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Technological Innovations in Nigerian Sericulture: A Pathway to Industry Revival and Environmental Sustainability

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Abstract
Despite Nigeria's rich history in sericulture, the sector remains underdeveloped due to outdated techniques, low technological adoption, and poor policy integration. This study investigates the extent to which modern silkworm rearing techniques and automated silk production equipment can revitalize Nigeria's sericulture industry, enhancing both productivity and quality. Using secondary panel data from 60 sericulture programs between 2010 and 2024 (900 observations), the study applies multiple linear regression models with robust econometric diagnostics via EViews 12. Findings reveal that both technological innovations exert statistically significant and positive effects on silk production and quality. Specifically, modern rearing techniques, including controlled temperature, improved feeding regimes, and hygienic rearing environments, demonstrated the strongest influence, enhancing output by 3.94 index points per unit increase. Similarly, automation tools such as reeling, degumming, and drying machines improved outcomes by 2.67 points, validating their transformative impact on operational efficiency and product uniformity. Innovation funding, used as a control variable, also showed a meaningful positive contribution. Robustness checks confirmed the model's reliability, indicating no serial correlation, heteroskedasticity, or structural instability. The study rejects both null hypotheses, affirming that technological innovation is central to Nigeria's sericulture revival. It concludes that structured rearing protocols and mechanized processing are not merely modern luxuries but essential tools for global competitiveness and environmental sustainability. Based on these insights, the study recommends upscaling farmer training and subsidizing access to automation equipment through public-private partnerships. These steps are vital to reposition Nigerian sericulture as a viable, sustainable agro-industrial sector in the modern textile economy.

Keywords: Automation, Environmental Sustainability Sericulture, Nigeria, Technological Innovation, Silk Production.

1. Introduction

The global sericulture industry, long celebrated for its ecological harmony and economic significance, is experiencing a technological renaissance. From Asia to Africa, nations are reimagining silk production through modern tools that improve efficiency and elevate sustainability. Sericulture, which hinges on the delicate relationship between silkworms and their environment, is particularly ripe for innovation. In Nigeria, a country historically rich in indigenous silk practices, such modernization is not only timely but vital.

As rural economies seek new lifelines, the fusion of tradition with cutting-edge technologies in silk farming offers promising solutions (Ibitoye, Ayanniyi, Ayeni, & Adekoya, 2024).

Modern silkworm rearing techniques, such as temperature-controlled environments, disease-resistant breeds, and nutritional optimization have significantly improved silk yield and quality in countries leading sericulture advancement (Ajrawat, Isharb, Jeeva, & Devi, 2024). These methods are gradually making inroads into Nigerian silkworm farming practices. Notably, digital climate monitoring systems and semi-automated cocoon harvesting technologies are reducing mortality rates and boosting silk thread density. As demonstrated in Ethiopia and India, where similar systems were implemented, production increased by over 30% within a span of three years (Mijena, Shanku, & Getiso, 2024). These precedents affirm Nigeria's potential for revival through targeted technology adoption. Moreover, institutions such as the Federal Ministry of Agriculture and Rural Development (FMARD) and the Raw Materials Research and Development Council (RMRDC) have repeatedly emphasized the role of innovation in strengthening the nation's agro-industrial base and enhancing rural employment.

Automation has become a cornerstone of modern sericulture, especially in tasks such as degumming, reeling, and dyeing. Nigerian sericulturists are beginning to explore automated silk spinning machines, some of which have been locally adapted to fit the resource limitations of rural areas. According to Dutta, Dutta, Yadav, and Prabhu (2024), automated silk production equipment improves both fiber uniformity and tensile strength, leading to globally competitive products. Such enhancements are critical in repositioning Nigerian silk in regional and international markets, while simultaneously reducing labor-intensive bottlenecks that have historically hampered growth. Without such mechanization, Nigeria risks continued inefficiency, low-quality outputs, and missed opportunities in the global textile supply chain.

Equally transformative is the integration of digital tools in sericulture management. Mobile-based advisory systems, data-logging applications for cocoon development, and real-time pest detection software are increasingly accessible to Nigerian farmers (Kumari, Moneekha, & Sree, 2024). These digital innovations not only democratize access to technical expertise but also enhance traceability in the value chain, a key requirement for sustainable certification. The convergence of ICT and sericulture is redefining what it means to manage a silk farm in Nigeria, transforming it from a subsistence craft into a data-driven enterprise.

Beyond production efficiency, technological innovation in sericulture also serves environmental objectives. Precision agriculture practices, such as micro-irrigation for mulberry fields and eco-friendly dyeing units, are being adopted in pilot projects across Sub-Saharan Africa (Falana, Aderounmu, & Ayandokun, 2023). Nigeria stands to benefit from these sustainability-aligned innovations, particularly in reducing water use, chemical runoff, and post-harvest waste. When implemented at scale, such practices could make Nigerian silk not just more profitable, but also more planet-friendly. Furthermore, innovation aligns with the country's climate adaptation and green growth strategies, especially as outlined in the national environmental sustainability roadmap.

Importantly, the revival of Nigerian sericulture must be contextualized within broader economic and developmental goals. With rising unemployment and rural-urban migration, revitalizing agro-based industries like sericulture presents an opportunity for inclusive growth. Investments in technological infrastructure, both physical and digital, can turn sericulture into a vibrant sector that supports livelihoods, especially for women and youth (Ssemugenze, Esimu, & Nagasha, 2021). The convergence of innovation, environmental stewardship, and socioeconomic development makes sericulture a potent platform for policy and practice. This also supports strategic objectives outlined in the Nigeria Industrial Revolution Plan (NIRP), which prioritizes agro-industrial value chains with export potential and environmental synergy.

Despite these promising developments, Nigeria's sericulture sector continues to underperform due to systemic challenges. These include limited access to rearing equipment, outdated production techniques, and poor linkage between research and on-ground practice. Many farmers still rely on manual methods that produce low-yield cocoons susceptible to diseases and temperature variations. A national strategy that fosters innovation adoption, enhances capacity building, and bridges public-private partnerships remains conspicuously absent (Aleme, 2020). The absence of a cohesive policy framework further exacerbates fragmentation in the sector. Without urgent and coordinated technological adoption, Nigeria risks being excluded from the emerging global market for sustainably produced silk.

This research is therefore grounded in a pressing need: to investigate how technological innovations, specifically modern silkworm rearing, automation, and digital tools, can meaningfully improve silk production and quality in Nigeria. The core problem is not merely the lack of production, but the absence of a scalable, technology-driven model for sericulture that aligns with contemporary sustainability demands. Addressing this gap is critical to unlocking the latent potential of Nigerian silk and ensuring the country's relevance in a rapidly modernizing textile economy. In line with this, the study tests the following hypotheses in null form:

H_{01}: The adoption of modern silkworm rearing techniques has no statistically significant effect on silk production and quality in Nigeria.

H_{02}: The use of automated silk production equipment has no statistically significant effect on silk production and quality in Nigeria.

2. Literature Review

Silk production and quality are multidimensional outcomes influenced by biological, technological, and environmental inputs. Recent innovations in rearing systems, mulberry cultivation, and post-harvest processing have shown significant improvements in both cocoon yield and filament quality (Zhao, Dai, & Peng, 2021). Automated reeling and improved silkworm breeds have led to consistent filament length and fewer defects in countries like India and Thailand (Wang, Jin, & Zhang, 2023). Enhanced climate-controlled rearing chambers have been shown to reduce mortality and increase silk luster, strength, and density (Liu, Chen, & Zhan, 2022). Furthermore, disease management protocols using IoT-enabled surveillance have increased cocoon harvest rates by up to 40% in pilot studies (Nguyen & Bui, 2020). Digital traceability systems also contribute by enabling quality control throughout the supply chain (Mishra & Ray, 2021). In Africa, hybrid innovations combining indigenous knowledge with modern machinery have resulted in measurable gains in silk fiber fineness and reeling efficiency (Alemu, Getiso, & Debelo, 2023). These advancements collectively define the twin goals of quantity (measured in yield per unit) and quality (measured in filament properties and commercial grade) in sericulture today. For this study, increased silk production and quality is conceptualized as the measurable enhancement in both the volume of silk cocoons harvested per production cycle and the physical properties of the raw silk output, including filament length, tensile strength, fineness, and luster, directly attributable to the adoption of modern technological innovations.

The adoption of modern silkworm rearing techniques has been recognized as a pivotal factor in enhancing both silk yield and quality in contemporary sericulture. These techniques encompass controlled environmental conditions, disease-resistant silkworm hybrids, optimized feeding schedules, and hygienic rearing practices that collectively reduce larval mortality and improve cocoon characteristics (Liu, Tang, & Zeng, 2022). Temperature and humidity regulation, facilitated by automated rearing houses, has been found to significantly influence cocoon weight and filament length, especially under fluctuating climatic conditions in Sub-Saharan Africa (Habtegiorgis & Mijena, 2024). Artificial diet formulations and photoperiod manipulation have also yielded promising results, allowing farmers to rear silkworms in multiple cycles per year (Zhou & Zhang, 2021). Moreover, hygienic rearing protocols have reduced pathogen outbreaks and promoted larval health, leading to uniform cocoons with higher silk recovery rates (Kumari & Moneekha, 2023). Studies in Nigeria and Ethiopia reveal that rearing method upgrades alone can raise cocoon production efficiency by up to 45% (Shanku, Getiso, & Tefera, 2023). The introduction of tray-rearing systems and vertical space utilization has optimized labor input and land use (Chen, Wang, & Liu, 2021). These advancements are further supported by continuous extension training and farmer field schools, which accelerate the adoption curve among rural producers (Alemu & Debelo, 2023). Thus, modern silkworm rearing techniques serve not only as technological interventions but as knowledge-intensive systems that elevate productivity and product consistency in sericulture. For this study, "Adoption of Modern Silkworm Rearing Techniques" is conceptualized as the systematic use of improved biological, environmental, and procedural methods in silkworm cultivation, including controlled rearing environments, enhanced feeding regimens, and hygiene-focused practices, aimed at increasing cocoon yield, silk extraction efficiency, and larval survival rates.

Automated silk production equipment has emerged as a transformative innovation within modern sericulture, enabling consistent productivity, quality standardization, and operational scalability. Mechanical systems such as reeling, degumming, and drying units significantly reduce labor time and variability in silk fiber quality (Giora, Assirelli, & Cappellozza, 2024). In countries with established sericulture systems, semi-automatic and fully automated machines have cut production cycles by up to 40%, while improving filament uniformity and tensile strength (Thamizharasu, Srikanth, & Madhanram, 2024). Innovations like automated mulberry leaf shredders and robotic silkworm feeding arms have further optimized resource allocation (Singh, Verma, & Jadia, 2025). Moreover, production chain mechanization has enhanced traceability and reduced post-harvest cocoon spoilage (Kiruba, Mangammal, & Anand, 2024). In Sub-Saharan Africa, pilot projects employing hybrid solar-powered reeling machines demonstrated not only reduced operational costs but also increased output by over 50% (Nandaniya, Barad, & Patel, 2023). These automation tools are increasingly integrated with digital monitoring systems, enabling real-time adjustments that preserve silk fiber integrity (Ramesh, Bhat, & Gowda, 2022). The alignment of automation with sustainability goals also makes these innovations pivotal in developing nations where labor shortages and inefficiencies persist. For this study, "Use of Automated Silk Production Equipment" is conceptualized as the deployment of mechanical or semi-automatic tools and machinery in the post-rearing stages of sericulture — including reeling, degumming, drying, and feeding — with the goal of enhancing operational efficiency, product quality, and scalability in silk production.

Empirical Review

Modern Silkworm Rearing Techniques and Silk Production and Quality

A growing body of empirical literature supports the positive correlation between modern silkworm rearing techniques and increased silk yield and quality. Sowmya, Krishnaveni, and Narayana (2024) observed that controlled environmental rearing—incorporating precise temperature and humidity regulation—improves larval development, cocoon weight, and filament strength. Similarly, Suresh, Saha, and Alam (2024) highlighted the integration of genome-based hybrid silkworm strains and optimized feeding regimens as a major breakthrough, increasing cocoon yield by 35% under field conditions. Akin to these findings, Pandey and Tripathi (2023) reported that rearing silkworms under pathogen-controlled and hygiene-enhanced conditions led to longer filament lengths and higher silk denier uniformity. In a comparative study, Yang, Hu, and Xiao (2021) demonstrated that mulberry fortification combined with semi-automated rearing units resulted in both higher productivity and lower larval mortality in tropical climates. Rahman and Sultana (2022) found that vertical tray systems not only enhanced spatial efficiency but also promoted better air circulation, which significantly reduced cocoon deformities. Meanwhile, Rajan, Kaur, and Bansal (2023) used a longitudinal approach to establish that larval survival rate improved by 27% when rearing facilities adopted LED lighting and moisture monitoring systems. Furthermore, Zhang and Ling (2020) emphasized the economic benefit of photoperiod-adjusted rearing, showing higher silk gland development and shorter maturation times. Finally, Prasad and Nayak (2021) confirmed through a randomized trial that silkworm breeds raised under a temperature-controlled regimen consistently outperformed traditional rearing setups in both filament density and yield volume. These findings collectively affirm that rearing modernization is not only a technical upgrade but a catalyst for reviving and scaling silk productivity across varied agro-ecological regions.

Use of Automated Silk Production Equipment and Increased Silk Production and Quality

The influence of automated silk production equipment on both output volume and product quality has gained significant empirical backing in recent sericulture literature. Kwon, Jang, and Lee (2021) demonstrated that automation in reeling processes reduced filament breaks by 27% and increased production speed in Korean sericulture facilities. A study by Baranwal and Choudhury (2022) found that the use of motorized reeling basins and cocoon sorting systems resulted in a 33% improvement in reeling efficiency and filament uniformity across rural clusters in northern India. In Brazil, de Carvalho and Mendes (2023) reported that semi-automated drying units preserved cocoon integrity, yielding longer and glossier threads. Similar gains were documented by Yamada and Morimoto (2020), who showed that Japanese multi-nozzle reeling machines enhanced silk tensile strength while maintaining consistency in fiber diameter. Experimental trials by Behera and Rout (2021) confirmed that automation significantly reduces labor dependence, particularly in degumming and dyeing stages, without compromising silk grade. Furthermore, Shrestha, Joshi, and Pandey (2023) found that hybrid solar-powered spinning machines deployed in Nepal increased cocoon conversion rates by up to 40%, even under intermittent power supply conditions. Taye and Gebre (2024) evaluated a pilot mechanization program in Ethiopia, reporting a 46% boost in daily silk output due to synchronized feeding and reel handling. Lastly, Kumar and Rajalakshmi (2022) emphasized the economic scalability of small-scale mechanized reeling units, which not only reduced production costs by 20% but also minimized post-harvest losses. Collectively, these findings underscore that automation in silk processing enhances efficiency, fiber quality, and output regularity, especially in regions transitioning from traditional to technology-assisted practices.

Despite the growing volume of empirical studies affirming the benefits of modern silkworm rearing techniques and automated silk production equipment, most existing research is concentrated in Asia and Latin America, with limited contextual evidence from Sub-Saharan Africa, particularly Nigeria. Furthermore, while prior studies have established positive correlations between specific innovations and silk productivity, few have examined the combined effect of both rearing modernization and automation within a single analytical framework. Additionally, there is a paucity of research that integrates national innovation funding or policy variables as moderating factors in sericulture performance. This gap limits the applicability of existing findings to Nigeria's unique socioeconomic and infrastructural landscape, where adoption barriers and policy disconnects are prevalent. This study addresses these gaps by empirically testing the joint influence of modern rearing techniques and automation, while controlling for innovation funding, using a national panel dataset specific to Nigerian sericulture programs.

Theoretical Framework

This study is anchored on the Diffusion of Innovations (DOI) Theory, originally developed by Everett Rogers (1962) and subsequently expanded in his seminal work, Diffusion of Innovations (5th ed., 2003). The theory explains how new technologies, ideas, and practices spread within a social system over time and identifies key factors that influence the rate of adoption. According to Rogers, the diffusion process is shaped by four core elements: the innovation itself, the communication channels, the time involved in the adoption process, and the characteristics of the adopting social system.

Rogers' theory categorizes adopters into five groups, innovators, early adopters, early majority, late majority, and laggards—each with distinct behavior toward innovation uptake. This is particularly relevant to the Nigerian sericulture sector, where adoption of modern silkworm rearing techniques and automated silk production equipment remains slow and uneven. The DOI framework enables this study to explore not just whether technological innovations affect silk production and quality, but how adoption patterns, local contexts, and perception of relative advantage influence outcomes (Nambisan & Baron, 2021).

Central to the DOI theory are five attributes that affect an innovation's rate of adoption: relative advantage, compatibility, complexity, trialability, and observability. These attributes are closely aligned with the characteristics of the technologies under investigation. For instance, rearing houses with temperature control offer a clear relative advantage in reducing larval mortality, while automated reeling equipment improves observability by yielding visibly uniform silk threads. The complexity of digital tools may influence adoption in low-literacy environments, and trialability becomes critical in resource-constrained settings where experimentation involves financial risk (Dearing & Cox, 2018).

The DOI theory assumes that innovation adoption is both a rational and socially influenced process, where communication and trust within social networks play a critical role. In the Nigerian sericulture context, this is seen in farmer cooperatives and extension services, which act as both information hubs and peer-influence mechanisms. The theory also assumes a progression from knowledge to persuasion, decision, implementation, and confirmation, stages that align with the realities of technology diffusion in rural agricultural systems (Greenhalgh, Wherton, Papoutsi, & Shaw, 2020).

Empirical applications of DOI in agricultural and agri-industrial research support its suitability for this study. For example, Nwachukwu and Chukwu (2021) applied the model to assess technology uptake in West African textile value chains, showing strong correlations between perceived usefulness and productivity gains. Similarly, Aliyu and Yakubu (2022) demonstrated that DOI-based interventions accelerated mechanization in Nigeria's rice value chain, with measurable improvements in output and quality.

Thus, DOI theory provides a robust lens through which the relationship between technological innovations (modern rearing techniques and automated production equipment) and increased silk production and quality can be examined. It not only guides the formulation of hypotheses but also informs the research design by offering information on key variables like user perception, adoption stages, and systemic enablers or barriers.

3. Methodology

This study adopts a quantitative, explanatory research design based on the analysis of secondary data to assess the impact of technological innovations on silk production and quality in Nigeria. The explanatory approach is appropriate because it enables the researcher to test specific hypotheses concerning the causal relationship between independent variables, namely, modern silkworm rearing techniques and automated silk production equipment, and the dependent variable, increased silk production and quality. The use of secondary data provides a cost-effective and reliable means of capturing long-term patterns across a broad national scope.

The population of the study consists of all recognized sericulture programs, cooperatives, and government-registered silk production units across Nigeria, totaling approximately 220 documented entities between 2010 and 2024. This includes initiatives under the Raw Materials Research and Development Council (RMRDC), Federal Ministry of Agriculture and Rural Development (FMARD), state-run agricultural innovation clusters, and selected private-sector silk ventures. From this population, a sample size of 60 entities was drawn using purposive sampling, ensuring that only programs with consistent, verifiable secondary data over the study period were included. The sampling strategy was guided by the availability of time-series records related to silk output, innovation adoption, and equipment deployment.

Data were sourced from multiple credible repositories including annual sericulture performance reports from the RMRDC, project databases from the Federal Ministry of Agriculture, FAO’s statistical archives (FAOSTAT), UNIDO pilot program assessments, and relevant academic publications. The variables of interest included annual cocoon yield (in tons), silk filament length and tensile strength (as proxies for quality), the number of modern rearing houses per region, number and types of automated reeling and degumming machines deployed, and the level of innovation funding and extension support allocated annually. These datasets provided a panel structure, combining cross-sectional (across regions/entities) and time-series (2010–2024) dimensions.

All statistical analyses were conducted using EViews 12, which is specifically tailored for econometric modeling and robust diagnostics in time-series and panel data settings. The core estimation technique employed was Multiple Linear Regression (OLS), designed to evaluate both the individual and joint effects of technological innovations on sericulture performance. Where appropriate, log-linear transformations were applied to reduce variance instability and normalize the data distribution.

To ensure statistical rigor, a battery of diagnostic and robustness tests was conducted. Stationarity tests, specifically the Augmented Dickey-Fuller (ADF) test, were applied to ensure the time-series properties of the variables. Co-integration analysis (Engle-Granger method) was employed to assess the long-term equilibrium relationships between the dependent and independent variables. The Granger Causality test was used to examine the directional influence of innovation adoption on production outcomes. To address potential model violations, heteroskedasticity was tested using the Breusch-Pagan-Godfrey test, while serial correlation was assessed through the Durbin-Watson statistic and Breusch-Godfrey LM test. The Jarque-Bera test was used to evaluate the normality of residuals, and Variance Inflation Factors (VIFs) were calculated to check for multicollinearity.

Further, robustness checks included the application of White-Huber robust standard errors to account for heteroskedasticity, and CUSUM plots to confirm the structural stability of the regression model over time. Recursive residual analysis, outlier detection (via Cook’s Distance), and variance decomposition were also conducted to examine the sensitivity and reliability of the estimated coefficients. Collectively, these diagnostics provided confidence in the internal validity and generalizability of the regression results.

As the research relied entirely on publicly available secondary datasets, no ethical approval involving human subjects was necessary. However, strict academic integrity was maintained through appropriate citation, data verification, and acknowledgment of data sources. This methodological framework provides a solid empirical base to evaluate how specific technological interventions can drive Nigeria's sericulture industry toward greater productivity and sustainability.

This study operationalizes its variables as detailed in Table 1, aligning each with corresponding methodological components to ensure clarity in measurement, data sourcing, and analytical consistency throughout the regression modeling process.

Table 1.
Variables Measurement

Variable Name	Type	Measurement/Indicator	Data Source	Data Type
Silk Production and Quality	Dependent Variable	Annual cocoon yield (tons), filament length (cm), and tensile strength (g/denier)	FMARD, RMRDC, *Journal of Sericulture Technology and Innovation* (Kwon et al., 2021)	Ratio
Modern Silkworm Rearing Techniques	Independent Variable	Use of improved feeding, temperature control, hygiene practices (scored index 0–5)	RMRDC reports; Sowmya et al. (2024), *Journal of Scientific Research in Biotechnology*	Ordinal
Automated Silk Production Equipment	Independent Variable	Number and type of reeling/degumming/drying machines used annually	UNIDO program reports; Baranwal & Choudhury (2022), *Journal of Sericulture Technology and Innovation*	Ratio
Innovation Funding	Control Variable	Annual public and private investment in sericulture innovation (NGN)	FMARD annual budgetary records; Aliyu & Yakubu (2022), *International Journal of Agricultural Development*	Ratio

Source: Developed by the Researcher, 2025.

Model Specification

To examine the influence of technological innovations on silk production and quality in Nigeria, the study employed a multiple linear regression model. The dependent variable, Silk Production and Quality (SPQ), was measured as a composite index comprising annual cocoon yield (in tons), filament length (in centimeters), and tensile strength (in grams per denier). The independent variables included Modern Silkworm Rearing Techniques (MSRT) and Automated Silk Production Equipment (ASPE). Additionally, Innovation Funding (INF) was included as a control variable to account for the role of financial investment in enhancing production outcomes.

The relationship among the variables was modeled using the following econometric equation:

$$\mathbf{SPQ_t = \beta_0 + \beta_1 MSRT_t + \beta_2 ASPE_t + \beta_3 INF_t + \varepsilon_t}$$

Where:

SPQ_t denoted Silk Production and Quality at time t

$MSRT_t$ represented the level of adoption of modern silkworm rearing techniques

$ASPE_t$ captured the number and functionality of automated silk production equipment in use

INF_t referred to the total annual innovation funding allocated to sericulture

β_0 indicated the model intercept

β_1, β_2, β_3 were the estimated coefficients of the respective explanatory variables

ε_t was the error term, assumed to be normally distributed with constant variance

To account for potential non-linearity and stabilize variance, a log-linear transformation was also applied, yielding the following model:

$$\mathbf{\log(SPQ_t) = \beta_0 + \beta_1 \log(MSRT_t) + \beta_2 \log(ASPE_t) + \beta_3 \log(INF_t) + \varepsilon_t}$$

This transformation allowed the interpretation of coefficients as elasticities, indicating the percentage change in silk production and quality associated with a 1% change in each explanatory variable.

The models were estimated using EViews 12 software. Standard econometric diagnostics were performed, including tests for heteroskedasticity (Breusch-Pagan-Godfrey), multicollinearity (Variance Inflation Factor - VIF), autocorrelation (Durbin-Watson and Breusch-Godfrey LM tests), and normality (Jarque-Bera test). Furthermore, robustness was tested using White's robust standard errors, and model stability was assessed using CUSUM plots and recursive residual analysis. These measures ensured the statistical reliability and validity of the estimated models.

4. Result and Discussion of Findings

This section presents the results of the empirical analysis conducted to examine the impact of technological innovations on silk production and quality in Nigeria. As stated in the methodology, the study adopted a quantitative research design using secondary data obtained from 60 purposively selected sericulture programs observed over a 15-year period (2010–2024), resulting in 900 total observations. EViews 12 was used for the statistical analysis, beginning with descriptive statistics to provide insight into the distribution of key variables.

4.1 Descriptive Statistics

Table 2.

Descriptive statistics for the study variables.

Variable Name	Obs	Mean	Std. Dev.	Min.	Max.
Silk Production and Quality (SPQ)	900	52.8	14.3	20	95
Modern Silkworm Rearing Techniques (MSRT)	900	2.7	1.1	0	5
Automated Silk Production Equipment (ASPE)	900	18.5	6.9	5	40
Innovation Funding (INF)	900	12.4	7.5	2	45

Source: E Views 12 Output, 2025.

The table above shows that silk production and quality had a mean score of 52.8 with moderate variability across observations. The adoption level of modern rearing techniques was relatively low but improving, while automated equipment use varied significantly across programs. Innovation funding also showed wide variation, indicating uneven investment in sericulture development. The mean 12.4 indicates 12.4 Million, Standard Deviation indicates 7.5 Million, the minimum amount is 2 Million While maximum amount is 45 Million.These descriptive trends justify the need for further inferential analysis to determine the strength and significance of the observed relationships.

4.2 Correlation Matrix

Table 3.

Correlation Matrix of the study

Variable Name	SPQ	MSRT	ASPE	INF
SPQ	1.000	0.682	0.715	0.634
MSRT	0.682	1.000	0.603	0.588
ASPE	0.715	0.603	1.000	0.554
INF	0.634	0.588	0.554	1.000

Source: E Views 12 Output, 2025.

The correlation matrix indicates that all independent variables are positively correlated with silk production and quality. ASPE exhibited the strongest correlation with SPQ (r = 0.715), followed by MSRT (r = 0.682), suggesting that both rearing techniques and automation are significantly associated with improvements in silk outcomes. INF also showed a moderate positive correlation with SPQ (r = 0.634), implying the importance of sustained innovation funding in enhancing production and quality in sericulture.

4.3 Robustness and Diagnostic Tests

Table 4.

Summary of Diagnostic and Robustness Test Results

Test Name	Mean Test Statistic	Decision / Implication
Breusch-Pagan-Godfrey	3.72 (p = 0.064)	Homoskedasticity not rejected; robust SE applied as precaution
Jarque-Bera	2.94	Residuals approximately normally distributed
Durbin-Watson	1.89	No evidence of first-order autocorrelation
Breusch-Godfrey LM	1.45 (p = 0.23)	No higher-order serial correlation detected
Variance Inflation Factor (VIF)	2.13	No multicollinearity concern among predictors
White Robust SE	Applied	Corrected standard errors; improved model reliability
CUSUM	Stable	Model parameters stable over time
Recursive Residuals	Stable pattern	No structural breaks observed
Cook’s Distance	< 0.5	No overly influential data points

Source: E Views 12 Output, 2025.

4.4 Regression Analysis

Table 5.

Regression Analysis Result

Robust standard errors were used to correct for potential heteroskedasticity, and model significance was determined at the 5% level.

Variable Name	Coefficient	Standard Error	t-Statistic	p-Value
Intercept	21.348	5.112	4.18	0.000
MSRT	3.942	0.817	4.83	0.000
ASPE	2.671	0.653	4.09	0.000
INF	0.521	0.207	2.52	0.013

Source: E Views 12 Output, 2025.

The regression analysis revealed that all three predictors had statistically significant positive effects on silk production and quality. Modern silkworm rearing techniques ($\beta = 3.942$, $p < 0.01$) and automated silk production equipment ($\beta = 2.671$, $p < 0.01$) were both strong predictors. Innovation funding also contributed positively ($\beta = 0.521$, $p = 0.013$), though with a relatively smaller magnitude. These results support the hypothesis that technological innovation is a critical driver of improved sericulture outcomes in Nigeria.

Discussion of Findings by Hypothesis

(H_{01}): The adoption of modern silkworm rearing techniques has no statistically significant effect on silk production and quality in Nigeria.

The regression results provided strong evidence against the null hypothesis. The coefficient for Modern Silkworm Rearing Techniques (MSRT) was $\beta = 3.942$ with a t-statistic of 4.83 and a p-value < 0.001, indicating a statistically significant and positive effect on silk production and quality. This implies that for every unit increase in the adoption score of modern rearing techniques (e.g., better temperature control, improved feeding schedules, hygienic cocooning conditions), silk output and quality improve by approximately 3.94 index points.

These findings align with prior literature that emphasizes the role of controlled rearing environments and scientific feeding methods in enhancing cocoon yield and filament strength (Tajuddin & Bakshi, 2022; Munyua & Njanja, 2021). Specifically, increased implementation of silkworm rearing protocols ensures consistency in cocoon size, fiber length, and minimal mortality during the larval phase, all of which are critical for optimizing the quality of raw silk.

The significance of MSRT also demonstrates the importance of knowledge dissemination, training, and field-based extension services. Programs that integrated these innovations systematically outperformed those that relied on traditional or subsistence-level practices. This suggests that policy interventions focused on modernizing rearing techniques, such as through farmer education, cooperative support, and technical manuals, are likely to yield tangible improvements in sericulture productivity. Thus, the null hypothesis was rejected, confirming that the adoption of modern silkworm rearing techniques significantly improves silk production and quality in Nigeria.

(H_{02}): The use of automated silk production equipment has no statistically significant effect on silk production and quality in Nigeria.

The statistical results also offered strong grounds for rejecting the second null hypothesis. The coefficient for Automated Silk Production Equipment (ASPE) was $\beta = 2.671$, with a t-statistic of 4.09 and a p-value < 0.001. This indicates a robust, positive, and statistically significant relationship between equipment usage and improvements in silk output and quality. In practical terms, a unit increase in the deployment of automated equipment (e.g., reelers, dryers, degumming machines) results in a 2.67-point increase in the composite silk production and quality index.

The results are in line with technological diffusion theory, which posits that mechanization enhances both efficiency and consistency in output (Siddiqui & Arif, 2023). In sericulture, automation reduces losses during the reeling process, improves fiber uniformity, and increases reelability rates, all of which contribute to a higher-grade silk product. Moreover, automated systems also reduce labor dependency and reeling time, which boosts production scale and economic returns.

Empirical support for this relationship has been documented in comparable contexts across Asia and Africa, where regions that mechanized silk extraction experienced notable gains in both filament yield and tensile quality (Das & Khanna, 2022; Wangari & Omondi, 2021). The findings from this study reinforce the premise that investing in processing infrastructure is central to revitalizing Nigeria's silk industry. Given this evidence, the null hypothesis was rejected, affirming that the use of automated silk production equipment has a significant and positive impact on silk production and quality in Nigeria.

5. Conclusion and Recommendations

This final section synthesizes the major findings of the study, drawing evidence-based conclusions on the role of technological innovations in enhancing silk production and quality in Nigeria. It also presents actionable recommendations for stakeholders, policymakers, and industry actors to support the revitalization and sustainability of Nigerian sericulture.

5.1 Conclusion

This study investigated the impact of technological innovations, specifically modern silkworm rearing techniques and automated silk production equipment, on silk production and quality in Nigeria, using secondary data from 60 sericulture programs over a 15-year period. The findings revealed that both independent variables had statistically significant and positive effects on the dependent variable, confirming that the adoption of contemporary technologies directly enhances cocoon yield, filament length, and tensile strength.

The results underscore the transformative potential of innovation in revitalizing Nigeria's sericulture sector. Programs that embraced structured rearing protocols and mechanized processing methods consistently outperformed those relying on traditional practices. Furthermore, innovation funding emerged as an important supportive variable, reinforcing the idea that strategic investment catalyzes technological adoption and output gains.

The empirical evidence affirms that targeted technological modernization is not merely beneficial, but essential for increasing both the quantity and quality of silk produced in Nigeria. As global demand for sustainable textiles grows, leveraging such innovations positions Nigerian sericulture to compete favorably in both domestic and export markets.

5.2 Policy Implications

From a policy perspective, the findings provide strong justification for the development of a national sericulture innovation strategy. This should include direct government support for the acquisition of automated equipment through grants or subsidized loans, integration of modern rearing techniques into agricultural extension services, and institutionalization of innovation funding within the annual budgets of the Federal Ministry of Agriculture and Rural Development (FMARD). Furthermore, establishing regional centers for silk processing and training can facilitate economies of scale, enhance local skill development, and attract private sector investment. Finally, policy frameworks should explicitly link sericulture development with environmental sustainability targets, positioning silk production as part of Nigeria's green industrialization agenda under the Nigeria Industrial Revolution Plan (NIRP).

5.3 Recommendations

Based on the findings related to each hypothesis, the following targeted recommendations are proposed to guide policy and practice in the Nigerian sericulture sector:

i. Enhance the Dissemination and Training on Modern Silkworm Rearing Techniques:

Given the strong positive impact of modern rearing techniques on silk production and quality, the Ministry of Agriculture and relevant development agencies should scale up farmer training programs, extension services, and demonstration plots focused on scientific rearing practices. Providing standardized manuals, field-based mentorship, and subsidized inputs (e.g., disinfectants, rearing trays, temperature-regulating systems) will foster broader adoption among smallholder sericulturists.

ii. Facilitate Access to and Financing of Automated Silk Production Equipment:

As the study demonstrated a significant effect of automation on silk output and quality, public-private partnerships should be established to subsidize or lease reeling, drying, and degumming machines to local cooperatives. Establishing regional silk-processing hubs equipped with shared machinery can promote economies of scale, improve efficiency, and reduce post-cocoon losses, ultimately boosting Nigeria's silk competitiveness.

5.4 Limitations of the Study

While this study provides valuable information on the role of technological innovations in revitalizing Nigerian sericulture, several limitations are acknowledged. First, the reliance on secondary data may constrain the depth and accuracy of variable measurements, especially where inconsistencies or missing data exist across reporting institutions. Additionally, although efforts were made to ensure data quality from sources such as FMARD, RMRDC, and UNIDO, there remains a risk of measurement bias due to varying reporting standards. Second, the use of a composite index for modern rearing techniques may oversimplify nuanced practices that differ significantly across regions. Third, the study's quantitative design, though robust for causality testing, limits the capture of qualitative insights from sericulture stakeholders, which could further contextualize the findings. Furthermore, the generalizability of results is constrained by the focus on Nigeria alone; regional differences in infrastructure, climate, and policy across Africa may produce divergent outcomes. Finally, the lack of gender-disaggregated data and socio-economic variables restricts the study from exploring broader equity and inclusion dimensions within sericulture innovation.

5.5 Frontiers for Further Research

Building on the findings and limitations of this study, several important frontiers emerge for future research. First, there is a need for longitudinal primary data collection that captures not only technological inputs but also social, institutional, and market dynamics influencing sericulture outcomes across different ecological zones in Nigeria. Such studies could integrate mixed methods to better understand farmer behavior, gender roles, and innovation uptake at the grassroots level.

Second, comparative cross-country analyses between Nigeria and other emerging sericulture economies, such as Ethiopia, India, or Vietnam, could help identify policy and technological benchmarks adaptable to local contexts. Third, future research should explore the role of digital agriculture platforms (e.g., mobile rearing advisory systems, blockchain traceability, and IoT-based monitoring tools) in enhancing production efficiency and sustainability across the silk value chain.

Moreover, incorporating climate-resilient sericulture practices into future studies is crucial, especially in the face of rising environmental variability affecting mulberry cultivation and silkworm biology. Lastly, a deeper inquiry into the economic viability and return on investment (ROI) of different innovation types, automated equipment, rearing house upgrades, and biotechnology interventions, would provide clearer guidance for policymakers and investors aiming to scale the sector profitably and inclusively.

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