Frequency of wars and geographical opportunity[1]

JAMES PAUL WESLEY

Center for Advanced Study in the Behavioral Sciences, Stanford, California

It will be shown here that the relationship between the frequency of wars and the size of wars may be derived on the basis of geographical opportunity alone. It is, of course, reasonable to expect geographical opportunity to affect the frequency of wars, since the frequency of wars between neighboring countries is greater than the frequency of wars between countries widely separated geographically. A man is much more likely to quarrel with his next-door neighbor than with someone several houses removed. Interactions of all sorts, both constructive as well as destructive, are more frequent between people in adjacent areas than between those widely separated geographically.

If war is more likely between neighboring countries, then the frequency of wars experienced by a particular country should correlate with the number of neighbors the country has. Lewis Fry Richardson (1960, p. 176), showed that this was indeed the case. He found that the number of external wars between 1820 to 1945 with more than 7,000 war dead correlated with the number of frontiers for the 33 countries he investigated.

This correlation, while demonstrating that the effect of geographical opportunity exists, does not indicate the precise magnitude of the effect. To evaluate the situation more accurately it is possible to proceed as Richardson did (p. 291). It may be noted that wars of a given size will usually be fought where the population of the smaller side sustains a loss of at most some fraction k of its population. Thus, the smallest population that can generally be expected to engage in a war with a total of n war dead is $n/2k$, it being assumed that both sides suffer about the same number of casualties, $n/2$. If the population of the world is broken up into cells whose populations are each of this minimum size, then there will be at most s potential belligerents that might engage in a war with n war dead where

$$s = 2kW/n, \qquad (1)$$

where W is the world population.

In terms of geographical opportunity it may be assumed that only neighboring cells

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will go to war against each other. Richardson (p. 290) compared the number of common boundaries or frontiers between neighboring cells with the frequency of wars of different sizes and failed to obtain precise agreement with observation. The *number* of boundaries is not, however, the proper measure of geographical opportunity, for if two countries share a *long* common boundary they will have greater opportunity for interaction than if they share only a *short* common boundary. The measure of geographical opportunity for war is, therefore, taken here as the length of frontiers or boundaries between the population cells. This measure is in population units and does not involve actual physical length. A long physical frontier between two countries with low population densities might afford the same geographical opportunity as a short frontier between two countries with high population densities. The opportunity for interaction as measured here by the length of the boundary between population cells is proportional to the number of individuals residing near a common boundary.

If A is the total land area of the earth, then each cell may be assumed to occupy an area $a = A/s$. The perimeter of each cell is proportional to $a^{1/2}$. Summing over all of the s cells then gives a total perimeter about all cells which is proportional to $s^{1/2}$,

$$P \propto s^{1/2}. \qquad (2)$$

From equations (1) and (2) the total perimeter P about all s cells is seen to be proportional to $n^{-1/2}$,

$$P \propto n^{-1/2}. \qquad (3)$$

It is now postulated that the rate at which war dead are generated is proportional to the geographical opportunity as measured by P, equation (3). If df/dn is the frequency of wars producing war dead in the range from n to $n + dn$, then the rate at which war dead are produced in wars of this size is given by

$$n\ df/dn. \qquad (4)$$

Equating this rate of generation of war dead, equation (4) to the geographical opportunity, equation (3), the result is found to be

$$n\ df/dn \propto n^{-1/2}. \qquad (5)$$

In terms of logarithms equation (5) may also be written in the form

$$\log_{10}\,(df/d\,\log_{10}n) = C - 0.5\,\log_{10}n, \qquad (6)$$

where C is some constant. This relation is precisely the same as the empirical relation already established by Richardson (1960, p. 148 and p. 292) whose summarized data for wars between 1820 and 1945 are reproduced in Table 1.

The constant C was chosen as 3.84 so that the theoretical curve would coincide with observation for wars involving 5×10^3 to 5×10^4 war dead.

TABLE 1

FREQUENCY AND MAGNITUDE OF WARS

War dead n	Magnitude $\log_{10}n$	Number of wars $\frac{df}{d\,\log_{10}n}$	Observation $\log_{10}\left(\frac{df}{d\,\log_{10}n}\right)$	Theory $C - 0.5\,\log_{10}n$
10^3	3	$\geqslant$198	$\geqslant$2.30	2.34
10^4	4	70	1.84	1.84
10^5	5	24	1.38	1.34
10^6	6	6	0.78	0.84
10^7	7	2	0.30	0.34

It cannot be claimed that the derivation of the distribution formula, equation (6), in terms of geographical opportunity alone is the only derivation possible. An investigation involving some direct measure of the geographical opportunity (such as a correlation of frequency of wars between two countries with the number of roads across their common frontier) is probably required to settle the matter.

REFERENCE

RICHARDSON, L. F. *Statistics of Deadly Quarrels.* Pittsburgh, Pa.: The Boxwood Press, 1960.