Pareto principle

The **Pareto principle** states that for many outcomes, roughly 80% of consequences come from 20% of causes (the "vital few").[1] Other names for this principle are the **80/20 rule**, the **law of the vital few,** or the **principle of factor sparsity.**[2][3]

Management consultant Joseph M. Juran developed the concept in the context of quality control, and improvement, naming it after Italian economist Vilfredo Pareto, who noted the 80/20 connection while at the University of Lausanne in 1896.[4] In his first work, *Cours d'économie politique*, Pareto showed that approximately 80% of the land in Italy was owned by 20% of the population. The Pareto principle is only tangentially related to Pareto efficiency.

Mathematically, the 80/20 rule is roughly described by a power law distribution (also known as a Pareto distribution) for a particular set of parameters, and many natural phenomena have been shown to exhibit such a distribution.[5] It is an adage of business management that "80% of sales come from 20% of clients".[6]

The Pareto principle applied to raising funds: 20% of the donors contribute 80% of the total

Contents

In economics

Pareto's observation was in connection with population and wealth. Pareto noticed that approximately 80% of Italy's land was owned by 20% of the population.[7] He then carried out surveys on a variety of other countries and found to his surprise that a similar distribution applied.

A chart that gave the effect a very visible and comprehensible form, the so-called "champagne glass" effect,[8] was contained in the 1992 United Nations Development Program Report, which showed that distribution of global income is very uneven, with the richest 20% of the world's population generating 82.7% of the world's income.[9] Among nations, the Gini index shows that wealth distributions vary substantially around this norm.

Distribution of world GDP, 1989[10]

Quintile of population	Income
Richest 20%	82.70%
Second 20%	11.75%
Third 20%	2.30%
Fourth 20%	1.85%
Poorest 20%	1.40%

The Pareto principle also could be seen as applying to taxation. In the US, the top 20% of earners paid roughly 80–90% of Federal income taxes in 2000 and 2006,[11] and again in 2018.[12]

In business, many examples of the 80/20 Principle have been validated. 20 per cent of products usually account for about 80 per cent of dollar sales value; so do 20 per cent of customers. 20 per cent of products or customers [13] usually also account for about 80 per cent of an organization's profits.

The causes of wealth owing so much to the "vital few" have been attributed to distributions of multiple talents, with the few having all the required talents and environments leading production in a meritocracy. Others have suggested that it may result from chance, Alessandro Pluchino at the Italian University of Catania suggesting that "The maximum success never coincides with the maximum talent, and vice-versa," and that such factors are the result of chance.[14]

The principle also holds within the tails of the distribution. The physicist Victor Yakovenko of the University of Maryland, College Park and AC Silva analyzed income data from the US Internal Revenue Service from 1983 to 2001, and found that the income distribution among the upper class (1–3% of the population) also follows Pareto's principle.[15]

An important property of Pareto distributions is that they have a fat tail. In the real world, this means that the wealthiest 1% of population possesses a substantially larger portion of the national income and wealth than would be predicted by extrapolating the distribution of middle income earners. Accordingly, greater understanding of the overall concentration of income and wealth requires increased attention be paid to why the distributions of top earners universally follow the Pareto distribution.[16]

In computing

In computer science the Pareto principle can be applied to optimization efforts.[17] For example, Microsoft noted that by fixing the top 20% of the most-reported bugs, 80% of the related errors and crashes in a given system would be eliminated.[18] Lowell Arthur expressed that "20% of the code has 80% of the errors. Find them, fix them!"[19] It was also discovered that in general the 80% of a certain piece of software can be written in 20% of the total allocated time. Conversely, the hardest 20% of the code takes 80% of the time. This factor is usually a part of COCOMO estimating for software coding.

WordPerfect and other software developers identify what customers want most of the time and how they want to do it: the 80/20 rule (people use 20% of a program's functions 80% of the time). Software developers work to make high-use functions as simple and automatic and inevitable as possible.[20]

In sports

It has been argued that the Pareto principle applies to sport, where leading players often take the majority of wins. For instance in baseball, the Pareto principle is reflected in Wins Above Replacement (an attempt to combine multiple statistics to determine a player's overall importance to a team). "15% of all the players last year produced 85% of the total wins with the other 85% of the players creating 15% of the wins. The Pareto principle holds up pretty soundly when it is applied to baseball."[21] It has been suggested (but not tested) that the principle applies to training, with 20% of exercises and habits having 80% of the impact, suggesting trainees should reduce the variety of training exercises to focus on this effective set.[22]

Occupational health and safety

Occupational health and safety professionals use the Pareto principle to underline the importance of hazard prioritization. Assuming 20% of the hazards account for 80% of the injuries, and by categorizing hazards, safety professionals can target those 20% of the hazards that cause 80% of the injuries or accidents. Alternatively, if hazards are addressed in random order, a safety professional is more likely to fix one of the 80% of hazards that account only for some fraction of the remaining 20% of injuries.[23]

Aside from ensuring efficient accident prevention practices, the Pareto principle also ensures hazards are addressed in an economical order, because the technique ensures the utilized resources are best used to prevent the most accidents.[24]

Other applications

Engineering and quality control

The Pareto principle has many applications in quality control where it was first created.[25] It is the basis for the Pareto chart, one of the key tools used in total quality control and Six Sigma techniques. The Pareto principle serves as a baseline for ABC-analysis and XYZ-analysis, widely used in logistics and procurement for the purpose of optimizing stock of goods, as well as costs of keeping and replenishing that stock.[26] In engineering control theory, such as for electromechanical energy converters, the 80/20 principle applies to optimization efforts.[17]

In the systems science discipline, Joshua M. Epstein and Robert Axtell created an agent-based simulation model called Sugarscape, from a decentralized modeling approach, based on individual behavior rules defined for each agent in the economy. Wealth distribution and Pareto's 80/20 principle emerged in their results, which suggests the principle is a collective consequence of these individual rules.[27]

Software testing

The Pareto principle in the context of software testing is commonly interpreted as "80% of all bugs can be found in 20% of program modules. In other words, a half of the modules may contain no bugs at all. Applying Pareto Principle to quality control activities of a software can help reduce the testing time and increase the efficiency of the system, but the application of the principle itself will require good analytical and logical skills.

Health and social outcomes

In health care in the United States, in one instance approximately 20% of patients have been found to use 80% of health care resources.[28][29][30] The Dunedin Study has found 80% of crimes are committed by 20% of criminals.[31] This statistic has been used to support both stop-and-frisk policies and broken windows policing, as catching those criminals committing minor crimes will supposedly net many criminals wanted for (or who would normally commit) larger ones. However, this principle has proven false in practice, as over 90% of citizens victimized by stop and frisk policies were found not to have committed any crime. The principle was erroneously applied, and instead residents were targeted by race, having little impact on crime. Improved economies overall have had a far greater correlation with lowering crime rates.

Some cases of super-spreading conform to the 20/80 rule,[32] where approximately 20% of infected individuals are responsible for 80% of transmissions, although super-spreading can still be said to occur when super-spreaders account for a higher or lower percentage of transmissions.[33] In epidemics with super-spreading, the majority of individuals infect relatively few secondary contacts. The 80/20 rule has been suggested to account for a large proportion of transmission events during the ongoing COVID-19 pandemic.[34][35][36]

General distribution operations

The Pareto principle is often referred to in distribution operations, normally called the 80/20 rule. In distribution operations it is common to observe that 80% of the production volume constitute 20% of the SKUs (Stock Keeping Units). During facility design, this rule often governs the storage area and processing area configurations.

Product lines

Many video rental shops reported in 1988 that 80% of revenue came from 20% of videotapes. A video-chain executive discussed the "*Gone with the Wind* syndrome", however, in which every store had to offer classics like *Gone with the Wind*, *Casablanca*, or *The African Queen* to appear to have a large inventory, even if customers very rarely rented them.[37]

In study

There is research to suggest that students can learn 80% of the required learning material with approximately 20% of the effort.[38]

Mathematical notes

Valid application of the rule requires demonstrating not that one can explain most of the variance or that some small set of observations are explained by a small proportion of process variables, but rather that a large proportion of process variation is associated with a small proportion of the process variables.[3]

This is a special case of the wider phenomenon of Pareto distributions. If the Pareto index $\boldsymbol{\alpha}$, which is one of the parameters characterizing a Pareto distribution, is chosen as $\boldsymbol{\alpha} = \log_4 5 \approx 1.16$, then one has 80% of effects coming from 20% of causes.

It follows that one also has 80% of that top 80% of effects coming from 20% of that top 20% of causes, and so on. Eighty percent of 80% is 64%; 20% of 20% is 4%, so this implies a "64/4" law; and similarly implies a "51.2/0.8" law. Similarly for the bottom 80% of causes and bottom 20% of effects, the bottom 80% of the bottom 80% only cause 20% of the remaining 20%. This is broadly in line with the world population/wealth table above, where the bottom 60% of the people own 5.5% of the wealth, approximating to a 64/4 connection.

The 64/4 correlation also implies a 32% 'fair' area between the 4% and 64%, where the lower 80% of the top 20% (16%) and upper 20% of the bottom 80% (also 16%) relates to the corresponding lower top and upper bottom of effects (32%). This is also broadly in line with the world population table above, where the second 20% control 12% of the wealth, and the bottom of the top 20% (presumably) control 16% of the wealth.

The term 80/20 is only a shorthand for the general principle at work. In individual cases, the distribution could just as well be, say, nearer to 90/10 or 70/30. There is no need for the two numbers to add up to the number 100, as they are measures of different things, (e.g., 'number of customers' vs 'amount spent'). However, each case in which they do not add up to 100%, is equivalent to one in which they do. For example, as noted above, the "64/4 law" (in which the two numbers do not add up to 100%) is equivalent to the "80/20 law" (in which they do add up to 100%). Thus, specifying two percentages independently does not lead to a broader class of distributions than what one gets by specifying the larger one and letting the smaller one be its complement relative to 100%. Thus, there is only one degree of freedom in the choice of that parameter.

Adding up to 100 leads to a nice symmetry. For example, if 80% of effects come from the top 20% of sources, then the remaining 20% of effects come from the lower 80% of sources. This is called the "joint ratio", and can be used to measure the degree of imbalance: a joint ratio of 96:4 is extremely imbalanced, 80:20 is highly imbalanced (Gini index: 76%), 70:30 is moderately imbalanced (Gini index: 28%), and 55:45 is just slightly imbalanced (Gini index 14%).

The Pareto principle is an illustration of a "power law" relationship, which also occurs in phenomena such as brush fires and earthquakes.[39] Because it is self-similar over a wide range of magnitudes, it produces outcomes completely different from Normal or Gaussian distribution phenomena. This fact explains the frequent breakdowns of sophisticated financial instruments, which are modeled on the assumption that a Gaussian relationship is appropriate to something like stock price movements.[40]

Equality measures

Gini coefficient and Hoover index

Using the "$A : B$" notation (for example, 0.8:0.2) and with $A + B = 1$, inequality measures like the Gini index (G) *and* the Hoover index (H) can be computed. In this case both are the same.

$$H = G = |2A - 1| = |1 - 2B|$$

$$A : B = \left(\frac{1+H}{2}\right) : \left(\frac{1-H}{2}\right)$$

See also

- 1% rule (Internet culture)
- 10/90 gap
- Benford's law
- Diminishing returns
- Elephant flow
- Keystone species
- Long tail
- Matthew effect
- Mathematical economics
- Megadiverse countries
- Ninety-ninety rule
- Pareto distribution
- Pareto priority index
- Parkinson's law
- Price's law
- Principle of least effort
- Profit risk
- Rank-size distribution
- Sturgeon's law
- Vitality curve
- Wealth concentration
- Zipf's law
- Microtransaction whale

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