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DIGITAL ESG GOVERNANCE AND NEXT-GENERATION DIGITAL COMPETENCY AS DRIVERS OF SUCCESSION IN FAMILY AGRICULTURAL ENTERPRISES: A CONCEPTUAL FRAMEWORK

Abstract: Family agricultural enterprises in China and Kazakhstan are passing through two transitions at once: the digital and sustainability transformation of agriculture and the transfer of leadership to the next generation. Research has so far examined these processes separately. This article develops a conceptual framework and a research design that connect them. Drawing on institutional theory, the resource-based view, human capital theory and absorptive-capacity theory, it argues that digital ESG governance – the embedding of environmental, social and governance practices in digital monitoring, traceability, data platforms and reporting – strengthens the succession readiness of the next generation, and that this effect operates largely through the successor's digital competency. Five propositions are formulated, including an exploratory proposition on differences between China (Xinjiang) and Kazakhstan. The article specifies the statistical model, with regression equations for the direct, indirect and cross-country effects, a bootstrap test of the indirect effect with 5,000 resamples, measurement-invariance testing and multi-group structural equation modelling. It also presents a measurement instrument with sample items, a sample-size plan based on Monte Carlo power analysis (150 usable responses per country) and remedies for common-method bias and reverse causality. The framework contributes to research on family business succession, agricultural digitalization and ESG.

Keywords: digital ESG governance, intergenerational succession, family agricultural enterprises, digital competency, mediation analysis, measurement invariance, China, Kazakhstan

Introduction. Family farms remain the backbone of world agriculture: more than 500 million of them account for the large majority of the world's farms and produce roughly 80 percent of the world's food in value terms [1]. In Kazakhstan, peasant and family farms are the most numerous form of agricultural producer and the core of rural

employment [2], while in China family farms, together with farmer cooperatives, are promoted as “new-type agricultural business entities” and are expanding rapidly in regions such as Xinjiang. Family agricultural enterprises in both countries therefore matter not only for food security but also for rural livelihoods and the social fabric of agricultural regions.

These enterprises are now passing through two transitions at once. The first is the digital and sustainability transformation of agriculture. Precision farming, sensor-based monitoring, product traceability and farm data platforms are changing how agricultural work is organized and how farms are evaluated by buyers, lenders and the state [3, 4]. In parallel, environmental, social and governance (ESG) expectations, originally developed in capital markets, are spreading along agricultural value chains [5]. In Kazakhstan, the financial market regulator announced that ESG disclosure would become mandatory for banks and for companies on the official list of the Kazakhstan Stock Exchange from January 2025 [6], and the government set the task of creating a digital map of agricultural land by the end of 2025 [7]. In China, the Digital Village Development Strategy has placed smart agriculture and rural digital services at the centre of rural policy [8]. As banks and processors adopt ESG criteria, these expectations reach family producers through credit conditions, contract-farming requirements and certification schemes.

The second transition is generational. Many family agricultural enterprises founded or expanded in the 1990s and 2000s are approaching the moment when leadership must pass to the next generation. Succession is widely regarded as one of the most critical and fragile events in the life of a family firm, and many firms do not survive it [9, 10]. In agriculture the problem is sharpened by rural youth out-migration and by the perception among young people that farming is an unattractive, low-technology occupation. Whether a capable and willing successor exists is therefore a central question for the continuity of family agriculture in both countries.

Although both transitions are well studied, they are usually studied separately. Research on ESG and digitalization concentrates on large, listed companies and on financial performance, whereas succession research concentrates on family relationships, planning and knowledge transfer. Little is known about whether, and how, the way a family enterprise governs its environmental, social and governance practices through digital systems affects the readiness of the next generation to take over. Evidence from Central Asia, and from the China–Kazakhstan agricultural corridor in particular, is especially scarce.

The purpose of this article is to develop a conceptual framework that connects these two transitions and to specify how it can be tested. It asks: how does digital ESG governance shape intergenerational succession in family agricultural enterprises, and what role does the digital competency of the next generation play in this relationship? The article makes three contributions. First, it introduces digital ESG governance as an antecedent of succession readiness. Second, it identifies next-generation digital competency as the mechanism that links the two. Third, it places the framework in the institutional settings of China (Xinjiang) and Kazakhstan and sets out a testable research design: a statistical model, a measurement instrument, a sample-size plan and procedures for cross-country comparison. The article proceeds with the theoretical background, the framework and its propositions, the research design, practical implications and conclusions.

Theoretical background

Digital ESG governance. In large corporations ESG is usually associated with disclosure ratings and investor reporting. In family agricultural enterprises it takes a more practical form: the monitoring of water, energy and agrochemical use; soil and land stewardship; product safety and traceability; working conditions and relations with the local community; and transparent records and decision-making. Digital tools make such practices measurable, verifiable and communicable to external partners [3, 4]. This article defines digital ESG governance as the extent to which environmental, social and governance practices are embedded in an enterprise through digital tools – digital monitoring, traceability systems, data platforms and digital reporting – together with the standards, responsibilities and incentives that sustain them. The definition distinguishes governance from the simple adoption of technology, which is captured by models such as the technology acceptance model [11]: a farm may own sensors without using their data to govern its practices. Family firms have particular reasons to adopt such governance, since concern for socioemotional wealth – reputation, legacy and identification with the land – makes them attentive to long-term stewardship [12].

Intergenerational succession and succession readiness. A family business is defined less by ownership alone than by the intention to shape and pursue a vision across generations [13]. Succession is accordingly understood as a long process of transferring knowledge, authority and legitimacy rather than a single legal act [14, 15]. Because completed succession is rare in any given period and family plans are often confidential, this article focuses on the successor's succession readiness: the next-generation member's intention to take over, confidence in running the business, clarity about the future role, perceived acceptance as the successor and affective commitment to the enterprise [16, 10]. Readiness is both a strong predictor of later succession outcomes and observable through the successor's own perceptions.

Next-generation digital competency. Digital competence frameworks distinguish several levels of skill [17, 18]. Operational skills concern the use of devices and applications; information skills concern finding, evaluating and analysing information and data; strategic skills concern the use of digital information to set goals, plan and decide. In the agricultural setting these correspond to operating farm devices and applications, interpreting field and market data, and using data in production and investment decisions. Human capital theory treats such skills as an investment whose returns appear as future productivity [19, 20], while absorptive-capacity theory shows that the ability to recognize, assimilate and apply new knowledge depends on prior related knowledge [21, 22]. The successor is thus the person in whom the enterprise's digital capability is embodied and through whom new knowledge enters the family firm [23].

Conceptual framework and propositions

The framework positions digital ESG governance as the explanatory construct (X), next-generation digital competency as the mediating mechanism (M) and succession readiness as the outcome (Y). Firm size and age, value-chain segment and the successor's age and education are treated as controls (C), and the country (W) is examined as a possible moderator. The dimensions of each construct and sample measurement items are presented in Table 1 in the next section.

Digital ESG governance and succession readiness. Institutional theory explains why practices become expected of organizations through regulatory, normative and mimetic pressures [24]. As lenders, processors and regulators in both countries raise ESG and digital expectations, enterprises that have already embedded these practices appear more legitimate and more viable. From the resource-based view, the combination of digital infrastructure and ESG routines is a firm-specific and socially complex resource that is difficult to imitate [25], and it supports the dynamic capability to sense and respond to changing market requirements [26]. For a potential successor, such an enterprise is a more attractive and less risky inheritance: it has a visible future, transparent records and clearly defined data-related roles in which the successor can take responsibility early. These arguments lead to the first proposition.

Proposition 1. *Digital ESG governance is positively associated with the succession readiness of the next generation in family agricultural enterprises.*

Digital ESG governance and digital competency. Governance does not create capability by itself; it creates the resources, expectations and occasions under which learning takes place. Digital monitoring and traceability require operational skills; digital reporting and data platforms require information skills; and data-driven decision routines require strategic skills. Enterprises with stronger digital ESG governance therefore both demand and enable the successor's skill development, consistent with human capital theory [20]. Because absorptive capacity is cumulative [21], repeated engagement with such systems progressively deepens the successor's competency.

Proposition 2. *Digital ESG governance is positively associated with next-generation digital competency.*

Digital competency and succession readiness. Succession research frames effective transition as a capability- and confidence-based process [14, 15]. A successor who can operate the enterprise's digital systems and use data in decisions gains mastery experience, which, according to social cognitive theory, is the strongest source of self-efficacy [27]. Demonstrated competence also strengthens the legitimacy granted by the incumbent generation and by employees, and clarifies the successor's role in the enterprise. Higher self-efficacy, role clarity and legitimacy in turn raise succession intention and commitment [16].

Proposition 3. *Next-generation digital competency is positively associated with succession readiness.*

The mediating mechanism. Taken together, Propositions 2 and 3 imply that digital ESG governance reaches succession readiness, at least in part, by building the successor's digital competency. Partial rather than full mediation is expected, because governance can also influence readiness directly through the attractiveness and legitimacy of the enterprise, as argued for Proposition 1.

Proposition 4. *Next-generation digital competency mediates the relationship between digital ESG governance and succession readiness.*

The institutional context. The two countries differ in how digital and ESG pressures reach family agriculture. In China, digital agricultural services are largely promoted through state programmes for digital villages and agricultural modernization [8], and family farms in Xinjiang operate within a dense system of cooperatives, leading enterprises and extension services. In Kazakhstan, ESG requirements have entered mainly through the financial sector [6], while the digitalization of the agro-industrial complex is advancing

through national information systems and land mapping [7]. These differences may change the strength of the proposed relationships, although there is no strong theoretical basis for predicting their direction. The cross-country proposition is therefore exploratory.

Proposition 5. *The strength of the direct and mediated relationships between digital ESG governance and succession readiness differs between family agricultural enterprises in China and Kazakhstan.*

The complete framework is presented as a path diagram in Figure 1. Paths a, b and c′ correspond to Propositions 2, 3 and 1; the product a × b is the indirect effect of Proposition 4; and the dashed arrows show that the country variable W may moderate each of the three paths (Proposition 5).

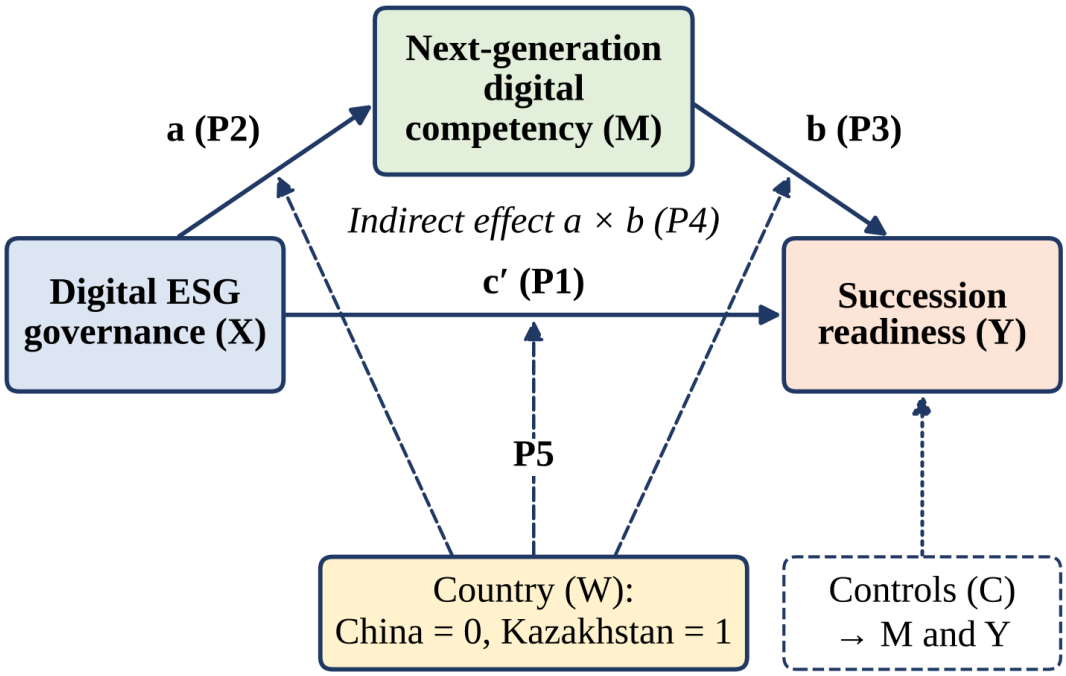


Figure 1 – Path diagram of the conceptual framework (compiled by the author). Solid arrows: proposed paths; dashed arrows: moderation by country; dotted arrow: control variables

Research design and analytical strategy

Sample and data collection

The population consists of market-oriented, family-controlled agricultural enterprises in Xinjiang (China) and in the southern agricultural regions of Kazakhstan (Almaty, Zhetisu, Zhambyl and Turkestan regions). Enterprises are stratified by value-chain segment (grain and oilseeds, horticulture, livestock, processing and trade) and by size class. Sampling frames are built from cooperative and family-farm directories and from the networks of agricultural universities and extension services on both sides of the border. The respondent is the designated next-generation member, or the most likely successor where none has been formally named. Ownership structure, family councils and the content of succession plans are not collected; only registry-type characteristics are used as controls. The questionnaire is prepared in English, translated into Chinese, Kazakh and Russian with

back-translation [28], reviewed by experts and piloted with 20–30 enterprises in each country.

Measurement

Each construct is modelled as a second-order construct whose first-order dimensions are measured by three to four items on a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree). Table 1 links each construct and dimension to a sample item and to the sources from which the items are adapted. Because no validated scale of digital ESG governance exists for family farms, its items are developed for this study from the literature on smart farming and ESG and are complemented by a factual checklist of the digital tools in use, such as field sensors, traceability codes, farm-management applications and digital reporting.

Table 1 – Constructs, dimensions, sample items and sources

Construct	Dimension	Sample item (7-point scale)	Source
Digital ESG governance (X)	Environmental digitization	Our enterprise uses digital tools (meters, sensors or apps) to monitor water, energy and fertilizer use.	Developed for this study from [3, 4]
	Social practices	Our enterprise uses digital channels to inform workers and the local community about safety and working conditions.	Developed from [4, 5]
	Governance and transparency	Production, sales and financial records are kept digitally and are available to family members and partners.	Developed from [3, 5]
Next-generation digital competency (M)	Operational skills	I can confidently use farm-management applications and digital devices.	[29, 18]
	Information skills	I can find and judge reliable online information on prices, weather and farming practices.	[29, 18]
	Strategic skills	I use farm data when planning production and investment decisions.	[18, 17]
Succession readiness (Y)	Intention	I intend to take over the management of our family enterprise.	[30, 16]
	Self-efficacy	I am confident that I could run the enterprise successfully.	[31]
	Role clarity	I clearly understand what my future role in the enterprise will be.	[32]
	Legitimacy	Family members and employees accept me as the future leader of the enterprise.	[33, 10]
	Affective commitment	I feel emotionally attached to our family enterprise.	[34]
Controls (C) and moderator (W)	Firm and successor characteristics; country	Firm size and age; value-chain segment; successor age and education; country (China = 0, Kazakhstan = 1).	Registry data and self-report

Note – compiled by the author; each dimension is measured by three to four items, and the full instrument is given in the dissertation.

Measurement quality will be assessed through confirmatory factor analysis (CFA). Internal consistency requires Cronbach's alpha and composite reliability (CR) of at least 0.70. Convergent validity requires standardized factor loadings of at least 0.70, with items loading between 0.60 and 0.70 retained only when CR and AVE remain adequate, and an average variance extracted (AVE) of at least 0.50 [35]. Discriminant validity is assessed with the Fornell–Larcker criterion and the heterotrait–monotrait ratio (HTMT < 0.85) [35, 36]. Model fit is judged by CFI and TLI (at least 0.90, preferably 0.95), RMSEA (no more than 0.08) and SRMR (no more than 0.08) [37].

Sample size

The required sample size was determined a priori by Monte Carlo simulation [38, 39]. Standardized paths of a = b = 0.26, between small and medium effects, and c′ = 0.14 were assumed. The indirect effect was tested with Monte Carlo 95 percent confidence intervals based on 5,000 draws, which closely approximate bootstrap intervals, and each condition was replicated 2,000 times at α = 0.05. To evaluate the cross-country comparison, the power to detect a difference in path a between the two countries was simulated for differences of 0.35 and 0.25. The results are reported in Table 2.

Table 2 – Monte Carlo estimates of statistical power (2,000 replications, α = 0.05)

Total N	n per country	Pooled indirect effect	Indirect effect within one country	Country difference in path a, Δ = 0.35	Country difference in path a, Δ = 0.25
150	75	0.80	0.36	0.63	0.36
200	100	0.91	0.52	0.73	0.44
250	125	0.97	0.67	0.83	0.53
300	**150**	**0.99**	**0.80**	**0.88**	**0.61**
400	200	> 0.99	0.91	0.96	0.75

Note – author's simulation; a = b = 0.26 and c′ = 0.14; the country difference was simulated as a = 0.10 vs 0.45 (Δ = 0.35) and a = 0.15 vs 0.40 (Δ = 0.25); the target sample is shown in bold.

With 150 usable responses per country (300 in total), the pooled indirect effect is detected with power of 0.99, the indirect effect within each country with power of 0.80, and a cross-country difference of 0.35 in path a with power of 0.88. A smaller difference of 0.25 is detected with power of only 0.61, so cross-country differences in path strength will be interpreted cautiously unless they are large. The target is therefore at least 150 usable responses per country. Assuming a response rate of about 40 percent under face-to-face administration with local partners, about 380–400 enterprises will be approached in each country. The simulation will be repeated with the effect sizes estimated in the pilot.

Statistical model

Propositions 1–4 are tested on the pooled sample. With X denoting digital ESG governance, M next-generation digital competency, Y succession readiness, C_k the control variables and i the enterprise, the model is:

$$M_i = \alpha_M + aX_i + \Sigma\gamma_k C_{ki} + \varepsilon_{Mi}, \quad (1)$$

$$Y_i = \alpha_Y + c'X_i + bM_i + \Sigma\delta_k C_{ki} + \varepsilon_{Yi}, \quad (2)$$

$$Y_i = \alpha_T + cX_i + \Sigma\lambda_k C_{ki} + \varepsilon_{Ti}. \quad (3)$$

In equation (3), c is the total effect of digital ESG governance, which decomposes into the direct effect c′ (Proposition 1) and the indirect effect a × b, so that c = c′ + ab. Proposition 2 is supported if a > 0 and Proposition 3 if b > 0. Proposition 4 is supported if the indirect effect a × b is positive and its 95 percent bias-corrected bootstrap confidence interval, based on 5,000 resamples, does not include zero [40]. Partial mediation is indicated when both a × b and c′ are significant. In the structural equation model the same paths are estimated between latent constructs, which corrects for measurement error.

Proposition 5 is tested by adding the country dummy W (China = 0, Kazakhstan = 1) as a moderator of all three paths, which corresponds to Model 59 in Hayes's classification [40]:

$$M_i = \alpha_M + a_1 X_i + a_2 W_i + a_3 X_i W_i + \Sigma \gamma_k C_{ki} + \varepsilon_{Mi}, \quad (4)$$

$$Y_i = \alpha_Y + c'_1 X_i + c'_2 W_i + c'_3 X_i W_i + b_1 M_i + b_2 M_i W_i + \Sigma \delta_k C_{ki} + \varepsilon_{Yi}. \quad (5)$$

The conditional indirect effect in each country and the index of moderated mediation (IMM) [41] are:

$$\theta(W) = (a_1 + a_3 W)(b_1 + b_2 W), \quad \text{IMM} = \theta(1) - \theta(0) = a_1 b_2 + a_3 b_1 + a_3 b_2. \quad (6)$$

A bootstrap confidence interval for the IMM that excludes zero indicates that the indirect effect differs between China and Kazakhstan, while the conditional direct effect is $c'_1 + c'_3 W$.

Measurement invariance and cross-country comparison

Before structural relationships are compared, measurement invariance across the two countries is tested by multi-group CFA in three steps [42, 43]: configural invariance (the same factor structure in both groups), metric invariance (equal factor loadings), which is required for comparing path coefficients, and scalar invariance (equal item intercepts), which is required only if latent means are compared. A more constrained model is accepted when the change in fit is small (ΔCFI $\leq$ 0.010 and ΔRMSEA $\leq$ 0.015) [44, 45]. If full invariance is not achieved, partial invariance is accepted when at least two loadings per factor are equal across groups [43].

Once at least metric invariance holds, a multi-group structural equation model is estimated. Paths a, b and c′ are first estimated freely in each country and then constrained to equality one at a time; a significant chi-square difference indicates a cross-country difference in that path. The difference between the two countries' indirect effects is tested with bootstrap confidence intervals. Multi-group SEM and the moderated mediation model in equations (4)–(6) thus provide two complementary tests of Proposition 5. Because each country sample contains about 150 cases, dimension scores or item parcels will serve as indicators in the multi-group model to keep the number of estimated parameters manageable.

Common-method bias and reverse causality

Because all perceptual measures come from one respondent at one point in time, common-method bias is addressed both procedurally and statistically [46]. Procedurally, anonymity is assured; the items for governance, competency and readiness are placed in separate sections with different instructions; digital ESG governance is partly measured by a factual tool checklist rather than by perceptions; and, where access allows, a time-lagged sub-sample is collected, with digital ESG governance and controls measured at time 1 and digital competency and succession readiness about three months later. Statistically,

Harman's single-factor test is reported as a first check, followed by the marker-variable technique [47], a model with an unmeasured latent method factor and a full-collinearity test in which all variance inflation factors should be below 3.3 [48].

Reverse causality is also possible: a successor who is already committed and digitally skilled may push the enterprise towards digital ESG practices. Three measures address this risk. First, the governance items refer to practices that have been in place for at least the past two years, so that they precede the successor's current competency and readiness. Second, alternative models with reversed ordering (Y → M → X and M → X → Y) are estimated and compared with the proposed model using information criteria (AIC and BIC). Third, the time-lagged sub-sample allows the temporal order of the variables to be checked. Even so, the core design remains cross-sectional, and its results will be interpreted as theory-consistent associations rather than as definitive causal effects.

The complete testing procedure is summarized in Figure 2.

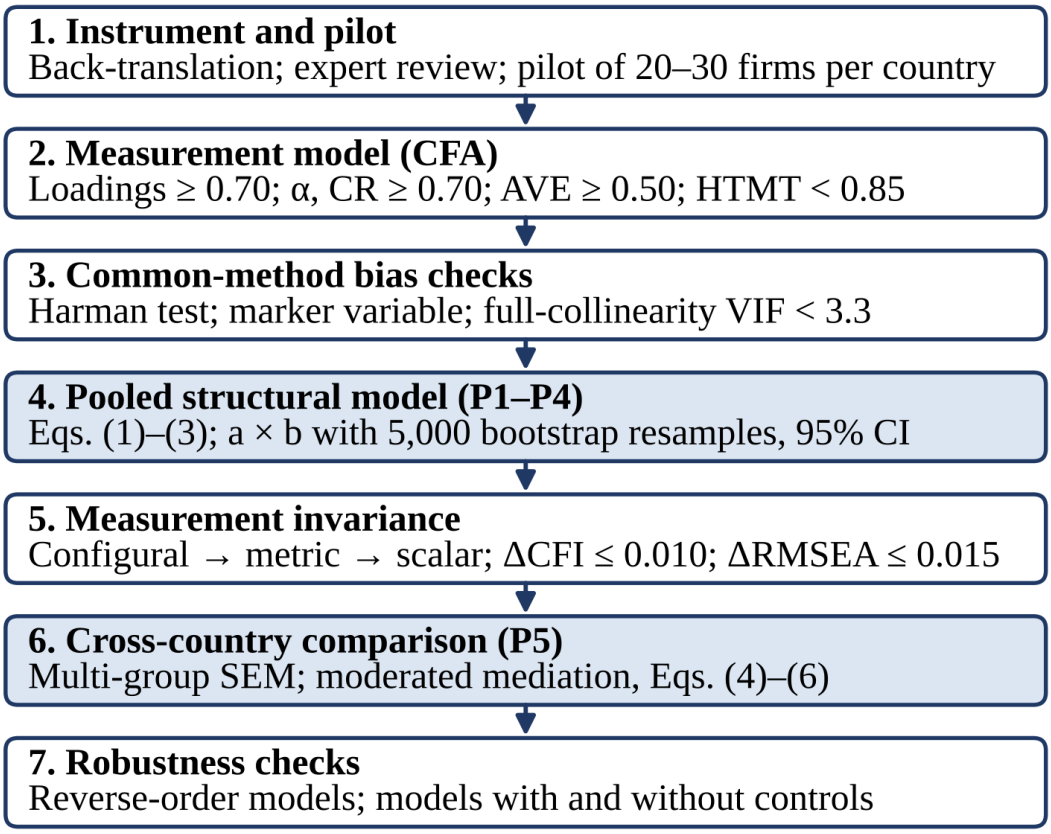


Figure 2 – Proposed statistical testing procedure (compiled by the author)

Practical implications

The framework suggests that founders of family agricultural enterprises can treat digital ESG governance not only as a compliance or market-access requirement but also as a succession instrument. Assigning the designated successor early responsibility for digital monitoring, traceability or ESG reporting gives the successor practical competence, a visible role and legitimacy in the eyes of family members and employees. For agricultural advisory and extension services, the framework points to training that combines digital skills with ESG content and that targets the next generation specifically. For policymakers, it suggests that programmes supporting agricultural digitalization and ESG adoption can

also serve the goal of keeping young people in family agriculture. China–Kazakhstan cooperation platforms, such as joint demonstration and training projects in agricultural technology, offer natural settings in which successors from both countries can acquire these skills.

Conclusion

This article has argued that the digital and sustainability transformation of agriculture and the generational transition of family enterprises are connected processes. It has proposed a conceptual framework in which digital ESG governance strengthens the succession readiness of the next generation, partly through the successor's digital competency, and in which the strength of these relationships may differ between China and Kazakhstan. The framework integrates institutional theory, the resource-based view, human capital and absorptive-capacity theory and social cognitive theory into a single chain, and the research design translates it into regression and structural equation models, a measurement instrument, a sample-size plan of 150 usable responses per country and a stepwise procedure for cross-country comparison.

The article has limitations. Its propositions are theoretical and still need empirical testing. Even with the remedies described above, a cross-sectional survey establishes associations rather than causal effects, and reliance on successors' perceptions may not fully capture enterprise-level governance. Future research should follow enterprises over a complete succession period, combine survey responses with objective digital and ESG indicators, and extend the comparison to other Central Asian countries. Such work would show how family agriculture in the region can secure both its sustainability and its continuity across generations.

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