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THE SECOND STAGE OF QUANTIFICATION

Zdeněk Pavlík

Abstract

The discovery of mass phenomena and their structure started the second stage of quantification. On the basis of natural philosophy John Graunt and William Petty invented the statistical method that became used with a big success in the whole science. It gave the impulse to new mathematical disciplines, the mathematical statistics and the probability theory. Adolf Quetelet was the first one to give to statistical structures the ontological meaning. However, he overestimated the average and unimodal symmetrical statistical distribution looking e.g. for an average man. One hundred years later Jaromír Korčák recognized the ontological meaning also of asymmetrical statistical distribution with the highest frequency if phenomena at its beginning. According to him two extreme statistical distributions exist and all distributions in reality could be found between them, closer to one or to the other extreme. The differentiation of reality expressed by statistical distribution shows its general regularity. Martin Hampl elaborated further this cardinal idea by elaborating the classification of real systems. He filled in the principle of evolution by the principle of complexity. A few efforts were made to formalize extreme left sided statistical distribution.

Key words: quantification, statistics, Graunt, Korčák, Hampl

JEL Code: A10, C10, Y50

Introduction

The second stage of quantification started in the middle of 17th century. The co-founder of statistic John Graunt (1620-1674) was born in the same year when Francis Bacon died. The process of quantification is very old one, it started in the moment, when numbers were invented, but the statistical method as a specific type of quantification arose only relatively recently. John Graunt was not academically educated, he was autodidact, but he had friends among many prominent persons in London's society. One of them, William Petty (1623-1687) is considered the founder of statistics with his publication Politicall arithmetick, which was published in 1776. Graunt published his book Political ad Natural observations already in 1662.

1 The origins of statistics

John Graunt visited London's vicarage and found out there the bills of mortality for last 20 years. Checking the bills an idea came to him that he should classify them. He realized that the numbers of deceased men and women were almost identical. He logically concluded their numbers in the population must also be the same. This was a new information, because of the then prevailing opinion that the number of women is higher (the doctors had among their patients more women, the polygamy among Muslims, etc.). He classified the bills also according to the cause of death and he estimated the age structure of deceased persons (because the age was not noted on the bills, he reckoned the age on the basis of the causes of deaths). He realized that the probability of dying is not equal in all ages and so he came to the idea of life tables. He opened the way for searching statistical regularities by the method of incomplete induction in all fields of reality. It is only necessary to define population units and their aggregate called also population. We do not need to define human population units and individual deaths. If we define the unit, at the same time the population is defined. If the reality is continuous (as the territory), we have to delimitate the unit first. It is evident that using the natural units (such as man or death) in statistical way suggests itself; so the beginning of statistics started with them.

John Graunt was influenced by Bacon's natural philosophy. He was very modest and in the introduction to his work stated that his results were a small contribution to natural philosophy based on mercantile calculations. He did not realize his phenomenal contribution to the whole science; statistical regularities emerge everywhere. He himself found beside different intensity of mortality according to age also statistically significant difference between the number of born boys and girls in the proportion of 14 boys to 13 girls. It lapsed 350 years from the release of John Graunt's book and the regularity has not still been explained, but only refined to the proportion 106 to 100. The first explanation one century later was theological. Johann Süssmilch (1707-1767) in accordance with the then predominant ideology interpreted this regularity as a manifestation of God's will (he gave even the reason for it: the celibate of priests). It shows one important thing, valid for all similar regularities based on incomplete inductive method: statistical method cannot explain the found regularities; it never deals with a substance of a given matter, it sees the reality from the phenomenal view, the explanation must be searched in the corresponding empirical discipline (in this case in biology, resp. in genetics).

The ontological meaning of statistical regularities and structures was invented a century later by Adolph Quetelet (1796-1874). According to him, statistical regularities have a deeper implication. By studying individual phenomena using the statistical method, a special collective entity appears with an existence of its own and governed by laws of its own. This requires, however, for the entity to be formed from similar elementary phenomena. "There exist a general law governing our world, which appears to be designed for the expansion of life; it gives to all that is breathing an infinite variety, without changing the principle of constancy…..that law, unknown to science for a long time and remaining unused for practical purposes until this day, I shall call the Law of Incidental Causes" (Quetelet, 1848, p.16). A logical consequence of the overestimation of the principle of constancy is Quetelet´s interest of the average – his attempts to define the average man are well known – and the concept of evolutionary trend to lessen deviations from the average as fundamental. It seems to him that there is an increasing equality among people, that wealth and wages are leveling out the more civilized the country becomes, that everything progresses towards a certain harmony and a stationary condition. He fails to see that in such a state of calm the development would cease altogether.

Adolph Quetelet deliberately confined his interest to elementary phenomena of one and the same kind, where he always found a distribution reminiscent of the Laplace-Gauss error curve (unimodal symmetrical distribution) with a typical average and deviations compensating each other. If he encountered phenomena which do not corresponded with such a distribution, he failed to investigate the causes of this event but found a simpler, though incorrect explanation. Thus, asked what the typical size of a country was, he replied that this could not be determined as countries have various borders according to their geographical position, but above all "they are not frequent and their incidental causes are too frequent for mutual compensation" (Quetelet, 1848, p. 156). It is not difficult to refute his contention of small frequency as in another instance he states that it suffices to investigate a small number of phenomena to determine their type. Obviously, a country is a different type of phenomena than a man, animal or plant. When investigating the distribution of countries according to their territorial area or population size, it will always be found that it is very far away from unimodal symmetric distribution: there will always be a majority of small countries and a small number of very large ones. With regard to the set of countries, their average size is a wholly untypical value.

2 Jaromír Korčák and two fundamental types of statistical structures

The first and most important feature of any collective entity is, apart from its size, its internal structure. Each section of reality has a certain pattern of quantities, which correspond with its qualitative structure. Every empirical discipline is concerned with the study of structures of reality as a means of discerning the internal differentiation and simultaneous integration of its subject; in the structure, the combination of a whole and a part is contained. Contemporary science is characterized by the distinct predominance of analytical findings on the nature of reality; this, and the concurrent development of mostly methodological aspects in the study of structures, leads to vagaries in the basic orientation of their evaluation. This is illustrated the best by the fact, that the most important classification of structures, characterized by means of the classification of scientific disciplines, has hardly changed over past two centuries, though it is in essence based only on the evolutionary principle. Because of this approach the position of many structures are very difficult to be included in such classification. In particular, this is the case of the structures of systems of phenomena of different kind and a set of complex phenomena.

In spite of growing interest to study the differentiation of complex systems, especially of uneven structures of various real systems, neither generalization nor systematization was reached, let alone their explanation. Such structures are common in geography or ecology. Studying these phenomena, even quantification or statistical methods were often refused and the singularity of such phenomena was stressed. However, for a more universal assessment of the differentiation and integration of reality, it is necessary to establish the classification of structures not only from the aspect of evolutionary principle, but also from the principle of their coexistence, and to try and find the hierarchy of those structures. On the basis of their features, the statistical distributions can be used for inclusion to the classification of structures.

The works of Jaromír Korčák (1895-1990), a geographer and statistician, represent a fundamental contribution in this direction. Although he expressed this idea already in 1936, his principal work was published in 1941, based on extensive study of literature and rich set of empirical examples. According to him, "statistical distribution is not a term specific to statistics….it shows a certain and general regularity in the structure of external world and thus contributes to the cognition of the world order, i.e. the clarification of a concept which belongs to the oldest in philosophic thought" (1941, p. 174).

The structure of the homogenous collective entity, characterized by the error frequency curve has been recognized and described countless times on biological and demographic phenomena of similar kind; at the same time it is a base for the development of formal mathematical branch of theory of probability and mathematical statistics. The structure of the heterogeneous collective entity, characterized by the left-sided statistical distribution, was practically neglected, or efforts were made to transform it formally into symmetrical one. It is obvious that the majority of geographical phenomena form very heterogeneous sets, where the typical unit cannot be determined. For a long time, statistical distribution was used also in geography for the verification of average values and no regularity was found in asymmetrical distribution.

Jaromír Korčák then developed his fundamental idea about the structure of objective reality further: "…symmetrical statistical distribution governs phenomena the less, the more their nature is geographical" (1941, p. 200) and he continued: "In the world of external reality, there exist two statistical structures, two statistical orders which essentially differ from each other: statistical distribution of the hyperbolic type and of Gauss curve type. The first is the statistical image of the inanimate base of organic nature, the second shows the quantitative variety of animate individuals distinguished into species. E.g. if we observe the size of such individuals, we find a symmetrical distribution, which thus actually proves the similarity of the species; here, variability is merely a manifestation of inessential deviations. However, if we could observe in a similar manner the biosphere as a whole, as a single set covering the surface of the Globe, then we would doubtlessly find an extremely asymmetrical distribution, as the smallest plants and animals are by far the most numerous, and their number declines with increasing size. Hence, the statistical distribution is the image of the wide variety of the Earth as a whole" (1941, pp. 221-2).

One century after Quetelet Korčák affirmed that the statistics has also an ontological value, that it reflects existing regularities in the objective reality, their integrated order. This does not lessen its use as one important method which can be applied in any part of reality; nevertheless, the ontological meaning of statistical structures is philosophically of primary importance because it gives a true picture of the differentiation of reality.

Jaromír Korčák was a geographer with a large understanding of problems of many other both natural and social disciplines, incl. philosophy; the statistical methods were traditionally refused in geography and the ideographic method was forced. Despite the importance of

Korcák´s idea, the response of scientists of that time was practically non-existent. This could partly be due to the Second World War, to the limitedness of Czech language (only short information was published in French in 1938), and last but not least to the marginal position of geographic knowledge in the whole science. It is necessary to bear in mind that there is only one science because the objective reality is also only one (if we speak about different sciences, we have in mind specific disciplines); the disintegration of contemporary science during last two centuries led to enormous and still growing unevenness in acquired knowledge in specific disciplines with the absence of comprehensive and integrated objective picture of reality. These facts make difficult both the internal development of science and its external application. So far science has been unable to provide a solution to complex problems. Many efforts from this sphere have led to failures or to unfair identification of the technocratic instead of scientific approach. The process of learning partial and simple phenomena is relatively simple; the cognition of complex phenomena and holistic structures is difficult.

3 Further elaboration of Korčák´s idea

According to the Korcák´s idea expressed for the first time in 1936, the geographical or regional systems (or elements of these systems) have always internal statistical structure of hyperbolic type. The hyperbola has a pure and simple mathematical formula known already in antiquity, but of no use in contemporary statistics. The mean is atypical value for majority of geographical structures and so the central limit theorem cannot be used for the expression of hyperbolic structures. On the other side there are biological systems, the homogenous collective entity, characterized by the error frequency curve, which have been recognized and statistically described countless times since Quetelet´s looking for the average man.

To make it more complicated, we will introduce the evolutionary view of V. S. Nyemtchinov (1894-1964): “Mass processes and individual phenomena in social life are of a considerably more complicated qualitative nature than analogous processes and phenomena in inorganic and organic nature. The transition from phenomena of the inanimate world to phenomena of animate nature and from those to the sphere of social phenomena is accompanied by the constantly increasing complicacy of the processes occurring in reality. The following law should be noted thereby: in the transition from the lower forms of the motion of matter to higher ones, growing variety is observed on the one hand, and also an increased complicacy of the qualitative nature of events and processes, and on the other hand, a declining number of homogeneous and inhomogeneous objects which form part of the respective mass processes.

Social phenomena are incomparably more varied and qualitatively complicated than biological phenomena, and those in turn are considerably more complicated than phenomena of inanimate nature; however, the number of individuals gradually decreases in the transition from inanimate nature to biological and social phenomena. Thus e.g. the number of protons and electrons of the atomic world gigantically outnumbers the molecules, not to speak of the macro-bodies forming the world of inanimate and animate nature. The number of elementary units forming social phenomena (people, families, nations, economies, factories) is incomparably smaller than the number of molecules, atoms, and their elementary particles" (1955, p.22).

In every part of reality (we can consider it as a system) reproduction occurs (evolution, development) due to internal and external causes and the hierarchical position among other systems. The internal causes (e.g. heritage of genes) tend to the reproduction of the homogeneity and the external causes (such as environmental causes) reproduce the heterogeneity. In reality not only these two extreme types exist, but also many intermediate types due to the various combinations of internal and external causes and their respective weight. The interaction of different systems is a primary source of the development of reality. At the same time, the essence of the contrast between heterogeneous and homogeneous systems represents the contrast between the whole and the part. Thus reality appears as heterogeneous set of partial homogeneous sets. The basic characteristic of the development of reality is its increasing evolutionary complexity and variety, the origin of new homogeneous sets and the increasing resultant heterogeneity of the structure of reality as a whole.

The most general view confirm the left sided extremely asymmetrical distribution of the matter in the world, reflecting the relation of the quantity of matter and the level of its qualitative differentiation (evolutionary level: inorganic matter– flora – fauna - people), which is a manifestation of the selectivity of the evolution of reality.

4 Classification of real systems

The classification of real systems was developed by Martin Hampl (born 1941). Originally he defined four basic systems, based on distinguishing their evolutionary intricacy (principle of development) and on distinguishing their qualitative completeness with regard to reality as a whole (principle of complexity). By combining this two principles following basic types can be defined:

1) System of natural elements, with relatively low complexity, evolutionary relatively simple and passive with low level of internal variability, certain stability and low integrity – e.g. atoms, molecules, individuals of the same biological species, biological features of plants and animals, IQ etc. The structure of these systems has high homogeneity and can be characterized by unimodal symmetrical distribution (see table 1).
2) System of social elements, with relatively low complexity, evolutionary developed and active with progressively oriented variability; these systems have various level of integrity and low stability. The statistical structure is similar to the preceding one, unimodal symmetrical distribution with oriented motion along the axis of quality – e.g. – similarity of biological features of people affected by various social conditions (see table 2).

Table 1: Distribution of cuckoo eggs according to their length

Variation groups	1	2	3	4	5	6	7	8	Total
Frequency of phenomena	3	22	123	300	201	61	6	1	717

Source: (V. Fabian, 1963); Hampl, 2000, p. 41

Table 2: Distribution of countries (territorial units) according to life expectancy of men[1)]

Variation groups	/ Year	1	2	3	4	5	6	7	8	9	10	11	12	Total
Frequency of countries	1950	8	31	32	27	20	26	20	24	8	4	-	-	200
	1960	1	16	29	23	18	27	19	33	28	6	-	-	200
	1970	-	1	23	25	18	21	25	32	53	13	-	-	200
	1980	-	2	9	17	22	17	17	42	52	22	-	-	200
	1990	-	-	1	15	19	18	10	35	58	40	4	-	200
	2000	-	-	4	10	21	12	14	19	50	50	20	-	200
	2010	-	-	-	1	9	18	11	23	29	64	39	7	200

Source: World Population Data Sheet, Population Reference Bureau, New York

1) To reach the same number of territorial units the smallest population units were omitted

3) Systems of natural complexes, e.g. physical geographic regions and the whole of natural reality. These systems are relatively complex with various kinds of qualities in

mutual coexistence; they manifest low level of evolutionary activity and integrity, are stable and passive. These systems are internally heterogeneous and their statistical expression is an extremely asymmetrical distribution, which characterizes the extreme lack of uniformity in the incidence of qualitatively different phenomena and extreme differences in their quantity (see table 3).

4) Systems of complete complexes, e.g. geographical regions comprising all kind of forms of the motion of matter in mutual coexistence (incl. social phenomena). Such systems can be characterized as highly heterogeneous and dynamic, which is ensured mainly by the development of society and its impact on nature. The statistical structure is again the extremely asymmetrical unstable distribution with the extension of hypothetical curve along the axis of quality. This corresponds with the qualitative withdrawal of society from nature and the increasing disproportions in the territorial distribution of social phenomena (see table 4).

Table 3: Distribution of main tributaries of 12 selected rivers according to their length

Variation groups	1	2	3	4	5	6	7	Total
Frequency of units	835	277	60	8	5	1	1	1 187

Source: (J. Korčák, 1950); M. Hampl, 2000, p. 41

Table 4: Distribution of population density in European provinces around the year 1960

Variation groups	1	2	3	4	5	6	7	8	9	Total
Frequency of provinces	125	60	18	11	5	2	1	1	2	255

Source: J. Korčák, 1973, p. 109-111

The delimitation of four basic distributions is only the first step in the searching for the integrated order of reality, although the most important. However, in reality the pure (balanced) distributions of either basic type are rare; usually transitional (intermediary) distributions are found which represent a combination of the system of elementary phenomena with complete complex phenomena, corresponding with the multi-leveled nature of the coexistence of phenomena in reality. The regularities do exist not only in the distribution of homogenous systems, but also in the heterogeneous ones. The underlying causes for the reproduction of homogeneous systems are of internal character and for heterogeneous of external character. The combination of both types of causes leads to intermediate distribution, what is the situation in majority of cases in reality.

The distribution of incomes could be a good illustration of such intermediate distribution, which is typical for all societies irrespective of their economic, social and political system. It was named the Pareto distribution. The human beings as one the biological species have similar abilities in the normal variation (physical force, IQ etc.). On the other side their social position, wealth, position in hierarchy of power are rather uneven. If we include also a regional dimension, the differences among people increase considerably. Such a distribution is even more heterogeneous (see table 5).

Table 5: Distribution if average wages of employees in Czech districts in the year 1996

Variation groups	1	2	3	4	5	6	7	8	9	10	Total
Frequency of districts	24	26	9	7	6	2	1	1	0	1	77

Source: M. Hampl, 2000, p.40

The transition of homogenous distribution can be represented by changes in the life expectancy during the demographic revolution. The process of demographic revolution can be described as revolutionary changes in the demographic behavior of people during which the level of both fertility and mortality is decreasing; the decreasing level of mortality can be described by the growth of life expectancy. The demographic revolution started at the end of 18th century in France, and then it gradually diffused to other European countries and in countries with population of European origin. The process ended in the middle of 20th century and simultaneously started in the developing countries, when the differences among countries were the biggest. Since that time, the differences are gradually decreasing with the expected homogenization during the second half of 21st century (see the table 2). Systems containing social phenomena may be called active systems, in view of their progressive nature and the intensity of their variability.

5 Formal expressions of statistical distributions

A few efforts were made to express known statistical distributions in a formal way. Most of them are based on general statistical principles, i.e. on methodological approach without taking into consideration the specific content of the given part of reality. The permanent movement occurred in the objective reality as well as in all of its parts (i.e. their reproductions), only the length of time differs extremely according to the substance of reality. The system of rivers and their tributaries might change in mils of years and so does the length of eggs of a biological species in hundredths ths of years (those are the passive systems); on the other side the reproduction of population or urbanization are changing relatively quickly during hundreds of years (those are the active systems).

One specific case could be mentioned as an example that is the reproduction of demographic system. The changes in the level of mortality in 200 world countries (territorial units) characterized by their life expectancy (see table 2) express the progress of demographic revolution in the world. It occurred in two periods: in the European countries and in other countries with formerly European population it occurred in 19th and in the first half of 20th century; it is occurring in the rest of the world after WW II. The life expectancy was very similar in all countries around the end of 18th century, the distribution is bi-modal around 1950 and the trend to new homogenization could be clearly seen afterwards. The length of life is basically a biological phenomenon and all people have similar internal predispositions for it. The changes in the length of life during the demographic revolution are due to the external factors (e.g. social) which have only transitional effect.

On the other side due to external factors, the urbanization and the system of territorial distribution of population tend to the steady growing of concentration. This is typical for the development of geographic, ecological or complex systems. There also exist regularities in the coexistence of different kind of phenomena contained in complex systems. The territorial physical concentration of people can be added to or replaced by concentration of their activities, especially by qualified working places, higher level of education, information or power etc. The statistical method should be ready to divide the effect (the weight) of internal and external factors.

J. Novotný and V. Nosek (2009) tried to find out models based on general statistical principles. They started with the Gauss unimodal distribution and followed by a study how different authors deal with these problems. The literature collected is rather rich in number. In 1879 already Galton criticized the "law of arithmetic mean", which was so important for Quetelet. After quoting a series of authors and describing their effort to transform variable into log-normal distribution, Novotný and Nosek came to the conclusion that further investigation was required. In my opinion the contemporary statistical methods based on mean and variability measured related to this mean is not adequate for extremely asymmetrical distributions. The average sizes of cities or average length of rivers (tributaries) are very problematic measures, which do not give any adequate information. Therefore also the measures of variability related to the mean are equally problematic. The statistical moments of higher degree (skewed or concentrate distribution) have similar meaning for extremely asymmetrical distribution.

However, for slightly skewed distributions authors tested and recommended six measures, which could effectively be used. The Coefficient of variation is the first, which does not need any explication. Two others are based on the logarithmic transformation of variable, the Theil coefficient and Mean logarithmic deviation. The variables of the two other measures were not transformed and often used: Gini coefficient and Robin Hood (or Hoover) index. Gini coefficient stems from Lorenz curve; these both measures are based on all values of variable, but also related to the mean. The last measure named by authors as the Rate of heterogeneity quantifies value at the 50^{th} percentile of the Lorenz curve. It was first suggested by Martin Hampl and therefore should be called the Hampl´s index (H). In contrast with the other measure H is insensitive to other values of the set and so to the shape of the distribution; on the other side it is not related to mean and this is its advantage. The H should be supplemented by the range of variability or by some measure of differences among units of the set.

Conclusions

Problems of quantification, the importance of Bacon's natural philosophy for the origin of statistics, and the significance of Quetelet´s and Korčák´s approaches for understanding of the ontological meaning of statistical structures were discussed in this contribution. Finally the initial effort of Martin Hampl with the elaboration of principles of integrated order of reality has been shown. It was not possible to deal with all problems connected with this idea as explained in Hampl´s work (Hampl, 2000). He deals with integrated approaches in science and geography: holistic vagueness versus biased clarity of reductionism, types of hierarchies and the classification of real systems, hierarchical levels and the organization of reality, integrated structure and evolution of reality, society in environment: structures, interactions and development mechanisms, physical geographic and sociogeographical organization: rank/scale differentiation of the environment, types, evolution and problems of assessing hierarchical organizations. At the end one effort to formalize of statistical structures was mentioned.

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Contact

Zdeněk Pavlík
University of Economics in Prague, Faculty of Informatics and Statistic
Department of demography
E-mail: pavz02@vse.cz