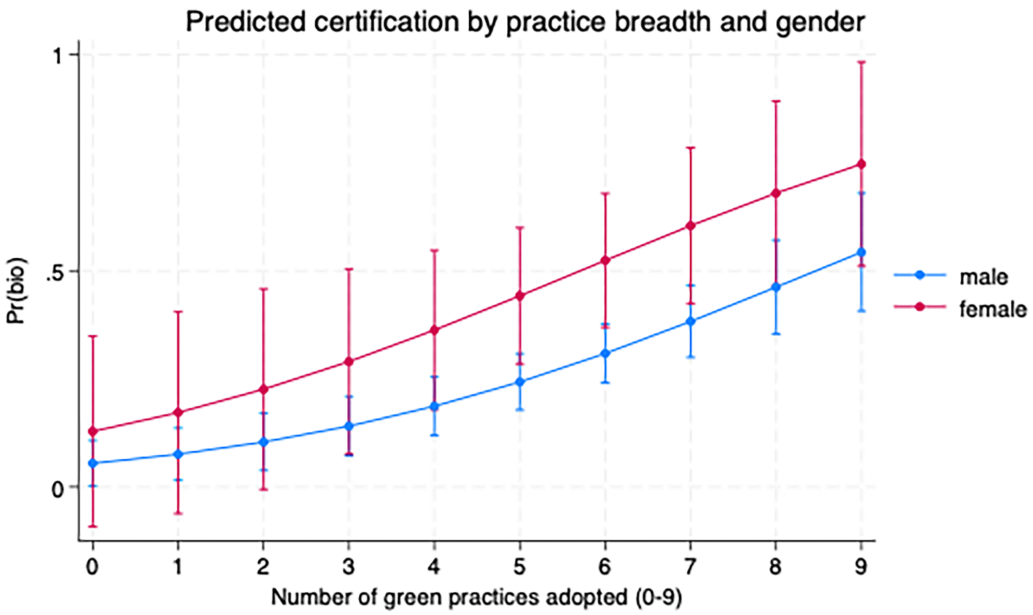

FIGURE 2 | Predicted certification by practice breadth and gender.

At the same time, the coefficient/residual component should be interpreted cautiously. Following the decomposition literature, this component captures differences in estimated associations rather than identified causal mechanisms (Oaxaca and Ransom 1994; Bauer and Sinning 2008). It may reflect omitted variables, measurement error, unobserved managerial strategies, family-firm selection, market positioning, advisory relationships, certification histories, or other unmeasured factors. The decomposition therefore documents an unexplained certification-pattern difference rather than providing direct evidence of discrimination, unequal treatment, institutional barriers, or any specific certification-process mechanism. This distinction is important because the cross-sectional design cannot determine whether the observed certification gap reflects different incentives, market channels, organizational histories, advisory access, certification timing, or unobserved preferences and strategies.

The land results are especially important for interpretation. Much of the broader agricultural gender literature emphasizes women's weaker access to land, credit, training, and productive resources as constraints on technology adoption and certification (Ruzzante et al. 2021; Ume et al. 2023; Tufa et al. 2022; Awoke et al. 2025). However, this pattern does not characterize the wineries in our sample. Female-managed wineries have higher median land area than male-managed wineries, and nonparametric as well as log-land comparisons indicate a statistically significant distributional difference. This suggests that female managers in the Hungarian wine sector may represent a selected group of decision-makers operating in relatively established or commercially oriented wineries. Consequently, the results should not be read through a conventional resource-deprivation lens. Rather than showing that women certify more despite weaker land endowments, the evidence suggests that gender dynamics in this sector may be shaped by selection into winery management and by sector-specific market or organizational conditions.

The robustness checks reinforce the descriptive pattern but also the need for caution. The adjusted female certification advantage remains similar across logit, probit, and linear probability specifications. The decomposition results are also stable when land is log-transformed or winsorized, when green-practice count is replaced by a normalized practice-share measure, and when principal-component scores are used instead of row-mean indices. A linear Oaxaca-style decomposition leads to the same substantive conclusion: the explained component remains small and statistically insignificant, while the coefficient/residual component accounts for most of the gap. These checks reduce the concern that the main result is an artifact of the nonlinear decomposition, land outliers, or the construction of the composite indices.

Nevertheless, the small number of female-managed wineries remains an important limitation. Gender-specific logit estimates show broadly similar signs across groups: managerial orientation, green-practice breadth, and absorptive capacity are positively associated with certification, while relational governance is negatively associated with certification. However, the female-specific estimates are imprecise and sensitive to small-sample estimation. Penalized logit estimates attenuate several female-specific coefficients, and leave-one-female-out diagnostics show that some estimates vary across omitted observations. For this reason, the group-specific regressions should be interpreted as descriptive diagnostics rather than as evidence of stable gender-specific mechanisms.

The practice-breadth results help clarify what the paper can and cannot say about certification as a sustainability indicator. Certification rates increase with the number of green practices adopted for both female- and male-managed wineries. Within each practice-breadth tertile, however, female-managed wineries display higher certification rates. Predicted certification probabilities show a similar pattern: female-managed wineries have higher predicted certification probabilities across the practice-count range. Yet the gender-by-practice interaction is not statistically significant, indicating that the marginal association between practice breadth and certification does not clearly differ by gender. The pattern is better understood as a level difference in certification probability among wineries with similar observed practice breadth.

This supports the paper's central argument in a limited but important sense. Organic certification should not be treated as a simple proxy for the number of sustainability-oriented practices reported by producers. Wineries with similar observed practice breadth may differ in certified status. However, this does not mean that certified and non-certified wineries are equally sustainable in environmental terms. The practice-count measure captures the breadth of self-reported practices, not their intensity, duration, quality, compliance, or environmental performance. This qualification is important because studies of organic adoption and certification emphasize that the costs, procedures, and perceived benefits of certification can lead producers to adopt organic-compatible practices without formal certification (Łuczka and Kalinowski 2020; Ningrum and Subroto 2023). Our results therefore show a divergence between reported practice breadth and formal certification, but they do not directly measure a divergence between actual environmental performance and certification.

Several possible explanations are consistent with the findings and should be treated as hypotheses for future research. First, certification may be linked to market positioning. Wineries selling into export markets, specialized retail channels, or buyer segments where third-party verification is valuable may have stronger incentives to certify than wineries relying on local reputation, direct sales, tourism, or repeated buyer relationships. This interpretation is consistent with the broader certification literature, which emphasizes that certification can function as a market signal and may be more valuable when buyers cannot directly observe production practices or quality attributes (Kuan et al. 2021; Dong and Liang 2023; Meemken and Qaim 2018).

Second, female-managed wineries may be selected into management within particular types of family firms or commercially oriented wineries. This would be consistent with the land results and with the broader finding that gender effects in sustainable technology adoption often depend on local institutional and socioeconomic conditions rather than reflecting fixed preference differences (Sapbamrer and Thammachai 2021; Rizzo et al. 2024; Fertő and Bojnec 2025). In this interpretation, female management in the Hungarian wine sector may capture a specific managerial and

organizational position rather than a general gender disadvantage or advantage.

Third, advisory support, producer networks, and prior experience with regulatory or quality schemes may affect whether reported environmental practices are formalized through certification. Research on adoption highlights the role of information, peer influence, perceived norms, and local institutional arrangements (Tran-Nam and Tiet 2022; Xia et al. 2023; Tennhardt et al. 2025). Studies of gender and technology adoption similarly show that access to extension, networks, and organizational channels can condition whether producers adopt new practices or standards (Lambrecht et al. 2016; BenYishay et al. 2020; Mishra et al. 2020; Rola-Rubzen et al. 2020; Voss et al. 2021). The present data do not observe these processes in sufficient detail, but the residual nature of the certification gap suggests that future work should examine them directly.

Fourth, time and labor constraints may shape the transition from practice adoption to certification. Prior research shows that organic and climate-smart practices can increase labor requirements and that additional labor burdens may fall disproportionately on women (Daadi and Latacz-Lohmann 2021; Awoke et al. 2025). Certification may add further administrative work through recordkeeping, inspections, and compliance routines. However, because the present survey does not measure household labor allocation, time use, care responsibilities, or certification-related administrative costs, labor-burden explanations remain plausible hypotheses rather than findings established by this study.

The negative association between relational governance and certification also deserves a cautious interpretation. One possible explanation is substitution: where wineries rely on trust-based, long-term relationships, third-party certification may add less value because quality and sustainability attributes are communicated through repeated interaction. Another possibility is market segmentation: certification may be more valuable in less relational, more standardized, or more distant market channels. Prior studies of technology adoption and certification suggest that social relations, peer influence, and local institutional arrangements can shape adoption decisions (Tran-Nam and Tiet 2022; Tennhardt et al. 2025), but the current data do not directly observe buyer composition, export orientation, or the contractual environment in sufficient detail to separate these mechanisms. The relational governance result should therefore be interpreted as suggestive of market-channel heterogeneity rather than as evidence that informal relationships reduce the need for certification in all cases.

The policy implications are therefore best framed around certification translation rather than gender-specific treatment. The results do not show that certification institutions treat female- and male-managed wineries differently. Nor do they show that certification barriers are gendered in a direct sense. They suggest, more modestly, that observed sustainability-oriented practices and capabilities are not sufficient to explain certification status. Policy and sectoral support should therefore focus not only on encouraging practice adoption, but also on the process through which practices are documented, verified, maintained, and connected to market opportunities. This interpretation is consistent with prior research showing that certification and sustainable technology adoption are shaped by organizational participation, extension services, institutional support, and market access (Kuan et al. 2021; Dong and Liang 2023; Ruzzante et al. 2021; Ume et al. 2023).

First, advisory support systems could introduce certification-readiness audits for wineries that already report multiple organic-compatible or sustainability-oriented practices but remain uncertified. Such audits could identify whether the main obstacles concern documentation, input records, vineyard-management routines, inspection preparedness, certification costs, or uncertainty about market benefits. This would allow advisory services to distinguish between producers who have not adopted relevant practices and producers who may already be close to certification but face procedural or informational frictions.

Second, certification-process support could reduce avoidable administrative burdens without weakening certification standards. Certifiers, producer organizations, and regional wine associations could develop standardized documentation templates, digital recordkeeping tools, group-based training sessions, and checklists for inspection preparation. These tools would be especially relevant for smaller wineries or wineries without dedicated administrative staff, for whom the fixed time costs of certification may be high relative to expected benefits.

Third, institutional design should connect certification support to market-channel strategies. Certification may be more valuable for wineries selling through export markets, specialized retailers, intermediaries, or buyer segments where third-party verification is important. By contrast, wineries relying mainly on direct sales, tourism, local reputation, or repeated buyer relationships may perceive lower marginal benefits from formal certification. This is particularly relevant in wine markets, where sustainability attributes may be communicated through both formal certification and reputation-based relationships, and where formal recognition can support market signaling and differentiation (Rugani and Lamastra 2022; Brito et al. 2024; Ceccacci et al. 2024; Stockl et al. 2024).

Fourth, monitoring systems should distinguish among practice adoption, conversion status, certified status, certification maintenance, and environmental outcomes. Counting certified producers or certified hectares is useful, but it misses producers who adopt several sustainability-oriented practices without formal recognition. More informative monitoring would combine survey data with certification records, inspection histories, advisory contacts, certification costs, buyer-channel information, and externally validated indicators of environmental performance. Such data would allow future studies to distinguish among the possible mechanisms suggested by this paper but not directly identified by it.

Overall, the findings suggest that expanding organic certification requires attention to more than environmental motivation or practice adoption. Certification is a formal recognition outcome shaped by administrative processes, organizational capabilities, market incentives, and unobserved managerial strategies. In the Hungarian wine sector, female-managed wineries are more likely to be certified, but the observed covariates included

in the analysis do not account for this difference. The result is robust descriptively, but its interpretation remains bounded: the study identifies an unexplained certification-pattern difference and points to mechanisms that future research should test with longitudinal, process-level, and market-channel data.

6 | Conclusion

This paper examined whether gender differences in organic certification among Hungarian wineries reflect differences in observed sustainability engagement, capabilities, and structural characteristics, or whether similar observed profiles are associated with different certification outcomes. Using a 2022 survey of Hungarian wineries and nonlinear Blinder–Oaxaca decomposition for binary outcomes, the analysis separated the female–male certification gap into a component associated with observable characteristics and a coefficient/residual component.

The results show that female-managed wineries are more likely to hold organic certification than male-managed wineries. This difference is not explained by observed differences in managerial orientation, green-practice breadth, absorptive capacity, relational governance, land, education, or firm age. Across the baseline and robustness specifications, the explained component remains small and statistically insignificant, while the coefficient/residual component accounts for most of the observed gap. Linear probability, probit, log-land, winsorized-land, practice-share, and principal-component specifications lead to the same substantive conclusion.

The analysis also qualifies how this result should be interpreted. Female-managed wineries in this sample do not appear to be land-disadvantaged; instead, they have higher median land area than male-managed wineries. This suggests that female management in the Hungarian wine sector may reflect a selected managerial group rather than the conventional resource constraints often emphasized in the broader agricultural gender literature. In addition, certification rates rise with green-practice breadth for both gender groups, but female-managed wineries display higher certification rates at comparable levels of reported practice breadth. This pattern supports the descriptive "same practices, different outcomes" framing, while also showing that the practice-count measure should not be treated as a direct indicator of environmental performance.

The contribution of the paper is therefore empirical and conceptual, but deliberately bounded. Empirically, it documents a robust gender difference in certified organic status that is not accounted for by the observed covariates available in the survey. Conceptually, it highlights the importance of distinguishing reported sustainability-oriented practices from formal certification. Certification is a regulated status that may reflect documentation, market positioning, advisory support, organizational history, and other unobserved factors in addition to practice adoption.

Several limitations define the boundary conditions of the study. First, the data are cross-sectional and do not identify causal mechanisms. The analysis cannot determine whether the observed certification gap reflects entry into certification, timing of conversion, persistence in certified status, advisory support, market-channel differences, or unobserved managerial strategies. In line with the decomposition literature, the coefficient/residual component should therefore not be interpreted as evidence of discrimination, institutional barriers, unequal treatment, or any specific certification-process mechanism unless such mechanisms are directly measured (Oaxaca and Ransom 1994; Bauer and Sinning 2008). It is a reduced-form residual component that may reflect omitted variables, measurement error, sample selection, differences in unobserved preferences, or unmeasured certification histories.

Second, external validity is limited by the single-sector and single-country setting. The Hungarian wine sector is a high-value agri-food context in which organic certification interacts with local reputation, tourism, direct sales, regional identity, and market signaling. This sectoral specificity matters because prior studies show that organic and sustainable adoption processes are strongly shaped by institutional context, farm structure, market incentives, extension services, and organizational participation (Sapbamrer and Thammachai 2021; Karipidis and Karypidou 2021; Rizzo et al. 2024; Ruzzante et al. 2021; Ume et al. 2023). The findings may therefore generalize most plausibly to agri-food sectors where certification serves as a formal market signal and where producers can also communicate sustainability through informal or relational channels. They may generalize less directly to standardized commodity sectors, contexts with stronger cooperative certification infrastructures, or countries with substantially different organic certification systems.

Third, the measurement of sustainability engagement remains imperfect. The green-practice count captures the breadth of self-reported practices, but not their intensity, duration, quality, compliance with organic standards, or environmental performance. This limitation is particularly important because wine-sector sustainability research emphasizes that environmental performance depends on multiple production, processing, packaging, and governance dimensions, and cannot be inferred from simple practice counts alone (Rugani and Lamastra 2022; Brito et al. 2024; Frasnetti et al. 2024). The composite measures, especially managerial orientation, are also imperfect proxies for broader managerial characteristics. Future research should therefore complement survey-based indicators with objective or externally validated measures, such as certification records, inspection histories, input-use data, vineyard-management logs, audited environmental indicators, or environmental performance metrics.

Fourth, omitted variables remain a central concern. The survey does not observe certification histories, prior conversion attempts, advisory contacts, inspection experiences, certification costs, buyer composition, export orientation, family-firm roles, or expectations about price premia in sufficient detail. These omitted factors are theoretically important because previous studies emphasize the role of organizations, advisory channels, local institutions, peer effects, and market access in shaping certification and sustainable technology adoption (Kuan et al. 2021; Dong and Liang 2023; Tran-Nam and Tiet 2022; Xia et al. 2023;

Tennhardt et al. 2025). Longitudinal data, process-based case studies, and mixed-method interviews with managers, certifiers, advisors, and producer organizations would help distinguish among these possible channels.

Fifth, statistical power is constrained by the relatively small number of female-managed wineries. Although the main descriptive pattern is robust across several specifications, the female subsample limits the precision of group-specific estimates and increases the risk that nonlinear decomposition components are sensitive to sparse data. This limitation is especially relevant because gender differences in sustainable agricultural adoption often vary across technologies, institutional contexts, and resource environments rather than reflecting stable or universal gender effects (Sapbamrer and Thammachai 2021; Rizzo et al. 2024; Awoke et al. 2025). The findings should therefore be interpreted as exploratory evidence of an unexplained certification-pattern difference rather than as precise estimates of gender-specific mechanisms.

Future research should move beyond cross-sectional certification status by collecting longitudinal and process-level data on conversion histories, application decisions, inspection experiences, certification costs, advisory contacts, buyer channels, recertification decisions, and exits from certification. Longitudinal data would help distinguish whether gender differences arise from entry into certification, timing of conversion, persistence in certified status, or market-specific incentives. More detailed and externally validated environmental and management data would also help clarify how formal certification relates to the actual intensity, quality, compliance status, and environmental effects of sustainability practices.

Overall, the findings show that gender differences in organic certification cannot be inferred simply from observed differences in practice adoption or resource endowments. In the Hungarian wine sector, female-managed wineries are more likely to be certified, but the observed covariates available in the survey do not account for this gap. The paper therefore identifies an unexplained certification-pattern difference and provides a basis for future research on how sustainability practices become documented, verified, maintained, and formalized through certification in sector-specific institutional and market contexts.

Author Contributions

Imre Fertő: conceptualization, investigation, funding acquisition, methodology, validation, visualization, writing – review and editing, software, formal analysis, writing – original draft, supervision. **Valéria Lekics:** conceptualization, data curation.

Acknowledgments

This work was supported by NKFIH — Nemzeti Kutatási Fejlesztési és Innovációs Hivatal = National Research Development and Innovation Office (grant number: NKFI-1 142441). Open access publishing facilitated by Ceska zemedelska univerzita v Praze, as part of the Wiley - CzechELib agreement. [Correction added on 21 July 2026, after first online publication: CzechELib funding statement has been added.]

Funding

This work was supported by Nemzeti Kutatási és Technológiai Hivatal (NKFI-1 142441).

References

Awoke, M. D., K. Löhr, A. Kimaro, et al. 2025. "Exploring Gender Dynamics in Climate-Smart Agriculture Adoption: A Study in Semi-Arid Dodoma, Tanzania." *Frontiers in Sustainable Food Systems* 8: 1507540. https://doi.org/10.3389/fsufs.2024.1507540.

Bauer, T. K., and M. Sinning. 2008. "An Extension of the Blinder–Oaxaca Decomposition to Nonlinear Models." *AStA Advances in Statistical Analysis* 92, no. 2: 197–206. https://doi.org/10.1007/s10182-008-0056-3.

BenYishay, A., M. Jones, F. Kondylis, and A. M. Mobarak. 2020. "Gender Gaps in Technology Diffusion." *Journal of Development Economics* 143: 102380. https://doi.org/10.1016/j.jdeveco.2019.102380.

Blinder, A. S. 1973. "Wage Discrimination: Reduced Form and Structural Estimates." *Journal of Human Resources* 8, no. 4: 436–455. https://doi.org/10.2307/144855.

Brito, C., S. Pereira, S. Martins, A. Monteiro, J. Moutinho-Pereira, and L.-T. Dinis. 2024. "Strategies for Achieving the Sustainable Development Goals Across the Wine Chain: A Review." *Frontiers in Sustainable Food Systems* 8: 1437872. https://doi.org/10.3389/fsufs.2024.1437872.

Ceccacci, A., L. Camanzi, C. Rota, R. Fiorentini, and G. Malorgio. 2024. "Enhancing Wineries' Sustainability Through Territorial Certifications: A Case Study in Emilia-Romagna, Italy." *International Journal of Wine Business Research* 37: 87–112. https://doi.org/10.1108/IJWBR-03-2024-0009.

Cotton, J. 1988. "On the Decomposition of Wage Differentials." *Review of Economics and Statistics* 70, no. 2: 236–243. https://doi.org/10.2307/1928307.

Daadi, B. E., and U. Latacz-Lohmann. 2021. "Organic Fertilizer Adoption, Household Food Access, and Gender-Based Farm Labor Use: Empirical Insights From Northern Ghana." *Journal of Agricultural and Applied Economics* 53, no. 3: 435–458. https://doi.org/10.1017/aae.2021.8.

Dong, H., and Q. Liang. 2023. "Agro-Food Quality Certification, Agricultural Organizations, and Farm Performance: Evidence From Vegetable Farmers in China." *International Journal of Agricultural Sustainability* 21, no. 1. https://doi.org/10.1080/14735903.2023.2205772.

Eti, H. S. 2025. "The Effects of Perceptions of Economic Sustainability and Barriers on Organic Farming Implementation." *Sustainability* 17, no. 2: 786. https://doi.org/10.3390/su17020786.

Fertő, I., and Š. Bojnec. 2025. "Gender Equality and Green Entrepreneurship in Farms." *Sustainable Development* 33, no. 3: 3985–4008. https://doi.org/10.1002/sd.3337.

Frasnetti, E., P. Ravaglia, D. D'Ammaro, E. Capri, and L. Lamastra. 2024. "Can Italian Wines Outperform European Benchmarks in Environmental Impact? An Examination Through the Product Environmental Footprint Method." *Science of the Total Environment* 919: 170630. https://doi.org/10.1016/j.scitotenv.2024.170630.

Karipidis, P., and S. Karypidou. 2021. "Factors That Impact Farmers' Organic Conversion Decisions." *Sustainability* 13, no. 9: 4715. https://doi.org/10.3390/su13094715.

Kismarjai, B., S. Illés, Á. Mendel, P. Simonyi, and B. Zsótér. 2024. "Development of the Wine-Growing Enterprises in the Mór Wine Region, Hungary." *European Countryside* 16: 134–150. https://doi.org/10.2478/euco-2024-0008.

Kuan, M.-Y., S.-Y. Wang, and J.-H. Wang. 2021. "Investigating the Association Between Farmers' Organizational Participation and Types of Agricultural Product Certifications: Empirical Evidence From a National Farm Households Survey in Taiwan." *Sustainability* 13, no. 16: 9429. https://doi.org/10.3390/su13169429.

Lambrecht, I., B. Vanlauwe, and M. Maertens. 2016. "Agricultural Extension in Eastern Democratic Republic of Congo: Does Gender Matter?" *European Review of Agricultural Economics* 43, no. 5: 841–874. https://doi.org/10.1093/erae/jbv039.

Lekics, V. 2023. "Fenntarthatósági innováció a szőlő-Bor ágazatban [Sustainability Innovation in the Hungarian Wine Sector]." *Köz-gazdaság* 18, no. 3: 71–96. https://doi.org/10.14267/RETP2023.03.05.

Łuczka, W., and S. Kalinowski. 2020. "Barriers to the Development of Organic Farming: A Polish Case Study." *Agriculture* 10, no. 11: 536. https://doi.org/10.3390/agriculture10110536.

Meemken, E. M., and M. Qaim. 2018. "Can Private Food Standards Promote Gender Equality in the Small Farm Sector?" *Journal of Rural Studies* 58: 39–51. https://doi.org/10.1016/j.jrurstud.2017.12.030.

Mishra, K., A. G. Sam, G. M. Diiro, and M. J. Miranda. 2020. "Gender and the Dynamics of Technology Adoption: Empirical Evidence From a Household-Level Panel Data." *Agricultural Economics* 51, no. 6: 857–870. https://doi.org/10.1111/agec.12596.

Neumark, D. 1988. "Employers' Discriminatory Behavior and the Estimation of Wage Discrimination." *Journal of Human Resources* 23, no. 3: 279–295. https://doi.org/10.2307/145830.

Ningrum, V., and A. Subroto. 2023. "Breaking Barriers: Engaging Women Farmers in Implementing Participatory Guarantee Systems for Sustainable Crop Production." *IOP Conference Series: Earth and Environmental Science* 1287, no. 1: 012010. https://doi.org/10.1088/1755-1315/1287/1/012010.

Oaxaca, R. 1973. "Male–Female Wage Differentials in Urban Labor Markets." *International Economic Review* 14, no. 3: 693–709. https://doi.org/10.2307/2525981.

Oaxaca, R. L., and M. R. Ransom. 1994. "On Discrimination and the Decomposition of Wage Differentials." *Journal of Econometrics* 61, no. 1: 5–21. https://doi.org/10.1016/0304-4076(94)90074-4.

Reimers, C. W. 1983. "Labor Market Discrimination Against Hispanic and Black Men." *Review of Economics and Statistics* 65, no. 4: 570–579. https://doi.org/10.2307/1935925.

Rizzo, G., G. Migliore, G. Schifani, and R. Vecchio. 2024. "Key Factors Influencing Farmers' Adoption of Sustainable Innovations: A Systematic Literature Review and Research Agenda." *Organic Agriculture* 14: 57–84. https://doi.org/10.1007/s13165-023-00440-7.

Rola-Rubzen, M. F., T. Paris, J. Hawkins, and B. Sapkota. 2020. "Improving Gender Participation in Agricultural Technology Adoption in Asia: From Rhetoric to Practical Action." *Applied Economic Perspectives and Policy* 42, no. 1: 113–125. https://doi.org/10.1002/aepp.13011.

Rugani, B., and L. Lamastra. 2022. "A Common Framework for Sustainability Indicators in the Wine Sector: Dream or Reality?" *Current Opinion in Environmental Science & Health* 31: 100408. https://doi.org/10.1016/j.coesh.2022.100408.

Ruzzante, S., R. Labarta, and A. Bilton. 2021. "Adoption of Agricultural Technology in the Developing World: A Meta-Analysis of the Empirical Literature." *World Development* 146: 105599. https://doi.org/10.1016/j.worlddev.2021.105599.

Sapbamrer, R., and A. Thammachai. 2021. "A Systematic Review of Factors Influencing Farmers' Adoption of Organic Farming." *Sustainability* 13, no. 7: 3842. https://doi.org/10.3390/su13073842.

Stockl, A. F., D. Moscovici, S. Tischler, M. W. Eitle, and C. Dolezal. 2024. "Consumer Knowledge and Preferences for Organic and Sustainably Certified Wines: Lessons From the DACH Region—Germany, Austria, and Switzerland." *Sustainability* 16, no. 11: 4464. https://doi.org/10.3390/su16114464.

Szilágyi, L., and A. S. Nagy. 2024. "Verseny és előny – A Decanter World Wine Awards Magyar vonatkozású eredményei és Azok összefüggése a Borok árával [Competition and Advantage: Hungarian Results of the Decanter World Wine Awards and Their Relationship With Wine Prices]." *Táplálkozásmarketing* 11, no. 1: 53–60. https://doi.org/10.20494/TM/11/1/4.

Tennhardt, L. M., R. Home, N. T. B. Yen, P. Van Hoi, P. Ferrand, and C. Grovermann. 2025. "Mixed Method Evaluation of Factors Influencing the Adoption of Organic Participatory Guarantee System Certification Among Vietnamese Vegetable Farmers." *Agriculture and Human Values* 42: 885–904. https://doi.org/10.1007/s10460-024-10643-7.

Tran-Nam, Q., and T. Tiet. 2022. "The Role of Peer Influence and Norms in Organic Farming Adoption: Accounting for Farmers' Heterogeneity." *Journal of Environmental Management* 320: 115909. https://doi.org/10.1016/j.jenvman.2022.115909.

Tufa, A. H., A. D. Alene, S. M. Cole, et al. 2022. "Gender Differences in Technology Adoption and Agricultural Productivity: Evidence From Malawi." *World Development* 159: 106027. https://doi.org/10.1016/j.worlddev.2022.106027.

Ume, C. O., O. G. Onah, B. C. Okpukpara, et al. 2023. "Factors Influencing Smallholder Adoption of Organic Agriculture in Southeast Geopolitical Region of Nigeria." *Frontiers in Sustainable Food Systems* 7: 1173043. https://doi.org/10.3389/fsufs.2023.1173043.

Voss, R., T. Jansen, B. Mané, and C. Shennan. 2021. "Encouraging Technology Adoption Using ICTs and Farm Trials in Senegal: Lessons for Gender Equity and Scaled Impact." *World Development* 146: 105620. https://doi.org/10.1016/j.worlddev.2021.105620.

Xia, M., P. Xiang, G. Mei, and Z. Liu. 2023. "Drivers for the Adoption of Organic Farming: Evidence From an Analysis of Chinese Farmers." *Agriculture* 13, no. 12: 2268. https://doi.org/10.3390/agriculture13122268.

Appendix A

TABLE A1 | Description of survey items and constructed variables.

Construct/variable	Survey code	Item wording/definition	Scale	Construction in this paper
Organic certification	bio	Winery holds organic certification	Binary: 1 = certified, 0 = not certified	Dependent variable
Manager gender	gender	Manager is female	Binary: 1 = female-managed, 0 = male-managed	Main grouping variable
Managerial orientation	manager1	Environmental protection and the well-being of workers are more important goals than profitability	Five-point Likert item	Standardized and averaged
Managerial orientation	manager2	How my life goes depends on me	Five-point Likert item	Standardized and averaged
Managerial orientation	manager3	I see myself as someone who is always original and comes up with new ideas	Five-point Likert item	Standardized and averaged
Green-practice count	proc1	Applying informatics in cultivation	Binary: 1 = adopted, 0 = not adopted	Summed across proc1–proc9
Green-practice count	proc2	Introduction of integrated cultivation	Binary	Summed across proc1–proc9
Green-practice count	proc3	Less use of agrochemicals	Binary	Summed across proc1–proc9
Green-practice count	proc4	Reusing stems and branches	Binary	Summed across proc1–proc9
Green-practice count	proc5	Applying energy- and water-saving measures	Binary	Summed across proc1–proc9
Green-practice count	proc6	Decreasing greenhouse gas emissions	Binary	Summed across proc1–proc9
Green-practice count	proc7	Utilizing renewable energy	Binary	Summed across proc1–proc9
Green-practice count	proc8	Novel green solutions on plantations	Binary	Summed across proc1–proc9
Green-practice count	proc9	Novel green solutions in cellars	Binary	Summed across proc1–proc9
Absorptive capacity	absorb1	We are able to recognize and understand new external knowledge	Five-point Likert item	Standardized and averaged/existing ABSORB index
Absorptive capacity	absorb2	We are able to combine newly acquired knowledge with our existing knowledge successfully	Five-point Likert item	Standardized and averaged/existing ABSORB index
Absorptive capacity	absorb3	We are able to use the new combined knowledge for new products and to improve the production process	Five-point Likert item	Standardized and averaged/existing ABSORB index
Relational governance	network1	We are able to build good personal relationships with our business partners	Five-point Likert item	Standardized and averaged
Relational governance	network2	We almost always solve problems constructively with our partners	Five-point Likert item	Standardized and averaged
Relational governance	network3	Our managers and employees often give feedback to each other	Five-point Likert item	Standardized and averaged
Land	land	Area of land cultivated, in hectares	Continuous	Structural control
Education	education	Manager's formal education	Ordinal	Structural control
Firm age	fage	Years since establishment	Continuous	Structural control

Note: The item wording follows the survey instrument used in the earlier Hungarian winery eco-innovation study. Eco-innovation practices are binary adoption indicators, while managerial orientation, absorptive capacity, and relational-governance items are measured on five-point Likert-type scales. The composite indices are based on standardized items.

TABLE A2 | Reliability and principal-component diagnostics for composite indices.

Construct	Items	No. of items	Cronbach's alpha	PC1 eigenvalue	PC1 variance explained
Managerial orientation	z_manager1, z_manager2, z_manager3	3	0.509	1.515	50.5%
Absorptive capacity	z_absorb1, z_absorb2, z_absorb3	3	0.818	2.205	73.5%
Relational governance	z_network1, z_network2, z_network3	3	0.721	1.935	64.5%

Note: PC1 eigenvalues are calculated as the number of items multiplied by the proportion of variance explained by the first component. Loadings are first-principal-component loadings from PCA on the standardized items.

TABLE A3 | Decomposition robustness using PC1-based composite measures.

Specification	Raw gap	Explained/characteristics	Coefficient/residual	Interaction
Baseline row-mean indices	0.172**	−0.002	0.207**	−0.033
PC1-based indices	0.172**	−0.003	0.206**	−0.031

Note: Bootstrap standard errors are based on 2000 replications. The PC1 specification replaces the row-mean indices for managerial orientation, absorptive capacity, and relational governance with first-principal-component scores. Significance levels: $^{**}p < 0.05$.

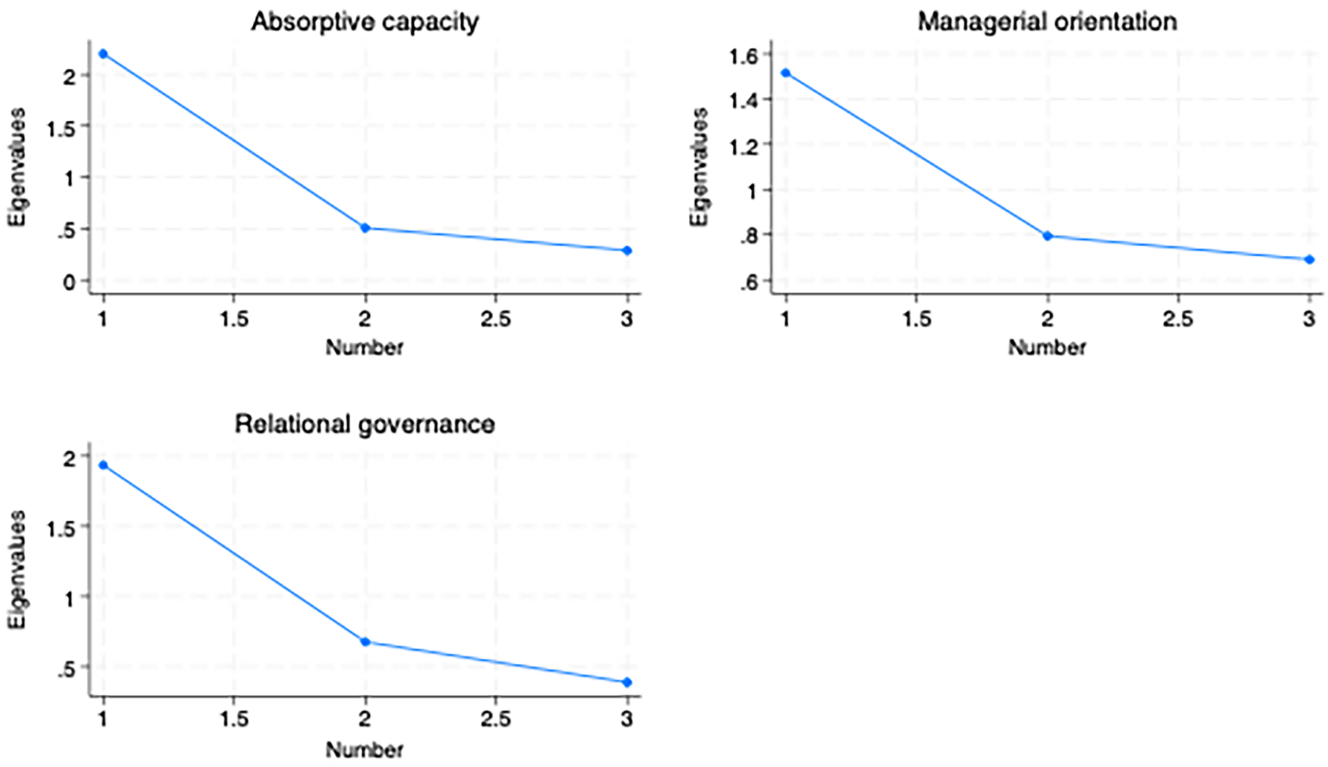

FIGURE A1 | Scree plots for composite indices.

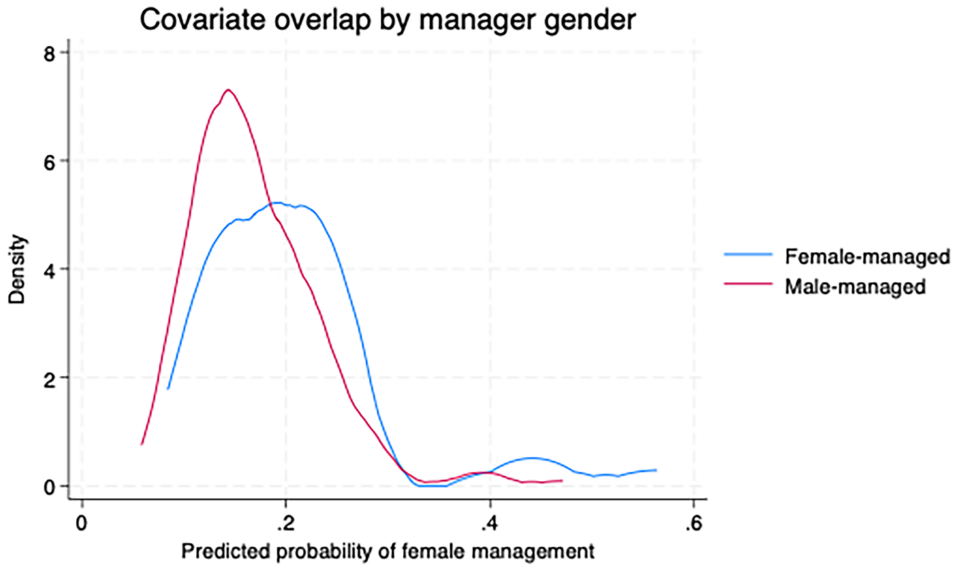

FIGURE A2 | Covariate overlap by manager gender.