A Regression Analysis of Some Late Romano-British Pottery: A Case Study

By Michael Fulford and Ian Hodder

SUMMARY. *A regression analysis of some late Roman fine wares has shown that the marketing of pottery from the Oxford centre was greatly influenced by water transport and rather less by the presence of the competing New Forest industry. The distance to which pottery travelled from the two centres in the area between them is largely a result of their different sizes.*

Introduction and aims

Late Roman fine wares (colour-coated, painted wares and mortaria) had two major production centres in central and southern England. These were located in the Oxford area and in the New Forest, although other minor centres also existed.[1] The percentages of the products of the two main centres, which can be identified by eye, have been counted at a number of major sites. The type of sample must be considered. For example, the amount of pottery which is not fine, such as the coarse, grey wares, but which has been kept, varies according to different excavators and the care in excavation. Also, even in good excavations, the percentage of fine pottery may vary considerably in different functional areas of the site. For the moment, however, we do not have evidence to assess this variation for most sites. The grouping together of contemporary material from different excavations from the same site has been thought necessary to provide as large a sample as possible for the comparative work. Clearly any conclusions reached in this paper are subject to revision when we know more about the distribution and function of types around a site (a subject not really studied so far). A further problem is the difficulty of providing accurate dates for assemblages. Those used in this study cover the fourth century A.D. and, while many of the fine wares can be more closely dated to within half a century, the coarse, grey wares can only be given a broad date range (*c.* 250–400).

Although there may have been marketing variations within this period as suggested at Portchester,[2] unfortunately the chronological detail possible on most sites is insufficient to define similar marketing variations elsewhere.

In spite of these difficulties it was hoped that some marketing patterns might be recoverable from the data, despite the wide dating of the pottery. Indeed, the comparative reliability of the sample was suggested by the very similar total percentage of fine wares from each site (see Table). However, the relative percentages from the two kiln centres are not at all constant and vary from the production centres in an uneven way. The purpose of this study is to examine this patterning.

[1] M. G. Fulford, 'A fourth century colour-coated fabric and its types in south-east England', *Sussex Archaeol. Collect.*, 111 (1973), 41–4.

[2] M. G. Fulford, 'The Pottery', in B. W. Cunliffe, *Excavations at Portchester Castle, Hants.*, Vol. 1, in press.

REGRESSION ANALYSIS

A regression curve[3] fitted to the Oxford products (FIG. 1) shows a generalized fall-off with distance from the production centre. There is, however, much variation

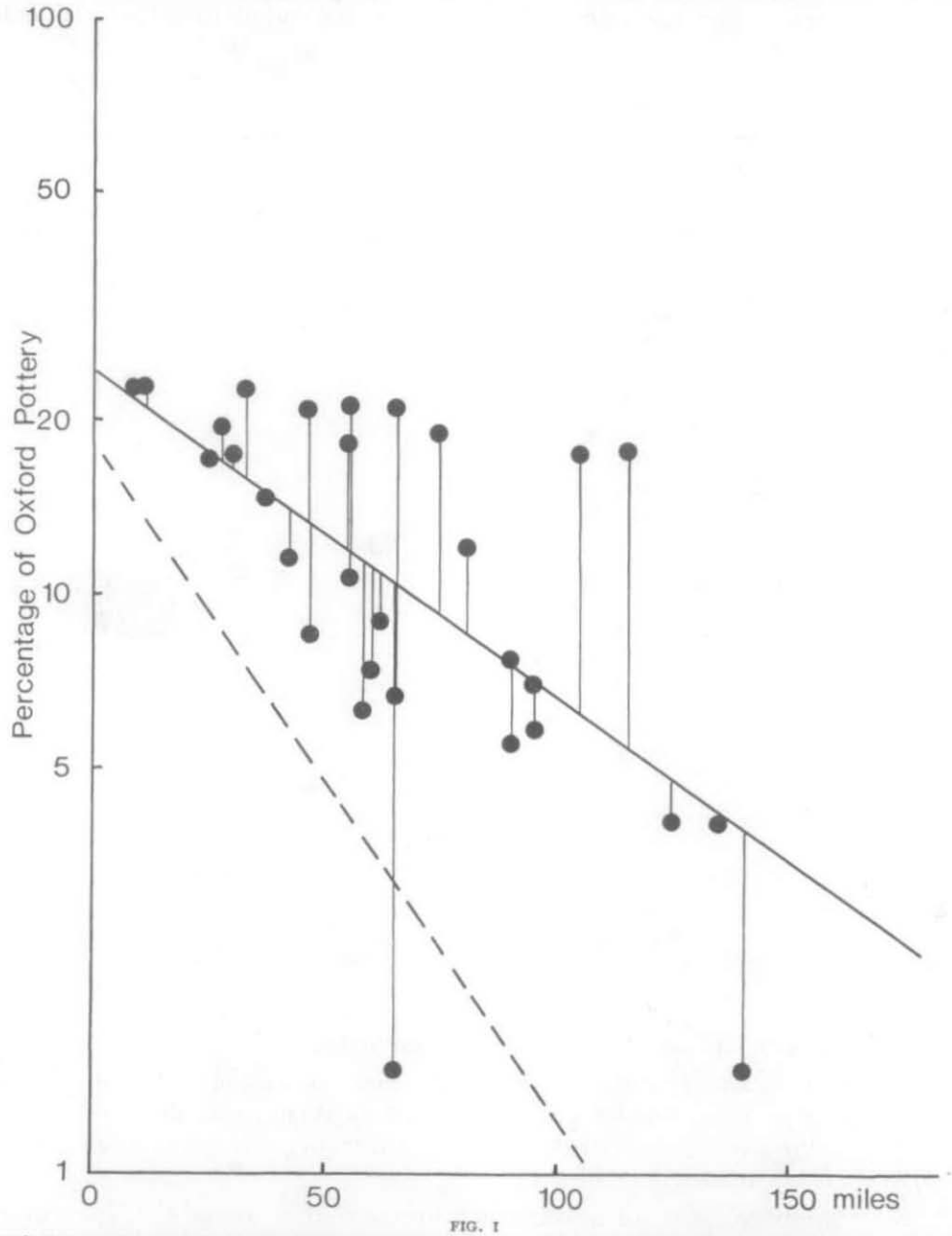

FIG. 1

Best fit linear regression line for the decrease in Oxford pottery with increasing distance from the kilns. Dotted line—the decrease in New Forest pottery away from the New Forest kilns.

[3] I. R. Hodder, 'Regression analysis of some trade and marketing patterns', *World Archaeology* 6 (1974), 172–89.

from the best-fit linear curve. This could be accounted for by the unreliability of the sample, but it was thought worthwhile to see if there is any patterning in the variation from the curve. Such patterning can be investigated by calculating the deviation of each site percentage from the regression line, and plotting these residuals on a map (FIG. 2).

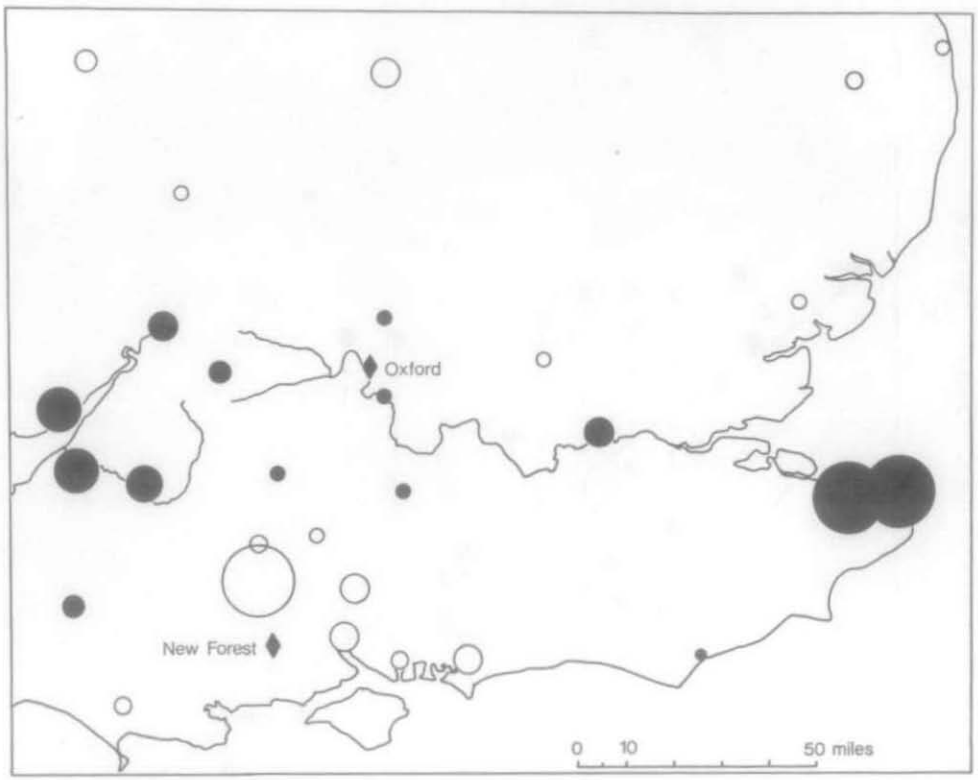

FIG. 2

Regression residuals for the distribution of Oxford pottery ; the size of the circles indicates the magnitude of the residuals. Filled circles = positive residuals ; open circles = negative residuals (for figures, see Table).

Two factors are apparent in the pattern of residuals :

(1) There is a marked distribution to the west and east of Oxford of positive residuals (that is, more Oxford pottery is found in these areas than is expected according to the average overall decrease with distance). Negative residuals are found in the north and south of this area.

(2) High negative residuals occur in a localized area around the New Forest.

These two factors can be considered separately.

(1) The area of high positive residuals may indicate further undiscovered centres producing wares indistinguishable from Oxford wares. There is, however,

no evidence of this as yet, and a further explanation must be found. All the sites with high positive residuals are in areas to which some water transport of pottery could have been involved. Indeed the Oxford kilns are centrally situated for eastward movement down the Thames to London, Canterbury and Richborough, and westward movement to sites flanking the Severn estuary. The same scatter of points as those graphed in Fig. 1 can be divided into those sites to which water transport may have been involved, and those best reached by land (FIG. 3 ; Appendix, Table). The scatters of points can be interpreted as two curves. The ' by-land ' curve is of similar gradient to the New Forest curve, while the ' by-water ' curve has a much less steep gradient suggesting greater and probably cheaper movement of pottery over longer distances. This hypothesized cheaper transport of pottery in

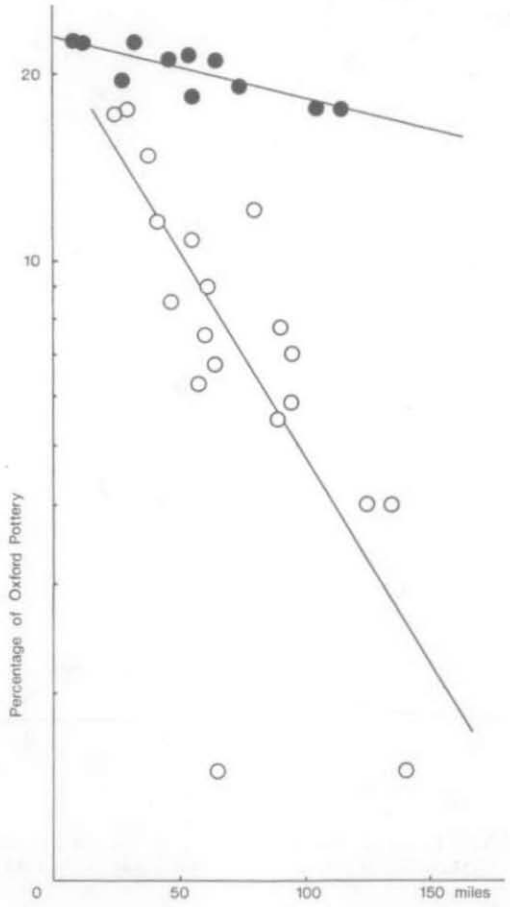

FIG. 3

The decrease in Oxford pottery away from the kilns. Filled circles = sites to which water transport could have been important ; open circles = sites not easily reached by water (see Table).

the Roman world has been discussed by Hartley,[4] Fulford,[5] and Jones,[6] and in ethnography by Foster.[7]

(2) The high negative residuals around the New Forest kilns may occur because in this area these products were able to compete successfully with the Oxford products. A closer examination of the distributions around the two centres allows an assessment of this hypothesized relationship.

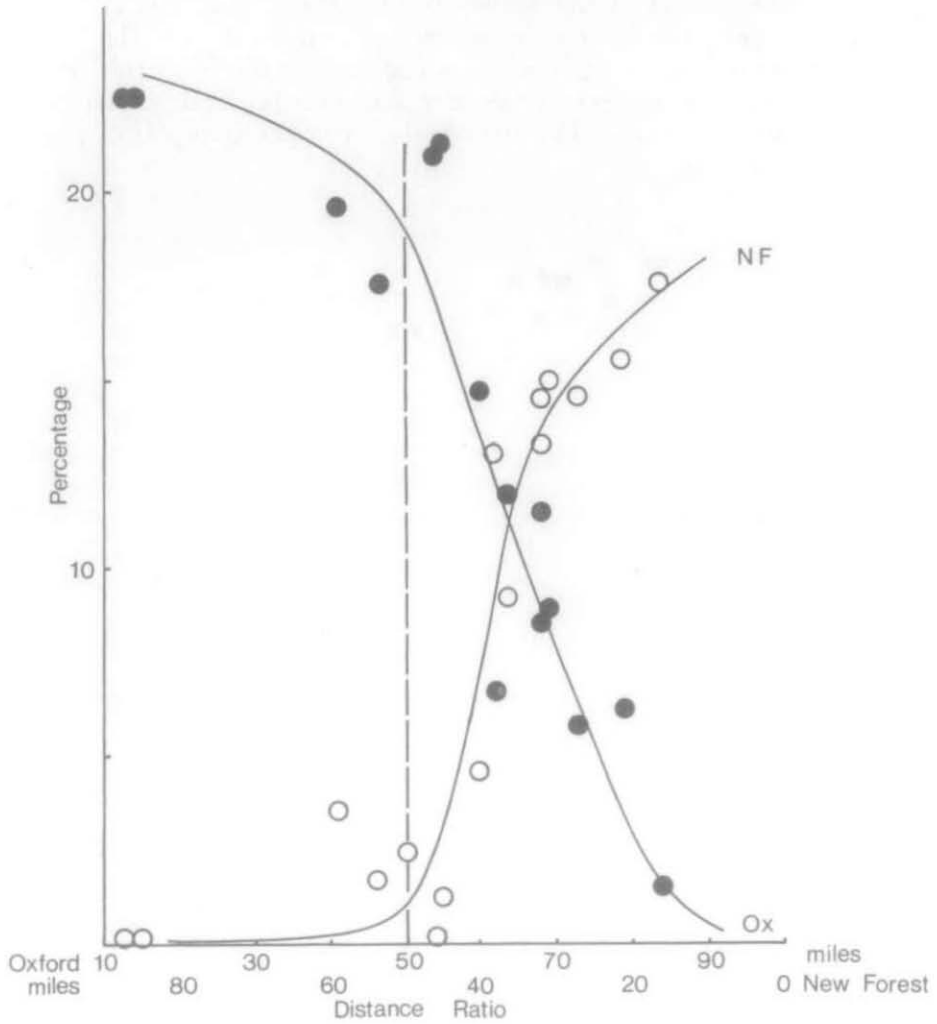

FIG. 4

The decrease in Oxford and New Forest pottery in the area between the two kiln areas. Filled circles = Oxford pottery ; open circles = New Forest pottery. The dotted line = the mid point between the two kiln centres.

[4] K. F. Hartley, ' The Marketing and Distribution of Mortaria ', in A. Detsicas (ed.), *Current Research in Romano-British Coarse Pottery* (1973), 39.

[5] M. G. Fulford, ' The Distribution and Dating of New Forest Pottery ', *Britannia*, IV (1973), 165.

[6] A. H. M. Jones, *The Later Roman Empire* (1964), II, 841–2 ; III, 283.

[7] G. M. Foster, ' The Sociology of Pottery : Questions and Hypotheses ', in F. R. Matson (ed.), *Ceramics and Man* (1966), 43–61.

The composite graph (FIG. 4) shows the percentages of Oxford and New Forest products on sites where they are both found. Since all the sites are not on a straight line between Oxford and the New Forest, the distance from each site is expressed as a ratio of the total distance to both centres. The curves, fitted by eye, show a symmetrical relationship with distance which is to be expected in this case because at each site the total percentage of fine wares from the two centres is very constant.

More interesting is that the point where the two curves cross, that is where the percentages from each centre are equal, is not at the mid-point between them, but in real terms is 39 miles from the Oxford kilns and 21 miles from the New Forest centre. The New Forest products are therefore predominant in a smaller area than the Oxford products. Its more restricted distribution can be seen by comparing its regression curve in Fig. 1. This difference in distribution can be adequately explained in terms of the difference in size of the two centres using Reilly's ' breaking-point ' formula.[8] The size of the two centres can be roughly determined as the area containing the known kilns producing fine wares.[9] It is probable that further kilns will be found, but it seems unlikely that the total area covered will be significantly altered. According to Reilly's model, the distance from the Oxford kilns to the trade area boundary should be :

$$\text{Distance from Oxford} = \frac{60 \text{ miles}}{1 + \sqrt{\frac{20 \text{ sq. miles}}{7 \cdot 8 \text{ sq. miles}}}} = 38 \text{ miles}$$

This result is very close to the actual location of the breaking point at 39 miles from the Oxford kilns. This close correspondence encourages the suggestion that the relative importance of the two production concerns is reflected in the estimated areal size of the centres, and that the observed uneven pattern of distribution of the products in the area between the centres is the result of competition.

The greater importance and scale of the Oxford centre may also be seen in the evidence for more specialized production than in the New Forest, the bigger group of kilns, and the greater number of ancillary buildings which have been found.[10] A larger scale of production than in the New Forest has also been suggested by a study of the best-fit distance transformations for the regression curves.[11] One of the reasons for the greater scale of the Oxford industry may have been its position relative to waterways, as already discussed (but see Swan[12] and Young[13] for an opposing view). The New Forest centre is close to the Hampshire Avon and could be linked by it to a coastal market. This factor may indeed have had some effect on the New Forest pottery distribution. But this did not bring it into touch with very large regional centres of the size of London and Cirencester—both within easy reach of the Oxford kilns—which acted as nodes for considerable areas including the

[8] Hodder, *op. cit.* note 3.

[9] V. G. Swan,' Aspects of the New Forest Late Roman Pottery Industry ', in Detsicas, *op. cit.* note 4, 118, Fig. 1 ; C. J. Young,' The Pottery Industry of the Oxford Region ', *Idem*, 106, Fig. 1.

[10] Young, *op. cit.* note 9, 109.

[11] Hodder, *op. cit.* note 3.

[12] Swan, *op. cit.* note 9, 124.

[13] Young, *op. cit.* note 9, 108, 111.

Thames and Severn estuaries. This larger potential market may have stimulated the Oxford centre to expand in size, production and marketing efficiency at the expense of the New Forest concern.[14]

MULTIPLE CORRELATION

A number of factors has been identified as important for the amount of Oxford pottery found at each site. Apart from sampling errors, these are distance from the Oxford kilns, distance from the New Forest kilns, and a link by water to the Oxford centre. Another factor which might be expected to be relevant is the size (acreage) of the towns in which the pottery is found. Larger, more important sites may have attracted more of the fine pottery than those smaller sites at the same distance from the Oxford region. This is the principle involved in the gravity model.[15] What is the relative importance of these four variables in determining the Oxford fine ware distribution? This question was investigated by applying multiple correlation(Computer programme BMDO2R ; Stepwise multiple regression). Only walled towns were used because their acreage is known. The coefficient of determination (r^2), a measure of the covariation between variables, can range from zero to 1 with increasing covariation. The value of r^2 for the covariation between the percentage of Oxford wares (Y, logarithmically transformed. See Appendix, Table) and distance from Oxford (X_1) is 0·570. As other variables are added, the coefficient of determination shows no marked increase except in the case of the presence or absence of a water link to Oxford (X_4). In fact, the r^2 value for the covariation between Y and (X_1, X_4) is 0·690. Too much reliability should not be placed on these results because the use of multiple correlation on these data poses several problems. In particular the variables X_1 and X_2 are not independent, while there are dangers in mixing continuous (X_1, X_2, X_3) and discrete (X_4) information. In spite of these difficulties a clear pattern has emerged which may perhaps be considered. The analysis results stress the importance of a water link for Oxford as has already been discussed. However, the effect of the New Forest industry was localized and appears to have had little impact on the overall distribution of Oxford wares. Also of little importance is the size of the walled towns. The size of the interacting centres has been shown to play a significant part in so many recent studies of human spatial behaviour that a similar pattern might be expected in Roman Britain. That this is not found may be because only one class of site, the walled town, has been considered. Although variation of size within this group might have influenced the distribution of pottery, any such effect may have been too small to be visible in the archaeological record. If it had been possible to include size information for other types of site, the relevance of the gravity model might have been apparent. Rural sites were certainly less able to attract pottery from long distances. In Wiltshire ' the towns always seem to have been supplied with a wider range of pottery than rural settlements in the county '.[16]

[14] Fulford, *op. cit.* note 2.
[15] Hodder, *op. cit.* note 3.
[16] Swan, *op. cit.* note 9, 123 ; Young, *op. cit.* note 9, 111.

APPENDIX

Table

	Y	Logarithm of Y	Regression residual	X_1	X_2	X_3	X_4	% of New Forest ware	Total % of New Forest and Oxford ware on sites in the areas supplied by both centres
Dorchester (Dorset)	5·85	1·766	−0·212	95	35	70	0	14·55	20·40
Ilchester	12·00	2·485	+0·312	80	45	32	0	9·25	21·25
Bath	21·25	3·057	+0·559	55	45	22	1	1·25	22·50
Gatcombe	21·00	3·045	+0·677	65	55	16	1	—	21·00
Mildenhall	17·50	2·862	+0·039	30	35	15	0	1·75	19·25
Salisbury	1·50	0·405	−1·963	65	12	—	0	17·50	19·00
Winchester	8·50	2·140	−0·462	47	22	138	0	14·50	23·00
Portchester	9·00	2·197	−0·210	62	28	—	0	15·00	24·00
Pevensey	7·75	2·048	+0·005	90	90	—	0	2·50	10·25
Durrington	11·50	2·443	−0·224	42	20	—	0	13·25	24·74
Chichester	6·75	1·909	−0·459	65	40	101	0	13·00	19·75
Clausentum	6·25	1·833	−0·426	58	15	—	0	15·50	21·75
East Anton	14·75	2·691	−0·028	38	25	—	0	4·50	19·25
Silchester	19·50	2·971	+0·122	28	40	107	1	3·50	23·00
Caerwent	19·00	2·945	+0·694	74	72	44	1		
Gloucester	21·00	3·045	+0·430	46	69	41	1		
Cirencester	22·50	3·114	+0·330	33	56	230	1		
Droitwich	10·75	2·376	−0·122	55	96	—	0		
Verulamium	17·25	2·848	−0·040	25	81	200	0		
London	18·25	2·904	+0·406	55	80	330	1		
Richborough	17·50	2·862	+1·144	115	136	—	1		
Canterbury	17·50	2·862	+1·014	105	125	130	1		
Colchester	7·00	1·946	−0·032	95	131	108	0		
Norwich	4·00	1·386	−0·202	125	169	—	0		
Caister	4·00	1·386	−0·072	135	172	35	0		
Leicester	7·50	2·015	−0·418	60	120	87	0		
Brough-on-Humber	1·50	0·405	−0·988	140	128	13	0		
Wroxeter	5·50	1·705	−0·338	90	200	170	0		
Dorchester-on-Thames	22·50	3·114	+0·018	9	56	13·5	1		
Alchester	22·50	3·114	+0·044	11	72	27	1		

Explanation

Y = Percentage of Oxford pottery

X_1 = Distance from Oxford kilns (miles).

X_2 = Distance from New Forest kilns.

X_3 = Acreage of walled towns

X_4 = The presence (1) or absence (0) of a probable water link with the Oxford kilns.