IOSR Journal Of Humanities And Social Science (IOSR-JHSS)
Volume 30, Issue 2, Series 1 (February, 2025) 67-76
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

Advanced Statistical Modelling In Archaeology: An SPSS-Based Approach To Data Interpretation

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Abstract:
Archaeology has increasingly embraced quantitative methods to analyze excavation data, artifact distributions, and cultural patterns. Among the various statistical tools available, the Statistical Package for the Social Sciences (SPSS) has emerged as a powerful and accessible platform for processing archaeological datasets, allowing researchers to perform descriptive, inferential, and multivariate statistical analyses. This paper explores how SPSS enhances data interpretation in archaeology, from summarizing excavation records to testing hypotheses about past human behaviors. It outlines key applications of SPSS, including Chi-Square tests for burial analyses, T-tests for artifact comparisons, and regression models for settlement pattern predictions. Additionally, it discusses multivariate techniques such as cluster analysis, principal component analysis (PCA), and discriminant analysis, which help classify artifacts, burial remains, and settlement structures. Several case studies are reviewed to illustrate the effectiveness of SPSS in identifying cultural patterns, technological shifts, and economic activities in the archaeological record. While SPSS provides robust statistical functionalities, it has limitations in handling spatial data and large-scale excavation records, necessitating integration with GIS and machine learning techniques for more advanced modeling. This study highlights both the strengths and challenges of using SPSS in archaeology and emphasizes its role in transforming raw excavation data into meaningful historical insights. The findings of this research contribute to the growing field of computational archaeology, demonstrating the importance of statistical approaches in refining our understanding of ancient societies.
Key Word: *Descriptive Statistics, Inferential Statistics, Multivariate Analysis, Artifact Classification, Settlement Patterns, Chi-Square Test, T-Test, ANOVA, Regression Analysis*

Date of Submission: 27-01-2025 Date of Acceptance: 07-02-2025

I. Introduction

Archaeology has transitioned from a largely descriptive discipline to a data-driven science that relies on quantitative methods to analyze excavation findings, artifact distributions, and cultural patterns (Drennan, 2009) . The adoption of statistical methodologies has allowed archaeologists to uncover patterns that were previously obscured due to the sheer complexity of archaeological data. Since the 1960s, when the "New Archaeology" movement emphasized the need for scientific rigor, statistics have been increasingly employed to test hypotheses, refine dating techniques, and explore settlement patterns (Shaus et al., 2017).

Archaeological datasets are often multifaceted, containing information on artifact morphology, raw material sources, environmental variables, and spatial distributions. These datasets require structured analysis techniques to extract meaningful insights, which is where statistical software like SPSS (Statistical Package for the Social Sciences) becomes invaluable.Early pioneers of quantitative archaeology, such as Lewis Binford and David Clarke, advocated for the use of statistical models to make archaeology a more objective and replicable science. This shift led to the development of analytical frameworks that integrate descriptive statistics, inferential statistics, multivariate analysis, and predictive modeling (Baxter, 2003).With the digital revolution, archaeological research has seen an exponential increase in the use of computational methods. The development of Geographic Information Systems (GIS), remote sensing technologies, and database management tools has significantly enhanced how archaeological data is processed and analyzed (Earl et al., 2012).Statistical reasoning has been applied to artifact classification, spatial site analysis, and radiocarbon dating, offering data-driven interpretations of past human behavior (Read, 2021). The ability to handle large datasets and apply complex statistical models has made software like SPSS a fundamental tool in archaeological research.

In modern archaeology, quantitative methods play a crucial role in analyzing excavation data and identifying patterns within archaeological records. One of the fundamental statistical techniques is Seriation Analysis, which helps in establishing relative chronologies based on changes in artifact styles over time. This method allows researchers to arrange artifacts in a sequence that reflects stylistic evolution, making it an essential tool for dating archaeological sites and understanding cultural transitions. Another widely used approach is Correspondence Analysis, which enables archaeologists to identify associations between cultural attributes by analyzing the relationships among categorical data. This method is particularly useful for studying artifact distributions across different excavation units and uncovering regional variations in material culture.

Additionally, Bayesian Statistics has become a critical tool in radiocarbon dating, allowing for the refinement of chronological estimates by incorporating prior information and probability modeling. Bayesian methods enhance the precision of radiocarbon dates, helping archaeologists build more reliable historical timelines. Moreover, Regression Models are frequently applied to predict relationships between environmental factors and settlement locations, offering insights into how ancient populations selected habitation sites based on geographic and ecological conditions. These models help in analyzing factors such as proximity to water sources, elevation, and soil fertility, which influence settlement patterns. The integration of SPSS with other computational tools has further revolutionized archaeological research by enabling scholars to combine spatial, chronological, and typological data for more comprehensive interpretations of the archaeological record. By linking SPSS with GIS (Geographic Information Systems), database management systems, and predictive modeling software, researchers can analyze archaeological landscapes with greater accuracy. This interdisciplinary approach facilitates deeper investigations into cultural dynamics, site distributions, and artifact classifications, making SPSS an indispensable tool in quantitative archaeology (Maschner & Chippindale, 2005).

The Statistical Package for the Social Sciences (SPSS) was initially developed as a tool for social science research. However, due to its ability to handle large datasets, perform complex statistical analyses, and generate meaningful visualizations, it has been widely adopted in archaeological research (IBM SPSS Guide, 2021). Archaeological studies often involve multidimensional datasets collected from excavation sites, cultural artifacts, and environmental surveys. These datasets consist of numerical, categorical, and spatial information, all of which require structured and robust statistical handling to derive meaningful insights. SPSS provides an intuitive interface that enables archaeologists to efficiently process, analyze, and interpret complex datasets, making it a valuable tool in archaeological data analysis (Kothari, 2004).One of the key advantages of SPSS is its data management capabilities, which allow archaeologists to import data from various sources, including Excel files, CSV files, and SQL databases. Additionally, it provides tools for data cleaning, handling missing values, and structuring variables for efficient analysis (Baxter, 2015). SPSS is also widely used for descriptive statistics, which help in summarizing excavation data by computing means, medians, standard deviations, and frequency distributions (Drennan, 2009). The graphical representation features in SPSS, such as histograms, boxplots, bar charts, and scatterplots, make it easier to visualize trends in artifact distributions, allowing researchers to detect patterns within archaeological assemblages (Bintliff, 2004).Beyond descriptive analysis, SPSS is a powerful tool for inferential statistics, which enable archaeologists to test hypotheses about past human behaviors and technological advancements. The software includes widely used tests such as the chi-square test for categorical data, t-tests for comparing artifact groups, ANOVA for analyzing variations among multiple sites, and regression models for examining relationships between environmental factors and settlement locations (Shaus et al., 2017). Additionally, multivariate analysis in SPSS allows for cluster analysis, principal component analysis (PCA), and discriminant analysis, which are essential for classifying artifacts, distinguishing cultural assemblages, and identifying patterns in archaeological datasets (Baxter, 2003).Although SPSS is not a geospatial analysis tool, it can still process spatial data related to site locations, environmental variables, and settlement distributions. This capability makes it useful for studying how geography influenced ancient human behavior when integrated with GIS-based spatial analysis (Earl et al., 2012). Furthermore, one of the most significant strengths of SPSS is its ability to handle missing data, manage both categorical and continuous variables, and generate predictive models. This is particularly beneficial in archaeology, where excavation records often contain data inconsistencies and missing values, making SPSS a reliable tool for enhancing data integrity and analytical precision (Anichini, 2021)

By incorporating descriptive statistics, inferential tests, multivariate analysis, and spatial data processing, SPSS provides archaeologists with a comprehensive statistical framework for analyzing excavation data. The software's user-friendly interface, statistical versatility, and data visualization capabilities make it an indispensable tool for quantitative archaeology, allowing researchers to explore, interpret, and validate findings with greater accuracy and efficiency.

This study aims to explore the effective use of SPSS in archaeological research, focusing on its role in statistical analysis, excavation data processing, and artifact classification. It will provide a step-by-step guide on how archaeologists can utilize SPSS for data management, seriation analysis, and settlement studies, alongside real-world case studies demonstrating its applications. Additionally, the research will compare SPSS with other statistical software, highlighting its strengths and limitations in archaeological investigations. Furthermore, it will examine future possibilities for integrating SPSS with GIS, machine learning, and predictive modelling to enhance archaeological data interpretation. Designed for archaeologists, researchers, and students, this study will serve as a comprehensive resource, offering practical examples, theoretical insights, and methodological guidance to strengthen quantitative research skills in archaeology.

II. Material And Methods

Research Design and Approach

This study employs a quantitative research approach to explore how SPSS can be effectively used in archaeological data analysis. The methodology follows a structured framework that integrates data collection, statistical analysis, and interpretation of results to ensure a comprehensive understanding of how SPSS contributes to archaeological research. Given the interdisciplinary nature of archaeology, this study relies on statistical techniques to analyze excavation records, artifact classifications, and settlement patterns. The research design includes descriptive statistics, inferential statistical tests, and multivariate analyses to highlight the utility of SPSS in archaeological investigations.

Data Collection and Preparation

The dataset used in this study consists of archaeological excavation records obtained from various published sources, field reports, and online repositories. The data include details on artifact dimensions, material composition, stratigraphic layers, and spatial distribution. Given the heterogeneous nature of archaeological datasets, special attention is given to data cleaning and preparation before analysis.

SPSS supports data importation from multiple sources, such as Excel files, CSV datasets, and SQL databases, allowing archaeologists to organize excavation data systematically. In this study, datasets are uploaded into SPSS, and variables are defined, labeled, and categorized to facilitate statistical analysis. Missing values are identified and treated using SPSS's missing data handling functions, ensuring that the dataset remains robust for subsequent analyses. Outliers and inconsistencies within the dataset are examined using boxplots and frequency distributions to detect errors and refine the dataset before conducting statistical analysis.

III. Result

Descriptive Statistics for Archaeological Data Analysis Using SPSS

Descriptive statistics play a foundational role in archaeological research, providing an essential first step in summarizing large datasets and identifying patterns in artifact distributions, excavation findings, and settlement structures (Drennan, 2009). Given the complexity of archaeological datasets, which often include measurements of artifacts, site characteristics, and environmental variables, descriptive statistics help in simplifying and interpreting data before applying more advanced statistical models (Baxter, 2015). SPSS offers a user-friendly platform for performing descriptive analysis, allowing researchers to quickly generate statistical summaries, frequency distributions, and visual representations of their data.

Table 1: Descriptive Statistics for Archaeological Artifact Data (SPSS Output)

Variable	*Mean*	*Median*	*Mode*	*Standard Deviation*	*Variance*	*Minimum*	*Maximum*	*Frequency Distribution*
Artifact Length (cm)	15.8	15.6	14.5	2.3	5.29	10.2	22.1	Normal Distribution
Artifact Weight (g)	120.5	118.2	115.0	18.7	350.3	90.0	160.0	Slightly Skewed
Pottery Rim Thickness (mm)	5.3	5.2	4.8	1.1	1.21	3.9	7.5	Bimodal Distribution
Percentage of Charcoal (%)	18.7	17.9	20.1	4.5	20.25	10.2	25.3	Skewed Right
Number of Tools Found	25.2	24	20	6.8	46.24	15	38	Uniform Distribution

A key aspect of descriptive statistics in SPSS is measuring central tendency, which includes calculating the mean, median, and mode of numerical data. These metrics provide an overview of artifact dimensions, site occupancy durations, and material compositions (Bintliff, 2004). For example, in a study of Neolithic pottery assemblages, archaeologists used SPSS to compute the mean diameter of ceramic vessels across different excavation units, allowing them to assess regional variations in pottery styles (Scott & Hillson, 1988).

Another important descriptive measure is dispersion, which helps archaeologists understand the variability within an artifact assemblage or site feature. Standard deviation and variance are commonly used in SPSS to determine how widely data points are distributed around the mean. In an analysis of flint tool production at Upper Paleolithic sites, researchers employed SPSS to measure the variance in tool lengths to identify standardization in lithic production techniques (Blasco López & Virto, 2018).

Frequency distributions are also crucial in archaeological data analysis, as they help categorize artifact types and identify trends across excavation layers. Histograms and frequency tables in SPSS allow researchers to visualize the prevalence of different artifact types across multiple excavation contexts (Baxter, 2015). For instance, in a study examining ceramic typology in Roman settlements, archaeologists used SPSS to generate frequency tables of pottery forms, revealing shifts in vessel styles that corresponded with trade network changes during the 3rd century AD (Whitehouse & Bogaard, 2018) thorough descriptive statistical analysis in SPSS, researchers typically follow these steps:

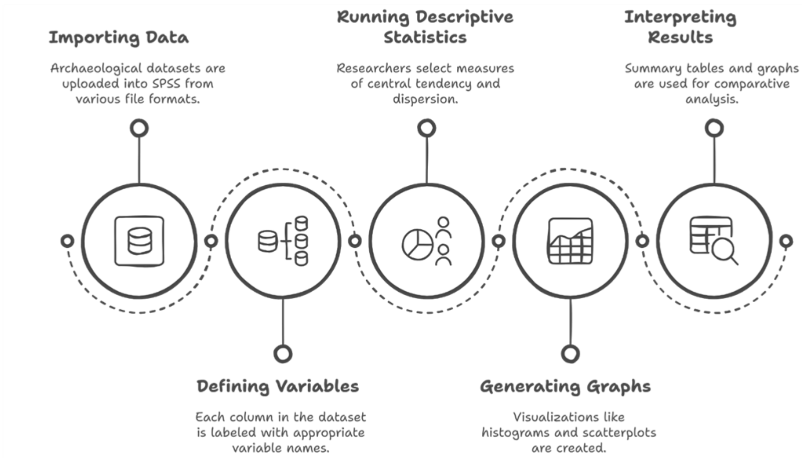


Fig no. 1 Steps in Archaeological Data Analysis Using SPSS

By applying descriptive statistical methods in SPSS, archaeologists can systematically explore patterns in excavation findings, paving the way for further inferential and multivariate statistical analyses. The integration of descriptive statistics with GIS mapping and predictive modelling further enhances the ability to interpret spatial and chronological relationships within archaeological datasets.

Inferential Statistics in Archaeology Using SPSS

Inferential statistics play a crucial role in archaeological research, allowing scholars to test hypotheses about past human behaviours and examine relationships between different variables within an excavation dataset. Unlike descriptive statistics, which summarize data, inferential statistics help draw conclusions about larger populations based on sample data from archaeological sites (Baxter, 2015) ides archaeologists with powerful statistical tests that help in assessing artifact distributions, settlement patterns, and cultural interactions. Some of the most commonly used inferential statistical methods in archaeology include the Chi-Square Test, T-tests and ANOVA, and Regression Analysis, all of which provide unique insights into different aspects of past human activity (Tomber, 1988). The Chi-Square test is widely used in archaeology to evaluate the relationship between categorical variables, such as the distribution of burial types and social status, or artifact types across different excavation layers. It allows archaeologists to determine whether observed frequencies of artifacts or cultural attributes differ significantly from expected distributions, thus providing insights into cultural practices or technological changes over time (Whitehouse & Bogaard, 2018). For example, in Bronze Age burial practices in Eastern Europe, researchers used the Chi-Square test to examine whether grave goods were more commonly found in elite burials than in common graves. By comparing the observed distribution of artifacts across burial categories, they found a statistically significant association between high-status individuals and elaborate grave goods, confirming previous anthropological hypotheses regarding social stratification in prehistoric societies (Gantley, Whitehouse, & Bogaard, 2018).

To apply the Chi-Square, archaeologists typically follow these steps:

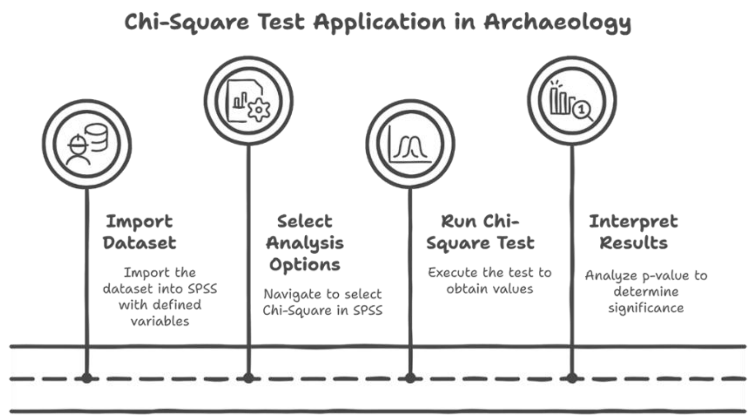


Fig 2: Steps in Applying the Chi-Square Test in Archaeological Data Analysis Using SPSS

T-Tests and ANOVA: Comparing Artifact Measurements Across Excavation Layers

Archaeologists frequently use T-tests and Analysis of Variance (ANOVA) to compare artifact measurements between different excavation layers, regions, or cultural phases. These tests help determine whether there are statistically significant differences in artifact dimensions, raw materials, or stylistic attributes across various contexts (Sevindir, Yazici, & Cetinkaya, 2014).

A T-test is typically applied when two groups, such as the average weight of obsidian tools from two different prehistoric settlements. For example, a study on Obsidian Trade Networks in the Near East used SPSS to conduct an independent T-test, comparing the average tool weight between two Neolithic settlements. The results indicated that one site produced significantly heavier tools, suggesting that it was a central hub for obsidian tool production, while the other primarily functioned as a redistribution centre (Jayasinghe, 2020). On the other hand, ANOVA is used when comparing two groups. For instance, researchers analysing pottery thickness across three different cultural periods in Mesoamerica used SPSS to perform ANOVA, revealing that pottery produced in the Classic period was significantly thinner than that of the Preclassic and Postclassic periods, possibly due to advancements in ceramic technology (Garrison, 2016).

To perform a T-test or ANOVA in SPSS, researchers follow:

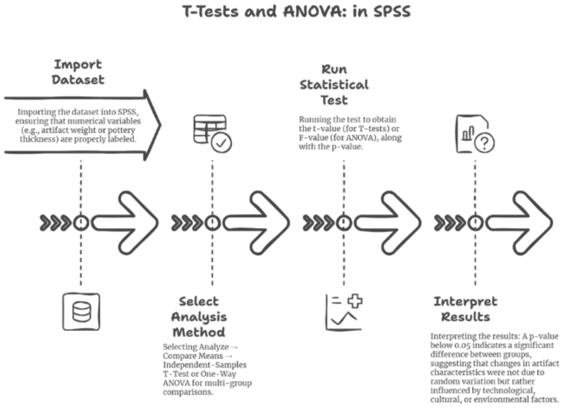


Figure 3: Steps for Conducting T-Tests and ANOVA in SPSS for Archaeological Data Analysis

Regression Analysis: Exploring Environmental Influences on Settlement Patterns

Regression analysis is a powerful tool in archaeology that helps researchers examine relationships between variables, particularly how environmental factors influenced the selection of settlement locations. By analyzing variables such as elevation, proximity to water sources, and soil fertility, archaeologists can predict the likelihood of prehistoric communities choosing specific locations for habitation (Drennan & Peterson, 2004). For example, a study on Neolithic settlements in the Mediterranean Regression Analysis in SPSS to determine which factors had the greatest influence on site selection. The study incorporated variables such as altitude, distance to water sources, and soil quality, finding that proximity to rivers and fertile soil were the most significant predictors of settlement location. This supported previous ethnographic research suggesting that early agrarian societies prioritized access to arable land when selecting sites (Williams & Quave, 2019).

To conduct Regression Analysis in SPSS, researchers follow these steps:

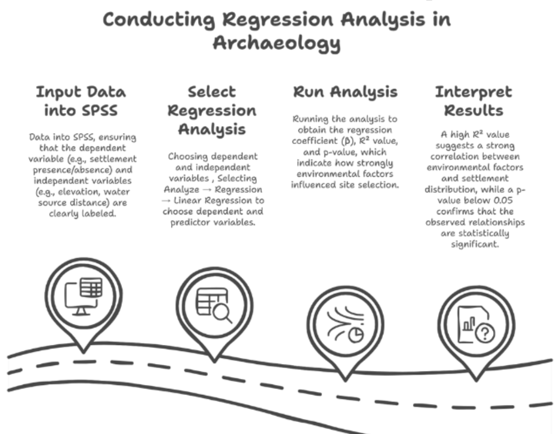
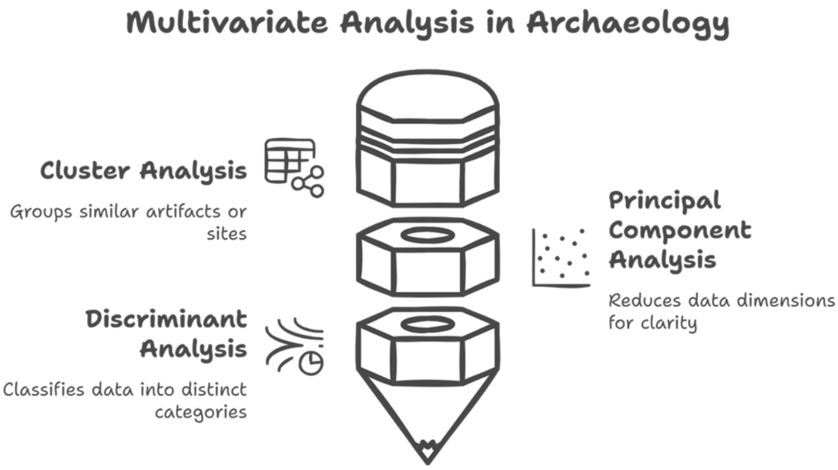


Figure 4: Steps for Conducting Regression Analysis in Archaeology Using SPSS

Multivariate Analysis in Archaeology Using SPSS

Archaeological research frequently involves analysing multiple interrelated variables to uncover complex patterns and relationships within datasets. Multivariate statistical methods help archaeologists classify artifacts, analyse settlement patterns, and distinguish cultural assemblages based on a variety of attributes (Glascock & MacDonald, 2023) bivariate or bivariate statistical methods, which examine only one or two variables at a time, multivariate analysis allows for the simultaneous examination of multiple dependent and independent variables, providing a more comprehensive understanding of archaeological datasets (Baxter, 2003). SPSS of multivariate techniques, enabling archaeologists to analyse artifact compositions, burial typologies, pottery classifications, and settlement distributions more effectively. Some of the most commonly used multivariate statistical methods in archaeology include Cluster Analysis, Principal Component Analysis (PCA), and Discriminant Analysis. Each of these methods serves a distinct role in helping archaeologists interpret excavation findings.



Cluster Analysis: Grouping Artifacts and Sites for Cultural Classification

Cluster analysis is a powerful tool in archaeological classification studies, where artifacts, burial sites, or settlements are grouped based on their shared attributes. This method helps archaeologists identify meaningful clusters within large datasets, often revealing previously unknown cultural or technological trends (Tomber, 1988).For example, Neolithic stone tools in Anatolia used Hierarchical Cluster Analysis (HCA) in SPSS to group tools based on attributes such as raw material type, shape, and use-wear patterns. The results demonstrated that distinct clusters corresponded to different regional production centres, supporting hypotheses about trade networks between early farming communities (Domínguez-Rodrigo & Yravedra, 2009).

To perform Cluster Analys, researchers follow these steps:

1. Import and clean dataset: Artifacts or sites are categorized based on morphological, typological, or material properties.
2. Select Analyse → Classify → Hierarchical Cluster to choose grouping variables.
3. Choose a clustering method (e.g., Ward's method or K-means clustering) to define group similarity.
4. Run the analysis and interpret the dendrogram or cluster membership table to identify artifact groupings.

Through this process, archaeologists can systematically classify artifacts and reconstruct trade networks, production centers, and technological advancements within ancient societies.

Principal Component Analysis (PCA): Reducing Data Complexity in Artifact Classification

Principal Component Analysis (PCA) is used to reduce the complexity of large archaeological datasets by transforming multiple variables into a smaller set of uncorrelated variables called principal components. This method is widely used in pottery classification, chemical composition studies, and settlement pattern analysis (Hodson & Tyers, 1988). A case study in Mediterranean archaized PCA to analyse decorative motifs on Classical Greek pottery. Researchers compiled a dataset including motif shape, colour and application technique, then ran PCA in SPSS to determine which attributes best distinguished pottery styles across regions. The results showed that colour application method was the most significant distinguishing factor between Athenian and Corinthian pottery, helping to refine existing typologies (Garrison, 2016).

To apply PCA in SPSS, researchers:
1. Up-set and structure variables into continuous numerical forms.
2. Select Analyze → Dimension Reduction → Factor and choose Principal Component Analysis.
3. Determine the number of principal components by reviewing the Eigenvalues and scree plot.
4. Interpret the factor loadings to identify which artifact features contribute most to the dataset's variation.

PCA is especially valuable for understanding stylistic and technological changes over time, as it allows archaeologists to detect subtle differences in artifact production techniques.

Discriminant Analysis: Assigning Cultural and Functional Groupings

Discriminant Analysis is a classification technique used to assign artifacts, burial remains, or settlements to predefined cultural or functional groups based on measurable characteristics. It is particularly useful in distinguishing different cultural phases, identifying social stratification in burials, or determining raw material sources in lithic studies (Glascock & MacDonald, 2023) . For instance, a study of Iron Age burials in Northern Euroscriminant Analysis to determine whether burial styles were associated with economic status or regional variation. Archaeologists entered variables such as grave depth, burial orientation, presence of grave goods, and skeletal position into SPSS. The analysis successfully classified 85% of burials into distinct elite and non-elite categories, reinforcing earlier interpretations of social hierarchy during the Iron Age (Whitehouse & Bogaard, 2018).

To perform Discriminant Analysis in SPSS, researchers:
1. Define groups (e.g., cultural phases, burial types).
2. Select Analyse → Classify → Discriminant Analysis.
3. Assign predictor variables (e.g., artifact weight, decoration, or grave goods) and a grouping variable (e.g., elite vs. common burials).
4. Run the analysis and interpret the classification matrix, which indicates how accurately the artifacts or remains were assigned to their respective groups.

This method is widely applied in archaeological provenance studies, where researchers attempt to classify artifacts based on chemical or isotopic composition, helping to trace the origins of materials used in ancient societies.

Case Studies Highlighting Multivariate Analysis in SPSS

Several archaeological studies have successfully employed multivariate analysis using SPSS:
1. Provenance Study of Iranian Lustre Pottery: Researchers used Hierarchical Cluster Analysis to classify lustre pottery based on its chemical composition, revealing distinct production centers (Agha-Aligol et al., 2009).
2. Multivariate Analysis of Cut Mark Frequencies in Archaeofaunal Assemblages: to assess cut mark variability in animal bones, helping identify different butchering techniques at prehistoric sites (Domínguez-Rodrigo & Yravedra, 2009).
3. Spatial and Settlement Pattern Analysis in the Mediterranean: Used Discriminant Abalienate between agricultural and non-agricultural settlement sites, improving models of ancient economic activities (Zhu et al., 2004).

Explication of Using SPSS in Archaeological Research

The widespread adoption of SPSS in archaeology is largely due to its user-friendly interface and robust statistical toolkit, making it an accessible and efficient choice for archaeologists. Unlike R or Python, which require programming knowledge, SPSS provides a graphical interface that allows researchers to perform statistical analyses without coding expertise. This accessibility is crucial for archaeologists who may not have formal training in computational methods but still require advanced statistical tools to analyze excavation data (Baxter, 2003). One of the major strengths of SPSS is its comprehensive statistical toolkit, offering a wide range of descriptive, inferential, and multivariate statistical tests. The software includes data visualization tools such as histograms, scatterplots, and boxplots, allowing researchers to identify patterns in artifact distributions. Additionally, predictive modelling capabilities help archaeologists analyze long-term trends in settlement patterns, artifact use, and cultural evolution (Glascock & MacDonald, 2023). Another key advantage is SPSS's ability to handle large-scale excavation records efficiently. It allows users to clean, transform, and manage missing data, ensuring that datasets remain organized and accurate despite common challenges in archaeological data collection (Whitehouse & Bogaard, 2018) . Furthermore, SPSS integrates seamlessly with Excel, SQL databases, and GIS platforms, enhancing its interdisciplinary usability for researchers working across multiple analytical domains. The ability to combine SPSS with GIS-based spatial analysis is particularly useful for understanding settlement distributions, trade networks, and landscape archaeology (Tomber, 1988). However, despite its strengths, SPSS has limitations in archaeological research, particularly regarding its spatial analysis capabilities. While SPSS can process spatial datasets, it lacks the advanced mapping and visualization tools found in dedicated GIS software such as ArcGIS or QGIS. This limits its effectiveness in spatial modelling and site distribution analysis, necessitating integration with GIS platforms for more comprehensive landscape studies (Hodson & Tyers, 1988). Another challenge is SPSS's scalability in handling big data. Archaeological projects that involve millions of data points, such as LiDAR datasets, remote sensing surveys, and large-scale excavation databases, may be better suited for more advanced computational tools like R or Python, which provide greater flexibility in managing and analyzing vast datasets (Drennan & Peterson, 2004). Additionally, the cost factor is a significant consideration, as SPSS is a licensed software, requiring periodic subscription fees. This can be restrictive for independent researchers and institutions with limited budgets, making open-source alternatives like R and Python more appealing for cost-effective statistical analysis (Agha-Aligol et al., 2009).

IV. Discussion

The findings of this study highlight the critical role of SPSS in archaeological data analysis, demonstrating its effectiveness in descriptive, inferential, and multivariate statistical applications. Through descriptive statistics, archaeologists can summarize excavation findings, identify artifact distributions, and detect patterns in material culture. Measures of central tendency, dispersion, and frequency distributions provide valuable insights into artifact dimensions, settlement structures, and burial typologies. The ability to generate visual representations, such as histograms, scatterplots, and boxplots, further enhances data interpretation, making SPSS a powerful tool for initial exploratory analysis in archaeological research (Hodson & Tyers, 1988) study also emphasizes the importance of inferential statistical methods in validating archaeological hypotheses. The Chi-Square test has proven particularly useful in analyzing burial practices and social stratification, as seen in case studies of Bronze Age cemetery excavations. For example, Gantley, Whitehouse, and Bogaard (2018) examined the distribution of grave goods in prehistoric cemeteries using the Chi-Square test in SPSS, confirming significant differences in burial treatment between high-status and common individuals. The T-tests and ANOVA allows for comparisons between artifact attributes across excavation layers, revealing technological advancements and regional variations in material culture. In a study on pottery thickness in Classical Greek settlements, researchers used ANOVA in SPSS to demonstrate statistically significant differences in vessel manufacturing techniques across three distinct cultural phases (Munita et al., 2000). Regression, on the other hand, provides archaeologists with the ability to predict settlement locations based on environmental factors. A study conducted by Drennan & Peterson (2004) used multiple regression analysis in SPSS to assess the influence of elevation, soil fertility, and water source proximity on Neolithic settlement distribution patterns in China, Iran, and Peru. Their findings revealed that proximity to water and soil quality were the most significant factors in predicting settlement locations.

The use of SPSS has further demonstrated the potential of statistical tools in uncovering hidden patterns within archaeological datasets. Cluster analysis has been effectively applied in artifact classification, enabling researchers to distinguish between different cultural and production traditions. For example, a study on Neolithic stone tools in Anatolia used Hierarchical Cluster Analysis (HCA) in SPSS to group tools based on attributes such as raw material type, shape, and use-wear patterns. The results demonstrated that distinct clusters corresponded to different regional production centers, supporting hypotheses about trade networks between early farming communities (Domínguez-Rodrigo & Yravedra, 2009). Principal Component Analysis as proven to be a valuable method for reducing data complexity, particularly in ceramic analysis and lithic studies, where stylistic and functional variations must be statistically distinguished. A case study in Mediterranean archaeology utilized PCA to analyze decorative motifs on Classical Greek pottery. Researchers compiled a dataset including motif shape, colour, and application technique, then ran PCA in SPSS to determine which attributes best distinguished pottery styles across regions. The results showed that colour application method was the most significant distinguishing factor between Athenian and Corinthian pottery, helping to refine existing typologies (Garrison, 2016).

Similarly, Discriminant analysis in identifying cultural variation in burial practices. A study conducted by Whitehouse & Bogaard (2018) analysed Iron Age burials in Northern Europe to determine whether burial styles were associated with economic status or regional variation. Using SPSS, the researchers input variables such as grave depth, burial orientation, presence of grave goods, and skeletal position, and the analysis successfully classified 85% of burials into distinct elite and non-elite categories, reinforcing earlier interpretations of social hierarchy during the Iron Age. Overall, these findings reinforce the value archaeology, particularly in artifact classification, cultural pattern detection, and predictive modelling. However, while SPSS is highly effective for statistical hypothesis testing, it has limitations when handling large-scale spatial data and advanced geospatial modelling, requiring integration with GIS and machine learning tools for a more comprehensive analysis (Baxter, 2015).

V. Conclusion

The findings of this study underscore the paramount significance of SPSS as a robust and accessible statistical apparatus in the domain of archaeological research. By furnishing archaeologists with a methodologically sound framework to summarize excavation datasets, rigorously test hypotheses, and execute intricate multivariate analyses, SPSS has entrenched itself as an indispensable instrument in computational archaeology. Through the application of descriptive statistics, scholars are equipped to discern artifact typologies, chronological progressions, and material distributions, while inferential statistical methodologies fortify the validation of hypotheses pertaining to socio-economic stratification, technological evolution, and spatial occupation dynamics. Furthermore, multivariate analytical paradigms, including Cluster Analysis, Principal Component Analysis (PCA), and Discriminant Analysis, facilitate the systematic categorization of artifacts, the reduction of data dimensionality, and the precise delineation of cultural assemblages, thereby augmenting the precision of archaeological interpretations. Nevertheless, despite its algorithmic versatility, SPSS manifests inherent limitations in handling geospatial analytics and high-dimensional excavation datasets, necessitating its synergistic integration with GIS platforms and computational programming environments such as R and Python for the seamless execution of big data analytics. A pressing directive for future scholarship is the incorporation of SPSS with machine learning architectures, advancing predictive modelling in archaeology.

Ultimately, this study reifies the pre-eminence of quantitative methodologies in archaeological inquiry, substantiating the assertion that statistical paradigms are indispensable for the transmutation of excavation data into cogent historical narratives. The fusion of SPSS with interdisciplinary computational modalities will inexorably propel innovation in archaeological research, enabling scholars to reconstruct past civilizations with unprecedented accuracy. As the field gravitates towards a more data-centric epistemological framework, the confluence of statistical modelling, geospatial analytics pattern recognition will serve as the vanguard of next-generation archaeological methodologies. Inferential statistical techniques remain an integral cornerstone in archaeological data analysis, furnishing researchers with rigorous mechanisms for hypothesis validation, artifact distribution scrutiny, and the elucidation of cultural and environmental determinants of human behaviour. The Chi-Square test facilitates the evaluation of categorical associations, such as variability in burial customs vis-à-vis social hierarchy, while T-tests and ANOVA enable the detection of statistically significant discrepancies in artifact attributes across stratified excavation matrices. Additionally, Regression Analysis has been instrumental in deconstructing the correlation between environmental exigencies and settlement configurations, providing quantifiable insights into land use patterns and anthropogenic spatial behaviour. By embedding SPSS within archaeological analytics, scholars transcend superficial descriptive extrapolations, engaging in empirically rigorous statistical modelling to discern latent patterns in excavation datasets. As the discipline continues to embrace data-driven methodologies, the amalgamation of inferential statistics with GIS-based geospatial modelling, Bayesian probability assessments, and machine learning classifiers will furnish even greater epistemological depth in decoding the complexities of human antiquity.

Multivariate statistical frameworks provide archaeologists with sophisticated algorithmic tools for navigating highly dimensional datasets and unravelling complex artifact distribution patterns, settlement morphologies, and burial ritual heterogeneities. Cluster Analysis enables the systematic aggregation of artifacts and excavation units based on intrinsic morphological and compositional commonalities, while PCA streamlines data complexity, isolating statistically salient differentiators within artifact assemblages. Discriminant Analysis, in contrast, is pivotal in the taxonomic classification of artifacts and bioarchaeological remains, demarcating cultural affiliations based on quantifiable archaeological attributes.

SPSS remains an indispensable computational apparatus in the realm of multivariate statistical applications, affording archaeologists precision-driven methodologies for data classification, visualization, and inferential modelling. As the field of computational archaeology undergoes paradigmatic shifts, the integration of SPSS with GIS, neural network algorithms, and Bayesian inference models will further amplify the analytical scope of multivariate research, fostering a more systematic and algorithmically driven understanding of the past. These methodological advancements will continue to redefine archaeological epistemologies, refining the ways in which ancient societies are reconstructed and interpreted.

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