Workshop on Smart PLS to Enhance Quantitative Data Analysis Literacy at ICMA 2025

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ABSTRACT

Quantitative research increasingly requires sophisticated analytical techniques capable of modeling latent constructs and complex relationships. Partial Least Squares–Structural Equation Modeling (PLS-SEM) has emerged as a widely adopted approach due to its predictive orientation, flexibility, and suitability for small samples and non-normal data. However, many academics and postgraduate students face challenges in correctly applying PLS-SEM using Smart PLS software, particularly in model specification, validity and reliability evaluation, and interpretation of structural results. This community engagement activity aimed to enhance quantitative data analysis literacy through a Smart PLS workshop conducted at ICMA on February 5, 2025. The program employed a capacity-building approach integrating theoretical explanation and hands-on simulation. Participants were trained in data preparation, measurement model evaluation, structural model assessment, and bootstrapping procedures. The results indicate significant improvement in participants' conceptual understanding, technical competence in operating Smart PLS, and ability to interpret and report statistical outputs systematically. The workshop also strengthened research confidence and publication readiness. This initiative demonstrates that structured methodological training is an effective strategy to enhance research quality and academic productivity within higher education communities.

INTRODUCTION

Quantitative research plays a central role in advancing academic knowledge, particularly in the fields of business, management, accounting, and social sciences (Nyoto et al., 2022). In recent years, the increasing complexity of research models has required scholars to adopt more sophisticated statistical techniques capable of analyzing latent constructs and multivariate relationships (Renaldo et al., 2023). Structural Equation Modeling (SEM) has become one of the most widely used approaches for examining causal relationships among variables in quantitative studies (Sudarno et al., 2022).

Among SEM approaches, Partial Least Squares – Structural Equation Modeling (PLS-SEM) has gained significant popularity due to its flexibility, predictive orientation, and suitability for small sample sizes and non-normal data distributions (Jahrizal et al., 2025). Smart PLS, as one of the most user-friendly software platforms for PLS-SEM, enables researchers to build measurement models (outer models), structural models (inner models), and perform bootstrapping procedures efficiently (Renaldo et al., 2025). Its ability to handle both reflective and formative indicators makes it particularly valuable for exploratory and predictive research contexts (Junaedi et al., 2025).

Despite its advantages, many academics and postgraduate students still face challenges in applying Smart PLS correctly (J. F. Hair et al., 2024). Common difficulties include misunderstanding the difference between reflective and formative models, misinterpreting validity and reliability criteria (AVE, Composite Reliability, HTMT), and incorrectly evaluating structural model metrics such as R^2, f^2, and Q^2. These gaps in methodological literacy often led to improper model specification and inaccurate research conclusions.

The need to strengthen quantitative data analysis literacy is especially important in academic forums such as ICMA 2025, where participants are expected to produce high-quality research outputs and publications. Enhancing competence in Smart PLS not only improves methodological rigor but also increases the potential for publication in reputable national and international journals.

In response to these challenges, a Smart PLS workshop was conducted at ICMA on February 5, 2025. The program aimed to improve participants' understanding of PLS-SEM concepts, develop practical skills in data processing using Smart PLS, and enhance their ability to interpret and report analytical results systematically. The workshop combined theoretical explanation with hands-on practice, covering data preparation, model construction, measurement model evaluation, structural model testing, and bootstrapping procedures.

This community engagement activity is expected to contribute to strengthening research capacity among participants by bridging the gap between statistical theory and practical application. Through structured training and direct simulation, the workshop supports the development of competent researchers capable of conducting rigorous quantitative analysis using Smart PLS.

LITERATURE REVIEW

Quantitative Research and Structural Equation Modeling (SEM)

Quantitative research is widely used in social sciences, business, accounting, and management to test hypotheses and examine causal relationships among variables (Sekaran & Bougie, 2016). As research models become increasingly complex, traditional statistical techniques such as multiple regression are often insufficient to analyze latent constructs measured by multiple indicators. Structural Equation Modeling (SEM) addresses this limitation by allowing simultaneous estimation of measurement models and structural relationships among latent variables.

SEM consists of two major approaches: Covariance-Based SEM (CB-SEM) and Variance-Based SEM or Partial Least Squares SEM (PLS-SEM). While CB-SEM focuses on theory confirmation and model fit indices, PLS-SEM emphasizes prediction and variance explanation. PLS-SEM is particularly suitable for exploratory research, complex models, and studies with small sample sizes or non-normal data distributions. These characteristics make it highly relevant for academic environments where data limitations are common.

Partial Least Squares – Structural Equation Modeling (PLS-SEM)

PLS-SEM is a component-based estimation technique that aims to maximize the explained variance (R^2) of endogenous constructs (J. F. H. Hair et al., 2019). Unlike CB-SEM, which relies heavily on distributional assumptions, PLS-SEM is more flexible and robust when dealing with non-normal data and formative measurement models.

PLS-SEM consists of two main components:

1. Measurement Model (Outer Model). This model evaluates the relationship between latent variables and their indicators. For reflective constructs, assessment includes: Outer loadings (≥ 0.70), Average Variance Extracted (AVE ≥ 0.50), Composite Reliability (≥ 0.70), Discriminant validity (Fornell-Larcker and HTMT < 0.85). For formative constructs, evaluation focuses on: Multicollinearity (VIF $\leq$ 5), Significance and relevance of indicator weights.

2. Structural Model (Inner Model)

   This model examines relationships among latent variables using: Path coefficients (β), Coefficient of determination (R^2), Effect size (f^2), Predictive relevance (Q^2), Bootstrapping for hypothesis testing. The predictive orientation and methodological flexibility of PLS-SEM have contributed to its increasing use in academic publications.

Smart PLS as a Research Tool

Smart PLS is one of the most widely used software platforms for implementing PLS-SEM. Its graphical user interface allows researchers to construct models using drag-and-drop features, making it accessible even for

beginners. The software provides automated evaluation outputs, including reliability, validity, structural path coefficients, and bootstrapping results.

Key advantages of Smart PLS include: Ability to handle small sample sizes, no strict normality assumptions, Support for reflective and formative indicators, Bootstrapping procedures for hypothesis testing, PLS-Predict feature for predictive assessment. Due to these features, Smart PLS is increasingly adopted in postgraduate research and academic training programs.

Quantitative Data Analysis Literacy

Statistical literacy refers to the ability to understand, interpret, and critically evaluate statistical information. In the context of higher education, quantitative data analysis literacy involves not only the technical operation of software but also conceptual understanding of modeling assumptions, validity testing, and interpretation of results.

Several common issues observed in academic research include: Incorrect specification of measurement models, Misinterpretation of reliability and validity criteria, Overreliance on software output without theoretical grounding, Inadequate reporting of statistical findings.

Capacity-building initiatives such as workshops and training programs play a crucial role in bridging the gap between statistical theory and practical application. Experiential learning approaches that combine conceptual explanation with hands-on practice are particularly effective in improving research competence.

Capacity Building through Academic Workshops

Workshops are widely recognized as an effective community engagement strategy for enhancing professional and academic skills. In the context of research methodology training, workshops allow participants to: Apply statistical concepts directly to real datasets, Receive guided feedback from experts, engage in collaborative learning environments, and develop confidence in using analytical tools.

By integrating theoretical explanation with practical simulation, methodological workshops contribute to strengthening research productivity and publication readiness.

Literature Gap

Although extensive literature discusses PLS-SEM and Smart PLS applications, limited studies focus on structured training interventions aimed at improving quantitative data analysis literacy within academic communities. There is a need to document and evaluate community-based training programs that enhance methodological competence in applied research settings. This study addresses that gap by examining the implementation and impact of a Smart PLS workshop conducted at ICMA 2025, focusing on its role in strengthening participants' quantitative research capabilities.

METHODOLOGY

Approach and Design

This community engagement activity employed a capacity-building and participatory training approach aimed at enhancing participants' quantitative data analysis literacy using Smart PLS. The program was designed as an intensive methodological workshop combining theoretical explanation, guided practice, and hands-on simulation.

The workshop was conducted at ICMA on February 5, 2025, targeting academics, researchers, postgraduate students, and conference participants who required practical skills in Partial Least Squares–Structural Equation Modeling (PLS-SEM).

Participants

The participants consisted of ICMA attendees with diverse academic backgrounds in business, management, accounting, and social sciences. Most participants had basic knowledge of quantitative research but limited experience in applying PLS-SEM using Smart PLS software. The training was structured to accommodate varying levels of statistical competence, from beginners to intermediate users.

Training Materials and Instruments

The workshop materials were developed based on standard PLS-SEM methodological frameworks and included:

- Introduction to SEM and differences between CB-SEM and PLS-SEM

- Measurement model evaluation (outer model)
- Structural model evaluation (inner model)
- Bootstrapping procedures for hypothesis testing
- Interpretation and reporting of Smart PLS outputs

Participants were provided with:

- A sample dataset in Excel/CSV format
- Step-by-step Smart PLS tutorial guidelines
- Practice exercises
- Model evaluation checklists

Smart PLS software was used as the primary analytical tool during the training session.

Implementation Stages

The workshop was conducted in four main stages:

1. Preparation Stage
   - Identification of participants' needs
   - Preparation of training modules and datasets
   - Installation and technical setup of Smart PLS software

2. Theoretical Session

Participants received structured explanations covering:

   - Concepts of latent variables and indicators
   - Reflective vs. formative measurement models
   - Validity and reliability criteria (AVE, CR, HTMT)
   - Structural model metrics (R^2, f^2, Q^2)

3. Hands-on Practice Session

Participants practiced directly using Smart PLS, including:

   - Importing datasets
   - Building measurement and structural models
   - Running the PLS Algorithm
   - Conducting bootstrapping (5,000 subsamples)
   - Interpreting path coefficients and significance levels

4. Discussion and Evaluation Session

Participants discussed model interpretation, common mistakes, and reporting techniques for journal publication. A reflective evaluation was conducted to assess participants' understanding and perceived improvement.

Evaluation of Program Effectiveness

The effectiveness of the workshop was assessed using:

1. Observational Evaluation. Monitoring participants' ability to construct models and interpret results independently.

2. Interactive Question-and-Answer Sessions. Measuring conceptual understanding and clarification of methodological issues.

3. Participant Feedback. Collecting qualitative feedback regarding clarity of materials, usefulness of training, and perceived competence improvement.

The evaluation focused on three main indicators:

- Improvement in conceptual understanding of PLS-SEM
- Ability to operate Smart PLS software
- Ability to interpret and report statistical outputs

Expected Outcomes

The workshop aimed to achieve the following outcomes:

- Increased quantitative data analysis literacy among participants
- Improved competence in applying PLS-SEM using Smart PLS
- Enhanced confidence in conducting and publishing quantitative research
- Strengthened research productivity within the academic community

RESULTS AND DISCUSSION

Implementation Outcomes

The Smart PLS workshop conducted at ICMA on February 5, 2025, was successfully implemented according to the planned stages. Participants actively engaged in both theoretical and practical sessions. The training combined conceptual explanation with direct software application, allowing participants to immediately practice building and evaluating PLS-SEM models.

During the hands-on session, participants were able to:

- Import datasets into Smart PLS correctly,
- Construct measurement (outer) and structural (inner) models,
- Evaluate convergent and discriminant validity (AVE, HTMT, Fornell-Larcker),
- Assess reliability using Composite Reliability and Cronbach's Alpha,
- Run bootstrapping procedures,
- Interpret path coefficients, R^2, f^2, and Q^2 values.

Most participants initially faced difficulties distinguishing between reflective and formative constructs. However, after guided explanation and practical demonstration, they demonstrated improved understanding and were able to correctly specify model types.

Improvement in Quantitative Data Analysis Literacy

The workshop contributed to measurable improvements in three main areas:

1. Conceptual Understanding

Participants showed improved comprehension of:

- Differences between CB-SEM and PLS-SEM,
- The logic of variance-based modeling,
- The role of measurement model validation,
- Interpretation of structural relationships.

Many participants reported that prior to the workshop, they relied heavily on software output without fully understanding the theoretical meaning of validity and reliability metrics. After the training, they were able to explain statistical indicators such as AVE, Composite Reliability, R^2, and Q^2 in conceptual terms.

2. Technical Skills in Smart PLS

Participants demonstrated enhanced ability to:

- Build research models using drag-and-drop features,

- Conduct bootstrapping with appropriate subsample settings,

- Identify insignificant paths,

- Detect validity and reliability issues.

Hands-on practice significantly reduced technical hesitation and increased confidence in using Smart PLS independently.

3. Analytical Interpretation and Reporting Skills

A critical outcome of the workshop was the improvement in participants' ability to interpret statistical results systematically. They learned to:

- Report outer model results before structural results,

- Explain the significance of path coefficients,

- Interpret R^2 values appropriately,

- Connect empirical findings to theoretical frameworks.

This competence is essential for producing publishable research articles.

Discussion

The findings confirm that structured methodological training is an effective strategy for improving research literacy. In line with capacity-building theory, experiential learning, combining explanation with simulation, enhances knowledge retention and skill acquisition.

From a methodological perspective, many researchers struggle not because of software complexity but due to limited understanding of underlying statistical concepts. The workshop addressed this gap by integrating theoretical clarification with practical execution.

The participatory format also encouraged peer discussion and collaborative problem-solving, which strengthened collective learning. This aligns with adult learning principles that emphasize interactive engagement over passive instruction.

Furthermore, the workshop contributed to strengthening research productivity readiness. By improving competence in PLS-SEM analysis and interpretation, participants are better equipped to produce methodologically sound research suitable for national and international journal publication.

The activity demonstrates that community engagement programs focusing on methodological literacy can directly support academic quality improvement. Such initiatives are particularly relevant in academic conferences like ICMA, where research dissemination and publication preparation are key objectives.

Impact on Academic Community

The broader impact of the workshop includes:

- Increased confidence among researchers in using advanced statistical tools,

- Reduction in common methodological errors in quantitative research,

- Strengthened research collaboration among participants,

- Enhanced awareness of publication standards in empirical studies.

Overall, the Smart PLS workshop functioned not only as a technical training session but also as a strategic academic empowerment initiative aimed at improving research rigor and output quality.

CONCLUSION

Conclusion

The Smart PLS workshop conducted at ICMA on February 5, 2025 successfully enhanced participants' quantitative data analysis literacy, particularly in applying Partial Least Squares–Structural Equation Modeling (PLS-SEM). The integration of theoretical explanation and hands-on practice enabled participants to better understand measurement model evaluation, structural model assessment, and hypothesis testing using bootstrapping procedures.

The program improved not only technical software skills but also conceptual understanding of statistical validity, reliability, and predictive metrics. Participants demonstrated greater confidence in constructing models, interpreting statistical outputs, and preparing research reports suitable for academic publication. Overall, the workshop contributed to strengthening methodological competence and research readiness within the academic community.

Implications

Academic Implications. This community engagement activity highlights the importance of methodological capacity-building programs in improving research quality. Strengthening statistical literacy directly contributes to more rigorous research design and accurate interpretation of findings.

Practical Implications. For researchers and postgraduate students, enhanced Smart PLS competence increases their ability to: Conduct valid and reliable quantitative analysis, produce publishable research articles, and reduce methodological errors in thesis and journal submissions.

Institutional Implications. For academic institutions and conference organizers, structured methodological workshops can serve as strategic programs to increase research productivity and publication performance.

Limitations

Despite its positive outcomes, this community service activity has several limitations:

1. Short Duration. The workshop was conducted in a limited time frame, which restricted deeper exploration of advanced PLS-SEM techniques.

2. Heterogeneous Participant Backgrounds. Participants had varying levels of statistical knowledge, making it challenging to ensure uniform learning outcomes.

3. Limited Quantitative Impact Measurement. The evaluation primarily relied on observational and qualitative feedback rather than formal pre-test and post-test quantitative assessment.

4. Single Event Implementation. The activity was conducted as a one-time workshop, limiting long-term impact monitoring.

Recommendations

Based on the implementation results, several recommendations are proposed:

1. Conduct follow-up advanced workshops focusing on: Mediation and moderation analysis, multi-group analysis (MGA), PLS-Predict and advanced reporting techniques.

2. Implement structured pre-test and post-test evaluation to quantitatively measure literacy improvement.

3. Develop modular training materials that can be accessed online for continuous learning.

4. Encourage participants to apply Smart PLS in their ongoing research projects and submit manuscripts to reputable journals.

Future Community Service

Future community engagement initiatives may include:

1. Advanced Research Methodology Series. A multi-level training program covering beginner to advanced SEM techniques.

2. IoT and Data Analytics Integration Training. Combining Smart PLS with emerging digital data analytics tools.

3. Research Clinic and Mentoring Program. Providing one-on-one mentoring for participants preparing journal submissions.

4. Collaborative Research Development Program. Facilitating joint research projects among ICMA participants.

5. Hybrid or Online Training Expansion. Expanding outreach through online platforms to reach broader academic communities.

These initiatives can ensure sustainable improvement in quantitative research competence and strengthen academic productivity across institutions.

REFERENCES

Hair, J. F. H., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate Data Analysis* (Eighth). Cengage. https://doi.org/10.1002/9781119409137.ch4

Hair, J. F., Sarstedt, M., Ringle, C. M., Sharma, P. N., & Liengaard, B. D. (2024). Going beyond the untold facts in PLS–SEM and moving forward. *European Journal of Marketing*, *58*(13), 81–106. https://doi.org/10.1108/EJM-08-2023-0645

Jahrizal, J., Dalil, M., Amri, R., Yovita, I., Koto, J., Faruq, U., Junaedi, A. T., Tendra, G., Renaldo, N., & Mammadova, U. (2025). Enhancing Goat and Sheep Farm Management with IoT-Enabled Weighing Devices. *Seroja Journal of Empowerment and Community Service*, *1*(1), 23–27. https://doi.org/10.61230/seroja.v1i1.119

Junaedi, A. T., Renaldo, N., Panjaitan, H. P., Veronica, K., Putra, R., Tendra, G., Jahrizal, J., Yovita, I., Musa, S., Cecilia, C., & Miskon, S. (2025). Development of Digital Business Literacy and Culture for Generation Z in Southeast Asia on International Webinar Future Ready, Digital Business Model & IOT Driven Ventures in Southeast Asia. *Seroja Journal of Empowerment and Community Service*, *1*(1), 1–7. https://doi.org/https://doi.org/10.61230/seroja.v1i1.105

Nyoto, Nyoto, R. L. V., Renaldo, N., & Purnama, I. (2022). Peran Pemuda Mengisi Kemerdekaan Bangsa Melalui Pemantapan Wawasan Kebangsaan. *JUDIKAT: Jurnal Pengabdian Kepada Masyarakat*, *2*(2), 65–73.

Renaldo, N., Junaedi, A. T., Fadrul, Sudarno, Suhardjo, Suyono, Andi, & Veronica, K. (2023). Manajemen Utang untuk Perencana Keuangan Perusahaan (Target Generasi Z). *JUDIKAT: Jurnal Pengabdian Kepada Masyarakat*, *3*(1), 19–33.

Renaldo, N., Tanjung, A. R., Mukhsin, M., Santoso, P. H., Tjahjana, D. J. S., Suhardjo, S., Rusilawati, E., Okalesa, O., Damasari, R., Setyawan, O., Infante, Y. O. T. A. Y., & Hadi, S. (2025). AI Content Generator in the Young Accounting Scholars Association. *Seroja Journal of Empowerment and Community Service*, *1*(1), 8–13. https://doi.org/https://doi.org/10.61230/seroja.v1i1.107

Sekaran, U., & Bougie, R. (2016). *Research Method for Business A Skill-Building Approach Seventh Edition* (Seventh Ed). John Wiley & Sons. https://doi.org/10.1007/978-94-007-0753-5_102084

Sudarno, Suyono, Renaldo, N., Yusrizal, Fransisca, L., Mukhsin, & Andi. (2022). Sistem Perkuliahan MM IBTPI untuk Mahasiswa Kabupaten Rokan Hulu. *JUDIKAT: Jurnal Pengabdian Kepada Masyarakat*, *2*(2), 74–78.