Modeling the Percentage of Chemical Components in Roman Pottery

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Background information

(1)Classification of pottery.

For example, if a new piece of pottery artifact is obtained from an archaeological excavation, we can detect the percentage of MnO and determine its relation with other chemical components. Such a relationship may somehow indicate the source of this piece of pottery. This kind of evidence can serve as a complement of archaeologists ’ professional knowledge.

(2)Inference for composite components.

For example, it is proposed by archaeologists that in paintings of pottery the Fe and Mn combined to make red-brown color on the surface of the pottery. [1] I want to find out the correlation between certain kinds of elements in order to support this hypothesis. If a linear relationship is founded, then its coefficient of determination can give us some evidence about this relationship.

(3)Inference for climate conditions.

For example, the small percentage of certain kind of chemicals may indicate the weather effect. [2] [3]

[1] [Sabbatini et.al] pp.120-121

[2] [Sanders]

Data source

(1)R-package HSAUR
(2)Completion of missing entries from [Tubb et.al].
Lesson: Always double-check the data source to make sure it is reliable.
(3)New validation dataset from [Mirti et.al].
Lesson: Try your model out with new data to see how well it works.

MLR group-indicator model

(1)Scatterplot matrix and boxplots[4] as major tools for exploratory data analysis, in this procedure I determine which variables should be predictors and how they are related to the response variable *MnO*.
(2)Although a cluster method seems more favorable to archaeologists [Mirti et.al], I think a linear regression might not only offer a better explanation but also present a better prediction.
(3)I use multiple linear regression[5] as my basic regression tool, and use the transformation tools[6] to make the model satisfy the linear model assumptions.
(4)In all, I derive my model in form of a group indicator model[7] in order to express the blocking effect caused by different kilns mentioned in the data source part.

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[4] [Weisberg] Chap.1
[5] [Weisberg] Chap.3
[6] [Weisberg] Chap.8,9
[7] [Weisberg] Chap.5

Group 1: Linear regression with small samples

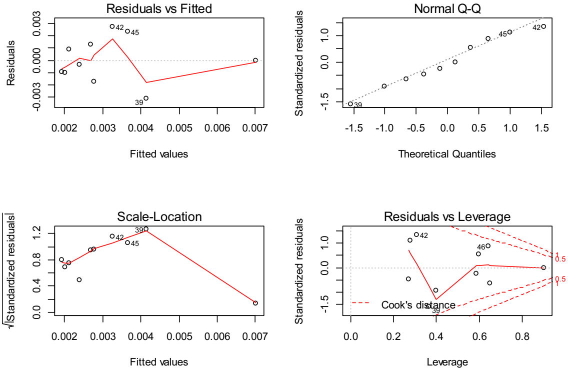


Figure: Diagnostic plot

Group 2: Potential outliers and low determination coefficient

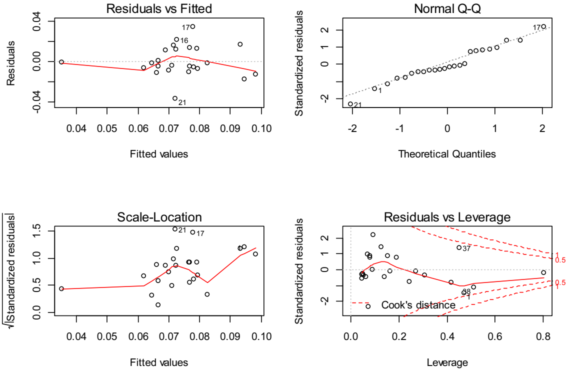
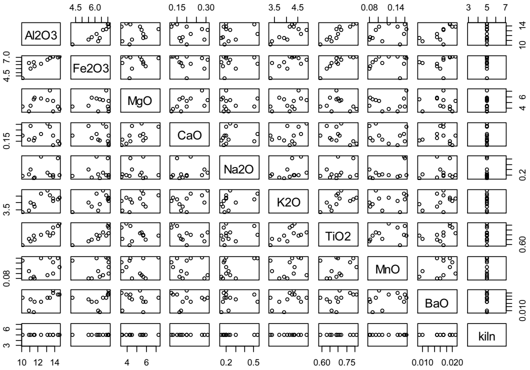


Figure: Diagnostic plot(full, there is one outlier and one potential->reduced)

Group 3: No obvious linear relationship from the scatterplot matrix

Figure:



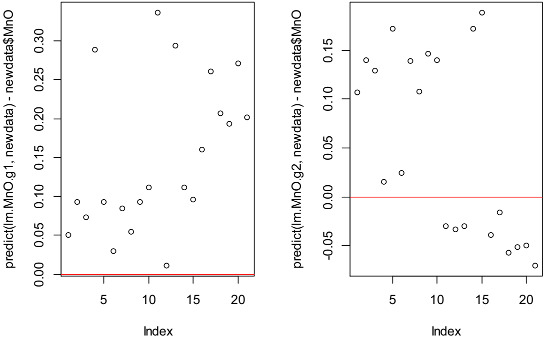
Fitted group-indicator model

$$\begin{cases} MnO = 0.009089 - 0.000113 \cdot Fe_2O_3 + 0.020145 \cdot MgO & IslandsThorns, AshleyRails \\ +0.032156 \cdot CaO - 0.009824 \cdot K_2O & \\ MnO = -0.10162 + 0.01704 \cdot Fe_2O_3 + 0.02657 \cdot MgO & Gloucester, Caldicot \end{cases}$$

This model tells us:
(1) There is difference between relationships of MnO with other chemical elements in different kiln groups.
(2) The Group 1 kilns may use a lot of CaO as raw materials while the Group 2 may use a large quantity of $Mn-Fe$ pigment.[Sabbatini et.al]

Prediction on a new dataset [Mirti et.al]

Figure: Result is that the Augusta Praetoria Roman pottery may have similar chemical composition as pottery from from kilns Gloucester,Caldicot.



Further Improvements.

The limitation of my study is that I do not include the variable selection as part of my study but borrow from existing results about the choice of predictors. As indicated in [Tubb et.al] , [Mirti et.al] and [Baxter&Jackson], I can make my own choice of variable using principal component analysis or professional knowledge from archaeology.

Try to select predictor variables using principal component analysis as [Tubb et.al]

Try to introduce a formal method of variable selection into my scheme. Step-wise selection or Information Criteria like AIC, BIC to determine how to drop predictors.

References

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Sanders, H. P. (1973). PORESIZE DISTRIBUTION DETERMINATIONS IN NEOLITHIC, IRON AGE, ROMAN AND OTHER POTTERY. Archaeometry, 15(1), 159-161.

Weisberg, S. (2005). Applied linear regression (Vol. 528). John Wiley & Sons.

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