5. *Statistical Relation between the Frequencies of Earthquakes in Japan and Other Parts of the World.*

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(Read Sep. 15, 1931.—Received Dec. 20, 1931.)

Introduction.

The present investigation was made with the intention of studying the statistical relation between the annual seismic frequencies in Japan and other regions of the world, if such a relation may at all exist. In this respect, South America which is nearly antipodal to Japan, comes first in view, since it was already remarked by some authorities that an earthquake seems to be liable to induce another in the antipodal region. For this reason, South America was taken first and then the other countries have been taken into account one after another. For the statistical investigation, we have tried to apply a method which is somewhat different from the usual method of finding correlation coefficient, as will be described below.

Method of Investigation.

From Rikwa Nenpyô (the Scientific Chronological Table), the conspicuous earthquakes were taken which occurred in different parts of the world, during the period of 30 years, 1900–1930, and they were classified into 7 groups according to the geographical regions of occurrence: those are Japan, South America, Central America, the Coast of the Mediterranean Sea, Continent of Asia, the Philippines with neighbouring oceanic regions, and Australia including the oceanic environments.

The yearly frequency curves were plotted, with the year as the time axis, respectively for these groups, and compared with each other in order to find out some apparent relations among them. In order to smooth out minor irregularities, the number, n, of the earthquakes falling within the successive overlapping time interval of 3 years, was counted and plotted against the middle point of the interval. Next, the deviation, δ, from the mean value of n, was calculated for each region. Also, the reduced value, δ_r, was calculated referred to Japan, i.e. $\delta_r=\delta_x\frac{|\delta_{\text{Japan}}|}{|\delta_x|}$,

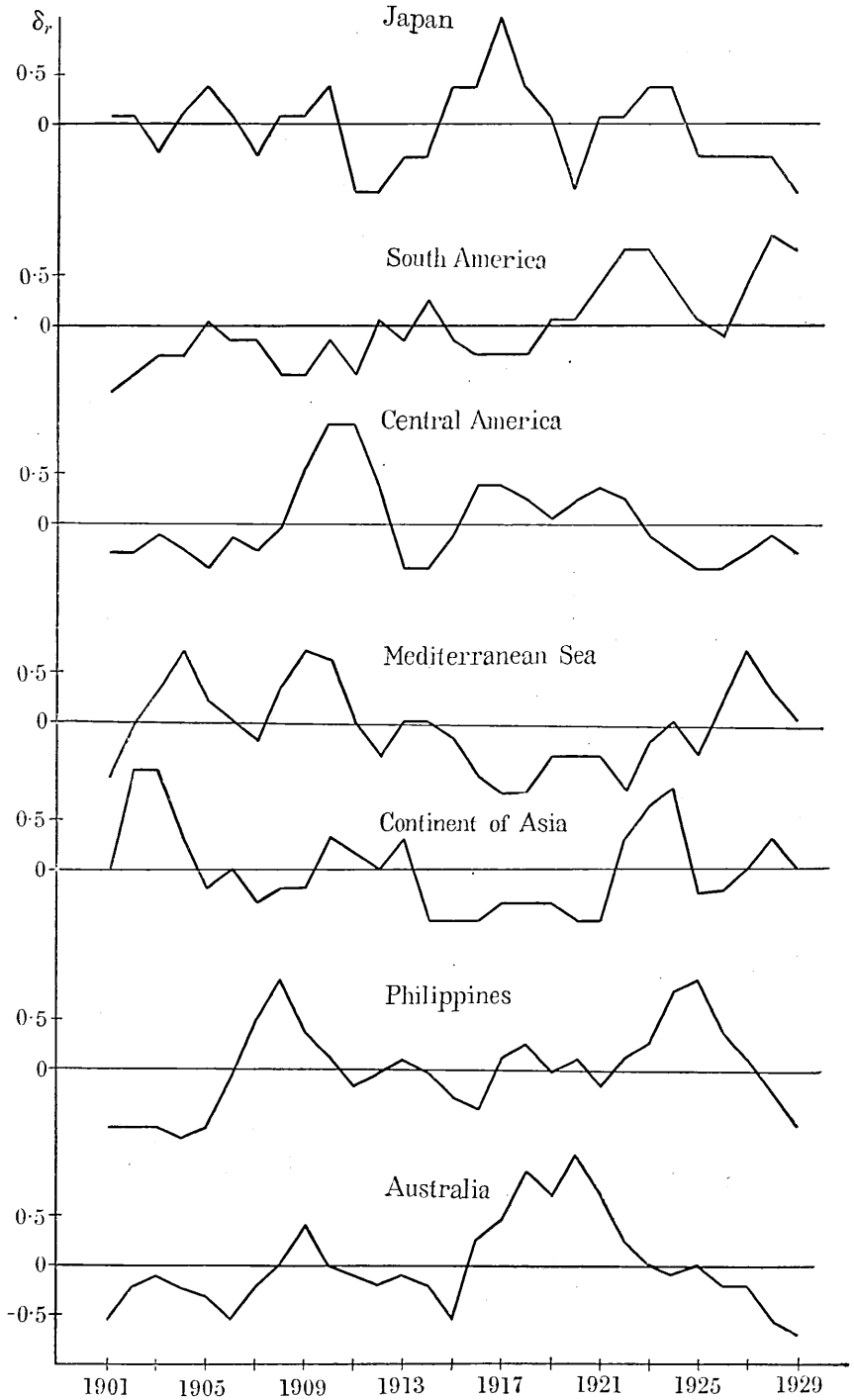

Fig. 1.

$\delta = \frac{n - n_{\text{mean}}}{n_{\text{mean}}}$, $\delta_r = \delta_x \times \frac{|\delta_{\text{Japan}}|}{|\delta_x|}$ reduced to Japan.

where δ_x corresponds to δ for any regions. Thus, all the curves were reduced to the similar amplitude and then plotted as shown in Fig. 1.

The deviation from the mean value of 7 regions for each year, was also calculated with the reduced values above obtained and plotted, which showed the similar features[1] as above curves. Next, with the aim of finding out any characteristic relation which may exist between a pair of regions, we have taken the sums and differences of δ_r's for different pairs. The results were, however, not so conspicuous.

Lastly, taking the yearly number of earthquakes which occurred in Japan as abscissa, and the corresponding number for one of the other regions as ordinate, we have drawn a diagram, in which the points representing successive years were connected by straight lines in the order of time. The directions of these straight lines were classified into the following 4 Classes : *a*) Numbers of earthquakes increase or decrease simultaneously for the two regions, i.e. positive correlation of abscissa

Table 1, *a*.

a	*b*	*c*	*d*	
48%	14	24	10	South America
24	38	17	10	Central America
28	24	14	21	Mediterranean Sea
31	17	21	21	Continent of Asia
38	28	21	7	Philippines
24	31	24	14	Australia

Japan is taken as abscissa

Table 1, *b*.

a	*b*	*c*	*d*	
48%	14	10	24	Japan
31	35	14	21	Central America
31	28	3	28	Mediterranean Sea
28	31	14	28	Continent of Asia
28	48	10	10	Philippines
31	45	7	10	Australia

South America is taken as abscissa

1) These curves are here omitted.

x and ordinate y; *b*) Negative correlation of x, y; *c*) Number for Japan, i.e. x, remains the same while the number y for the other region changes for the successive 2 years; *d*) y remains constant while x changes. The percentage value of the number of cases *a*, *b*, *c*, and *d* were calculated respectively as shown in Table 1, *a*. The result of the case in which South America was taken as abscissa, is shown in Table 1, *b*.

For Japan, South America and China, we have also tried to apply the similar method, taking the more ancient data, i.e. the earthquakes which occurred during the period of 350 years (1550–1900). For this case, the number of earthquakes for 10 years was taken instead of the annual number. South America was to be omitted here, the number being too scanty for comparison. The result for the ancient data of Japan and China are shown in Fig. 2 and Table 2.

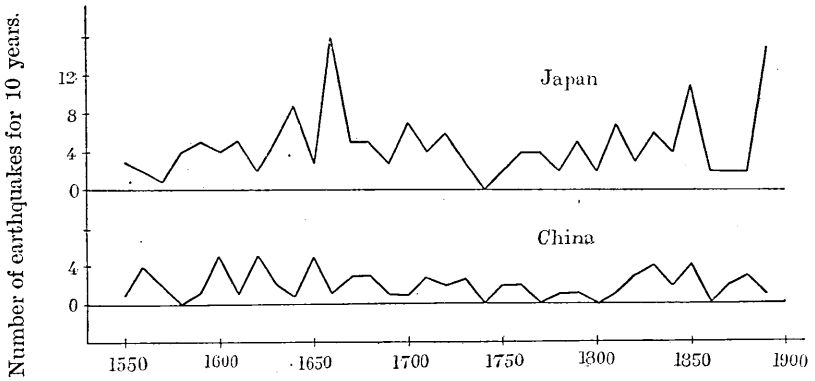

Fig. 2. Number of earthquakes for 10 years.

Table 2.

a	*b*	*c*	*d*
32%	47	9	9

Next, to apply the same method of investigation on the frequencies of earthquakes in different parts of Japan, the conspicuous and the somewhat conspicuous ones occurred during the period of 80 months (May, 1924–Dec., 1930), were taken from the Abridged Monthly Report of the Central Meteorological Observatory in Japan and separated into 4 groups, according to their localities, which are the Districts West to Kwantô, Kwantô, Tôhoku, and Hokkaidô. Being treated as before, the numbers of earthquakes experienced during successive 3 months were compared with each other. The percentage values of the Classes *a*, *b*, *c* and *d* above defined were also calculated, taking all the combinations of these regions. The results are shown in Fig. 3 and in Table 3.

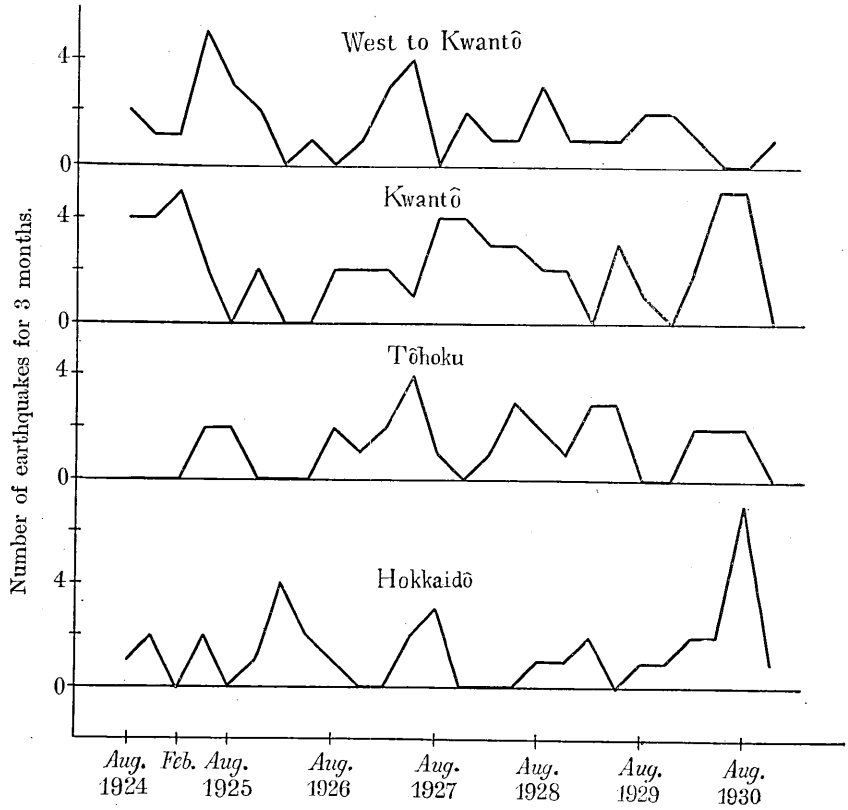

Fig. 3. Number of earthquakes for 3 months.

Table 3.

a	*b*	*c*	*d*	
20%	24	24	20	Kwantô and Tôhoku
20	36	20	12	Kwantô and Hokkaidô
12	40	24	16	Kwantô and West to Kwantô
28	20	32	16	Tôhoku and Hokkaidô
24	32	20	8	Tôhoku and West to Kwantô
24	36	16	16	Hokkaidô and West to Kwantô

Lastly, with the prospect of finding out any relation between the earthquakes occurred in land area and in sea bed respectively in the District of Kwantô, we have taken the "*felt*" earthquakes recorded in the above Report during the period of 80 months. The monthly numbers were treated here as usual. The results are shown in Table 4.

Table 4.

a	*b*	*c*	*d*
40%	53	5	1

Results and Discussions.

Looking at Fig. 1, we may suspect some trace of positive correlation between the seismic frequencies of Japan and South America, though not quite conspicuous. The fact that the value of percentage of *a* in Table 1, is much greater than *b*, may also be considered to show the existence of such a correlation. We can also trace some probable correlation between South America and Philippines referring to Table 1, *b*. For other regions, we can hardly find out any definite relations.

According to the present result as to the ancient earthquakes during the period of 350 years (1550–1900), Japan and China are considered to be in the opposite relation i. e. negative correlation to each other, in other words, when Japan is in the state of increasing number of earthquakes, China is in decreasing, and vice versa, which may be shown in Fig. 2 and Table 2, though not quite conspicuously.

Again, from Fig. 3 and Table 3, we may be able to say that there are no apparent correlations among the earthquakes which respectively occurred in the Districts West to Kwantô, Tôhoku and Hokkaidô, while between Kwantô and Hokkaidô, as well as between Kwantô and the Districts West to Kwantô, we can notice somewhat larger value of *b* than the other cases, which seams to suggest the existence of a negative correlations, as already explained.

Lastly, we can scarcely recognize any definite relations between the earthquakes in the land area and of those in sea bed near the District of Kwantô, except that *b* is somewhat greater than *a*.

In conclusion, I wish to express my best thanks to Prof. T. Terada under whose supervision the entire work has been carried out and who has given me many useful suggestions throughout the course of my investigation.

5. 本邦地震と世界各地地震の頻度間に存する統計的關係

山口生知

本研究は日本に於て年々起る地震の頻度と、世界の他の地方に起る地震の頻度との間には何か或る關係が存在しはせぬかを調べる目的で爲された。

殊に或る地點に起る地震は、地球上之と對蹠的位置にある地點の地震を誘導すると云ふ說が或る學者間に唱へられて居るから、其れが事實か否かを確かめる爲めに、日本と殆ど對蹠的位置に有る南阿米利加の地震を採り日本の地震と比較した。次いで中米、地中海沿岸、亞細亞大陸、フイリツピン群島並に其の附近及び濠洲並びに其の附近の地震をとつて、それ等の間の關係を調べた。

其の結果は第一圖及び第一表に示す通り、日本と南米の地震の頻度間には正の相關關係の有る事が認められる。又南米とフイリツピンとの間には負の相關關係のあることが窺はれる。其の他の國々の間には、一定の關係あることが認められない。又日本と南米及び支那の地震に就いては、更に昔に遡つて 1550 年から 1900 年までの 350 年間に起つた地震をとつて調べて見た。而しこの場合に南米の地震は餘りに數が少ないので止むを得ず取り除いた。

前記 350 年間の昔の地震に就いては、日本と支那との間には負の相關關係がある。即ち日本が地震の數を增す狀態に有る時は、支那は地震の數を減ずる狀態にあり、又日本が數を減ずる時は支那は數を增す樣な傾向があることが認められる。

日本內地の地震に就いても前同樣の調べ方をして見たが、關東と北海道及び關東と關東以西の地震に就いては負の相關關係があるらしく思はれる。

最後に關東地方に於ける內陸地震と海底地震の起り方に就いても關係を調べて見たが、判然とした關係を認むる事は困難であつて僅かに負の相關關係あることを疑はしめるに過ぎない。