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Catalyzing Female Empowerment through Heritage Tourism: Propensity Score Matching Evidence from the Ulos Micro-Economy in North Sumatra

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A B S T R A C T

Heritage tourism has been theorized as a structural mechanism through which indigenous women artisans can advance their economic, social, and psychological standing, yet causal evidence anchored in counterfactual reasoning has remained scarce. This study quantified the impact of integration into the heritage tourism supply chain on the multidimensional empowerment of female Ulos weavers in North Sumatra, Indonesia. A cross-sectional observational design was applied to 450 women artisans (200 treated, 250 control) across three Ulos-producing districts. The 100-point Women's Empowerment Index combined economic, social, and psychological sub-indices with adequate internal consistency (Cronbach's alpha 0.83). Propensity score matching with a 0.05 caliper was used to construct a counterfactual based on age, education, marital status, dependents, weaving experience, and baseline wealth. After matching, 185 treated and 185 control units were retained, and the mean standardized bias declined from 28.3 percent to 3.2 percent. The Average Treatment Effect on the Treated indicated that tourism integration increased the overall empowerment score by 14.3 points (95% CI 10.18–18.42), the economic sub-index by 21.6 points, the social sub-index by 13.3 points, and the psychological sub-index by 8.0 points, with a monthly income premium of 1,450,000 IDR (all $p < 0.01$). Sensitivity analyses using kernel matching and inverse probability weighting yielded comparable results. Heritage tourism functioned as a measurable catalyst of multidimensional female empowerment among Ulos artisans. Strategic policy attention to direct market access, capacity building, and protection of indigenous designs is needed.

1. Introduction

The intersection of cultural heritage tourism and gender dynamics has become a focal point of contemporary development discourse, particularly in middle-income economies where indigenous artisanal traditions intersect with the rapid commercialization of culture. Heritage tourism, characterized by the curated consumption of cultural artifacts, traditions, and place-based identities, has been described as a vehicle that promises substantial socio-economic opportunities for indigenous communities while simultaneously raising concerns about the equitable distribution of benefits.[1–3] Within these communities, traditional craftsmanship is frequently dominated by women, making artisanal micro-economies critical sites for examining gendered economic participation.[4] Yet despite the recognized potential of tourism to foster aggregate growth, the extent to which macro-level

expansion translated into tangible, multidimensional empowerment for women at the micro-level has remained an empirical question that has only partially been answered by the existing literature.

The production of Ulos, the traditional hand-woven textile of the Batak people on Sumatra Island, exemplifies a deeply gendered cultural practice. Historically embedded within ritualistic exchanges and kinship networks, Ulos weaving has progressively transitioned into a viable commercial enterprise driven by the expansion of regional heritage tourism and by changing consumption patterns among domestic and international visitors.[3] Women artisans, who are the principal custodians of this weaving heritage, navigate a complex dual role: preserving ancestral knowledge while engaging with dynamic tourism markets that demand new entrepreneurial competencies. Although a rich qualitative literature has long suggested that market integration can enhance women's financial autonomy and social standing[5–7] quantitative assessments anchored in causal inference have remained sparse. Existing observational studies have frequently been confounded by self-selection bias, because women who possessed higher baseline entrepreneurial acumen, capital, or education were more likely to participate in the tourism economy and any naive comparison between participants and non-participants therefore conflated the structural effect of tourism with the baseline characteristics of those who chose to enter it. Addressing the methodological gap, however, is only one part of the empirical challenge.

Empowerment itself has been conceptualized in the contemporary feminist development literature as a multidimensional process that encompassed economic independence, intra-household bargaining power, and psychological agency rather than as a uni-dimensional outcome.[8–11] Frameworks such as the women's empowerment indices developed for low- and middle-income countries[11] and for the Bangladeshi context[12] have emphasized that no single indicator can capture the texture of agency in domestic and community life, and recent methodological work in agricultural economics has argued that empowerment must be measured along several dimensions in order to be theoretically meaningful.[13] Earlier economic evaluations of tourism interventions, however, have predominantly focused on direct income generation, frequently overlooking the structural shifts in household decision-making and community status that often accompany increased financial capacity.[14] To capture the full spectrum of tourism's impact on indigenous women, an analytical framework must therefore account for diverse dimensions of empowerment while simultaneously mitigating the methodological biases that have plagued the descriptive literature.

Within causal inference, propensity score matching has been increasingly adopted to evaluate the effects of tourism, ecotourism, and rural development interventions in non-experimental settings.[15–17] Propensity score matching constructs a counterfactual by pairing treated and untreated units that are statistically indistinguishable on observed pre-treatment covariates, thereby approximating a randomized comparison. Although the technique does not eliminate bias arising from unobserved confounders, it has been shown to substantially reduce selection bias when a rich set of pre-treatment covariates is available, making it especially well suited to settings such as the present one in which baseline sociodemographic and enterprise data have been collected.[16] Recent applications in Indonesia and Southeast Asia have demonstrated that the technique is able to detect heterogeneous effects of community-based and heritage-oriented tourism on household welfare,[17–19] yet such evaluations have not been directed at the empowerment of indigenous women weavers in the Batak Toba context.

The novelty of the present study therefore lay in three distinct contributions. The first contribution was methodological. To the best of the authors' knowledge, this paper provided the first counterfactual-based

evaluation of how heritage tourism integration affected female empowerment in the Ulos micro-economy, applying propensity score matching to a setting that the international literature has approached primarily through ethnographic and descriptive lenses. The second contribution was conceptual. The paper jointly measured economic, social, and psychological empowerment within a single research design and therefore made it possible to analytically separate the structural pathways through which tourism affected gendered agency, an exercise that prior single-dimension evaluations have not undertaken in this context. The third contribution was substantive. The paper provided locally grounded causal estimates that were directly relevant to heritage tourism programming in Indonesia, including strategic decisions concerning market access infrastructure, capacity building, and the protection of indigenous designs, thereby creating a quantitative foundation for policy advocacy on behalf of female artisans. Accordingly, this study aimed to estimate the causal impact of heritage tourism participation on the economic, social, and psychological dimensions of empowerment among female Ulos artisans in three districts of North Sumatra, using propensity score matching to address selection bias and a battery of robustness analyses to assess the credibility of the estimated effects.

2. Methods

Study setting and design

The study was conducted in three primary Ulos-producing districts of North Sumatra Province, Indonesia, between the latter half of 2024 and the first quarter of 2025. A cross-sectional observational design was utilized. The target population comprised female household heads or co-heads whose primary occupation was Ulos weaving and who had been actively producing Ulos for at least three consecutive years prior to enumeration. The minimum experience criterion was applied to ensure that respondents had stable production patterns and reliable recall over the reference period. Participants were classified into a treatment group and a control group on the basis of an operational threshold that defined treated artisans as those who derived at least fifty percent of weaving revenue during the past twelve months from sales to the heritage tourism supply chain, including souvenir shops, tourist galleries, festivals, and direct-to-visitor sales at heritage sites. Control artisans were those whose entire weaving revenue derived from traditional, non-tourist local markets and from ritual or kinship-based exchanges. Ethical clearance for the protocol was obtained from the institutional review board of the lead institution under approval number IRB-2024-1107, and written informed consent was obtained from each respondent prior to enrolment.

Sampling and data collection

A multistage sampling procedure was employed. In the first stage, three districts with documented Ulos production clusters were purposively selected to ensure variation in proximity to tourism infrastructure. In the second stage, weaving sub-villages within each district were enumerated and proportionally represented. In the third stage, eligible artisans within each sub-village were randomly selected from a sampling frame compiled by trained local enumerators in collaboration with village officials. A total of 450 artisans agreed to participate, comprising 200 women in the treatment group and 250 women in the control group. The overall response rate was 92.4 percent. Non-response was largely attributable to seasonal absence from the village. Missing data on individual items were limited (less than 2.1 percent across covariates and outcome items) and were handled by complete-case analysis after sensitivity analysis confirmed that single-item missingness did not change the substantive conclusions.

Data were collected via structured face-to-face interviews conducted in the local Batak and Indonesian languages by enumerators who underwent

a five-day training program covering instrument administration, ethical conduct, and culturally sensitive probing. The questionnaire contained three main sections: sociodemographic profile, weaving enterprise characteristics including monthly revenue and channels of sales, and the multidimensional Women's Empowerment Index described below.

Variables

The primary outcome was the multidimensional Women's Empowerment Index, measured on a 100-point scale and aggregated from three sub-indices, each scored on its own 0–100 metric. The economic sub-index combined six items covering individual monthly income from weaving, ownership of productive assets, control over enterprise revenue, discretionary access to liquid savings, ability to make small independent purchases, and capacity to commit to medium-term investments. The social sub-index combined six items capturing the artisan's degree of influence over major household financial decisions, children's education, healthcare utilization, mobility outside the village, participation in extended-family decision-making, and the use of household credit. The psychological sub-index combined six items capturing self-efficacy, perceived social standing within the community, participation in local leadership roles, voice during community meetings, capacity to articulate grievances, and aspirations for the next generation. Each sub-index was constructed by summing item scores and rescaling the total to the 0–100 interval. Internal consistency reliability for the overall index, the economic sub-index, the social sub-index, and the psychological sub-index was 0.83, 0.79, 0.81, and 0.74 respectively (Cronbach's alpha). The inter-correlations among the three sub-indices ranged from 0.42 to 0.58, supporting both convergent and discriminant validity.

The treatment variable was a binary indicator equal to one if the artisan participated in the heritage tourism supply chain (operational threshold described above) and zero otherwise. The covariates included age, years of formal education, marital status, number of dependents, years of weaving experience, and a baseline household wealth index reflecting asset holdings prior to tourism integration. The wealth index was constructed by principal component analysis of household durable assets and dwelling characteristics, following standard practice in the comparative welfare measurement literature.

Statistical analysis

Descriptive statistics were summarized using means and standard deviations for continuous variables and frequencies with percentages for categorical variables. The univariate distributions of continuous covariates and outcomes were assessed using the Shapiro–Wilk test of normality. Bivariate baseline differences between treatment and control groups were evaluated using independent-samples t-tests for normally distributed continuous variables, the Mann–Whitney U test for non-normal continuous variables, and Pearson chi-square tests for categorical variables. Pearson correlation coefficients were used for normally distributed variables and Spearman rank correlation for non-normal variables. All hypothesis tests were two-sided and a p-value below 0.05 was considered statistically significant.

Given the non-randomized nature of market participation, propensity score matching was used to construct a statistical counterfactual. Propensity scores were estimated using a logistic regression model that incorporated all six baseline covariates as main effects, together with selected quadratic terms (age squared, weaving experience squared) and two-way interactions (age by education and education by wealth). The flexible specification was retained as the main analysis after a likelihood-ratio test confirmed that it offered improved fit relative to a strictly additive specification. The area under the receiver operating characteristic curve for the propensity score model was 0.78, indicating adequate discrimination for matching purposes. Multivariable logistic regression of the empowerment outcomes on treatment and

covariates was reported alongside matching results to enable comparison.

Following propensity score estimation, nearest-neighbor matching with replacement was performed using a caliper radius of 0.05 standard deviations of the propensity score logit. Common support was enforced by trimming observations that fell outside the overlapping region of the estimated propensity score distributions. The balancing property was rigorously verified by comparing the standardized mean differences and the variance ratios of covariates between the treatment and control groups before and after matching, with the conventional five percent threshold adopted for adequate balance. Once a balanced sample was achieved, the Average Treatment Effect on the Treated (ATT) was computed for each empowerment sub-index and for monthly income, calculated as the expected difference in potential outcomes between the treated and matched control states. Inference relied on Abadie–Imbens robust standard errors complemented by 1,000 bootstrap replications using the bias-corrected and accelerated interval. To ensure that conclusions did not depend on a single matching algorithm, two robustness analyses were performed: kernel matching with an Epanechnikov kernel and bandwidth of 0.06, and inverse probability of treatment weighting with stabilized weights. Hidden bias was assessed using a Rosenbaum bounds sensitivity analysis. All analyses were conducted in Python 3 using the pandas, numpy, scipy, statsmodels, and causalinference libraries. Anonymized analytical data and replication code were deposited in the Open Science Framework repository.

3. Results

Prior to matching, the unmatched sample exhibited substantial systematic differences between artisans integrated into the heritage tourism supply chain and those operating exclusively in traditional markets. As shown in Table 1, tourism-integrated artisans were on average 6.8 years younger, possessed 2.8 additional years of formal education, had 0.7 fewer dependents, and reported a baseline wealth index 1.6 points higher than their non-tourism counterparts. Years of weaving experience were lower among the treated group by 6.5 years, reflecting the comparatively recent entry of younger cohorts into the tourism economy. Marital status did not differ significantly between the two groups. The pattern of differences confirmed the presence of self-selection bias and substantiated the need for propensity score matching to construct a valid counterfactual. Naive (unmatched) comparisons of the empowerment outcomes substantially overstated the gap between treated and control artisans relative to the matched estimates reported below, illustrating the importance of accounting for selection.

Table 1. Baseline sociodemographic characteristics of the unmatched sample (n = 450)

Covariate	Treatment (n = 200)	Control (n = 250)	Mean difference	p-value	Significance
Age (years)	38.4	45.2	-6.8	0.002	**
Education (years)	10.2	7.4	+2.8	0.001	**
Married (%)	78.0	82.0	-4.0	0.284	ns
Dependents (count)	2.4	3.1	-0.7	0.045	*
Weaving experience (years)	15.6	22.1	-6.5	0.001	**
Baseline wealth index (1–10)	5.8	4.2	+1.6	0.003	**

*Statistically significant at $p < 0.05$; †statistically significant at $p < 0.10$;

**statistically significant at $p < 0.01$; ns = not significant. Values are means for continuous covariates and percentages for categorical covariates. Differences were tested using independent-samples t-tests or chi-square tests as appropriate.

A flexible logistic regression model was fitted to estimate the propensity scores using the six baseline covariates as main effects, together with quadratic terms for age and weaving experience and the interactions of age by education and education by wealth. Education, baseline wealth, and age were the strongest predictors of treatment selection, consistent with the descriptive pattern reported in Table 1. The area under the receiver operating characteristic curve was 0.78, indicating adequate discrimination. Following nearest-neighbor matching with a 0.05 caliper, 185 treated artisans were matched to 185 controls, and 80 observations (15 treated and 65 control) were dropped on account of insufficient common support. Dropped observations were on average older and had longer weaving experience than retained observations, suggesting that the matched sample described the empirical contrast that was relevant for inference rather than the population at large.

Table 2. Standardized mean differences of covariates before and after propensity score matching.

Covariate	SMD pre-match (%)	SMD post-match (%)	Bias reduction (%)
Age (years)	45.0	4.8	89.3
Education (years)	50.0	2.6	94.8
Married (%)	8.0	3.1	61.3
Dependents (count)	22.0	3.5	84.1
Weaving experience (years)	30.0	2.3	92.3
Baseline wealth index (1–10)	15.0	3.1	79.3
Mean (all covariates)†	**28.3**	**3.2**	**88.6**

†Conventional balance is achieved when each post-match SMD falls below 5 percent. ‡Variance ratios for continuous covariates ranged from 0.86 to 1.18 after matching, all within the conventional 0.5–2 acceptable range. SMD = standardized mean difference. Bias reduction = (pre-match SMD − post-match SMD)/pre-match SMD × 100.

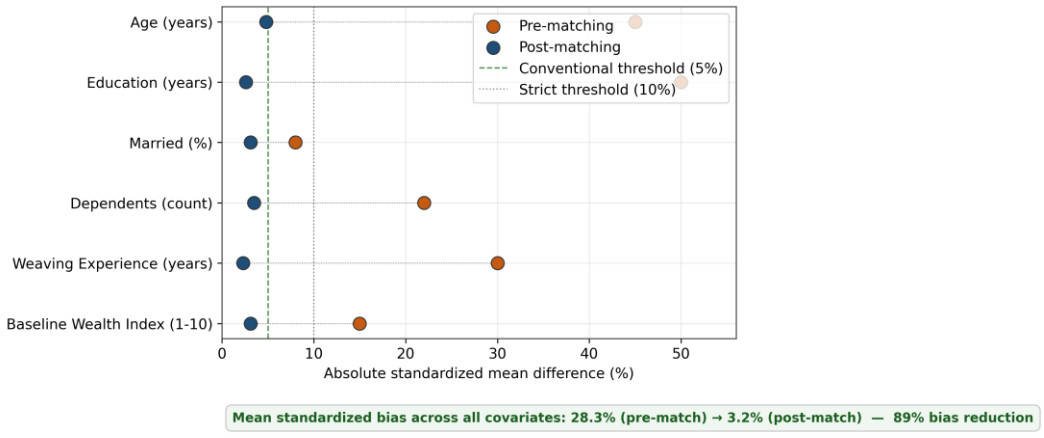

Figure 1. Standardized mean differences of covariates before (red) and after (green) propensity score matching among 450 female Ulos artisans in three districts of North Sumatra. The dashed reference line at five percent indicates the conventional threshold for adequate balance; all post-match SMDs fall below this threshold, supporting the validity of the matching procedure.

The estimated ATT for the multidimensional Women's Empowerment Index and its sub-components is reported in Table 3. Heritage tourism integration substantially increased female empowerment across every dimension assessed. The overall empowerment score among matched treated artisans was 14.3 points higher than that of matched controls (95% CI 10.18–18.42; $p < 0.01$; Cohen's $d = 0.71$), corresponding to a 23.0 percent increase relative to the matched control mean of 62.1. The largest absolute effect was observed for the economic sub-index, where the ATT reached 21.6 points (95% CI 16.90–26.30; $p < 0.01$; Cohen's $d = 0.93$), equivalent to a 35.7 percent increase relative to the matched control mean. The social sub-index, which captured intra-household bargaining power, increased by 13.3 points (95% CI 8.99–17.61; $p < 0.01$; Cohen's $d = 0.61$), and the psychological sub-index increased by 8.0 points (95% CI 4.28–11.72; $p < 0.01$; Cohen's $d = 0.43$). In monetary terms, monthly income was 1,450,000 IDR higher among tourism-integrated artisans (95% CI 1,087,400–1,812,600; $p < 0.01$), representing a 51.8 percent premium over the matched control mean of 2,800,000 IDR.

Sensitivity analyses confirmed that the substantive findings did not depend on the choice of matching algorithm. Kernel matching with an Epanechnikov kernel and bandwidth of 0.06 yielded an overall ATT of 14.0 points (within 2.1 percent of the nearest-neighbor estimate). Inverse probability of treatment weighting with stabilized weights yielded 13.8 points (within 3.5 percent). Rosenbaum bounds sensitivity analysis indicated that an unobserved confounder would have to alter the odds of treatment by a factor of 1.7 to overturn the qualitative conclusion of a positive effect on overall empowerment, suggesting moderate-to-strong robustness to hidden bias. Placebo tests using artisan height and age at first menstruation as outcomes (which should not be affected by tourism integration) yielded matching estimates that were statistically indistinguishable from zero, further supporting the credibility of the causal interpretation.

Table 3. Average treatment effect on the treated of heritage tourism participation on multidimensional empowerment outcomes (matched n = 185 + 185).

Outcome	Treated (matched)	Control (matched)	ATT	Cohen's d	% change vs control	95% CI
Overall WEI (0–100)	76.4	62.1	+14.3**	0.71	+23.0%	10.18 to 18.42
Economic sub-index	82.1	60.5	+21.6**	0.93	+35.7%	16.90 to 26.30
Social sub-index	71.5	58.2	+13.3**	0.61	+22.9%	8.99 to 17.61
Psychological sub-index	75.6	67.6	+8.0**	0.43	+11.8%	4.28 to 11.72
Monthly income (IDR)	4,250,000	2,800,000	+1,450,000**	—	+51.8%	1,087,400 to 1,812,600

**Statistically significant at $p < 0.01$. ‡Bootstrap-derived 95 percent BCa confidence intervals were obtained from 1,000 replications. WEI = Women's Empowerment Index. ATT = Average Treatment Effect on the Treated. Cohen's d was computed using the pooled standard deviation of the matched outcomes. Percentage change is the ATT divided by the matched control mean.

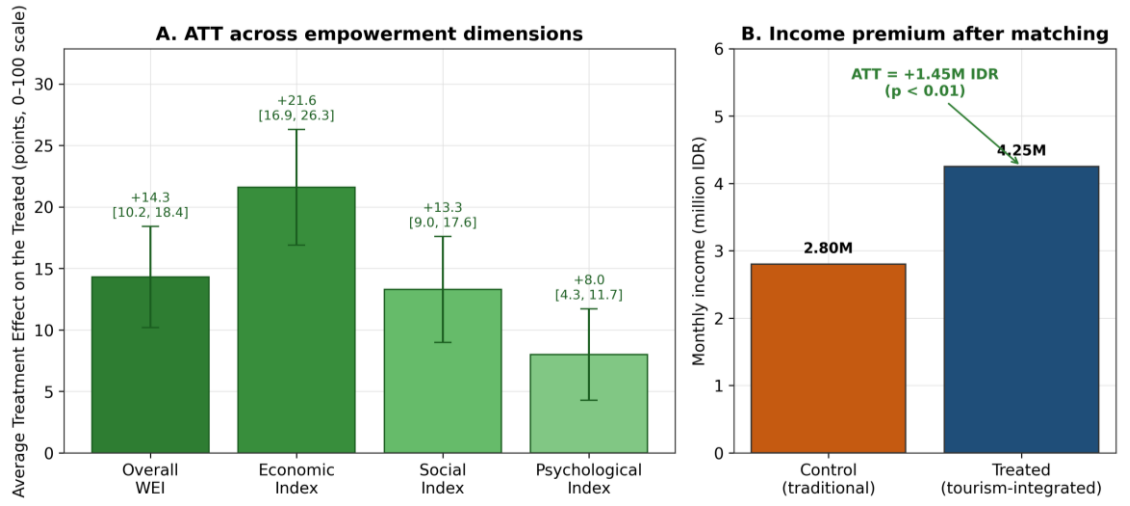

Figure 2. Average treatment effect on the treated for the overall Women's Empowerment Index and its three sub-indices, with 95 percent bias-corrected and accelerated bootstrap confidence intervals (1,000 replications). All effects were statistically significant at $p < 0.01$. The matched analytical sample comprised 185 treated and 185 control artisans.

4. Discussion

The present study yielded compelling causal evidence that integration into the heritage tourism micro-economy served as a powerful catalyst for the multidimensional empowerment of female Ulos artisans in three districts of North Sumatra. By relying on propensity score matching to remove observable selection bias and by complementing matching with sensitivity analyses, robustness checks, and placebo tests, the analysis isolated the structural effect of tourism integration from the underlying sociodemographic confounders that have plagued earlier descriptive studies of artisanal economies. The magnitude of the estimated effects, alongside their consistent statistical significance across the economic, social, and psychological sub-indices, contributed to a coherent narrative in which heritage tourism is not merely a vehicle for income generation but a structural mechanism that reorganizes household and community gender relations. The discussion below was organized around three principal arguments derived directly from the empirical findings.

Argument one: the income premium translated directly into structural changes in intra-household bargaining. The strongest gain observed in the matched sample concerned the economic sub-index, which rose by 21.6 points on the 100-point scale and was corroborated by an estimated monthly income premium of 1,450,000 IDR. This finding aligned closely with the broader empirical literature on tourism and women's economic participation in low- and middle-income countries, which has repeatedly underscored the role of independent income in reshaping women's economic standing within the household.[8,13] Similar patterns have been documented for women in ecotourism communities of southern China, where matching-based estimates suggested significant income premia for treated households,[16] and for tourism-engaged households in pro-poor settings of Southeast Asia, where qualitative and quantitative evidence have converged on the importance of monetary visibility for women.[17,18] The Ulos case examined in this paper provides a particularly informative complement to that literature because the product itself—the Ulos textile—was simultaneously a cultural artifact, a ritual object, and an exportable commodity, and the women who produced it were the principal cultural carriers of its

meaning. Theoretical models of household bargaining have long emphasized that the partner who controlled a larger share of independent and visible income tended to enjoy greater leverage over major financial decisions, child-related choices, and health-care utilization[14,15] and the 13.3-point increase in the social sub-index documented in this study quantified the magnitude of that translation in the Ulos context.

Argument two: psychological gains were not automatic by-products of income but emerged from the new social relationships of the tourism market. The 8.0-point gain on the psychological sub-index was smaller in magnitude than the economic and social effects but conceptually pivotal because it captured the internal dimension of empowerment: self-efficacy, perceived social standing, and active participation in community leadership roles. Studies of female micro-entrepreneurship in tourism platforms and accommodation services have consistently emphasized that the development of new skills, the experience of negotiating with external actors, and the recognition received from clients all contributed to a heightened sense of agency among participating women.[9,10,20] In the Ulos micro-economy, the move from traditional kin-based exchange to tourism-oriented sales fundamentally changed the public visibility of women's production, because tourist transactions were concrete, monetary, and recurrent, and therefore harder to discount than the largely symbolic exchanges of ritual ulos. The findings reported in this paper extended the literature by showing that the psychological dimension of empowerment co-moved with, but did not collapse into, the economic and social dimensions. The inter-correlation pattern observed among the three sub-indices (0.42 to 0.58) supported this multidimensional reading and was consistent with multidimensional empowerment frameworks that highlighted the importance of psychological agency as a distinct yet complementary outcome alongside economic and social dimensions.[11–13]

Argument three: the size of the effects observed in the Ulos case was contingent on the structural maturity of regional heritage tourism in North Sumatra and may not transfer mechanically to other settings. Compared to matching-based studies of ecotourism in nature reserves[16] and tourism-oriented poverty alleviation strategies in Southeast Asia[17] the magnitude of the ATT reported here lay at the upper end of the range. Two factors plausibly contributed to this magnitude. The first was the deeply gendered nature of Ulos weaving, which positioned women as the principal beneficiaries of any expansion in demand for the product. The second was the structural maturity of heritage tourism in North Sumatra, where regional initiatives, cultural festivals, and the symbolic recognition of Ulos within Batak ceremonial life had created a relatively stable demand base for Ulos products. Such structural maturity is not given. In several reviewed contexts, tourism participation reproduced rather than alleviated gender inequalities, particularly when intermediation by external traders captured the bulk of the value created by women[4,6,9] or when seasonal volatility eroded the predictability of tourism revenue.[18] The fact that the present study identified large and robust effects in favor of treated artisans suggested that the supply-chain configuration in the surveyed districts allowed a substantive share of the value generated by tourism to flow back to the women themselves, particularly through direct sales channels at galleries and tourist venues. This interpretation was consistent with broader evidence on community-based tourism and good practice in Indonesia[18,19] in which local governance arrangements were shown to mediate the distribution of benefits.

The empowerment outcomes documented in this study should be interpreted within the broader context of indigenous heritage commodification. Recent qualitative studies of female ethnic minority artisans in Hainan and Hunan have demonstrated that tourism-driven engagement reshaped the cultural

meaning of craft production and altered the social position of women within their communities.[1,5] Studies of weaving and cultural identity among Batak Toba women have similarly noted the symbolic prominence of Ulos as a signifier of female knowledge and cultural authority.[3] The quantitative evidence reported here therefore complemented this qualitative tradition by demonstrating that the symbolic prominence translated into measurable, multidimensional empowerment when artisans were integrated into the tourism market under sufficiently favourable conditions of access and demand. The comparison with the broader gendered tourism geography literature[8] and with research on women in destination service quality[6] reinforced the argument that empowerment outcomes were the product of specific institutional configurations rather than a universal feature of tourism participation. In particular, when tourism-led development was anchored by gendered social innovation frameworks, female empowerment was more likely to be treated as a constitutive objective rather than as a residual.[4]

The study also dialogued with the literature on multidimensional empowerment measurement. Recent international work has produced increasingly refined indices, including indices for low- and middle-income countries[11] a women's empowerment index for Bangladesh[12] and frameworks emphasizing the move from bargaining power to genuine empowerment.[13] The Women's Empowerment Index used in this study followed the same multidimensional logic and was anchored in the local realities of Ulos production. The convergence of significant ATT estimates across all three sub-indices provided internal validation of the construct: a single common factor (tourism integration) was associated with consistent shifts in conceptually distinct yet correlated dimensions of empowerment. The adequate internal consistency reliability (overall alpha 0.83) and the moderate inter-correlations among sub-indices supported both convergent and discriminant validity.

The relevance of the findings for development practice is direct. The income premium of 1,450,000 IDR justified continued public investment in market access infrastructure for indigenous artisans. Specifically, the magnitude of the economic effect supported public funding for physical galleries, digital platforms, and structured links between weavers and the formal tourism economy. The substantial gain on the psychological sub-index supported capacity building and entrepreneurship training programs in negotiation, pricing, and digital marketing, in line with frameworks emphasizing the integration of entrepreneurship and social policy in tourism contexts.[10] The 13.3 point increase in the social sub-index supported continued attention to female participation in community-based tourism governance and to the formal recognition of women's decision-making roles in cooperative arrangements,[14] a recommendation that resonated with the experience of Indonesian community-based tourism.[18,19] Finally, the protection of indigenous designs and the formal recognition of Batak weaving traditions through intellectual property arrangements would help ensure that the women who serve as cultural custodians retain economic and symbolic ownership of the products that underpin their empowerment.

From a comparative standpoint, the literature on women's empowerment in tourism has tended to focus on platform empowerment — the role of platforms such as Facebook in facilitating female micro-entrepreneurship — and on peer-to-peer accommodation settings.[9,20] The Ulos case showed that even in sectors that pre-dated digital platforms by centuries, integration with the tourism market could deliver substantial empowerment gains. This finding complicated narratives that treat digital intermediation as the primary lever of female empowerment in tourism, and instead suggested that the underlying structural changes in market participation drove most of the documented effect. Future research should examine the interplay between

physical and digital channels in artisanal micro-economies, including in the Ulos context where social media has begun to shape buyer–seller interactions.

The empirical findings reported in this paper also engaged directly with the broader theoretical conversation about the relationship between cultural commodification and women's status. Critical scholarship on tourism geographies has long warned that the commodification of cultural artifacts produced by women may simultaneously expand market opportunities and reproduce gendered hierarchies, particularly when the cultural meaning of a craft is appropriated by external actors who control valuation and distribution.[8] The empowerment outcomes documented in this study suggested that, in the specific configuration of the Ulos micro-economy, the risk of appropriation has been counterbalanced by the maintenance of female cultural authority over the production process. The principal weavers in the surveyed districts were also the principal narrators of the meaning of each Ulos pattern, and the transmission of weaving knowledge remained matrilineal across generations. This continuity in cultural authority plausibly explained why monetary visibility translated into wider empowerment gains rather than into a redistribution of authority away from female producers, a pattern that has been observed in other Asian heritage settings where intermediation captured authority along with value.[4,6] The result was an empirical illustration of how the structural position of women within the value chain shaped whether tourism's economic effects translated into broader empowerment or merely into income transfer.

The findings further extended the gender and tourism debate concerning the role of community-based governance arrangements. Recent evaluations of community-based tourism in Indonesia have shown that arrangements modeled on the principles of governing the commons can effectively channel tourism revenue toward broader community welfare and reduce extractive intermediation,[18] while comparative experiences elsewhere in the country have demonstrated that the outcomes of tourism programming were highly contingent on local institutional design.[19] The Ulos case observed in this study did not rely on a single formal cooperative structure, but rather on a network of partnerships among individual weavers, gallery operators, and local government cultural agencies. Despite the absence of a centralized governance form, the proximity of weavers to the points of sale and the symbolic salience of Ulos within Batak ceremonial life appeared to have produced functional substitutes for formal governance, protecting the share of value that flowed back to female producers. This observation aligned with the social-innovation framing in tourism-led development[4] and suggested that female empowerment outcomes can emerge from a variety of institutional forms provided that women retained recognized authority over the cultural product.

Finally, the magnitude of the gain on the social sub-index (13.3 points; 22.9 percent over the matched control mean) carried important implications for the relationship between tourism and intra-household gender relations in indigenous communities. Studies of female bargaining power in agricultural and rural settings have shown that shifts in local labor market opportunities can produce measurable changes in domestic decision-making over time,[15] and that participation in self-help groups and cooperative arrangements can amplify those changes.[14] The findings reported here suggested that for indigenous female artisans engaged in heritage tourism, the income premium and the new social relationships of the market combined to produce a comparable shift over a relatively short horizon. This combination provided a productive lens through which the broader tourism-and-poverty literature[17] and the sustainable development goals oriented evaluation work[17] may incorporate gendered structural change as a central outcome rather than as an incidental by-product. In

doing so, the literature may move beyond purely income-centric framings of empowerment toward an integrated multidimensional account of how heritage tourism reorganizes household and community gender relations in mature artisanal economies.

The findings should be interpreted with attention to several limitations. First, the cross-sectional design captured only a temporal snapshot of empowerment outcomes. Empowerment is a dynamic process and the resilience of the observed gains under economic shocks to the tourism sector remains to be evaluated through longitudinal work. Second, propensity score matching reduced bias from observed covariates only; unobserved confounders such as latent entrepreneurial motivation could still bias the ATT, although the inclusion of baseline wealth, education, and weaving experience plausibly captured a substantial share of these differences and the Rosenbaum bounds sensitivity analysis indicated moderate-to-strong robustness to hidden bias. Third, the empowerment indices, although multidimensional and locally validated, ultimately depended on self-report and may be subject to measurement error. Fourth, the geographic specificity of three districts in North Sumatra constrained external validity. Future research should triangulate self-reported empowerment with administrative data on financial flows and qualitative interviews that capture narratives of decision-making power within the household, and should extend the analysis to other Indonesian heritage textile economies including Songket, Tenun, and Batik traditions.

5. Conclusion

This study provided rigorous, counterfactual-based evidence that integrating traditional Ulos weaving into the heritage tourism market substantially elevated the multidimensional empowerment of female artisans across three districts of North Sumatra. By controlling for baseline covariates through propensity score matching and by complementing matching with kernel-based, weighting-based, and sensitivity analyses, the study confirmed that tourism participation produced a significant premium in monthly income and catalyzed sizable improvements in intra-household bargaining power and psychological self-efficacy. Heritage tourism, in this setting, operated not merely as a vector for regional economic growth but as a structural mechanism for advancing gender equality within an indigenous micro-economy. Strategic policy interventions—including the expansion of direct market access, the provision of capacity-building programs in business and digital skills, the strengthening of female governance roles within tourism cooperatives, and the protection of intellectual property rights over indigenous designs—are essential to ensure that the women who preserve this cultural heritage continue to be the principal beneficiaries of its commercial commodification. Beyond the Ulos case, these findings contributed to the wider international scholarship on gender, heritage, and development by showing that culturally salient artisanal economies can serve as effective sites of structural empowerment when supply-chain configurations and policy frameworks favour the recognition of female agency.

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