

How highland communities in Peru used to measure the efficacy of irrigation maintenance work with knotted cords.

Maria Koulouri

PhD researcher, University of St Andrews

Summary

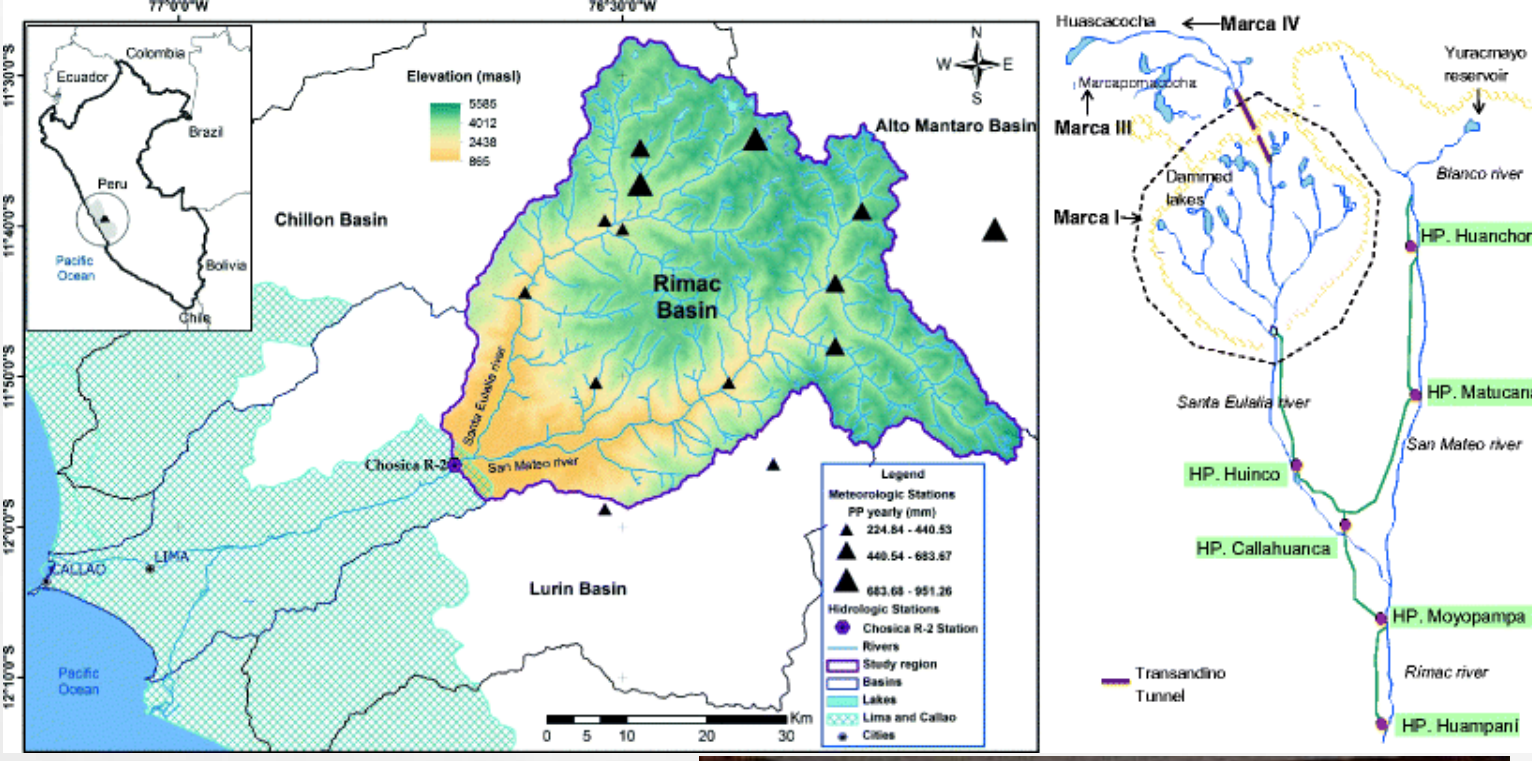
- Archaeological anthropology from the 1920s classifies Andean irrigation work as multidimensional.
- Dimensions of ceremonial work were encoded in knotted cords of various colours and sizes which hung from a wooden tablet.
- No other study to date has been able to show how all Khipu signs found on a Khipu (ethnographic or archaeological) cluster together and provide an interpretation.
- Using data science I identified four dimensions of ceremonial work through a dimension reduction technique.



Source: Tello & Miranda 1923.

Introduction

- Today, peasant communities in Huarochiri continue an ancient ceremony intended to clean irrigation canals and reservoirs under their ownership.¹
- The work eases waterflow from high altitudes to the lowland where multiple hydroelectric dams are situated.
- In the past, a wooden tablet with knotted pendant cords hanging from both sides, called a Khipu Board, functioned as a measurement instrument for the evaluation of ceremonial contributions from community members.² Today, the same ceremony is overseen by the local Indigenous government highlighting the accounting responsibilities of household members to the community and to the ancestral land.
- Excavated Khipu artefacts are primarily associated with the Wari³ and the Inka⁴ cultures. The Inka established the Khipu as standardised devices for recording tax collection throughout a vast empire that stretched geographically from Peru to Chile, Bolivia, Northwest Argentina, to parts of Ecuador and Colombia. There are also several chronicle accounts that describe the use of Khipu during the early colonial years. In 1912 mathematician Leland Locke deciphered the meaning of knots on Inka Khipu.

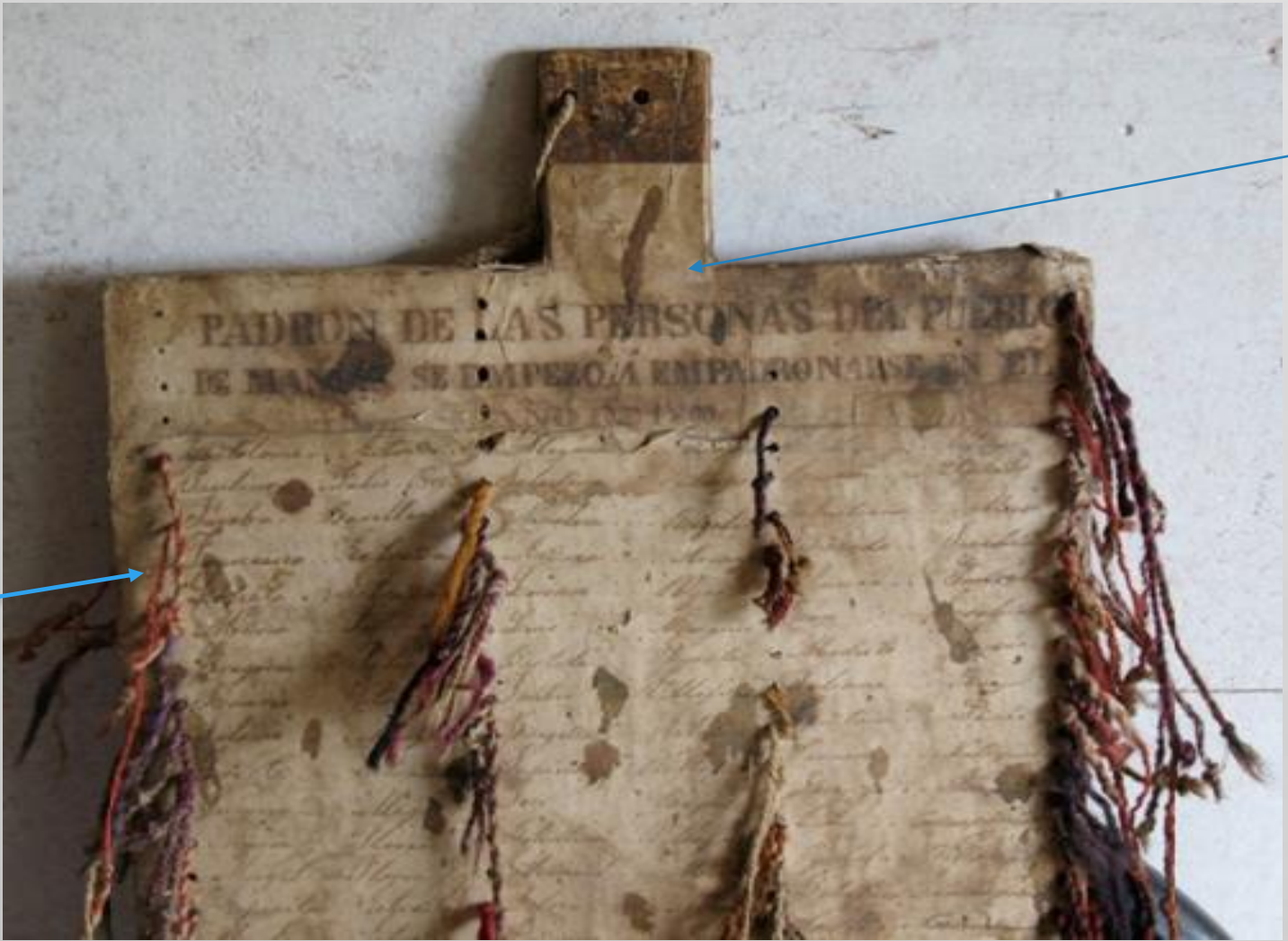


Source: Vega et al. 2018.



Guaman Poma, Nueva crónica y buen gobierno (c. 1615). Credit: Royal Danish Library.

- Anthropologist and National Geographic Explorer Professor Sabine Hyland⁵ discovered a Khipu tablet in Ancash, Peru.



Source: Hyland et al. 2014.

Knotted multicoloured cords of variable wool thickness passed from one side to the other side of the tablet through holes

The title suggests this tablet had been reused for about a century since the 1800s

Acknowledgments

This work was funded by the Leverhulme Trust. Sabine Hyland's meticulous data collection of the Mangas Khipu measurements made the creation of the datasets possible.

Mixed methods

- This project used a mixed-methods strategy.
- I designed and curated a set of digital products⁶ (quantitative datasets of the Mangas Khipu Board) from measurements collected by Hyland⁷ in the field.
- I participated in water rituals to understand how Indigenous elder officials, responsible for water management, assess the work carried out by community members.
- The aim was to identify work dimensions as previously observed by native archaeologist Julio C. Tello in the 1920s, when Khipu Boards were still in use during the irrigation ceremony.

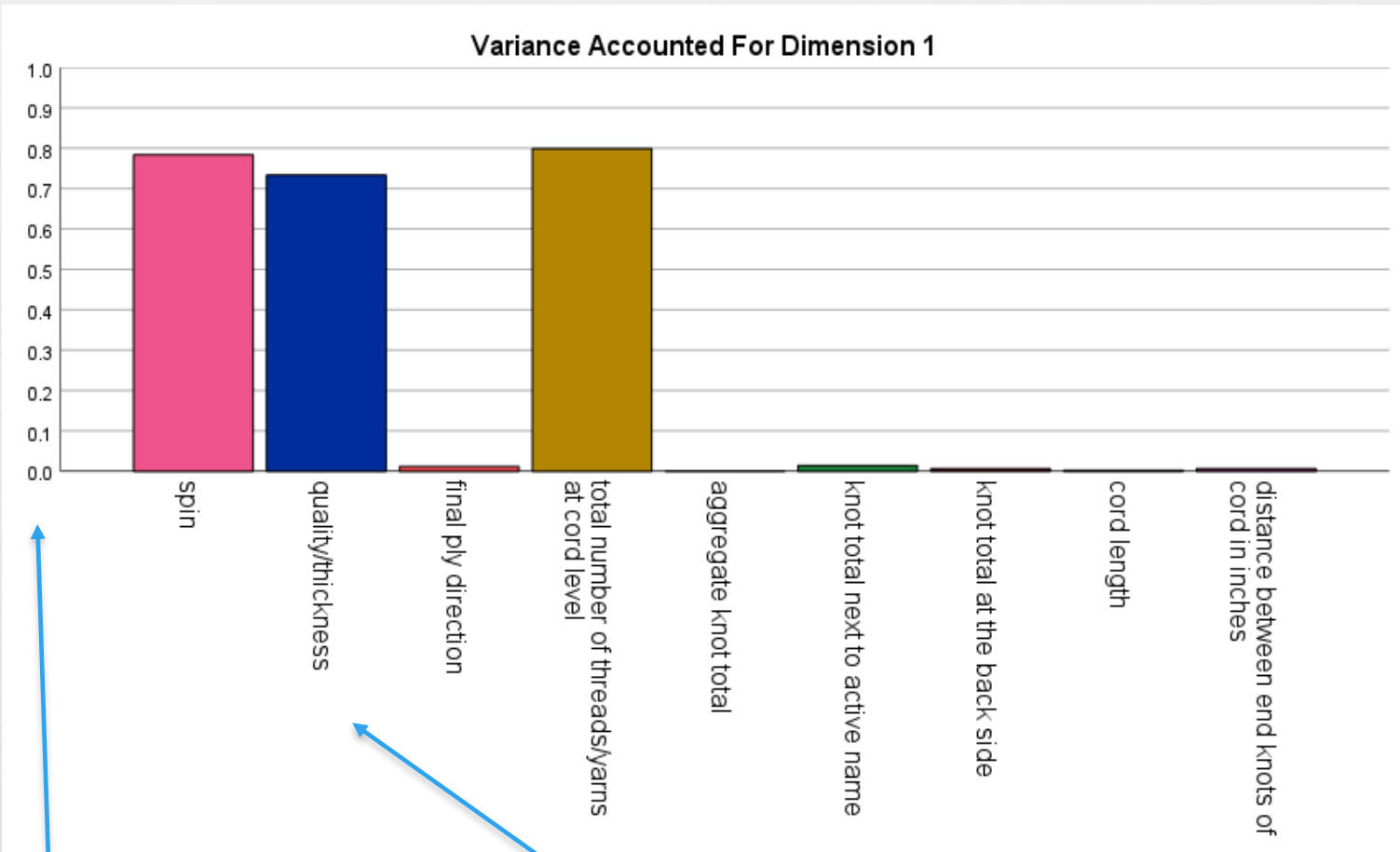


Women during work. Author's photo.

- A Categorical Principal Components was run in SPSS to detect multidimensionality (sign redundancy) on the Khipu artefact.
- Reliability Analysis was run separately to check internal consistency.
- Bootstrapping confirmed the number of dimensions suggested by the Orthogonal Rotation.

Results

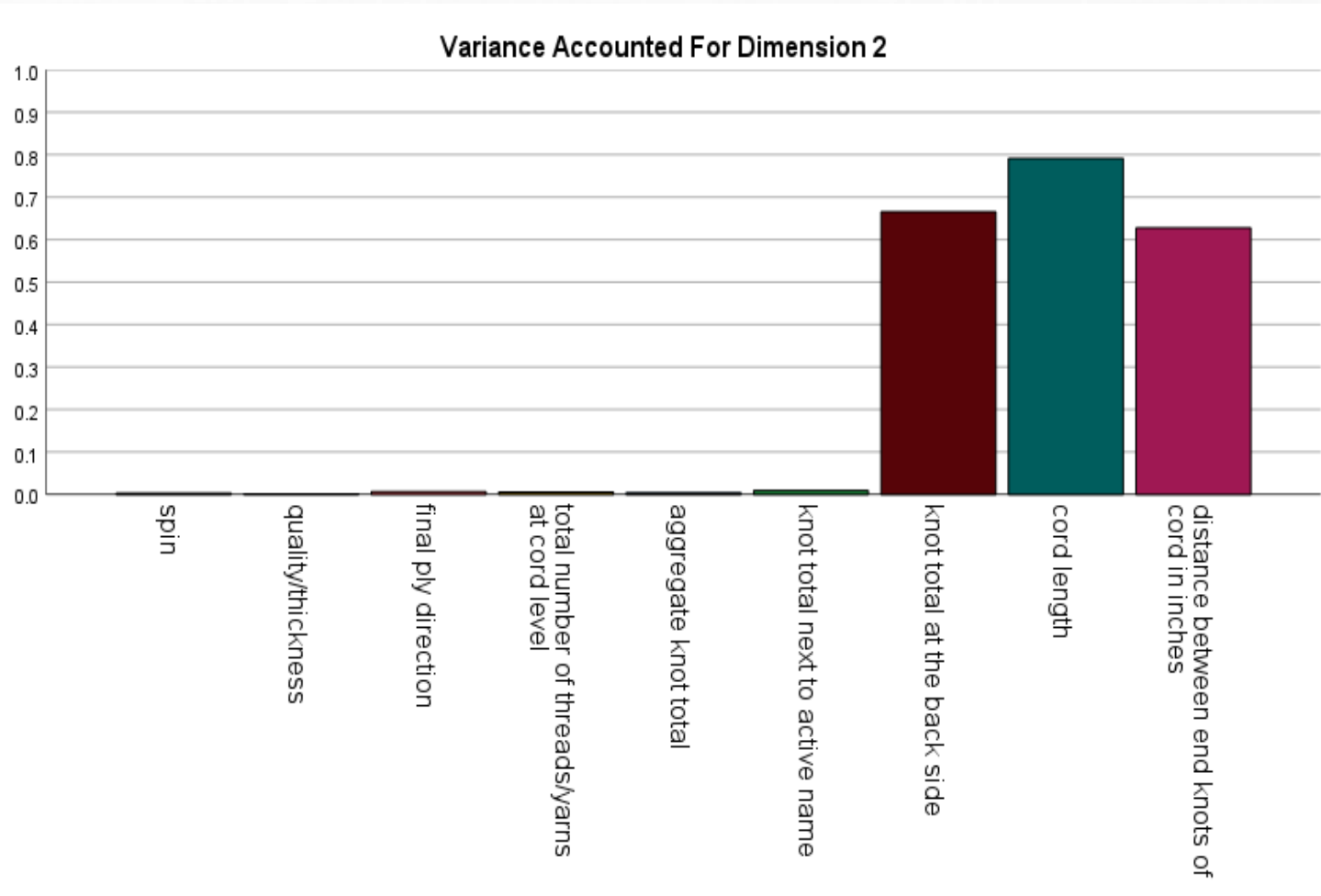
- The final dimension reduction (varimax) model suggested four dimensions of work tribute which explained over 80% of the variation in the data.
- Dimension 1, 'quality of work', was explained by three Khipu signs/items (Cronbach's alpha = .808).
- The wool quality or 'thickness' of the cord must have been used as a proxy due to its immediate visibility.
- The thickness denoted the financial value of each of the material contributions (signed by colour) offered by a household member. The finer the string, the more valued the contribution of a member. The overall quality of contributions was the aggregate thickness total of all coloured combinations in the cord construction.



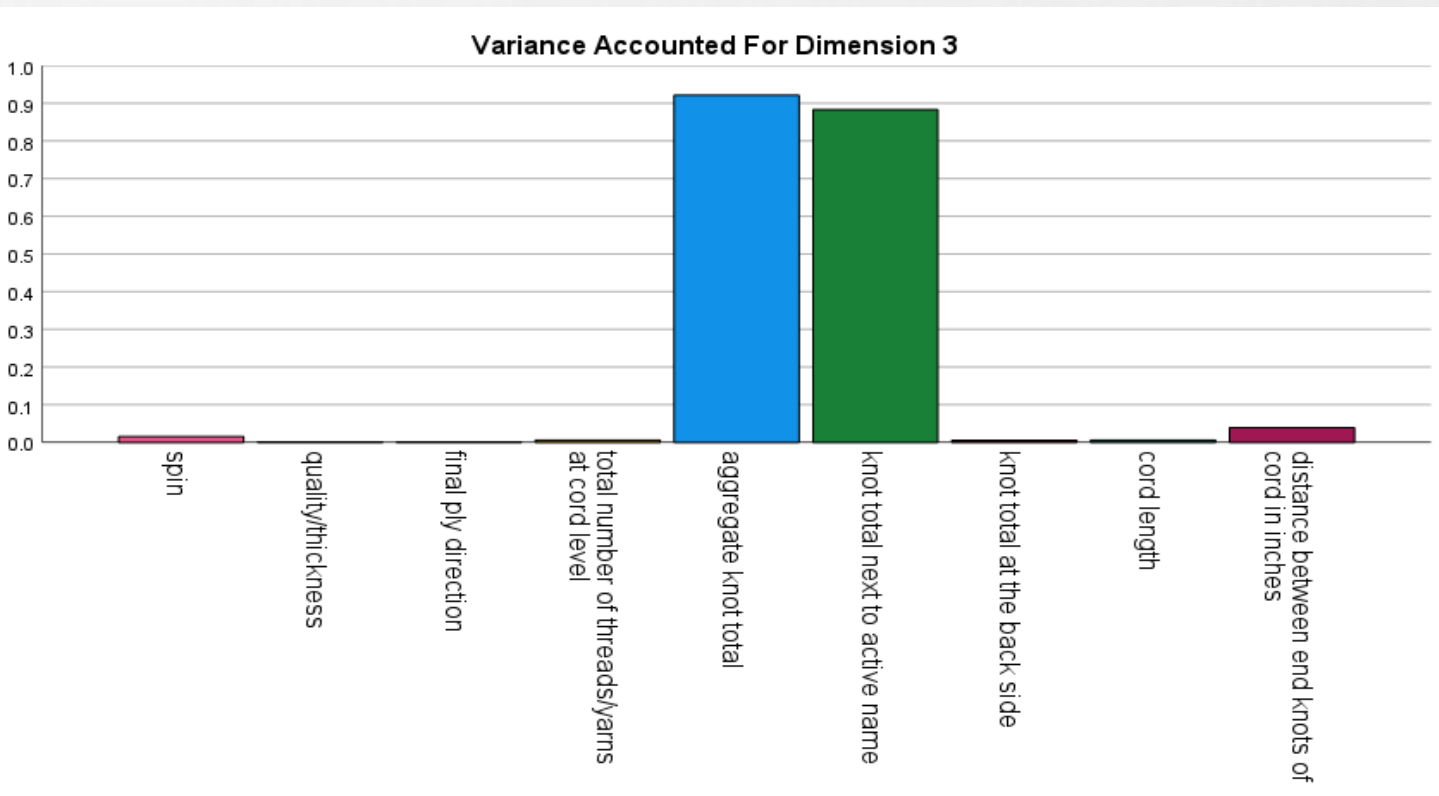
Component loadings for each of the items explaining a dimension

Item used as a proxy

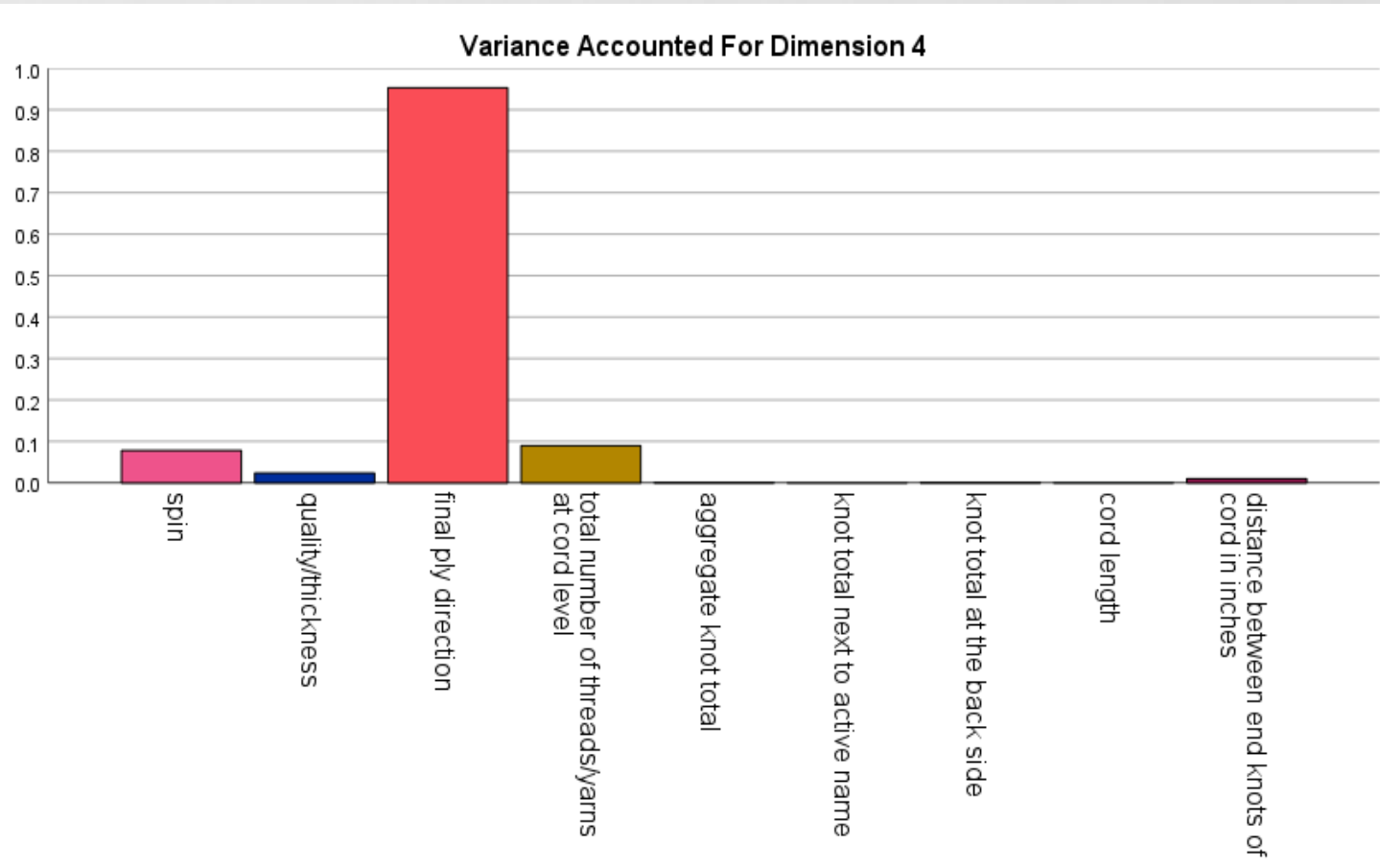
- Dimension 2, 'completion of work', was explained by three items (Cronbach's alpha = .707).
- Cord length is associated with the position of the end knot on cord as length after end knot can be variable.
- These three Khipu signs/items on the Khipu take into account work owed (i.e. tasks assigned to those who are less able).



- Dimension 3, 'the degree of individual enthusiasm', was explained by two items (Cronbach's alpha = .891).
- This dimension takes into account how an individual has been coping with work tasks. Enthusiasm is associated with singing traditional water prayers and being cheerful.



- Dimension 4, 'attendance at ceremony', was explained by a single item.
- Separate Reliability Analysis could not run due to violation of minimum requirements. However, Cronbach's alpha based on total Eigenvalue for dimension 4 was unacceptable (.222).



References

- 1 LLANOS, O. 1986. *Champería: ritual de la fiesta del Agua en San Pedro de Casta, Perú*. Chosica: Asociación Casteña.
- 2 TELLO, J.C. & P. MIRANDA 1923. Wallallo: ceremonias gentílicas realizadas en la region cisandina del Perú Central. *Inka* 1:2, 475-549.
- 3 CONKLIN, W. 1982. The information system of Middle Horizon quipus. *Annals of the New York Academy of Sciences* 385.
- 4 ASCHER, M. & R. ASCHER 1981. *Code of the quipu: a study in media, mathematics and culture*. Michigan: The University Press.
- 5 HYLAND S., A.G. WARE & M. CLARK 2014. Knot direction in a khipu alphabetic text from the Central Andes. *Latin American Antiquity: A Journal for the Society of American Archaeology* 25:2, 189-97.
- 6 KOULOURI, M. & S. HYLAND 2023. 3_PCA. Thesis dataset. <https://doi.org/10.17630/b968ddc2-38b7-4465-9d2b-5f3a29ff8ca4>
- 7 HYLAND S. 2017b. Mangas Khipu Board. Archived Narrative Field Report. University of St. Andrews.

