DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

AND

FIRE OFFICES' COMMITTEE

JOINT FIRE RESEARCH ORGANIZATION

REVISED & ISSUED AS FRN 681

FIRE RESEARCH NOTE

NO. 558

THE RANKING OF SOME INDUSTRIES IN GREAT BRITAIN IN ACCORDANCE WITH THEIR RELATIVE FIRE HAZARD

by

JANE M. HOGG and J. M. FIRTH

June 1964.

Fire Research Station.
Boreham Wood.
Herts.
('phone ELStree 1341)

F.R. Note No. 558

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

THE RANKING OF SOME INDUSTRIES IN GREAT BRITAIN IN ACCORDANCE WITH THEIR RELATIVE FIRE HAZARD

by

Jane M. Hogg and J. M. Firth

Introduction

The determining features which make one industry more of a fire hazard than another are, broadly speaking, the frequency and the subsequent spread of fire. If the industries being compared were similar in every respect but for their product, that is, the goods they produce, any differences in the frequency of fire, and their subsequent spread, could be attributed to the products of the industries. The very nature of these products, however, precludes the industries from being similar in every other respect. The processes of production vary in accordance with the goods being produced, as also will the market conditions for buying and selling, resulting in a diversity between industries. The aircraft manufacturing and repairing industry, for example, consists of 384 establishments*, each establishment employing, on average, 716 people, but there are relatively few buyers in the market. The buildings tend to be large one-storey buildings, without internal partitions. The industry specializing in watches and clocks is made up of only 119 establishments. These have an average of 86 employees, but the market contains many more buyers than that of the aircraft industry. Their premises and internal spaces are small when compared with those pertaining to the aircraft industry. The bread and flour confectionery industry, on the other hand, consists of 2371 establishments employing 58 people on average, while its market contains virtually every household at least once a week. The internal spaces in this industry tend to be similar to those in the watches and clocks industry, on average, but the variation in size is probably larger.

A method of reducing the complexity of the problem

The various facets of industry, that is, for example, the number of establishments, the number of people employed, the kind of market for their product, and the size and shape of their premises, all vary between industries. The interrelationship between these factors may vary between no relationship and a complete relationship between any two or more of the factors.

The frequency of fire and the spread of fire in industry may depend upon any or all of these factors.

In order to simplify the problem the total variation between industries from all of the factors under consideration can be allocated to new factors, referred to as components, (necessarily abstract), in a way which ensures that these new components are not related to each other, or, in other words, that they vary independently of each other. The method of calculating these components is shown in the Appendix. For example, if one component represents the size of the industry in its entirety, another which represents the value of stocks would be, in fact, measuring only the residual value of the stocks after the effect of industry size upon its stock value had been removed.

---

* "An establishment usually corresponds to an individual factory or workshop, although returns have sometimes been accepted for a group of establishments engaged in the same industry".
Extract from Board of Trade Journal - 2nd December, 1960.

The number of components obtained depends upon the number of factors considered. In turn, the number of factors considered depends upon the data available. The Census of Production for 1958 furnished the data. Unfortunately, data relating to the size and shape of premises were not available. (Not all of the industries contained in the report of the Census of Production have been included in this analysis, since the report was not complete when the calculation of the components was carried out. Notable absentees include the cotton and rubber industries).

The components of industry

The six largest components (between them they account for 85% of the variation between industries) are shown in Table 1 together with the original factors thus indicating the relationship between the new components and the original factors. The component which accounts for the largest part of the variation between industries (40%) appears to be that which is a measure of size.

An attempt at interpretation gives:

Component two - measure of competitiveness (or size of individual establishments) within the industry

Component three - measure of productivity

Component four - measure of the value of stocks relative to industry size

Component five - measure of the proportion of total costs which are spent on administration

Component six - measure of sensitivity to external economic conditions.

Component one - measure of industry size

The original factors related to size are:

Number of establishments

Purchases of materials, fuels, etc.

Products on hand for sale

Stocks of materials and fuel

Payments for transport

Net output minus wages and salaries

Wages and salaries

Average number employed

New building work

Plant and machinery (acquisitions minus disposals)

Vehicles (acquisitions minus disposals)

All of these factors are highly correlated with the first component.

If all of these incomplete measures of size (standardized on mean and variance) had just been totalled the result would have contained much duplication, since the factors are interrelated. The factors have, therefore been weighted before totalling in a manner which ensures no duplication. The

resultant measure is, itself incomplete in so far as any factor pertaining to other elements of size (not already accounted for) has not been included in the original data. For example, the floor areas of buildings and internal spaces have not been included in the data, although some part of this concept of size will have been accounted for by a knowledge of the number of employees.

Frequency of fire in industry - introduction.

The data on fire frequency and spread were obtained from annual samples of all the reports of fires attended by the fire brigades during the years 1957 to 1961 inclusive. Only the fires which occurred in buildings have been examined.

The frequency of fire in industry was found to be affected by the size of the industry. The ranking of industries by the frequency of fire would therefore need to incorporate an allowance for their respective sizes.

As the other five components examined apparently had no effect upon the frequency of fire, the ranking of industry by fire frequency alone would confuse the effect of size only with other effects not incorporated in these five components. Once an allowance for size has been made the resultant ranking would reflect these residual effects alone. Since the nature of the industry's product, and processes of production, can be expected to have an effect upon the frequency of fire, and as no data of this nature were incorporated into the system for evaluating the components of industry, the ranking has been assumed to reflect the nature of the product, and the processes of production.

Frequency of fire in industry - analysis

One hundred and eighteen industries were examined. These are listed in Table 2. In order to rank these industries by their frequency of fire, while at the same time making an allowance for their respective sizes, it was necessary to group them. Eight industry groups were obtained which are relatively homogeneous with respect to the product of the individual industries.

The types of area in which the fires originated were also grouped; the three groups being (1) production areas (2) storage areas, and (3) a miscellaneous group consisting of all the remaining areas.

As is shown in Fig. 1, at every industry size more fires originated in the production areas than in either the storage or miscellaneous areas, but as industry size increased the resultant increase in fire frequency was greater in the production and miscellaneous areas than in the storage areas.

The ranking of the industry groups by the frequency of fire has been done separately for all three areas. Fig. 2 shows how the frequency of fire originating in production areas in the eight industry groups was affected by changes in industry size. At the average size of industry the frequency of fire was highest in the industry group 'Timber, furniture, etc.', and lowest in the groups 'Food, drink and tobacco', and 'Engineering and electrical goods'. As industry size increased, however, the increase in fire frequency was greatest in the group 'Food, drink and tobacco', and lowest in the group 'Textiles and paper', so that once the industry size was larger than approximately $x = 3250$ it would not be possible to rank these two groups separately.

The final frequency ranking is as follows:-

Class	Industry group	Frequency of fire at average industry size
1 high hazard	Timber, furniture, etc.	216
2 medium hazard	Metal, shipbuilding and vehicles Miscellaneous Textiles and paper Leather, fur, clothing Chemicals and allied industries Food, drink and tobacco	68 (average without food, drink and tobacco)
3 low hazard	Engineering and electrical goods	27

The group 'Food, drink and tobacco' has been included in Class 2 because 9 of the 14 industries in this group were larger than $x = 3000$ in size.

The ranking of industry groups according to the frequency of fire in storage areas and areas associated with miscellaneous activities was found to be similar to the ranking by the frequency of fire in production areas. The industry groups, however, fall into two classes instead of three, in the areas associated with miscellaneous activity.

Class	Storage areas		Areas associated with miscellaneous activity	
	Industry group	Frequency of fire at the average industry size	Industry group	Frequency of fire at the average industry size
1	Timber, furniture, etc.	47	Timber, furniture, etc.	36
2	Six industry groups	16	Seven industry groups	18
3	Engineering and electrical goods	9		

There therefore appears to be very little divergence in the frequency of fire between industries of equivalent size. The number of fires which are attended by the fire brigades would, however, tend to be affected by both the effort made by industry in fire prevention and the effectiveness of its fire fighting equipment and personnel. The industries may thus be tending to counteract the effect of their product and processes of production upon fire incidence by their own fire prevention and control activities.

The spread of fire

Data supplied by the reports of the brigades on those fires used in the analysis of the frequency of fire in industry were used to provide a measure of the spread of fire. The measure used is the proportion of fires which were extinguished by the national fire brigades using hose reel jets and power pumps. This is a crude measure of spread, only distinguishing between

relatively small fires and the more sizeable fires (most of which are probably not very large in terms of either the amount of floor area damaged, or the financial loss incurred). Nevertheless, it is to some degree a measure of a lack of control over fire by industry itself. For example, a fire which is immediately tackled by a works fire brigade may not require the use of hose reel jets and power pumps on the part of the national fire brigade which responded to the fire alarm.

As in the analysis of the frequency of fire the area in which the fire originated was also considered, the three groups being, as before (1) production areas, (2) storage areas, and (3) miscellaneous areas.

In none of these areas did the measure of fire spread appear to be dependent upon the measure of industry size, or upon the other 5 components of industry mentioned above.

The ranking of the industry groups was, therefore, performed only on the basis of the average proportion of fires extinguished by the public fire brigades using hose reel jets and power pumps for each group.

The ranking is as follows:-

Class	Proportion of fires extinguished by brigades using hose reel jets, etc.	Industry group
1	0.92	Timber, furniture, etc.
2	0.77	Textiles and paper Miscellaneous Metal, shipbuilding and vehicles Leather, fur, clothing Food, drink and tobacco Chemicals and allied industries
3	0.69	Engineering and electrical goods

This ranking is identical to the ranking by the frequency of fire originating in production and storage areas, which may imply that the greater the chance of a fire per unit area in an industry the greater is the likelihood of the fire spreading beyond that area.

On the other hand, irrespective of industry, the fires originating in storage areas, although less frequent than those in production areas, appear, on average, to be larger as is shown below:-

Proportion of fires extinguished by brigades using hose reel jets, etc.	Area of origin of fire
0.87	Storage
0.70	Production and miscellaneous

The lower chance of fire and the greater spread of fire in storage areas may imply that although storage conditions may provide fewer sources of ignition than the production processes, fires in storage areas may be larger because their discovery is comparatively delayed. (The unit size of storage areas in industry, may, of course, be considerably smaller than the unit size of production areas).

The logarithm of the number of persons employed as an alternative measure of industry size

It may not always be possible, or convenient, to calculate the component of industry which appears to correspond to industry size. An alternative would be to consider the number of persons employed as the unit of measurement. The number of persons employed appears to be highly dependent upon the measure of industry size, as can be seen from Fig. 3. It is, nevertheless, important to be aware that for any given size of industry there is a variation in the number of persons employed by the particular industries of this size. As industry size increases, either the number of establishments may increase, leading to a proportionate increase in the number of employees, or the establishments may themselves grow in size, which may lead to an increase in the numbers employed, but very probably also leads to a substitution of men by machines and an increase in the division of labour; both the number and the size of the establishments may, of course, increase simultaneously, and it is also possible for an industry to increase in size while the number of establishments decreases.

Since these and other events may occur as industry size increases it follows that the variation about the average number of persons employed must increase with an increase in industry size. In fact, the variation about the average number of persons employed was found to increase as the meausre of industry size increased. By substituting the logarithm of the number of persons employed for the actual numbers employed it can be seen from Fig. 3 that the variation about the average of the logarithm of the number of persons employed is similar at every point of the measure of industry size. Because there is this constancy of variance in the dependence of the logarithm of the number of persons employed upon the measure of industry size the use of the logarithm, rather than the actual numbers employed, is recommended as an alternative measure of industry size.

The relationship between the number of people employed and the measure of industry size was, however, found to be different in the industry group, 'Leather, fur, clothing' from the relationship which existed in the other seven industry groups. As the measure of industry size increased the number of people employed in the industry group 'Leather, fur, clothing' appeared to increase faster than in the other industry groups. It would, therefore, appear that industries other than those associated with 'Leather, fur, clothing' are more ready, or more able, to substitute machines for men than the industries associated with 'Leather, fur, clothing'.

It also appears to be possible to rank the industry groups by the average number of people employed.

The following table ranks the industry groups at the average industry size.

Industry group	Average number of people employed
Leather, fur, clothing	882
Engineering and electrical goods Metal, shipbuilding, vehicles Miscellaneous Textiles and paper	802
Timber, furniture, etc.	717
Food, drink and tobacco Chemicals and allied industries	631

When the logarithm of the number of people employed is used as an alternative measure of industry size, it would appear to be advisable to transform to the measure of industry size, as defined in this paper, using the equations given in the Appendix.

Conclusions

A measure which appears to rank industries effectively by their relative size was constructed. The frequency (but not the spread) of fire was found to be dependent upon this measure of size. The frequency of fire is, of course, dependent upon the number of rooms at risk, while the spread of fire is dependent upon the average size of the rooms.

An attempt was made to interpret some of the other components of industry which were constructed simultaneously with the measure of size. These components appear to have no effect upon either the frequency or the spread of fire.

At every industry size more fires originated in production areas than in either the storage or miscellaneous areas, but as industry size increased the resultant increase in fire frequencies was greater in the production and miscellaneous areas than in the storage areas.

The ranking of industry groups by the frequency of fire (making allowances for the effect of size) was similar for all areas, although it was possible to differentiate between three classes in production areas and storage areas, but only two in other areas, as shown below:-

Class	Industry group	Number of fires at average industry size		
		Production	Storage	Miscellaneous
1	Timber, furniture, etc.	216	47	36
2	(Six industry groups)	68	16	18
3	Engineering and electrical goods	27	9	

Ranking the industry groups in terms of the spread of fire produced the same order as with the frequency of fire in production and storage areas.

The proportion of fires extinguished by the public fire brigades using hose reel jets or power pumps was higher in storage areas than in other areas.

The logarithm of the number of persons employed may be used as an alternative measure of industry size if allowances are made (1) for the variation in this measure at every industry size, and (2) for the differences in the relationship between the number of people employed and industry size in the various industry groups.

Acknowledgement

The Board of Trade assisted in the industrial classification of the fire reports.

References

1. Board of Trade. The report on the Census of Production for 1958. London, 1960-1961.

2. KENDALL, M. G. A course in multivariate analysis. Griffin's statistical monographs and courses No. 2. London, 1957.

APPENDIX

Component Analysis

$$\begin{matrix} X_{11} & X_{12} & \cdots & X_{1.n} \\ X_{21} & X_{22} & \cdots & X_{2.n} \\ \vdots & \vdots & & \vdots \\ X_{p.1} & X_{p.2} & \cdots & X_{p.n} \end{matrix}$$

X_{ij} are standardized $N(0,1)$ variates

$p = 26$

$n = 118$

26 variates $X_1, X_2 \ldots X_p$, were each observed on 118 industries.

The problem is largely one of reducing the 26-dimensional variation to a one-dimensional variation, so that the resulting component might be used as a measure of size, but the other components are also of interest.

Components were obtained which are uncorrelated, and which account for all of the variation in the variates between industries[2] i.e.

$$\zeta_{ti} = \sum_{k=1}^{p} a_{tk} X_{ki}$$

t	represents the component	$t = 1, 2, \ldots p$
k	represents the variate	$k = 1, 2, \ldots p$
i	represents the industry	$i = 1, 2, \ldots n$

All of the variation in the variates X_k was accounted for by the orthopanal components ζ_t as follows:-

	% of variation	cum. % of variation
ζ_1	37.9	37.9
ζ_2	24.1	62.0
ζ_3	8.1	70.1
ζ_4	6.1	76.2
ζ_5	4.6	80.8
ζ_6	4.1	84.8
ζ_7	3.0	87.9
⋮	⋮	⋮
ζ_p	-	100.0

The correlation matrix of the variates X_k and the components ζ_t may be used as a measure of size. The components ζ_2 to ζ_6 do not appear to affect either the frequency of fire, or the degree to which fires spread. The dependency or otherwise of fire frequency and spread upon the components ζ_7 to ζ_{26} was not verified, since only 15.2% of the variation between industries was accounted for by these 20 components.

Reports of fires

Reports of fires attended by fire brigades for the years 1957 to 1961 inclusive, have been used for this study. The frequencies of fire in these years for each industry have been obtained from a systematic random sample of all reports, the sampling fraction for each year being as follows:-

1957	:	full sample
1958-1960	:	1-in-4 sample
1961	:	1-in-2 sample

The different sampling fractions meant that the sampling variation within years differed. Correction has been made as follows.

z_{ij} represents the number of fires in the ith industry in the j^{th} year

f_j represents the sampling fraction in the j^{th} year

S_j^2 represents the variation in the number of fires between industries in the j^{th} year

ω_j represents the multiplier applied to the numbers in the sample in the j^{th} year

$$V(z_{ij}) = (1-f_j)S_j^2 + S_j^2$$
$$= \text{sampling variation} + \text{chance variation}$$
$$= S_j^2(2-f_j)$$

(i) When $f_j = \frac{1}{4}$ $\quad V(z_{ij}) = S_j^2(2-\frac{1}{4})$

$$= s^2(7/4)$$

Therefore $W_j = \frac{4}{\sqrt{7/4}}$

$$= 3.024$$

(ii) When $f_j = \frac{1}{2}$ $\quad V(z_{ij}) = S_j^2(2-\frac{1}{2})$

$$= s^2(3/2)$$

Therefore $W_j = \frac{2}{\sqrt{1.5}}$

$$= 1.633$$

Industry groups

The n industries were grouped as shown in Table 2.

The reports of fires, which occurred between the years 1957 and 1961 inclusive in these n industries, have also been grouped; the categories being as follows:-

(i) fires which originated in areas associated with production processes, i.e. factory sections, workshop, welding shop, drying

or heat treatment sections; paint shop, paint store.

(ii) fires which originated in areas associated with storage, i.e. store, stockroom; loading bay, packaging department; showroom.

(iii) fires which originated in other specified areas.

Those reports which did not specify the sub-occupancy from which the fires originated, appear, from a χ^2 contingency table, to have originated in areas associated with production, hence they have been included in this category.

Actual number of fires in sample

Fires originating in areas associated with	1957	1958	1959	1960	1961	Total
Production	2869	764	891	851	1664	7039
Storage	592	119	190	189	418	1508
Miscellaneous activities	779	183	216	255	528	1961
Unspecified activities	277	16	17	65	294	669
Total	4517	1082	1314	1360	2904	11177

Expected numbers in the contingency table

Fires originating in areas associated with	1957	1958	1959	1960	1961	Total
Production	2844.7	681.4	827.5	856.5	1828.9	7039
Storage	609.4	146.0	177.3	183.5	391.8	1508
Miscellaneous activities	792.5	189.8	230.5	238.6	509.5	1961
Unspecified activities	270.4	64.8	78.6	81.4	173.8	669
Total	4517	1082	1314	1360	2904	11177

It was not always possible to allocate fire reports further than an industry group. These fires have been distributed amongst the industries within the group in accordance with the distribution of fires known to have occurred in those industries. The number of fires which had to be distributed in this way are shown below:-

Standard Industrial Classification	Industry group	Weighted total of fires originating in areas of		
		Production	Storage	Miscellaneous activities
	Engineering and electrical goods			
330-340	Engineering goods	650.5	89.7	181.8
360	Electrical goods	170.7	35.4	58.5
380	Vehicles	63.0	10.3	15.3
440	Clothing	120.9	28.4	25.8

Not.

Dependence of frequency of fire upon the measure of size

The analysis of the dependence of fire frequencies upon the measure of size has been done in three separate parts, in accordance with the areas in which the fires originated.

The dependence of the fire frequencies $\sum_j z_{ij}$ upon the first component ζ_1 was found not to be linear nor were the chance variations normally distributed. The following transformations were, therefore, made:-

$$y_i = \log \sum_j z_{ij}$$

where i represents the industry and j represents the year

$$x_i = (50 + \zeta_{1i})^2$$

so that

$$y_i = \alpha + \beta x_i + \varepsilon_i$$

where ε_i represents chance variation and is $N(0, \sigma^2)$

β represents the linear dependence of y on x

and $\alpha = \bar{y} - \beta \bar{x}$

α is estimated by a
β is estimated by b
and ε is estimated by e
and σ^2 is estimated by S^2

The ε_i were, however, found to be $N(0, S_t^2)$, where t represents an industry group (the assumption was made that the ε_i were homoscedastic within an industry group). It was, therefore, necessary to weight the sums of squares for each industry group by the reciprocal of the estimated variation i.e. $W_t = c \cdot \frac{1}{S_t^2}$

Such that $e^2 = S_\omega y^2 - b S_\omega xy$

b is given by $\frac{S_\omega xy}{S_\omega x^2}$, a is $\bar{y} - b\bar{x}$

$$\bar{y}_\omega = \frac{\sum_t \omega_t \sum_i y_{it}}{\sum_t \omega_t n_t}$$

where n_t represents the number of industries (i) in the industry group t

similarly $\bar{x}_\omega = \frac{\sum_t \omega_t \sum_i x_{it}}{\sum_t \omega_t n_t}$

$$S_\omega y^2 = \sum_t \omega_t \sum_i (y_i - \bar{y}_\omega); \quad S_\omega x^2 = \sum_t \omega_t \sum_i (x_i - \bar{x}_\omega); \quad S_\omega xy = \sum_t \omega_t \sum_i (x_i - \bar{x}_\omega)(y_i - \bar{y}_\omega)$$

and $\sum_t \omega_t = 1$ $\qquad \left(\omega_t = c \cdot \frac{1}{S_t^2}\right)$

The variation attributable to the overall linear regression of fires associated with areas of production, storage and miscellaneous activities upon the measure of industry size was in every instance very highly significant, the confidence level being $< 0.1\%$.

Nevertheless, it is not the variation in fire incidence due to industry size which is of interest, since it would be surprising if it did not exist, but rather whether the regression line within each industry group was coincident with the regression line within every other industry group.

The regression lines pertinent to the fires associated with production were found to be neither parallel nor concurrent, whereas those pertinent to fires associated with either storage or miscellaneous activities were apparently not coincident.

The analysis of variance for each of the three groups of fire incidence are shown below:-

Fires originating in areas of production

Source of variation	Degrees of freedom	Sum of squares	Mean square	Variance ratio	Confidence level
Overall linear regression	1	$b_o S\omega xy_o$ = 1.736599	1.736599	245.62	0.1%
Within group slopes versus slope of means	1	$\frac{S\omega x_c^2 S\omega x_m^2 (b_c - b_m)^2}{S\omega x_o^2}$ = 0.011146	0.011146	1.58	-
About linear regression of group means	6	$S\omega y_m^2 - b_m S\omega xy_m$ = 0.727955	0.121326	17.16	0.1%
Between within group slopes	7	$\sum_c b_c S\omega xy_c - b_c S\omega xy_c$ = 0.145026	0.020718	2.93	1.0%
Residual	102	$\sum_c (S\omega y_c^2 - b_c S\omega xy_c)$ = 0.721166	0.00707025		
Total	117	$S\omega y_o^2$ = 3.341889			

Fires originating in areas of-Storage						—Miscellaneous activities			
Source of variation	Degrees of freedom	Sum of squares	Mean square	V/r	C.L.	Sum of squares	Mean square	V/r	C.L.
Overall linear regression	1	0.900636	0.900636	86.47	0.1%	1.869302	1.869302	242.45	0.1%
Within group slopes versus slope of means	1	0.041902	0.041902	4.02	5%	0.047602	0.047602	6.17	2.5%
About linear regression of group means	6	0.417223	0.069537	6.68	0.1%	0.219401	0.036567	4.74	0.1%
Between within group slopes	7	0.073128	0.010447	-		0.091534	0.013076	-	-
Residual	102	1.062368	0.010415			0.786468	0.007710		
Total	117	2.495258				3.014306			

$$S y_t^2 = \sum_i (y_{it} - \bar{y}_t)^2 \qquad S\omega y_c^2 = \sum_t \omega_t S y_t^2 \qquad S\omega y_m^2 = \sum_t \omega_t n_t (\bar{y}_t - \bar{y}_\omega)^2 \qquad S\omega y_o^2 = S\omega y_c^2 + S\omega y_m^2$$

$$S x_t^2 = \sum_i (x_{it} - \bar{x}_t)^2 \qquad S\omega x_c^2 = \sum_t \omega_t S x_t^2 \qquad S\omega x_m^2 = \sum_t \omega_t n_t (\bar{x}_t - \bar{x}_\omega)^2 \qquad S\omega x_o^2 = S\omega x_c^2 + S\omega x_m^2$$

$$S x y_t = \sum_i (x_{it} - \bar{x}_t)(y_{it} - \bar{y}_t) \qquad S\omega x y_c = \sum_t \omega_t S x y_t \qquad S\omega x y_m = \sum_t \omega_t n_t (\bar{x}_t - \bar{x}_\omega)(\bar{y}_t - \bar{y}_\omega) \qquad S\omega x y_o = S\omega x y_c + S\omega x y_m$$

$$b_c = \frac{S\omega x y_c}{S\omega x_c^2} \qquad b_m = \frac{S\omega x y_m}{S\omega x_m^2} \qquad b_o = \frac{S\omega x y_o}{S\omega x_o^2}$$

The average fire incidence in production areas was significantly higher than that originating in either storage areas or areas of miscellaneous activity, while the average fire incidence in areas of miscellaneous activity was also significantly higher than that in storage areas.

Fires associated with	$\bar{y}_\omega$	$V(\bar{y}_\omega) = \frac{S^2}{\Sigma \omega_t n_t}$
Production	1.8605	0.0005168
Storage	1.1482	0.0010659
Miscellaneous activities	1.3044	0.0006732

The regression coefficient b and its variation $V(b)$ for each group of fires are shown below.

Fires associated with	$b\ (10^3)$	$V(b) = \frac{S^2}{\delta_\omega x^2}\ [10^6]$
Production	0.296	0.000356
Storage	0.213	0.000782
Miscellaneous activities	0.323	0.000505

Thus, as the size of industry increases the increase in the number of fires associated with production and miscellaneous activities appears to be faster than the increase in the number of fires associated with storage.

The following table ranks the industry groups in accordance with the average fire incidence in production areas at the average industry size, i.e. $\bar{y}'_t = a_t + b_t \bar{x}_\omega$. The variances were calculated by

$$V(\bar{y}'_t) = \left[\frac{1}{n_t} + \frac{(\bar{x}_t - \bar{x}_\omega)^2}{Sx_t^2}\right] S_t^2$$

and $$V(b_t) = \frac{S_t^2}{Sx_t^2}$$ with $n_t - 2$ degrees of freedom

The 't' test was then used to split the industry groups into different classes.

Average frequency of fire in production areas at the average industry size of all industries

Industry group	$\bar{y}'_t$	$V(\bar{y}'_t)$	$b_t(10^3)$	$V(b_t)[10^6]$
Timber, furniture, etc.	2.3336	0.004879	0.4321	0.006396
Metal, shipbuilding and vehicles	1.9471	0.001635	0.2877	0.000754
Miscellaneous	1.8983	0.010241	0.3714	0.011905
Textiles and paper	1.8818	0.004162	0.2026	0.002401
Leather, fur, clothing	1.8031	0.012064	0.2948	0.010766
Chemicals and allied industries	1.7758	0.012026	0.2423	0.012590
Food, drink and tobacco	1.4775	0.003904	0.5530	0.005022
Engineering and electrical goods	1.4237	0.008213	0.2638	0.006081

$\bar{y}'_t$ is significantly high for the group 'Timber, furniture, etc.', and significantly low for the groups 'Food, drink and tobacco', and 'engineering and electrical goods', thus splitting the groups into three classes. On the other hand, b_t, significantly high for the group 'Food, drink and tobacco' and significantly low for the group 'Textiles and paper'. Taking into account the size of each individual industry in the group, 'Textiles and paper' remained in the medium hazard class, but it appeared better to move 'Food, drink and tobacco' from the low hazard class to the medium hazard class.

The frequency of fire in storage areas and areas of miscellaneous activity were examined further since the regression lines within the industry groups were apparently not coincident. The regression line associated with at least one industry group appeared to be parallel to the other coincident regression lines. From an examination of the tables below the industry group 'Timber, furniture, etc.' appeared to be the most likely group to differ in both areas.

Average frequency of fire in storage areas at the average industry size of all industries

Industry group	$\bar{y}'_t$
Timber, furniture, etc.	1.6760
Miscellaneous	1.3465
Textiles and paper	1.2715
Leather, fur, clothing	1.1136
Metal, shipbuilding and vehicles	1.1089
Chemicals and allied industries	1.1020
Food, drink and tobacco	0.9502
Engineering and electrical goods	0.7210

Average frequency of fire in areas of miscellaneous activity
at the average industry size of all industries

Industry group	$\bar{y}_c'$
Timber, furniture, etc.	1.6515
Miscellaneous	1.4989
Leather, fur, clothing	1.3826
Textiles and paper	1.3182
Chemicals and allied industries	1.2850
Engineering and electrical goods	1.2203
Metal, shipbuilding and vehicles	1.2103
Food, drink and tobacco	1.1811

The 'about linear regression of group means' variations were recalculated excluding the group 'Timber, furniture, etc.' for both the storage and miscellaneous areas. The calculations are shown below:-

Frequency of fire originating in storage areas
(excluding 'Timber, furniture, etc.')

Source of variation	d.f.	SS	MS	V/r	C.L.
About linear regression of group means	5	0.214698	0.042940	4.12	0.5%
Residual	98		0.010415		

Frequency of fire originating in areas of miscellaneous activity
(excluding 'Timber, furniture, etc.')

Source of variation	d.f.	SS	MS	V/r	C.L.
About linear regression of group means	5	0.051615	0.010323	1.34	-
Residual	98		0.007710		

In storage areas the within industry groups regression lines cannot be said to be coincident even with the exclusion of the group 'Timber, furniture, etc.' As the group 'Engineering and electrical goods' appeared the most likely to differ from the remaining groups the 'About linear regression of group means' was recalculated without either of the groups 'Timber, furniture, etc.' or 'Engineering and electrical goods.

Frequency of fire originating in storage areas
(excluding 'Timber, furniture, etc.' and 'Engineering and electrical goods')

Source of variation	d.f.	SS	MS	V/r	C.L.
About linear regression of group means	4	0.078913	0.019728	1.89	-
Residual	80		0.010415		

With the exclusion of the groups 'Timber, furniture, etc.' and 'Engineering and electrical goods' in storage areas, and the group 'Timber, furniture, etc.' in areas of miscellaneous activity, the null hypothesis that the within industry groups regression lines are coincident cannot be refuted.

The industry groups have, therefore, been ranked as follows:-

Class	Production	Storage	Miscellaneous
1	Timber, furniture, etc.	Timber, furniture, etc.	Timber, furniture, etc.
2	Six industry groups	Six industry groups	Seven industry groups
3	Engineering and electrical goods	Engineering and electrical goods	-

The spread of fire

The proportion of fires extinguished by public (as opposed to works) fire brigades using hose reel jets and power pumps was used as a measure of fire spread. This measure of fire spread appeared to be independent of the size of industry, as represented by the first component of industry.

The variation about the average spread of fire for each area of origin within every industry group was calculated as follows:-

Let ρ_{tij} be the measure of fire spread in the t^{th} industry in the i^{th} industry group and the j^{th} area of origin.

and $V(\rho_{tij})$ be the variation about ρ_{tij} within the i^{th} industry group and the j^{th} area of origin.

Then $$\bar{\rho}_{ij} = \frac{\sum_t f_{tij}\rho_{tij}}{\sum_t f_{tij}}$$

where f_{tij} represents the total number of fires which occurred in the t^{th} industry, in the i^{th} industry group and j^{th} area of origin

Hence $$V(\bar{\rho}_{ij}) = V\left(\frac{\sum_t f_{tij}\rho_{tij}}{\sum_t f_{tij}}\right)$$

$$= \sum_t f_{tij}^2 V(\rho_{tij}) \Big/ \left(\sum_t f_{tij}\right)^2$$

Also $$\bar{\rho}_{i\cdot} = \frac{\sum_j \omega_{ij}\bar{\rho}_{ij}}{\sum_j \omega_{ij}}, \quad \bar{\rho}_{\cdot j} = \frac{\sum_i \omega_{ij}\bar{\rho}_{ij}}{\sum_i \omega_{ij}}, \quad \bar{\rho}_{\cdot\cdot} = \frac{\sum_i\sum_j \omega_{ij}\bar{\rho}_{ij}}{\sum_i\sum_j \omega_{ij}}$$

~~and~~ where $\omega_{ij} = \frac{1}{V(\bar{\rho}_{ij})}$

The values for the $\bar{\rho}_{ij}$, $\bar{\rho}_{i.}$, $\bar{\rho}_{.j}$ and $\bar{\rho}_{..}$ are shown below.

Industry groups	Areas of Production	Areas of Storage	Areas of miscellaneous activity	All areas
Food, drink and tobacco	0.6596	0.7509	0.7299	0.7310
Chemicals and allied industries	0.5938	0.8060	0.5629	0.7218
Metal, shipbuilding and vehicles	0.6669	0.8347	0.7053	0.7990
Engineering and electrical goods	0.5446	0.8534	0.5581	0.6911
Textiles and paper	0.6799	0.8401	0.5911	0.7771
Leather, fur, clothing	0.6837	0.8405	0.6552	0.7645
Timber, furniture, etc.	0.8736	0.9243	0.8816	0.9166
Miscellaneous	0.6706	0.9086	0.6185	0.8472
All industry groups	0.6887	0.8732	0.6990	0.8175

Ranking the industry groups by $\bar{\rho}_{i.}$ gives the following table, which also shows $\sum_j \omega_{ij}$ since $V(\bar{\rho}_{i.}) = \frac{\sum_j \omega_{ij} V(\bar{\rho}_{ij})}{(\sum_j \omega_{ij})^2} = \frac{1}{\sum_j \omega_{ij}}$.

Industry group	$\bar{\rho}_{i.}$	$\sum_j \omega_{ij}$
Timber, furniture, etc.	0.9166	225.6996
Miscellaneous	0.8472	36.0644
Metal, shipbuilding and vehicles	0.7990	61.2266
Textiles and paper	0.7771	70.1974
Leather, fur, clothing	0.7645	46.3186
Food, drink and tobacco	0.7310	53.1282
Chemicals and allied industries	0.7218	52.1302
Engineering and electrical goods	0.6911	33.5509
All industry groups	0.8175	578.3158

From tables of 'percentage points of the extreme studentized deviate from the sample mean, $(x_n - \bar{x})/s_r$ or $(\bar{x} - x_1)/s_r$' it was found that the industry groups fell into three classes. These classes contain the same industry groups as do the classes pertinent to the frequency of fire i.e.

Class	Industry group	Average fire spread
1	Timber, furniture, etc.	0.9166
2	(Six industry groups)	0.7707
3	Engineering and electrical goods	0.6911

Ranking the areas of origin by $\bar{p}_{.j}$ gives

Area of origin	$\bar{p}_{.j}$	$\sum_i \omega_{ij}$
Storage	0.8732	415.2621
Miscellaneous	0.6990	102.9509
Production	0.6887	60.1028
All areas of origin	0.8175	578.3158

Fires originating in storage areas appear to spread more on average than do the fires originating elsewhere.

Dependence of the number of people employed upon the measure of size

The analysis was done in the same way as the analysis of the dependence of frequency of fire upon the measure of size. It was again necessary to weight the sums of squares.

The following straight line relationship was compared between industry groups:

$$y_i = \alpha + \beta x_i + \varepsilon_{it}$$

where y_i represents the logarithm of the number of people employed in industry i

x_i represents the measure of size in industry i

ε_{it} represents the chance variation in industry i, in industry group t, and is distributed as $N(0, \sigma_t^2)$

β represents the linear dependence of y on x

and $\alpha = \bar{y} - \beta \bar{x}$

The analysis of variance gives:

Source of variation	d.f.	SS	MS	V/	C.L.
Overall linear regression	1	1.537956	1.537956	780.69	0.1%
Within group slopes versus slope of means	1	0.000139	0.000139		
About linear regression of group means	6	0.095026	0.015838	8.040	0.1%
Between within group slopes	7	0.030290	0.004327	2.197	5%
Residual	102	0.200938	0.001970		
Total	117	1.864349			

The slopes of the within industry group regression lines appear to differ in at least one instance, while the group means at the average industry size also appear to differ.

The within group regression lines, other than that associated with 'Leather, fur, clothing' appear to be parallel to each other, b_o being 0.0003404.

The group means at the average industry size associated with 'Chemicals and allied industries' and 'Food, drink and tobacco' are significantly lower than the remaining groups other than the group 'Leather, fur, clothing'. The regression lines associated with the remaining five groups are nevertheless still not coincident under the null hypothesis. Either the group mean associated with 'Engineering and electrical goods' is significantly high, or more probably, that associated with 'Timber, furniture, etc' is significantly low, or even that both are significantly different from the group means associated with the groups 'Metal, shipbuilding and engineering', 'Miscellaneous' and 'Textiles and paper'.

It, therefore, appears that when the logarithm of the number of people employed is used as a measure of industry size it would increase precision if a transformation to the measure of industry size, as defined in this paper, were made within each industry group. The transformations are made using the estimated within industry group regression lines. These regression lines are shown in the following table, together with the variation about the regression line within each industry group:-

Industry group	$\bar{y}_i'$	Within group regression line	$V(e_i)$
Leather, fur, clothing	4.7619	$y_i = 3.571 + 0.000461\, x_i + e_i$	0.010048
Engineering and electrical goods	4.6732	$y_i = 3.910 + 0.000295\, x_i + e_i$	0.016056
Metal, shipbuilding and vehicles	4.6368	$y_i = 3.785 + 0.000329\, x_i + e_i$	0.041094
Miscellaneous	4.6345	$y_i = 3.719 + 0.000354\, x_i + e_i$	0.083563
Textiles and paper	4.6060	$y_i = 3.769 + 0.000324\, x_i + e_i$	0.033399
Timber, furniture, etc.	4.5215	$y_i = 3.618 + 0.000350\, x_i + e_i$	0.004482
Food, drink and tobacco	4.4492	$y_i = 3.514 + 0.000362\, x_i + e_i$	0.034776
Chemicals and allied industries	4.4112	$y_i = 3.501 + 0.000352\, x_i + e_i$	0.036098

The within industry group slopes of the regression line are shown below:-

Industry group	b_t (10³)
Food, drink and tobacco	0.3618
Chemicals and allied industries	0.3520
Metal, shipbuilding and vehicles	0.3294
Engineering and electrical goods	0.2952
Textiles and paper	0.3237
Leather, fur, clothing	0.4605
Timber, furniture, etc.	0.3495
Miscellaneous	0.3538

The slope of the regression line associated with the industry group 'Leather, fur, clothing' appears to differ most from the other b_t.

The following table shows the group means at the average industry size, together with the variation about the group means.

Industry group	$\bar{y}_t'$	$V(\bar{y}_t')$
Leather, fur, clothing	4.7619	0.001170
Engineering and electrical goods	4.6732	0.000922
Metal, shipbuilding, vehicles	4.6368	0.002605
Miscellaneous	4.6345	0.005914
Textiles and paper	4.6060	0.001868
Timber, furniture, etc.	4.5215	0.000747
Food, drink, tobacco	4.4492	0.002926
Chemicals and allied industries	4.4112	0.003828

The industry group 'Leather, fur, clothing' appears to have the highest mean number of people employed at the average industry side, as well as the fastest increase in numbers employed as industry size increases.

The analysis of variance excluding the industry group 'Leather, fur, clothing' gives the following results.

Source of variation	d.f.	SS	MS	V/r	C.L.
Overall linear regression	1	1.244134	1.244134	631.5	0.1%
Within group slopes versus slope of means	1	0.027564	0.027564	13.99	0.1%
About linear regression of group means	5	0.036683	0.007336	3.72	0.5%
Between within group slopes	6	0.005271	0.000878	0.45	-
Residual	92	0.181238	0.001970		
Total	105	1.494890			

Table 1

Correlation matrix between factors of industry and components of industry

Factors of industry	Component of industry					
	1	2	3	4	5	6
Number of establishments: employing 25 or more	+0.79	+0.32	-0.32	0	0	0
employing less than 25	+0.59	+0.62	0	0	+0.25	0
Purchases of materials, fuels, etc.	+0.76	-0.40	0	+0.21	0	0
Products on hand for sale: change during year	0	0	0	-0.31	+0.29	+0.21
at end of year	+0.23	0	0	+0.81	+0.23	0
Stocks of material and fuel: change during year	0	0	0	+0.25	-0.23	+0.79
at end of year	+0.42	-0.28	0	+0.69	+0.40	0
Payments for transport	+0.74	-0.22	+0.33	+0.23	0	0
Net output minus wages and salaries: 25 or more employed	+0.86	-0.38	0	0	0	0
less than 25 employed	+0.38	+0.79	+0.37	0	-0.22	0
Wages and salaries: operatives	+0.89	-0.22	-0.28	0	0	0
other employees	+0.87	-0.32	0	-0.22	0	0
Average number employed: (25 or more): operatives	+0.86	-0.23	-0.38	0	0	0
other employees	+0.87	-0.36	0	0	0	0
(less than 25): operatives	+0.43	+0.83	0	0	0	0
other employees	+0.68	+0.56	0	0	+0.21	0
New building work: (25 or more employed)	+0.73	-0.57	0	-0.21	0	0
(less than 25 employed)	+0.55	+0.60	+0.44	0	-0.22	0
Plant and machinery (acquisitions minus disposals): (25 or more employed)	+0.69	-0.64	0	0	0	0
(less than 25 employed)	+0.51	+0.65	+0.43	0	-0.27	0
Vehicles (acquisitions minus disposals)	+0.86	0	0	0	0	0
Net output per person employed	0	-0.49	+0.64	0	0	0
Wages and salaries per head (25 or more employed): operatives	+0.32	-0.58	+0.44	0	0	0
other employees	0	-0.45	+0.50	0	+0.24	+0.46
Average number of persons employed (less than 25 employed): males	+0.55	+0.77	+0.22	0	0	0
females	+0.43	+0.73	-0.30	0	+0.20	0

The data for each industry on measures of (1) size of industry, (2) frequency of fire, (3) spread of fire, (4) numbers employed

Standard Industrial Classification	Industry group	(1) Measure of size of industry	(2) Logarithm of weighted total of fires originating in areas of			(3) Proportion of fires extinguished by national brigades using hose reel jets and power pumps in areas of			(4) Logarithm of numbers employed
			production	storage*	miscellaneous* activity	production	storage	miscellaneous activity	
Order III	Food, drink and tobacco								
211	Grain milling	3 298	2.038	1.444	1.400	0.754	0.660	0.793	4.529
212	Bread and flour confectionery	4 332	2.461	1.736	1.986	0.586	0.850	0.784	4.141
213	Biscuits	2 532	1.431	0.771	1.111	0.667	1.000	1.000	4.739
214	Bacon curing, meat and fish products	3 453	2.090	1.373	1.346	0.817	0.765	0.717	4.769
215	Milk products	3 113	1.658	1.301	1.592	0.477	0.732	0.798	4.479
216	Sugar	1 717	1.443	0.987	0.919	0.545	0.460	1.000	4.272
217	Cocoa, chocolate and sugar confectionery	3 647	1.785	1.330	1.550	0.584	0.672	0.467	5.006
218	Fruit and vegetable products	3 307	1.789	1.360	1.586	0.584	0.785	0.848	4.785
219	Animal and poultry foods	3 423	1.737	1.422	1.121	0.687	0.724	0.516	4.489
229/1	Margarine	994	0.301	0.602	0.699	0.500	1.000	0.250	3.708
231	Brewing and malting	3 796	1.962	1.747	1.763	0.682	0.705	0.696	4.899
239/1	Spirit distilling and compounding	2 199	1.076	0.301	0.699	0.866	0.000	0.750	4.164
239/2 & 3	Wines, cider, perry and soft drinks	3 065	1.512	1.245	1.338	0.874	0.904	0.683	4.494
240	Tobacco	2 387	1.013	0.000	0.881	0.612	-	0.394	4.645
Order IV	Chemicals and allied industries								
261	Coke ovens and manufactured fuel	2 423	1.025	0.826	0.940	0.840	1.000	0.610	4.369
262	Mineral oil refining	1 457	1.398	0.903	1.301	0.628	1.000	0.316	4.292
263	Lubricating oils and greases	2 019	1.569	1.045	1.459	0.701	1.000	0.637	3.969
271/1	Dyestuffs	1 532	1.651	0.724	0.919	0.554	1.000	1.000	4.248
271/2	Fertilizers and chemicals for pest control	2 756	1.600	1.210	1.201	0.857	0.697	0.893	4.371
271/3 (part)	Other chemicals	1 261	1.759	0.869	1.049	0.599	0.901	0.292	3.792
272/1	Pharmaceutical preparations	3 134	1.649	0.996	1.373	0.462	1.000	0.588	4.675
272/2	Toilet preparations	1 767	1.326	1.045	0.602	0.547	0.693	1.000	4.124
273	Explosives and fireworks	1 618	1.330	1.000	0.477	0.762	0.556	0.500	4.486
274	Paint and printing ink	3 313	2.301	1.549	1.772	0.548	0.750	0.546	4.660
275/1	Vegetable and animal oils and fats	1 988	1.873	0.556	0.778	0.647	1.000	0.200	4.072
275/2	Soap, detergents, candles and glycerine	2 521	1.723	1.269	1.262	0.703	0.551	0.520	4.348
276	Synthetic resins and plastics materials	2 706	2.194	1.155	1.301	0.496	0.774	0.458	4.481
277/1	Polishes	1 237	1.473	0.699	0.000	0.505	1.000	-	3.771
277/2	Gelatine, adhesives, etc.	1 047	1.267	1.212	0.415	0.822	1.000	1.000	3.690
Orders V, VII, VIII, IX	Metal, shipbuilding and vehicles								
311	Iron and steel (general)	4 925	2.733	1.490	2.036	0.738	0.846	0.733	5.440
312	Steel tubes	2 910	1.943	1.297	1.111	0.527	0.729	0.697	4.727
313	Iron castings, etc.	3 965	2.564	1.459	1.752	0.746	0.709	0.804	5.046
321 & 322	Light and base metals	4 305	2.543	1.621	1.790	0.476	0.836	0.631	5.107
370	Shipbuilding and marine engineering	4 315	2.287	1.792	1.893	0.810	0.793	0.731	5.439
381	Motor vehicle manufacturing	5 354	2.425	1.543	1.830	0.619	0.714	0.689	5.533
382	Motor cycle, three-wheel vehicles and pedal cycle manufacturing	2 157	1.493	0.969	0.820	0.688	0.687	1.000	4.553
383	Aircraft manufacturing and repairing	4 064	2.202	0.969	1.734	0.377	0.880	0.425	5.439
384	Locomotives and railway track equipment	1 697	1.423	0.556	0.839	0.740	0.615	0.491	4.747
385	Railway carriages and wagons and trams	2 415	1.964	0.949	1.267	0.899	1.000	1.000	4.833
389	Perambulators, hand-trucks, etc.	885	1.398	0.845	0.322	0.856	0.833	0.000	3.778
391	Tools and implements	1 979	1.886	1.079	1.338	0.616	0.911	0.952	4.373

* Logarithm of weighted total of fires + 1

Table 2 (Contd.)

Standard Industrial Classification	Industry group	(1) Measure of size of industry	(2) Logarithm of weighted total of fires originating in areas of			(3) Proportion of fires extinguished by national brigades using hose reel jets and power pumps in areas of			(4) Logarithm of numbers employed
			production	storage*	miscellaneous activity	production	storage	miscellaneous activity	
Orders V, VII, VIII, IX	Metal, shipbuilding and vehicles (cont.)								
392	Cutlery	1 330	1.543	0.799	0.301	0.585	1.000	1.000	4.013
393	Bolts, nuts, screws, rivets, etc.	2 705	1.962	1.068	1.316	0.639	1.000	0.949	4.665
394	Wire and wire manufactures	2 893	1.995	1.279	1.415	0.720	0.850	0.492	4.593
395	Cans and metal boxes	1 965	1.939	1.316	1.238	0.640	0.797	0.755	4.452
396	Jewellery, plate and refining of precious metals	2 270	1.805	1.004	1.270	0.506	1.000	0.642	4.420
399	Metal industries not elsewhere specified	6 028	2.914	2.107	2.162	0.708	0.895	0.711	5.471
Order VI	Engineering and electrical goods								
331	Agricultural machinery (except tractors)	2 030	1.380	0.000	1.360	0.708	-	0.417	4.299
332	Metal-working machine tools	2 933	1.476	0.004	1.420	0.709	1.000	0.613	4.794
333	Engineers' small tools and gauges	3 087	1.258	0.000	1.479	0.470	-	0.438	4.710
334	Industrial engines	2 479	0.996	0.602	0.644	0.677	1.000	0.000	4.730
335	Textile machinery and accessories	2 499	1.960	0.954	1.525	0.418	0.500	0.542	4.690
336	Contractors' plant and quarrying machinery	2 367	0.949	0.000	1.137	1.000	-	0.500	4.439
337	Mechanical handling equipment	2 572	1.065	0.699	0.644	0.914	1.000	0.000	4.620
338	Office machinery	1 893	1.164	0.633	1.158	0.500	1.000	0.524	4.491
339	Other machinery	5 188	2.086	1.433	1.903	0.631	0.904	0.642	5.414
341	Industrial plant and steelwork	4 267	1.307	0.602	0.491	0.690	1.000	1.000	5.144
342	Ordnance and small arms	1 985	1.534	0.477	1.476	0.360	0.000	0.463	4.617
349	Other mechanical engineering not elsewhere specified	5 230	2.207	1.371	1.968	0.570	0.880	0.676	5.270
351	Scientific, surgical and photographic instruments, etc.	3 900	1.888	1.422	1.707	0.539	0.937	0.477	5.019
352	Watches and clocks	791	0.799	1.013	0.431	0.000	1.000	1.000	4.009
361	Electrical machinery	4 381	1.561	0.724	0.982	0.621	0.605	0.746	5.308
362	Insulated wires and cables	2 515	1.447	1.220	1.480	0.707	0.506	0.706	4.662
363	Telegraph and telephone apparatus	2 428	0.602	0.756	0.708	0.250	0.638	1.000	4.889
364	Radio and other electronic apparatus	3 865	2.044	1.380	1.811	0.420	0.913	0.479	4.243
365	Domestic electric appliances	2 351	2.044	1.305	1.534	0.240	0.781	0.165	4.666
369	Other electrical goods	3 655	2.193	1.446	1.905	0.661	1.000	0.690	5.017
Orders X, XV	Textiles and paper								
411	Production of man-made fibres	1 362	1.689	0.826	0.996	0.620	1.000	0.292	4.553
414	Woollen and worsted	4 072	2.548	1.741	1.602	0.746	0.906	0.856	5.264
415	Jute	1 093	1.863	1.339	1.068	0.986	1.000	0.850	4.215
416	Rope, twine and net	1 401	1.641	1.220	0.863	0.826	0.744	0.841	4.130
417	Hosiery and other knitted goods	3 500	1.843	1.068	1.496	0.770	0.813	0.538	5.060
418	Lace	1 298	1.167	0.000	0.845	0.592	-	0.500	4.045
419	Carpets	2 088	1.901	1.281	1.086	0.508	0.669	0.420	4.504
421	Narrow fabrics	1 564	1.396	1.124	0.845	0.361	0.870	0.500	4.295
422/1	Household textiles and handkerchiefs	1 556	1.467	1.013	0.477	0.662	1.000	1.000	4.342
422/2	Canvas goods and sacks	1 590	1.679	1.530	1.364	0.564	0.970	0.683	4.146
423	Textile finishing	2 807	2.321	1.501	1.520	0.693	0.795	0.592	4.880
429/1	Asbestos	1 847	1.377	0.778	0.845	0.828	0.800	0.500	4.272
429/2	Other textile industries	914	1.820	1.173	0.968	0.952	0.784	1.000	3.672
481	Paper and board	3 348	2.234	1.661	1.759	0.659	0.844	0.598	4.914
482	Cardboard boxes, cartons and fibre-board packing cases	2 938	1.783	1.408	1.579	0.682	0.829	0.629	4.748

Table 2 (Contd.)

Standard Industrial Classification	Industry group	(1) Measure of size of industry	(2) Logarithm of weighted total of fires originating in areas of			(3) Proportion of fires extinguished by national brigades using hose reel jets and power pumps in areas of			(4) Logarithm of numbers employed
			production	storage*	miscellaneous* activity	production	storage	miscellaneous activity	
Orders X, XV	Textiles and paper (Contd.)								
483	Manufactures of paper and board not elsewhere specified	3 357	1.792	1.637	1.610	0.608	0.785	0.768	4.857
486	Printing, publishing of newspapers and periodicals	4 289	1.955	1.185	1.784	0.448	0.888	0.425	5.091
489	Other printing, publishing, bookbinding, engraving etc.	5 658	2.459	2.044	2.011	0.604	0.796	0.473	5.314
Orders XI, XII	Leather, fur, clothing								
431	Leather (tanning and dressing) and fellmongery	2 234	1.971	1.193	1.636	0.842	1.000	0.820	4.447
432	Leather goods	1 530	1.746	1.149	0.886	0.666	1.000	0.746	4.250
433	Fur	992	1.452	0.969	0.602	0.541	0.880	0.000	3.909
441	Weatherproof outerwear	1 674	1.431	0.663	0.982	1.000	1.000	0.429	4.444
442	Men's and boys' tailored outerwear	3 208	1.740	0.826	0.978	0.647	0.702	0.623	5.096
443	Women's and girls' tailored outerwear	2 620	1.512	0.887	1.225	0.714	0.537	0.488	4.762
444	Overalls and men's shirts, underwear, etc.	2 127	1.111	1.042	0.851	0.643	0.600	1.000	4.729
445	Dresses, lingerie, infants' wear, etc.	3 330	2.076	1.260	1.724	0.659	0.849	0.646	5.000
446	Hats, caps and millinery	1 242	1.453	0.987	0.903	0.683	1.000	0.456	4.179
449/1, 3, 4	Corsets, umbrellas and walking sticks, and other dress industries not elsewhere specified	2 039	1.903	1.245	1.578	0.697	0.717	0.593	4.477
449/2	Gloves	800	0.845	0.556	0.771	0.143	1.000	0.250	3.964
450	Footwear	3 038	2.028	1.585	1.881	0.575	0.893	0.699	5.030
Order XIV	Timber, furniture, etc.								
471	Timber	3 818	2.698	1.943	2.178	0.883	0.942	0.873	4.864
472	Furniture and upholstery	3 791	2.860	2.145	2.313	0.854	0.911	0.860	4.989
473	Bedding, etc.	1 805	1.831	1.617	1.111	0.956	0.926	1.000	4.155
474	Shop and office fitting	1 998	1.836	0.996	1.201	0.806	1.000	1.000	4.346
475	Wooden containers and baskets	1 995	2.093	1.722	1.617	0.922	0.940	0.923	4.322
479	Miscellaneous wood and cork manufacturers	2 164	2.310	1.663	1.210	0.886	0.896	0.934	4.371
Orders XIII, XVI, XVIII	Miscellaneous								
461	Bricks, fireclay and refractory goods	3 340	2.119	1.754	1.838	0.848	0.982	0.841	4.850
462	Pottery	2 249	1.812	1.708	1.462	0.850	0.940	0.729	4.790
463	Glass	3 299	2.067	1.676	1.387	0.606	0.935	0.658	4.847
464	Cement	1 830	1.068	0.556	0.724	1.000	1.000	1.000	4.107
469/1	Abrasives	1 182	0.939	0.969	0.301	0.655	1.000	1.000	3.892
469/2	Building materials, etc., not elsewhere specified	4 404	2.287	1.714	1.805	0.705	0.896	0.725	4.903
492	Linoleum, leather cloth, etc.	1 290	1.879	0.633	0.826	0.390	1.000	0.702	4.167
493	Brushes and brooms	1 576	1.420	1.185	1.196	0.821	1.000	0.796	4.111
494	Toys, games and sports' equipment	2 121	1.805	1.417	1.322	0.725	1.000	0.845	4.498
495	Miscellaneous stationers' goods	1 382	0.987	0.556	0.826	0.485	0.385	1.000	4.124
496	Plastics moulding and fabricating	2 629	2.138	1.569	1.342	0.676	0.886	0.605	4.601
499	Miscellaneous manufacturing industries	2 330	2.165	1.519	1.446	0.752	0.969	0.714	4.435
601	Gas	2 417	2.208	1.439	1.772	0.670	0.940	0.826	5.131
602	Electricity	2 777	2.160	1.588	2.419	0.423	0.610	0.400	5.312
603	Water supply	2 790	1.387	0.826	1.761	0.709	0.825	0.707	4.625

Sources: Reports of fires attended by the national fire brigades in Great Britain during the years 1957 to 1961 inclusive
Census of production for 1959. Board of Trade. 1960-1961.

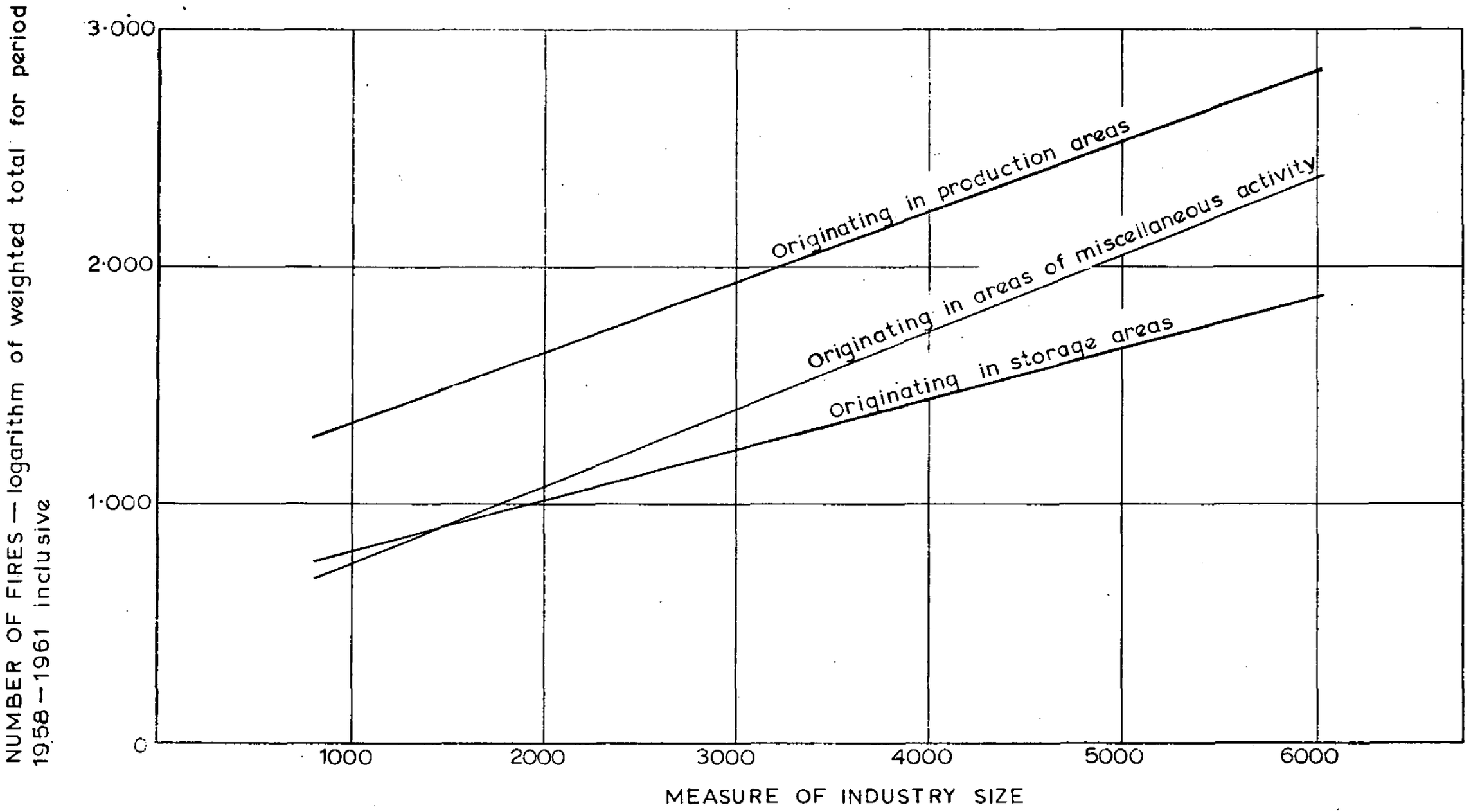

FIG. 1. FREQUENCY OF FIRE ACCORDING TO AREA OF ORIGIN IN RELATION TO A MEASURE OF INDUSTRY SIZE

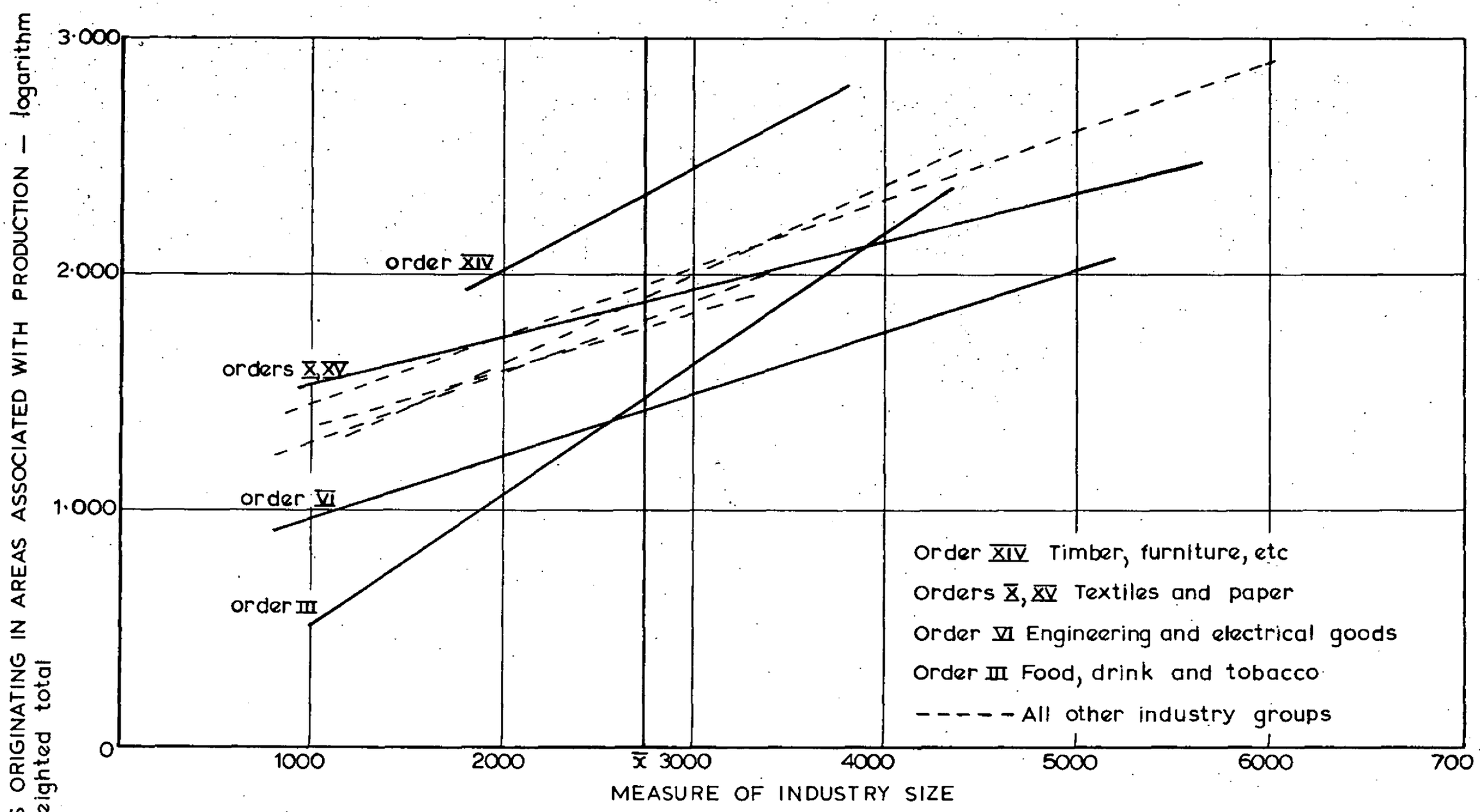

FIG.2. FREQUENCY OF FIRES ORIGINATING IN PRODUCTION AREAS ACCORDING TO INDUSTRY GROUP IN RELATION TO A MEASURE OF INDUSTRY SIZE

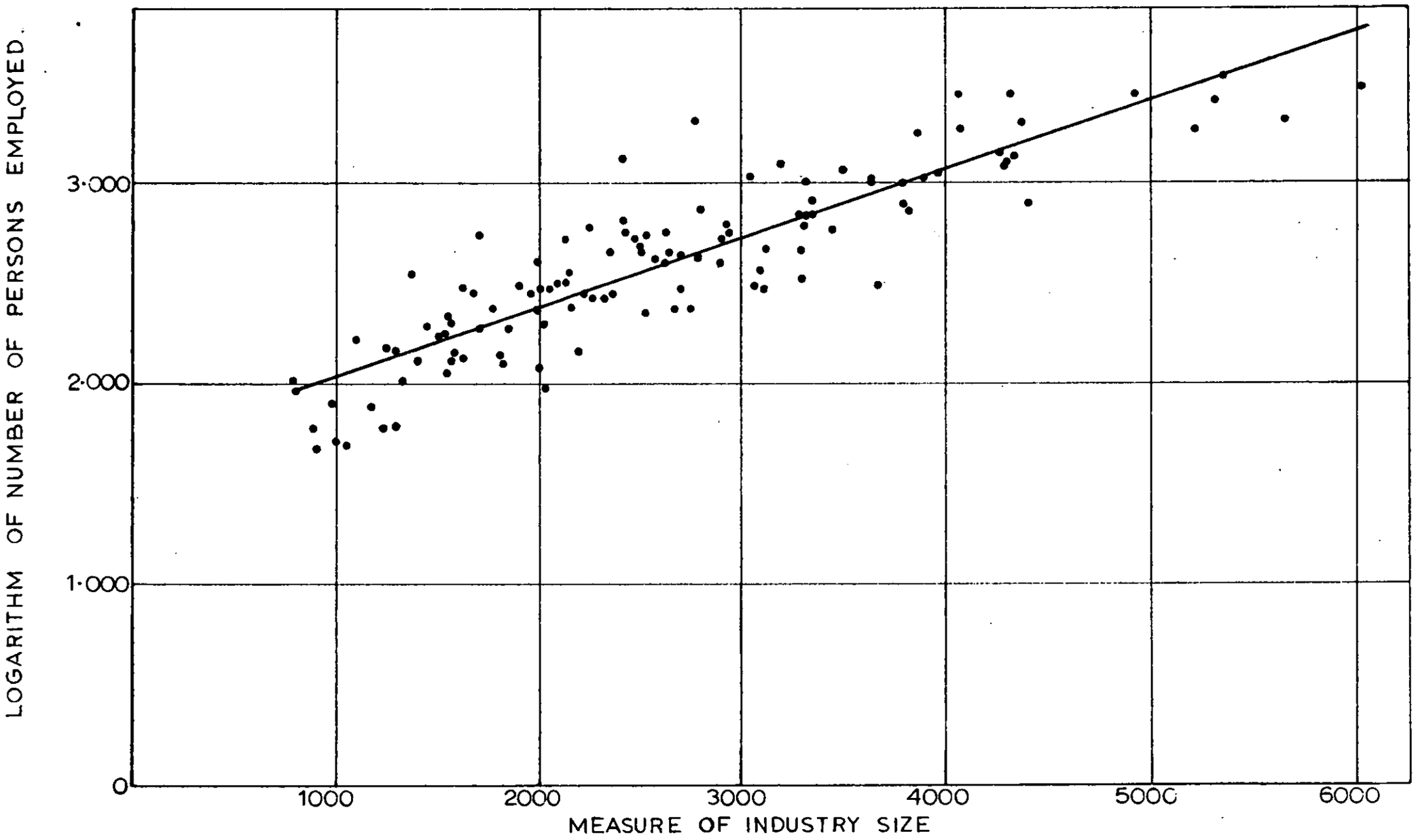

FIG.3. DEPENDENCY OF THE NUMBER OF PERSONS EMPLOYED UPON THE MEASURE OF INDUSTRY SIZE