The Pareto Principle

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Abstract

In this paper, we talk about the Pareto Principle, an important concept in business, economics, and many other scholarly domains. This paper discusses the historical development of the Pareto Principle, what topics and aspects fueled its development, and the changes in its name over time. The paper then discusses the similarities between the Pareto Principle and Chaos Theory, with an argument from *Richard Koch* that the Pareto Principle is directly derived from Chaos Theory. Next, the paper explains how the Pareto Principle itself can be viewed as a fractal, holding recursive properties based on it's own definition. This portion references work done by *Perry Marshall* in his submission to *Harvard Business Review Italia*. The paper then discusses the various use cases of the Pareto Principle and it's relevance in business, economics, technology and personal life, demonstrating its importance and versatility.

1 Introduction

The Pareto Principle is an observed phenomenon which states that 80% of effects result from 20% of causes. This phenomenon suggests that certain behavioral aspects follow an exponential pattern, where the cause and effect relationships are more disproportionate in nature than one would anticipate. Rather then intuitively following a normal distribution, the cause of many statistical data occurs from a small source of input. Other names for this principle exists as well, including the 80/20 rule, the Law of the Vital Few, the Principle of Factor Sparsity, the Principle of Least Effort, and the *Principle of Imbalance*.

The 80/20 Principle: The Secret to Achieving More with Less, written by *Richard Koch*, provides a thorough discussion on the background of the Pareto Principle, its development throughout history, and a plethora of important and useful applications of the principle in various fields of study. Richard Koch is a British management consultant, investor, and entrepreneur. Much of his literature makes suggestions on how individuals can improve their lifestyle in economics, business, and other aspects of life.

2 Important Figures

Although the premise of the Pareto Principle is generally straightforward, its development and public acceptance involved many important figures and a long period of research. Here,

we discuss key figures mentioned in Richard Koch's book that played a key role in the development of the Pareto Principle. [Koc18]

2.1 Vilfredo Pareto

Vilfredo Pareto, the source of the principle eponym, is an Italian economist who first discovered the principle while studying wealth and income in Europe. During his research, he noted that approximately 80% of wealth in Italy was owned by approximately 20% of the population. This initial realization sparked his interest in this disproportionate data, and Pareto decided to continue searching for other possibilities of this phenomenon. As it turns out, Pareto later realized that the pattern was consistent across different time periods and across different countries. However, while Pareto discovered the principle, Koch explains that Pareto was unfortunately incapable of concisely explaining his discovery to others. The essence of the principle has thus been renamed, re-explained, and popularized through other pioneers later in history.

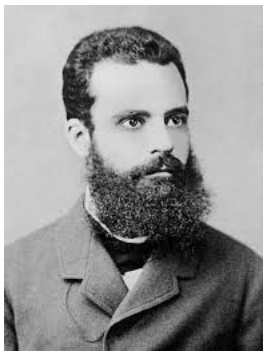

Figure 1: A picture of *Vilfredo Pareto* in the 1970s

2.2 George K. Zipf

George K. Zipf, and American linguist and philologist, is a prime example of an important figure who rediscovered and popularized the Pareto Principle. Zipf specifically stated that resources tend to arrange themselves in such a way that 20-30% of any resource resulted in 70-80% of the activity related to that resource. As can be recognized by the name, Zipf is also credited for the discovery of *Zipf's Law*, a phenomenon on word frequency in natural language.

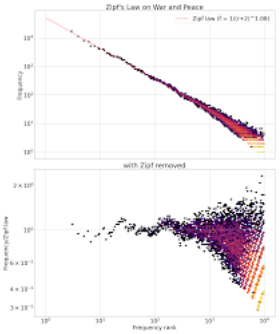

Figure 2: A graph regarding Zipf's Law and the *War and Peace*

This law states that there exists a small list of commonly used words in natural language that account for the most words in literature. For English, these words include *"the"*, *"of"* and *"and"*, which account for a surprising 13% of words in English text. In mathematical terms, the rth most frequent word has a frequency f(r) that adheres to the following distribution:

$$f(r) \propto \frac{1}{r^{\alpha}},$$

where $\alpha \approx 1$ [Pia14]. With this finding, we see that the Pareto Principle holds relevance in language and linguistics. Zipf referred to this phenomenon as the Principle of Least Effort, a version of the Pareto Principle which states that many aspects of nature will naturally choose a path of least resistance.

2.3 Joseph Moses Juran

Joseph Moses Juran, a Romanian-American engineer, is credited for officially coining the term *Pareto Principle*, and also referred to the principle as the *Rule of the Vital Few*. Juran was key in the development of the quality revolution of the late 20th century, where action was taken to counteract the imbalance seen between the quality of Japanese goods to that of American goods. The late 20th century placed new emphasis on quality improvement in addition to new industrial practices [Jur20]. Juran specifically used the Pareto Principle to root out quality faults and improve the reliability of industrial and commercial goods. In industrial terms, "the small percentage of root causes in manufacturing or service processes that account for the largest effect in terms of defects or costs" [Jur20].

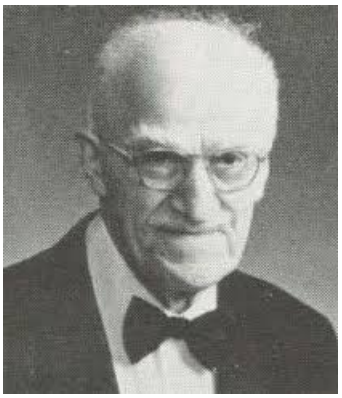

Figure 3: A photo of Juran in 1987

3 Chaos Theory and the Pareto Principle

Chaos Theory involves the scientific study of random, non-linear, and unpredictable events. Chaos Theory states that there tends to be randomized behavior in nature, but this behavior can simultaneously have unbalanced yet calculated results. In his book, Koch draws parallels between Chaos Theory and the Pareto Principle, stating that the Pareto Principle can in fact be derived from Chaos Theory. Koch describes Chaos Theory as "a self-organizing logic lurking behind the disorder, a predictable non-linearity" [Koc18]. According to Koch, similarities concepts between the two aspects include the non-linearity of the universe, the distortion and disturbance of balance from feedback loops, the tipping point, and the concept of "first come, first served".

Firstly, both phenomenon argue that the universe is unbalanced and that the world is non-linear. This idea is inherit in the Pareto Principle, which follows more of an exponential progression rather than a normal distribution. These principles are highlighted and implied by the naming of Principle of *Imbalance*.

Koch notes that between the two phenomenon, feedback loops distort and disturb balance. This means that in an environment, even slight yet advantageous differences in the initial conditions between two entities can result in unfair advantages and vastly different performances. In other words, "...small initial influences can become greatly multiplied and produce highly unexpected results, which nevertheless can be explained in retrospect" [Koc18].

Koch also notes that both phenomenon include the concept of a tipping point, an abstract concept that suggests that after a certain threshold, even small amounts of additional effort can reap drastic results. This arbitrary threshold is what is referred to as the tipping point. This concept originates from the principles of epidemic theory, where ordinary and stable

phenomenon can quickly transform into a public health crisis by crossing the tipping point.

Lastly, Koch notes that both phenomenon follow a "first come, first served" basis. Events that occur early on, even the seemingly trivial, can have long-term disproportionate effects. Chaos Theory specifically advocates for "sensitive dependence on initial conditions". Chaos theory can show and quantify the numerical differences in a system over time based on various initial conditions. In a sense, the final timestamp of various examples in Chaos Theory then resemble properties of the Pareto Principle.

4 Use Cases

Seen through its numerous applications in economics, business, science, technology, and other fields, the Pareto Principle is a versatile tool that can be used as a business strategy. As a matter of fact, Koch states that implementing the Pareto Principle in business strategy is not only recommended, but almost essential: "Unless you have used the 80/20 Principle to redirect your strategy, you can be pretty sure that the strategy is badly flawed' [cha]. In any case, Koch notes the following successful applications of the Pareto Principle: strategy, quality, cost-reduction, marketing, selling, information technology, decision making, inventory management, project management, and negotiation.

In terms of technology, Koch notes two separate testimonies from two separate project directors. One states "80 percent of the benefits will be found in the simplest 20 percent of the system, and the final 20 percent of the benefits will come from the most complex 80 percent of the system". Another testimonial suggests that customers tend to follow the Pareto Principle with their use of technology. According to this claim, customers use around 20% of the available services for a piece of software around 80% of the time.

Furthermore, RISC software and its development is a prime example of the value in implementing the Pareto Principle within technology. RISC (Reduced Instruction Set Computers) processors are computer architecture that simplify the instructions given to a computer to perform a certain task [Kir23]. RISC processors were specifically developed in order to optimize the performance of hardware used by the majority of software cases. With this strategy, developers implemented the Pareto Principle and assumed that software spends around 80% of its time executing only around 20% of the available instructions. This implementation, along with removing the other approximate 80% of hardware, reduced chip sizes and costs. The concept of RISC processors began with the IBM 801 project in the late 20th century. John Cocke, an American computer scientist, is credited as the "Father of RISC processors". Today, RISC processors are used in smartphones, tablets, printers, and other devices that perform a specific set of repeatable activities. In addition, there are many open-source instruction set architecture (ISA) widely available due to the simplicity of creating RISC architecture. The University of Berkeley, for example, provides the RISC-V open-source architecture [com].

However, not only does the Pareto Principle apply to the implementation stages of software and hardware development, but it's also applicable to the troubleshooting stages as well. In the early 2000s, Microsoft CEO Steve Ballmer released information from a study

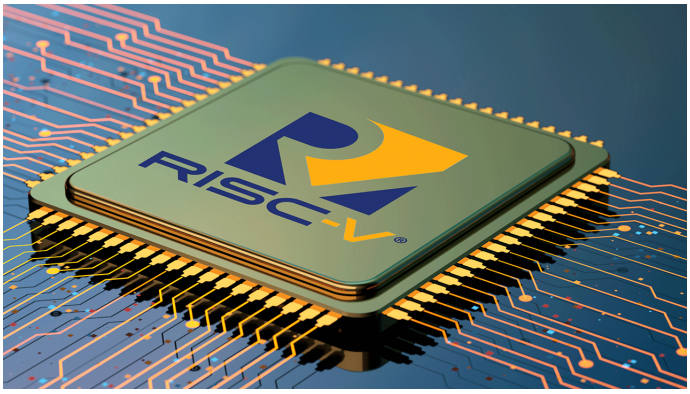

Figure 4: A picture of an RISC-V processor

which suggests that 80% of the errors in various Microsoft products like Windows and Office are caused by approximately 20% of all errors detected, and further that more than 50% of errors resulted from a mere 1% of code [Roo02]. Thus, not only does this study exemplify the Pareto Principle itself, but it also exemplifies a recursive property of the Pareto Principle (a topic that will be explored later in the paper).

The Pareto Principle also holds economic and monetary value. Plenty of studies throughout past and present time show the vast imbalances in the wealth distribution. The *Statista Research Department* states that, in the year 2023, 66.6% of total wealth in the United States belonged to the top 10% of earners [sta23]. In general, Income tends to be unequally distributed, with a minority of income accumulating from aggregate income, and a majority of income accumulating from investing.

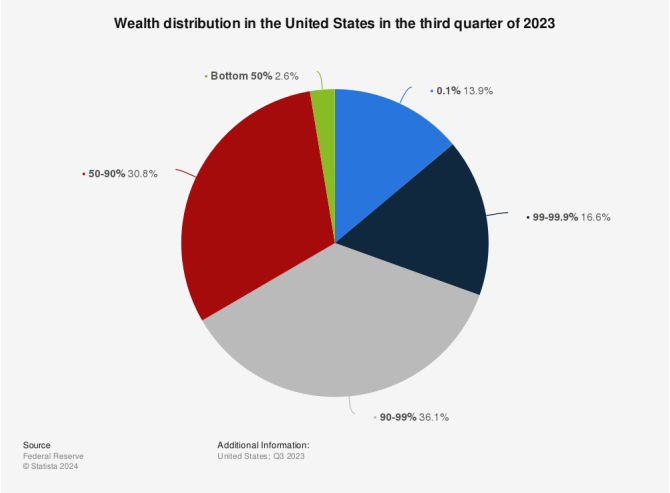

Figure 5: A graphic showing the discrepancies in the wealth distribution in the US in 2023 [sta23]

With this regard, Koch provides advice for its readers to follow for building wealth. Koch suggests that it's more likely to accumulate wealth from investments rather than from

employment income alone. Furthermore, Koch argues that, when negotiating for a pay raise, it's important to remember that around 80% of concessions will be made at the last 20% of negotiating time. If demands are made earlier on in the negotiation process, however, Koch notes that "neither side may be willing to yield, and the entire transaction can fall apart" [Koc18]. In other words, it's best to wait until the later portions of a negotiation period to mention a desire for a raise.

5 Fractals and the Pareto Principle

Fractals are patterns that repeat within itself. These patterns repeat indefinitely in a recursive manner; a portion of a fractal mirrors the whole. Fractals are an interesting and important field in mathematics, as it mathematical properties hold prevalence in many aspects of life, especially in nature.

Perry Marshall, an American business consultant, draws attention to Fractal mathematics, stating that the Pareto Principle itself is fractal. Marshall expands on this topic in an article of *Harvard Business Review Italia* [Mar18]. Here, Perry Marshall argues that the Pareto Principle itself behaves recursively. For events where 20% of effort causes 80% of the effect, 20% of the 20% further cause 80% of the 80%. In other words, the recursive nature of this principle implies that 4% of effort causes 64% of the effect, and 0.8% of effort causes 52% of the effect.

Marshall also develops the idea of an 80/20 curve. While a normal curve highlights averages, the 80/20 curve highlights outstanding performances: "Bell curves hide performers. The 80/20 Curve makes performers obvious" [Mar18]. This development mirrors an exponential curve, further exemplifying the exponential behavior and the property of imbalance present in the Pareto Principle. Marshall further argues that the use of the 80/20 curve allows a business to predict the outcome of a specific business approach, and more specifically to critically prioritize important inputs. With this approach, a business says *no* more often than not to specific inputs and business choices, as the goal would be to prioritize the minority that generates the most revenue. Marshall quotes American businessman, investor, and philanthropist *Warren Buffet* with the following statement that supports the approach suggested by the 80/20 curve: "The difference between successful people and very successful people is that very successful people say no to almost everything" [Mar18].

In addition, Perry Marshall defines the formula behind the recursive properties of the Pareto Principle. For this equation, we first consider a constant R representing the ratio being considered in the Pareto Principle. For an 80/20 ratio, we set R=0.8. For a 70/30 ratio, we set R=0.7. Note that for this equation, the sum of the values in the ratio should be 100. From here, Marshall defines the following parameter:

$$q = \frac{\ln(R)}{\ln(1-R)}.$$

Input $x \in [0,1]$ represents the rank in percentile, where $x = 1$ represents the best rank and $x = 0$ represents the worst rank. Marshall defines the 80/20 distribution function as

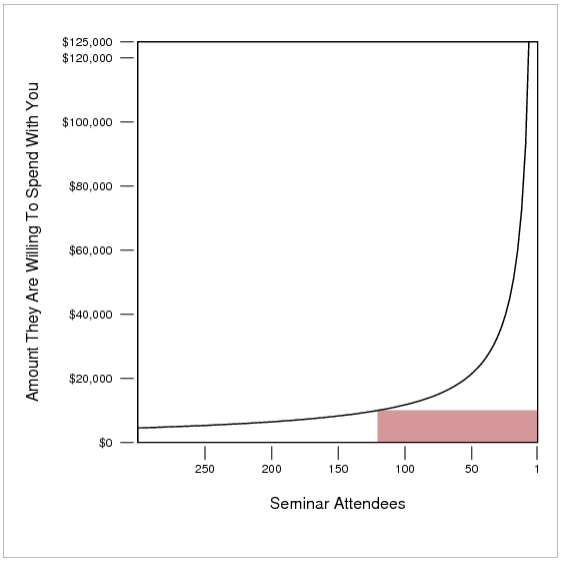

Figure 6: An example of the 80/20 curve developed by Perry Marshall [Mar18]

$$f(x) = q(1-x)^{q-1},\ x \in [0,1]$$

The 80/20 curve then calculates the output of members as an integral. The following formulas can be used to find the total output of the left (weak) and right (strong) side of the curve respectively at a given rank x. The area under A_1 represents the portion of the population that have meet the requirements of the given percentile x, while the area under A_0 represents the portion of the population that under-performed.

$$A_0(x) = 1 - \exp(q \cdot \ln(1-x))$$
$$A_1(x) = \exp(q \cdot \ln(1-x)$$

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In general, Marshall makes the following important claims that summarize his findings within his own business and during his research [Mar18].

1. The Pareto Principle is a fundamental rule of cause and effect
2. The Pareto Principle is fractal, being recursive in definition
3. In business and life, thinking exponential terms compared to averages bears the greatest consequences.

6 Applications

Koch's goal is to inform readers on how to apply the Pareto Principle to all walks of life. While the principle is commonly used within business and economics, sources suggest that

the principle holds more of a universal value and can be widely applied for ones own advantage. *Jesse Langel* of the Langel Firm in New York City wrote an article demonstrating many examples of applications of the Pareto Principle in various aspects of life, ranging from business/economics to even entertainment and personal life. Here, we highlight some interesting claims presented in this article [Lan18].

6.1 Business

- 80% of sales come from 20% of customers
- 80% of customer complaints come from 20% of customers
- 80% of business productivity results from the work of 20
- 80% of firm profits are driven by 20% of corporation's staff
- 80% of pollution originates from 20% of all factories

6.2 Economics

- In 2023, 66.6% of total wealth in the US was held by 10% of the population
- Globally, around 75% of total wealth is held by 10% of the population

6.3 Technology

- 80% of software glitches are caused by 20% of bugs
- 80% of the public uses 20% of their computers' features.
- 80% of software functionality is caused by 20% of the software developers' efforts.
- 20% of your phone apps get 80% usage.
- 20% of computer bugs fixed will stop 80% of crashes.

6.4 Personal Life

- 80% of stress is caused by 20% of stressors.
- 80% of your knowledge is used 20% of the time.
- 80% of sleep quality occurs in 20% of sleep.
- 80% of projects get completed in the last 20% of the time before a deadline.
- 20% of your wardrobe is worn 80% of the time.
- 20% of words in a language account for 80% of usage.

7 Conclusions

Based on the information presented, it's fair to argue that the Pareto Principle is an important mathematical occurrence in nature. The power behind this principle, as mentioned by Koch, is that the concept is counter-intuitive. Many would assume that nature generally follows more of a normal distribution, but this finding shows it's increasingly common for nature to follow an exponential distribution, where a small percentage or a small aspect of a system holds great importance and has a greater impact on the system as a whole. This isn't to say as an individual or in a business to only devote their time on a small percentage of their work and should always *completely* ignore the majority of the other aspects of their system. The principle, rather, can be used as a way of allowing an individual or business to efficiently manage their work and effort in order to maximize profit, however that outcome may look.

8 Presentation Reflection

I've briefly heard about the principle before the presentation, but I wanted to learn more on its implications, its historical development, and its implementation throughout time. My goal for the presentation was to introduce a concept to the class which may have not been commonly known but holds great importance in daily life. Ideally, speaking of the historical development, its mathematical properties, and also its numerous use cases allowed the class to understand the importance of the Pareto Principle and its versatility.

One thing that I personally noted to try to change for the second presentation is to try to stand throughout the duration of the presentation. Sitting while presenting most likely made it difficult for the class to view me as a speaker during the presentation, which is naturally a crucial element in presentations in general. I also would like to improve on my clarity and conciseness when presenting. This has been a persistent weakness of mine for as long as I could remember, so improving on this skill will require patience and practice.

In terms of Peer Feedback, it seemed like in general the class enjoyed the presentation and enjoyed learning about the Pareto Principle. For criticisms, many did recommend standing for the next presentation.

One student asked a question on a business scenario on the Pareto Principle, specifically the implications of the following claim: "80%" of customer complaints result from 20%" of customers". In my opinion, the implications of this claim can go in different ways. In one aspect, businesses can use this information to understand the demographic that uses their product and decide to specifically cater to that demographic. This concept has been implemented in many business strategies, with a majority bearing beneficial results. In another aspect, businesses could take this statistic and notice that the same, small minority of their customers or clients comprise the majority of complaints and therefore avoid placing substantial importance or effort in these complains.

Another student mentions *Pareto Efficiency*. This is a phenomenon that occurs in economics between separate parties where no action exists that allows one party to profit without

the consequence of another party suffering. This concept is holds great prevalence in economics and game theory, and this concept also holds interesting mathematical properties. Furthermore, Pareto Efficiency was also discovered by Vilfredo Pareto, the same individual who discovered the Pareto Principle. One possible area of further research could be exploring the historical context of Pareto Efficiency and developing a deeper understanding of its implications and use cases. An interesting discussion could arise on the similarities or the direct relationship between the Pareto Principle and Pareto Efficiency.

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