Generic Curve Shapes

The detection of these generic curve shapes is facilitated by developing a circular network, as illustrated above. Knowing a system's elements and their relationships is fundamental to identify weak signals.

Name: **Exponential Growth**

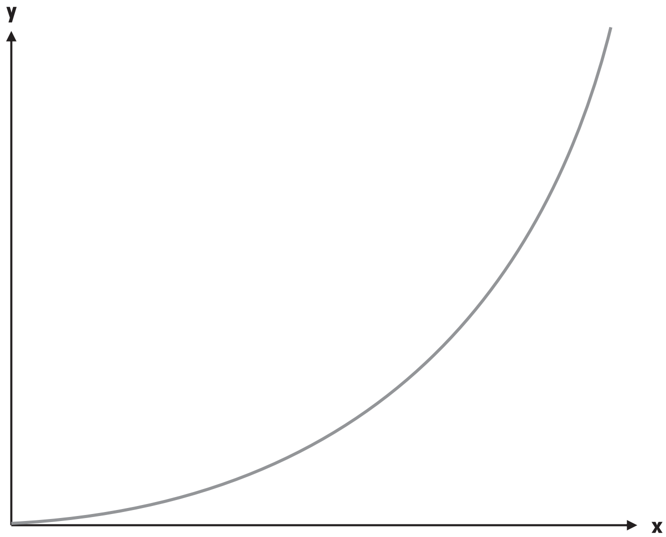

Figure 2.22: The exponential growth curve.

Discovery: Sissa ibn Dahir (legendary, between 400 and 600 AD)
Application: Startups, Innovation, Growth

Description: This curve represents the idea of unlimited exponential growth – and only a few phenomena can be described in this way (see card Phi M). Often only a particular phase of an evolutionary path is purely exponential because any system has a maximum carrying capacity. If one observes such a curve shape, it is wise to look out for dampening factors or inflections points (see also Logistic Growth).

Example: In the managerial context, this curve is characteristic for the introduction of new technologies, for new business models, and for market trends (e.g., web bubble of the early 2000s, transfer sums for soccer players, growth of stock value of Apple or Google). The same applies for the tulip mania in the Netherlands in 1637, which was based on speculation and greed, driven by a self-reinforcing loop of the availability of a product and its price. Obviously, this logic works in abstract domains like money flows, but natural systems have built in constraints which prevent endless growth (besides the aforementioned card Phi M). A good weak signal would be the discovery of elements in a system which are structurally too tightly coupled which reinforce each other's growth. A regulating element is missing in the scene.

Name: **Logistic Growth, S-Curve**

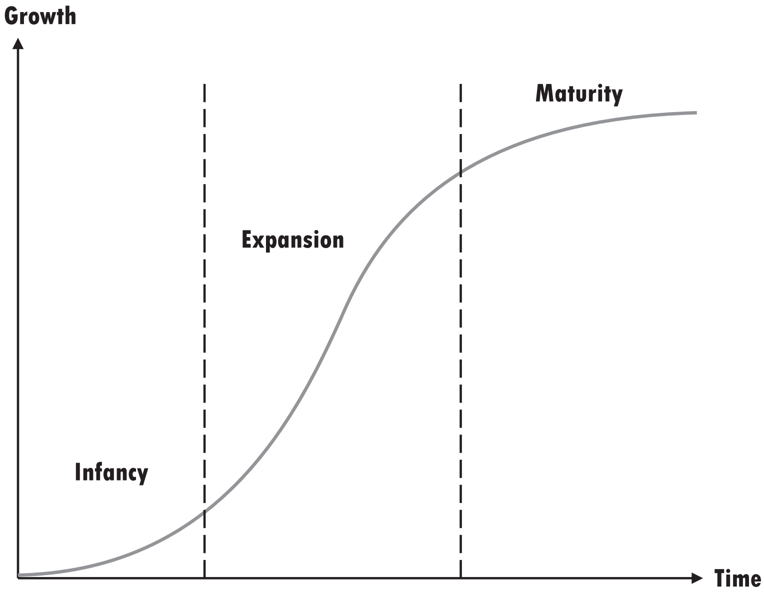

Figure 2.23: The famous S-curve, constrained by a given carrying capacity.

Discovery: Gompertz 1825 and Verhulst 1837
Application: life cycle of a company, product or service, market saturation

Description: the sigmoid shape can be found in many contexts (the growth rate of cells or the population of a species in an environment with a given carrying capacity). It is possible to model this function with different approaches. Still, the message always stays the same: growth starts slowly in the beginning, then a phase of exponential growth follows, after which a saturation effect comes into play.

Example: this is probably the most common curve type for all sorts of organizations, from biological, over economical, to social systems. To spot weak signals for this shape, it makes sense to understand the environment of the observed system. In the economic domain: which factors determine the maximum size of an ecosystem? How is energy flowing through the elements? Is there a certain degree of friction that determines the maximum capacity? How big is the market, e.g., the maximum number of customers or the availability of a resource? By understanding the boundaries of the systems, one can estimate the expected curve shape over time.

Name: **Strategic Inflection Point**

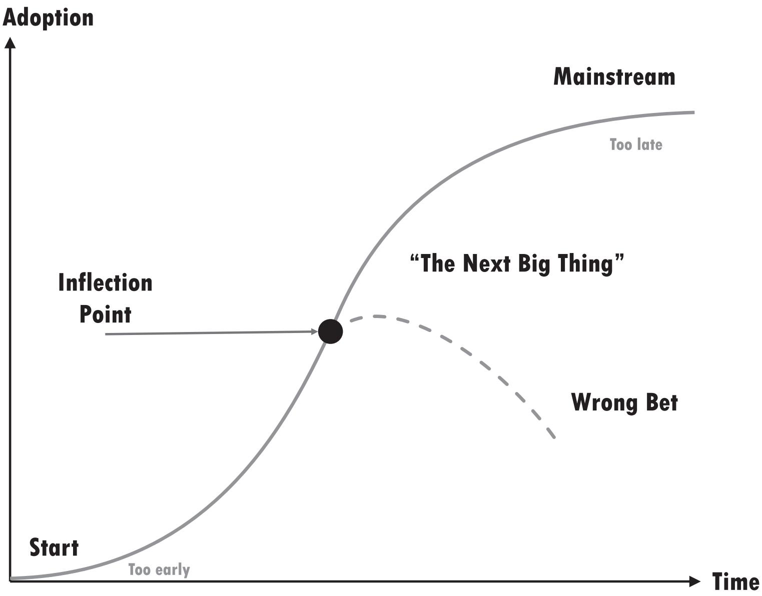

Figure 2.24: The turning of a curve is always critical, but it is the question whether this is a good or a bad thing.

Discovery: Andy Grove 1996 (in the business context)
Application: Strategy, Change, Business Models

Description: an inflection point is a marker for the change of a curve. From a mathematical perspective, it shows how a shape transforms from concave upwards to concave downwards or vice versa. In business, it is crucial for the business to discover these points as soon as possible to be able to cope with the upcoming change and to have enough time to prepare for the impact.

Example: the interpretation of an inflection point can be manifold, as it depends on the specific context. A company might have reached its highest revenue growth rate and starts to slow down towards its boundaries (the middle of a S-curve). But an inflection point can be also related to bad product reviews, as a quality initiative is showing its effect. The detection of a weak signal is very challenging because it is mathematically impossible to calculate the inflection point without a complete data set. A circular network could be promising to acquire an understanding of the given situation and to detect the deciding levers that will drive the inflection point. Unfortunately, this is the hardest law when working with weak signals and associated power laws.

Name: **Oscillation**

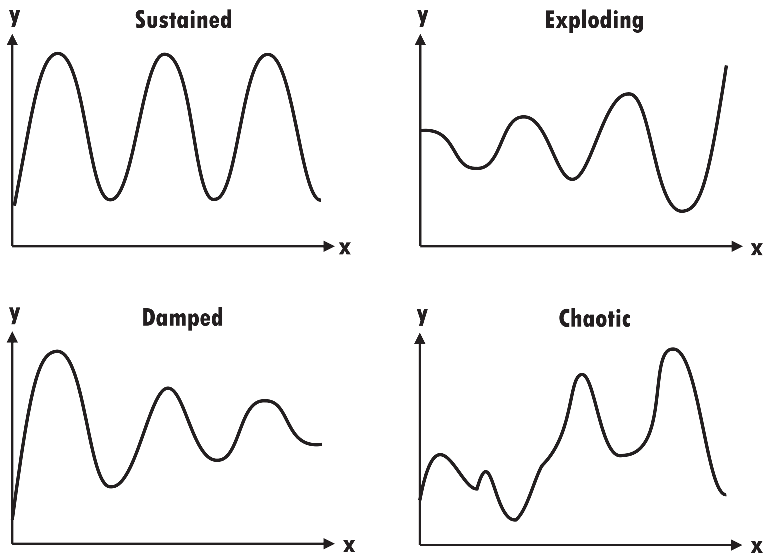

Figure 2.25: When is an oscillation healthy or pathological?.

Discovery: Christiaan Huygens, 1673
Application: Seasonality, Cycles, Resilience

Description: oscillations usually reveal a periodicity in a system and therefore show seasonality and overarching cycles in the business. If this shape is observed, it can be helpful to examine how regular the oscillation seems to be. Is it stable (sustained) within a certain range, or are there fluctuations (see also perturbation card)? Furthermore, are the oscillations converging, diverging, or even chaotic? In a nutshell: extreme oscillations are usually either a sign of an ongoing crisis or some sort of trial-and-error process.

Example: recurring events like Black Friday or Christmas are highly welcomed by retailers and online shops as they promise a nice peak in sales. This type is unproblematic because it is known in advance and can be planned. But if a seasonal trigger is not known, it makes sense to find the path that shall lead to its source. Due to the general nature of this curve, a weak signal can have various reasons. This applies also to the exploding or the damped oscillation – a (hidden) system element is intervening, either in a self-reinforcing or a self-balancing way. A chaotic oscillation must depict a chaotic weak signal as source – inherently, such a weak signal can only be explained retrospectively.

Name: **Goal Seeking**

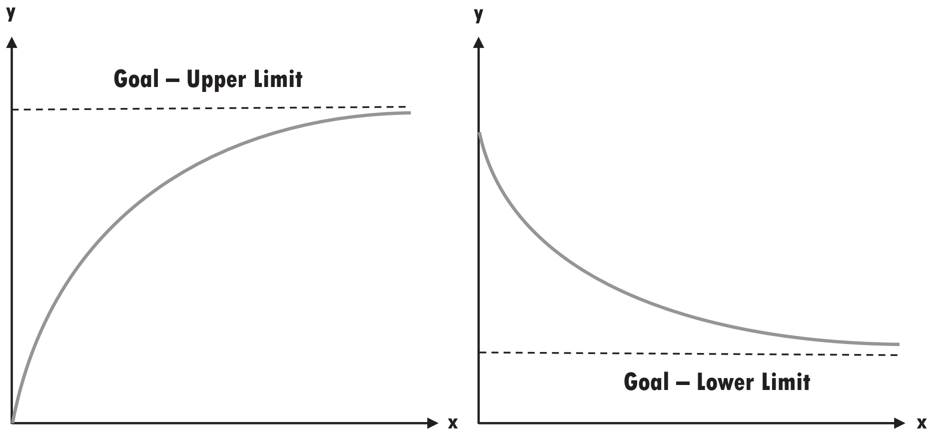

Figure 2.26: Goal seeking shapes indicate a regulator in the background.

Discovery: Archimedes, 287–211 BCE
Application: Goal Seeking, Stabilization, Control, Stagnation

Description: converging curves indicate a goal-seeking behavior, typically influenced by the dampening effect of a negative feedback loop in the system. In business, this shape can be related to the end of the life cycle of a product (sunset phase) and the maturity of a product (e.g., all feasible features are built, nothing is left to iterate). That phenomenon is also known as the marginal benefit curve.

Example: goal seeking shapes are closely related to the start and the end of a S-curve, as some sort of saturation effect is entering. A typical example is an enterprise reaching its maximum market position. On the other hand, we can find curves which converge towards a minimum limit, in situations where the lowest cost level has been reached (given the existing technology is not progressing). Weak signals for this type of curve must be found, in the truest meaning of the word, at the edges of the observed system, no matter if it is adjacent to a whole ecosystem, to a specific niche-market or to the company itself. The guiding questions are about the upper and lower limits of the observed variable, and again a circular network can be useful to identify the influencing weak signals.

Name: **Chaos**

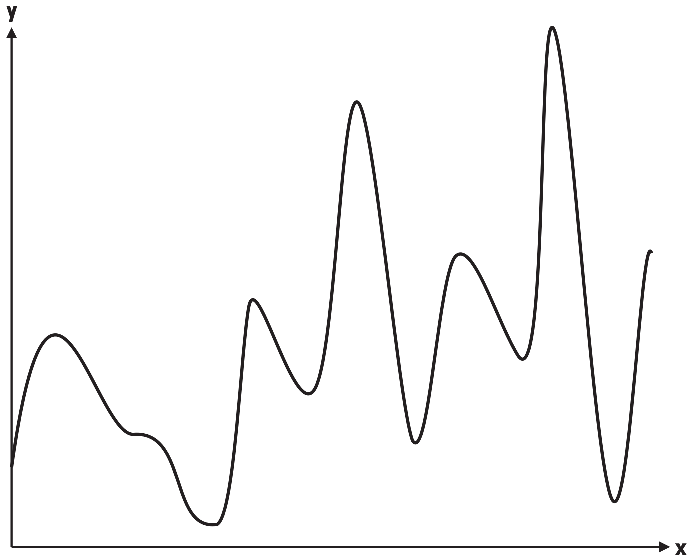

Figure 2.27: If patterns show no regularity, we call them chaotic, a pure random function.

Discovery: Newton, 1680s (Three Body Problem)
Application: Unstable system detection, Collapse, Warning Signs

Description: chaotic patterns point towards situations which call for immediate action. Let's take the example of a burning house as a chaotic situation, where it is necessary to evacuate – and where one needs a lot of training to survive such an incident (with a high likelihood). In a timeseries a chaotic pattern can be understood as a creative process, where a new behavior is about to emerge. It represents the edge of knowledge.

Example: a chaotic pattern in the economic sphere is often related to the fact that something new is going on. This curve can be found in start-ups which are still in the infant stage of company development. A new company is rarely perfectly organized, a lot of value is delivered initially, but the performance is too low, due to the lack of knowledge about the customer or the production process. The weak signals can have many sources, and usually they interact in a non-predictable way – otherwise it would not be a chaotic pattern.

Universal Natural Laws

These laws are omnipresent, independent of the industry or area of expertise. The question must be answered to what extent a company stays on a healthy evolutionary path. This requires a comparison of actual data with forecasts based on universal natural laws. A deviation from a predicted curve is investigated by looking for weak signals and the natural laws behind.

Name: **Punctuated Equilibrium**

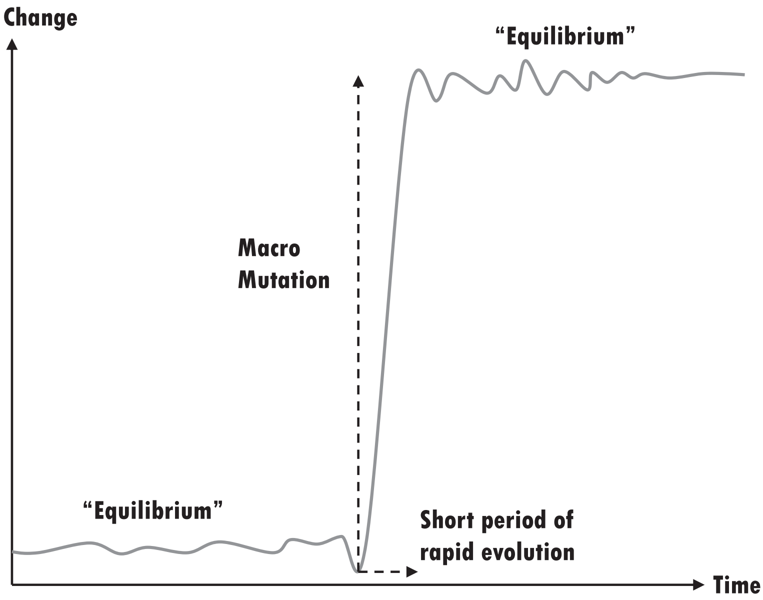

Figure 2.28: A sudden change could indicate an evolutionary shift.

Discovery: Eldredge and Gould, 1972
Application: Discovering Wildcards, Sudden Shifts in Markets, Macro Economic Changes

Description: the punctuated equilibrium represents a rapid change in a very short amount of time. These kinds of jumps can be observed when relevant internal or external factors change, which are leading to new behaviors or structural characteristics. A typical example would be a drop of stock value because of a pandemic situation, or a stock rises because of new customer preferences.

Example: this shape can be characterized as a "wildcard event," caused by a competitor which deploys a completely new technology that directly attracts a lot of customers. Alternatively, a sudden peak can also be affected by an emergent behavior of various actors in a system, e.g., when different players in a market decide to switch to a new standard. Suddenly, the old solution is obsolete and the new one is leading.

Name: **Critical Transitions**

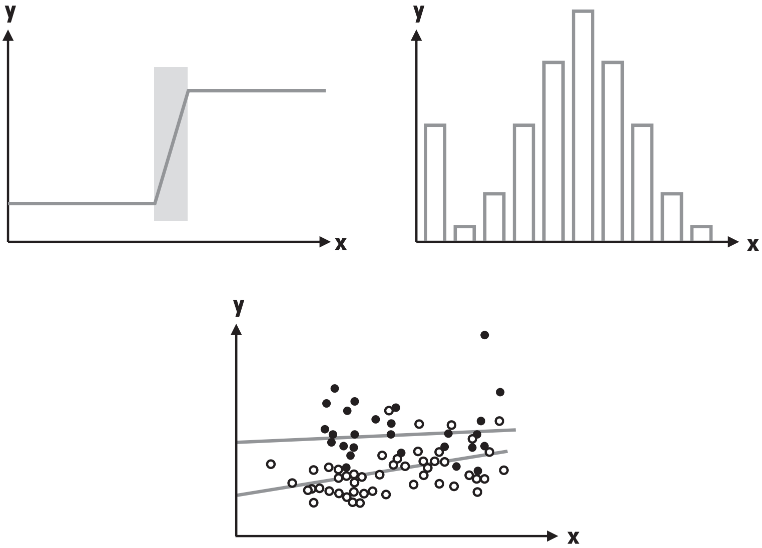

Figure 2.29: Critical transitions can show up in different forms.

Discovery: Marten Scheffer 2009
Business Application: Anticipating fundamental changes, especially catastrophes

Description: it is possible to anticipate critical transitions before they happen, by identifying "alternative attractors" in a system. This could be a shift in a time series (see also Punctuated Equilibrium), a multimodal distribution, or a dual relationship to a controlling factor. The term critical transition does not imply that a catastrophic event will happen – it can be also a positive outcome (anastrophe).

Example: in managerial practice, this kind of transition appears in various forms. The adoption rate of a new competitive solution could be the control parameter which leads to a dual relationship of two variables, e.g., the number of lost customers and the overall growth of a new market. This control parameter must be identified early as a weak signal, to adapt quickly to the upcoming change. A multimodal distribution is another indicator for an upcoming transition, e.g., a change in preferences of customers and expectations about a special feature of the product. This kind of change can be identified by weak signals about trend setters and influencers in social media and equivalent sources. One needs to find out the highly connected players in a social network which decide about "hot or not"?

Name: **Scaling of Units and Size**

Figure 2.30: The correlation between the number of employees and the net income. The black and white dots represent two different companies in the same market.

Discovery: Geoffrey West 2017
Business Application: Understanding Growth of an Organization

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Description: the visualization shows on a logarithmic scale the relationship between "units" (number of employees) and the "size" (net income in dollars). This proportion represents a sublinear scaling, which can be also found in mammals, where the size is proportional to the number of cells. The quarter-power scaling law derives its magic number 4 from our three-dimensional world in space plus one time dimension.

Example: to understand the scaling of units and sizes, weak signals can provide valuable information about change or evolution over time. For example, if one detects a weak signal indicating a greater popularity of a product, one can use this information to predict its demand, which may require adjusting your production or supply chain to accommodate this larger demand.

Name: **Metabolic Rate of Natural Systems**

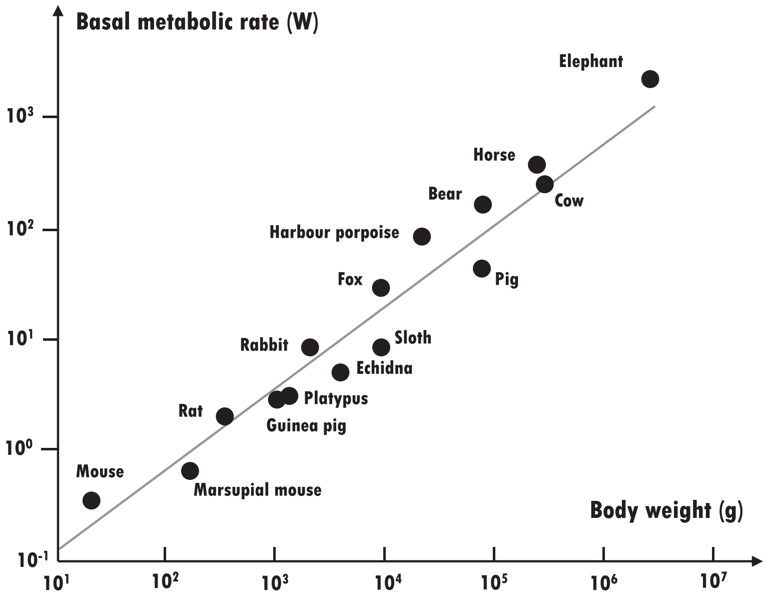

Figure 2.31: The proportional relationship of body weight and basal metabolism rate.

Discovery: Geoffrey West 2017
Application: Check healthiness of the proportion of size and maintenance efforts

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Description: the graph shows on a logarithmic scale how body weight (100%) and metabolic rate (75%) are related to each other. One could roughly say that per size doubling the heart rate is scaled by the exponent −1/4. This relationship can be found across mammals in nature.

Example: in the context of this power law, weak signals could refer to small changes in an organization: changes in "body weight" (e.g., number of employees) which are not easily noticeable but affect their "basal metabolic rate" (e.g., total workplace costs). An organization which loses a small number of employees may have a slightly lower metabolic rate, but this change may not be immediately apparent. It is important for organizations to pay attention to these weak signals and make workflow changes to maintain a healthy body weight and metabolic rate.

Name: **Size & Scaling Human Made Systems**

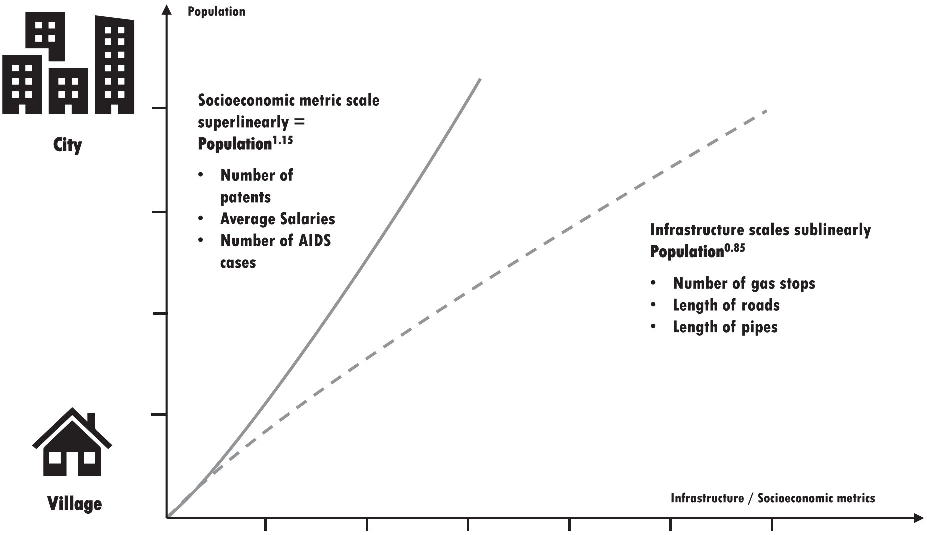

Figure 2.32: The benefits of size: While the infrastructure scales sublinearly, the socioeconomic growth scales superlinearly.

Discovery: Geoffrey West 2017
Application: Check healthiness of the proportion of infrastructure costs and benefits of scaling effects

Description: this law is valid for socio-economic contexts, and it describes two growth factors which are also relevant for companies. For sustainable growth, the scaling of the infrastructure costs (including maintenance) should be sublinear (^0.85). The benefits of a bigger organization (network effects) are expressed via a superlinear scaling of ^1.15. The known limits of this law can be observed when looking at the biggest cities in the world.

Example: size has several benefits, such as a sublinear scaling of the infrastructure. For example, a company with 10,000 employees may require a certain number of computers, utilities, and other infrastructure to support it. As the number grows to 100,000, the infrastructure required increases at a much slower rate. Furthermore, large systems can be more effective at detecting and responding to weak signals, because they have more and better data, which can help to identify and address issues before they become major problems.

Name: **Network Invariants**

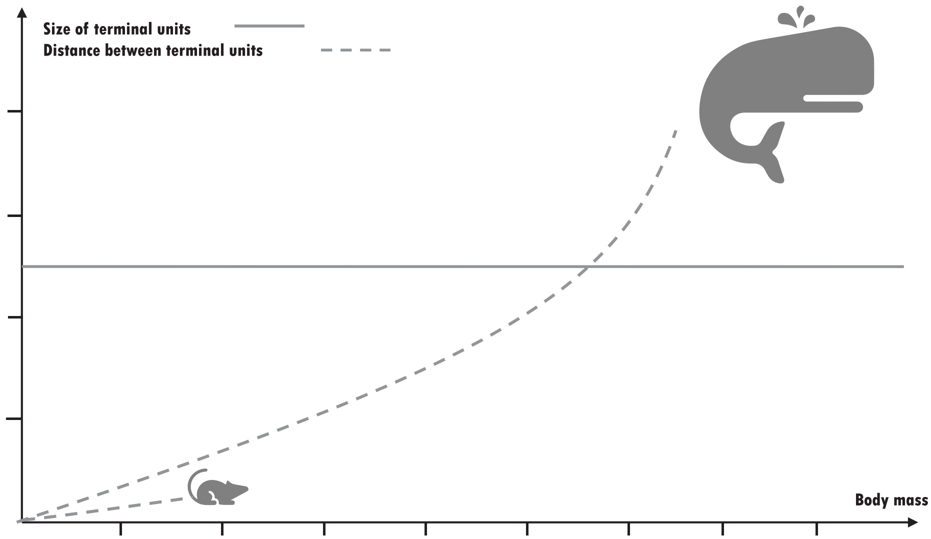

Figure 2.33: Some variables are invariant in a network, other traits scale with size.

Discovery: Geoffrey West 2017
Application: Understanding Networks, Market fit, Interoperability

Description: in each network/system, like the human body or a house, the "end pieces" are invariant. That means they are all of the same size, depending on the specific "piece type." In a house, the electric plug sockets are all the same size, and this applies also for water appliances. The capillaries of the blood system are another example: the "last meter" has always the same size. Insight: when designing networks, these terminal units define the constraints of the network (e.g., the flow rate in the capillary system). But the distance between the terminal units will scale differently.

Example: invariant variables can help to identify weak signals because they provide a consistent and stable reference point to be compared with changes in the network. For example, if a network has an invariant variable that measures the average number of connections between nodes, a change in this variable over time could indicate the presence of weak signals, such as the emergence of new connections or the loss of existing ones. By analyzing these changes, it is possible to identify new trends or problems that may require further investigation or action. E.g., the scaling of the distance could be detected via minor changes in the DNA.

Name: **Phi M, Rising Complexity**

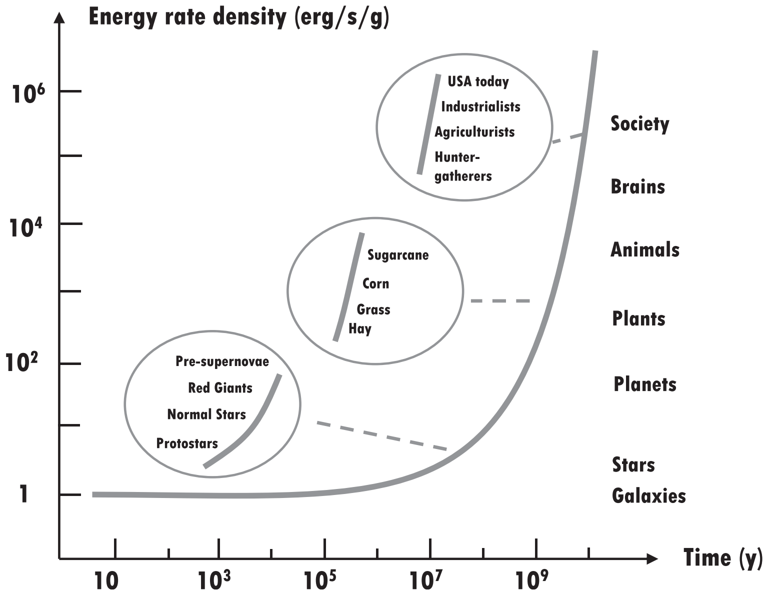

Figure 2.34: The ever-increasing complexity in the cosmos and how "pockets of complexity" evolve.

Discovery: Eric Chaisson 1996
Application: Unterstanding of Cosmological Evolution and New Technologies

Description: the ever-increasing complexity over time can be understood via the energy flow (information) rate density, which is called Phi M. It is a measure of the rate of evolution in a complex system and expresses the energy flow in a given space per time interval. Therefore, the Phi M value of a sunflower is much higher compared to the value of the sun – the plant is much more complex than our "hydrogen oven."

Example: when a complex system is operating at a low Phi M, weak signals may indicate a slowing down rate of evolution. The reasons can be manifold, e.g., inadequate or ineffective leadership or lack of clear objectives, which makes it difficult for the system to prioritize its efforts and resources. Finally, the lack of diversity or innovation within the system can prevent it from exploring new ideas or approaches favoring new growth and development.

Name: **Contagion Theory**

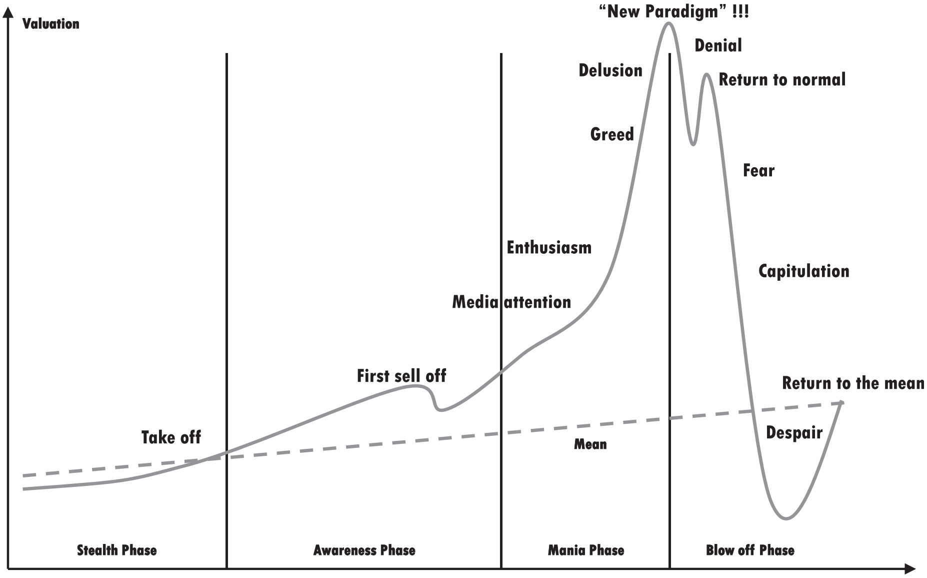

Figure 2.35: The distribution of contagious "material," here as a curve according to the four phases of a bubble (Jean-Paul Rodrigue).

Discovery: Starting with Lotka 1907 and for Business: Kucharski 2020
Application: Distribution of ideas, products, or services in networks

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Description: the idea of contagious ideas, also known as memes, is well known. With this card, one shall be inspired to look at a times series like an epidemiologist and ask yourself: what are the drivers behind the basic reproduction number, aka R0? Kucharski offers this formula as a guideline:

$$R = D \times O \times T \times S$$

$$(\text{Duration} \times \text{Opportunities} \times \text{Transmissibility} \times \text{Susceptibility}).$$

Example: all factors (D, O, T, S) can be important to predict how a message, e.g., a new hype (like Bitcoin), will spread through from early investors to the public – or how it could be stopped if one of the factors equals zero. Therefore, weak signals help to identify the probability that a message will travel through the network. While it is obvious that the time of exposure is key for duration, opportunities always depend on people in each space. Transmissibility and susceptibility are rather qualitative indicators in the social context, which are based on norms and questions around the topic of identity.

Cybernetic Laws

Communication and control are the main foci of cybernetic laws. They describe basic principles of organization and help to identify generic problems. The laws provide weak signals as a "solution" when the question about a problem arises. As cybernetic laws are often hidden in plain sight, they can show up in all sorts of curve shapes, even though the cause always remains the same.

Name: **Loose Coupling, High Cohesion**

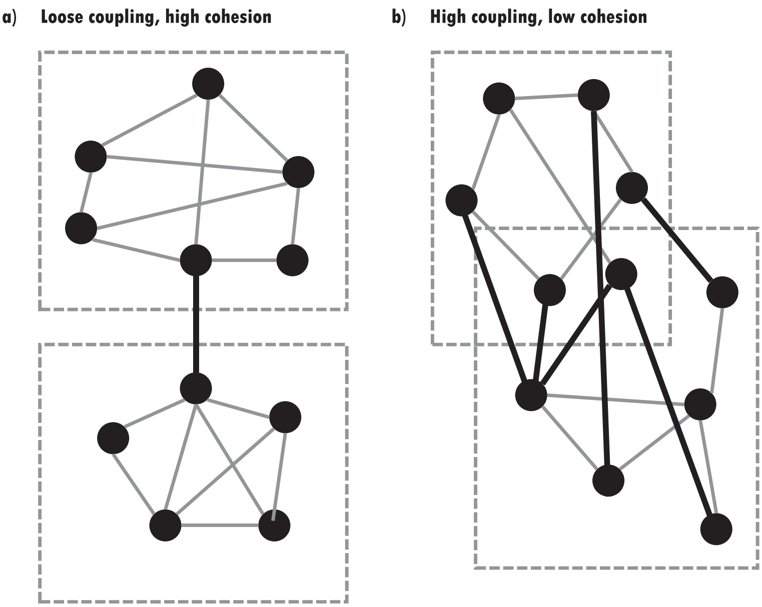

Figure 2.36: Loosely coupled systems are more resilient (variant a).

Discovery: Stevens, Myers, Constantine 1974
Application: Product-, service-, or organization design

Description: this law (or design principle) was described first in the context of programming and information systems design. It aims at robustness and reliability. It is easier to balance a system that is loosely coupled while showing a high level of cohesion. Systems that follow this approach require fewer dependencies and coordination efforts. Systems that claim to be modular need to follow this approach to be "truly" interchangeable.

Example: complex systems which are characterized by high coupling of their parts and little cohesion of the whole are doomed to failure. Catastrophes are looming when chain reactions destabilize a company acting in a complex environment. Weak signals can reveal inefficient or ineffective processes within the enterprise. Another structural reason could be long lead times for change or transformation, due to external perturbations from new competitors entering a market. Tight coupling leads to a lack of adaptability or flexibility within the system, which can prevent it from responding quickly and effectively to changing conditions. On the social level, conflicts among departments or teams are also a source of weak signals, which point to their ability to work together effectively.

Name: **Perturbation Recovery Time**

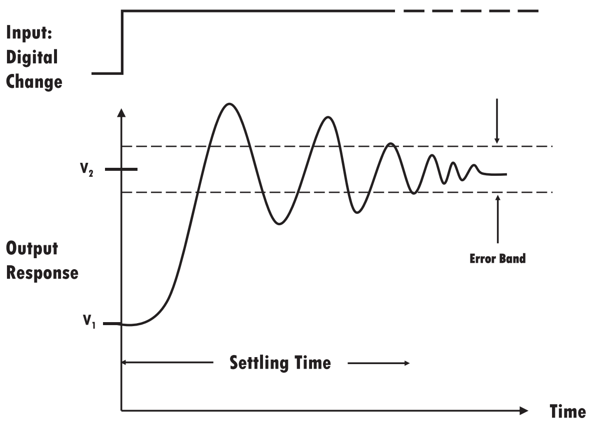

Figure 2.37: After a perturbation it takes some time to settle the output (from V1 to V2).

Discovery: Euler, La Place, Lagrange, 1748ff (Perturbation Theory)
Application: Interventions, Relaxation Time, Resilience

Description: many systems are exposed to internal and external perturbations. Usually, they use internal regulatory processes to find the desired stable state. But if the frequency of the perturbations is higher than the system's ability to compensate against them, it will be impossible to reach the equilibrium. Escalating positive feedback loops are a typical cause for perturbations.

Example: this law and the related weak signals have a strong link to the power law of "loose coupling and high cohesion." If a company operates this way, it will be resilient to deal with perturbations. Thus, the weak signals are very similar, but rephrased to emphasize the importance of a company's ability to cope with disruptions: watch out for interdependencies and conflicts, manage interfaces between departments or teams according to the concept of minimal necessary exchange, while ensuring the highest level of completeness to fulfill the purpose of the managed interface.

Name: **OODA loop**

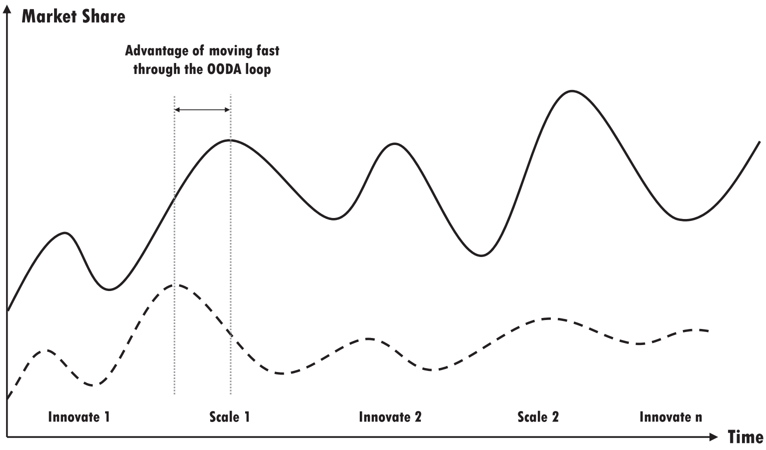

Figure 2.38: Illustrative visualization how moving fast through the OODA loop (Figure 2.18) creates a competitive advantage.

Discovery: Boyd 1995 (first PowerPoint visualization)
Application: Perception, Weak Signal Detection, Winning

Description: the OODA loop always needs a defined opponent (or enemy) to use it in the context of a timeseries. One scenario would be a comparison of the adoption rate (see Innovation Distribution) of new technologies, processes, or business models, with that of competitor XYZ. It makes sense to move as fast as possible through your own loop and to disrupt the challenger's loop by not letting them come to the decision point. That's the essence of winning or losing.

Example: this law points to a wide range of sources of weak signals. Any activity of a competitor related to gain higher market shares can be a weak signal, e.g., knowledge from market research about testing new products, or from a competitor starting strategic acquisitions. Furthermore, brand reputation can be an important source of weak signals as it provides hints about the speed of looping through the OODA sequence. For example, a sentiment analysis in social media helps to understand how new marketing efforts are perceived. Typical quantitative metrics like "likes" or shares are other indicators about the pace in the market race. Moreover, the reputation among "social influencers" is crucial.

Name: **Channel Capacity & Signal to Noise Ratio**

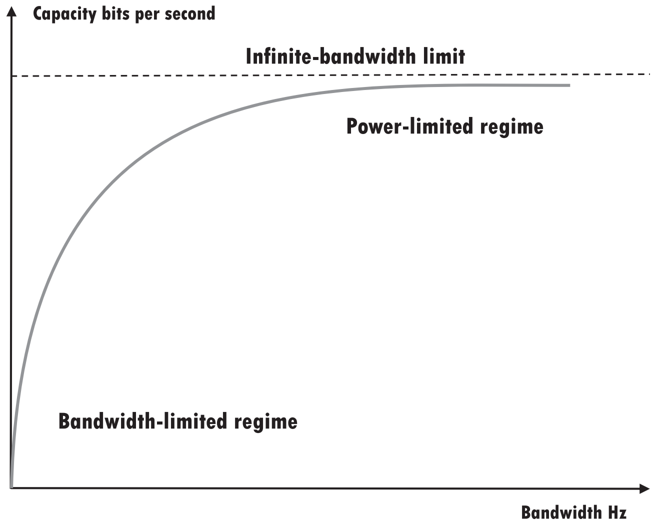

Figure 2.39: Every channel can carry only a certain bandwidth of information.

Discovery: Shannon-Hartley-Theorem 1948
Application: Communication Design, Information Transmission

Description: the law describes the relationship between a given channel and its inherent capacity to transmit information (e.g., bit/s). There is an upper limit, and the realized transmission rate is not only relevant for the signal as such, but also for "noise" (erroneous information, bias, etc.). Furthermore, the signal-to-noise ratio (SNR) reminds of the ever-present "unknown unknowns" in any data.

Example: in economic contexts, the Shannon-Hartley theorem is useful to understand the communicative performance of an organization. Any weak signal that could compromise channel capacity needs to be observed to ensure the optimal transmission rate. The signal-noise-ratio is an indicator of how well the real signal (e.g., reputation of a company) can be distinguished from noise. Are "error-correcting codes" in place that allow a better transmission to spot weak signals? Alternatively, are enough "antennas" available to cover a large area when receiving communication? Complementarily, how strong is the transmitter? All these aspects are crucial when applying this law.

Name: **Autonomy & Cohesion, first Axiom of Management**

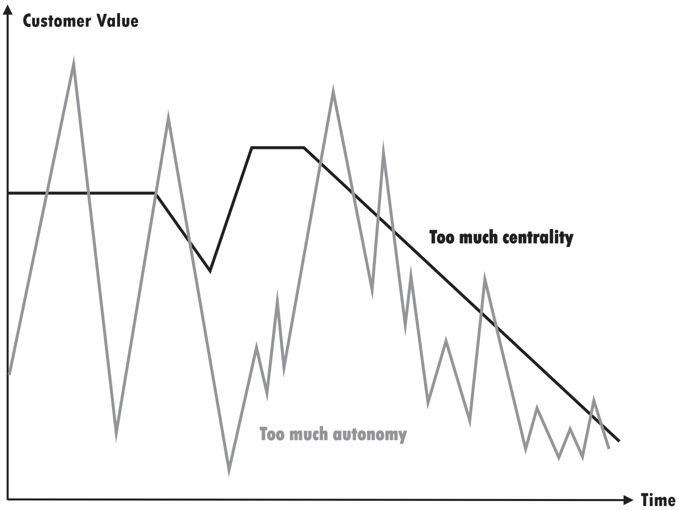

Figure 2.40: The essential balance of local autonomy and overarching cohesion, reflected as value delivered to customers.

Discovery: Beer 1985
Application: Enable healthy self-organization, prevent over- or under-engineering of control

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Description: Stafford Beer described with this law the universal insight that autonomy (self-organization) and cohesion (corporate interventions) need to be contextually balanced. If centrality is too high, it will be impossible to deliver customer value (bureaucracy). If autonomy is too high, it will be hard to deliver customer value in a relatively stable way (chaos). The effect of this axiom can be only found indirectly in a time series.

Example: weak signals resulting from this law can be found in any organization. If there are too many and too detailed policies and normative guardrails in place, the autonomy of the value generating units will be limited, which endangers success at the customer interface. If it is not possible to act fast when problems occur (e.g., a quality issue), the value for the customer will decrease and they will churn. Alternatively, if the degree of freedom of the value generating units is too high, it might be arguably possible to achieve a local optimum, but it will be impossible to achieve a global one. An indicator are dominating business divisions within a group, which dictate their interests to the whole enterprise.

Name: **Strategic and Tactical Fit, Second Axiom of Management**

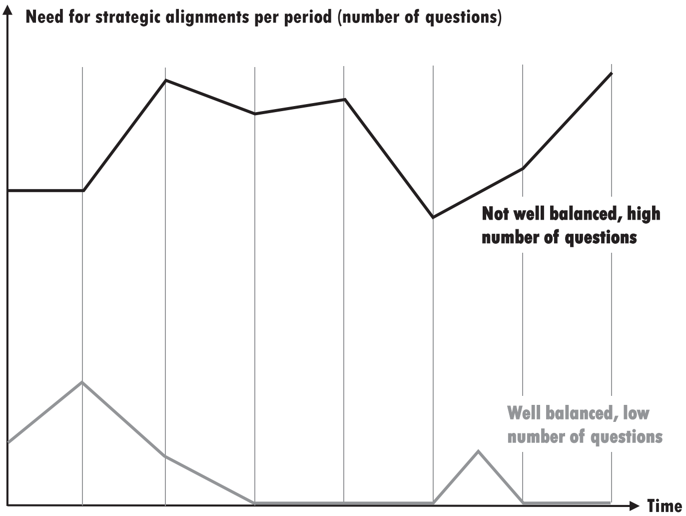

Figure 2.41: If the business strategy is not clear, it will create a communicative overhead and time lags (which affects the ability to go fast through the OODA loop).

Discovery: Beer 1985
Application: Balance the "inside and now" versus "outside and then," also known as Exploitation vs. Exploration

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Description: the second axiom points out that management must take care of different levels (strategic and tactical), and that each management level needs to take care of its scope. In short, the strategic function takes care of new ideas, insights, and prototypes, and it acts in the interest of the greater whole to adapt to new conditions. The tactical and operational levels are close to the customers and provide them with the best possible value.

Example: the most common weak signal for this law is reflected by the following statement: "I cannot make tactical decisions, because I do not know the business strategy." Another indicator could be missing trust in leadership or resistance to implement a strategy. The sharing of operational budgets and strategic investments is another source for weak signals. In general, when one constantly encounters misunderstandings, demoralization, or confusion in the business, it is likely that this loop is not well balanced.

Name: **Maintain the Whole, Third Axiom of Management**

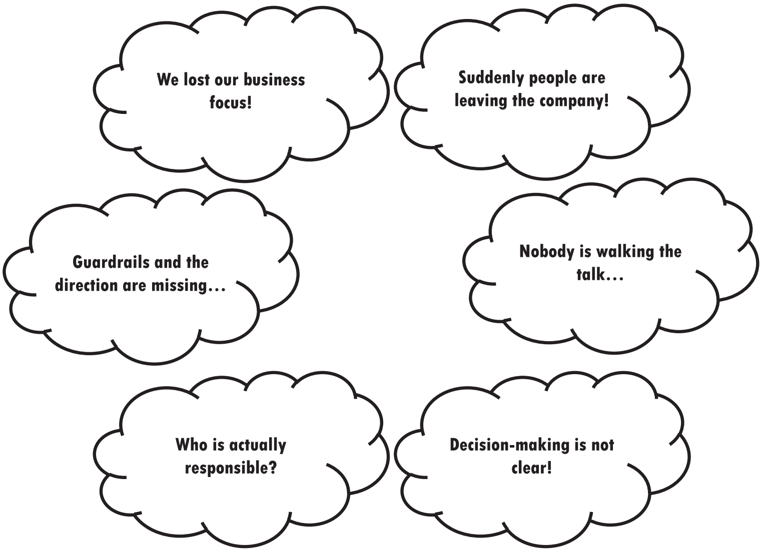

Figure 2.42: In this context it is not feasible to show a time series since this type has very strong qualitative aspects in it.

Discovery: Beer, 1985
Application: Identity, Vision, Purpose, and Mission, Policies and Norms

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Description: any decision can ultimately be derived from underlying ethical values and basic beliefs which determine cost structures, value creation, and the capability to maintain the existence in a turbulent environment. The viability of a system is defined in essence by this loops and all the explicit and implicit decisions.

Example: weak signals are basically connected with the identity of a business in a formal and an informal way. On the formal side, these signals point to a lack of artifacts, like a statement of purpose, a vision, a mission. On the other hand, weak signals can be found in the informal realm, when people complain about the company culture, when they can't remember their company's vision by heart. Those weak signals are clearly an expression of companies' autopoietic nature.

Empirical Business Laws

As the name suggests, these laws are based on empirical evidence. Each law is specific regarding context and curve shape, which facilitates the allocation of these laws to generate insights (e.g., the Hype Cycle and how innovation develops over time). Weak signals can be of quantitative and qualitative nature, as will be illustrated later.

Name: **Power Curve of Economic Profit**

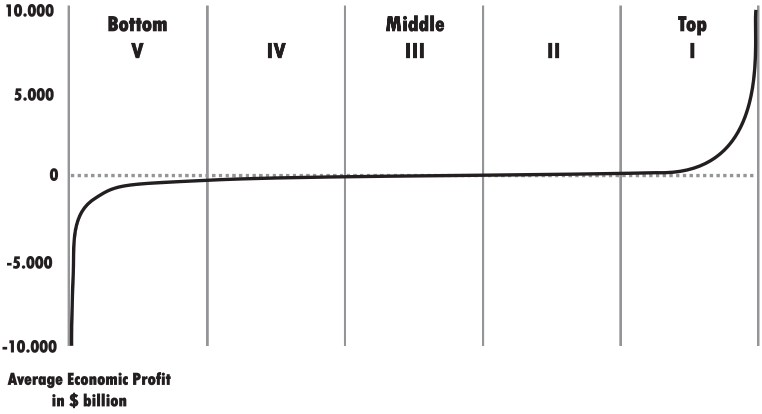

Figure 2.43: The power curve of economic profit.

Discovery: Bradley, Hirt, and Smit 2018
Application: Strategic positioning, competitive advantage

Description: empirical study of 2,500 worldwide leading companies over a time span of 15 years. It shows how successful companies created value by optimizing ten basic variables or levers (size, debt, research, industry trends, geographic trends, acquisitions, resources allocation, capital investment, productivity, differentiation). The companies are positioned in five quantiles of corporate success. The law assigns probabilities for companies to move from one quantile to the next by optimizing a certain combination of variables. As illustrated in Figure 2.21, this law has much in common with the natural universal law of Scale (growth proportion of Units and Size) and may be applied in combination.

Example: to move from quantile II to I, a company in a growing industry in worldwide leading countries decides to focus the strategy on a combination of improving research and development, forcing acquisitions, and optimizing the debt-equity ratio. To achieve optimal results, the law proposes to speed up R&D in line with the aging process of the company, to focus on programmatic (rather than growth-driven) acquisitions and to achieve a debt-equity ratio superior to the industry.

Name: **Disruptive Innovation**

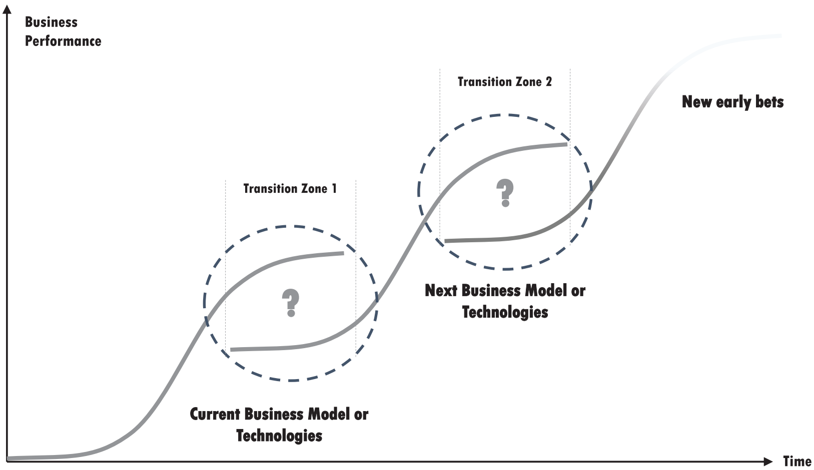

Figure 2.44: Combining S-curves allow us to understand continuous disruption.

Discovery: Clayton Christensen, Innovators' Dilemma, 1997 (in the business context)
Business: Application: Innovation, Change, Disruptive Technologies

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Description: Christensen coined the term "disruptive technologies" (later: disruptive innovation) to explain why big firms often fail to deal with new technologies. It explains how young companies can bypass mature businesses because they can better implement innovative business models which are enabled by new technologies (see also Logistic Growth). De Sola Price's work can be seen as the foundation because he is a co-inventor of scientometrics (science about science).

Example: the range of potential sources for weak signals is as rich as any approach that deals with the dynamics of markets and changing preferences of customers. The concept is related to the OODA loop and the S-curve. Next to market and customer surveys, trade shows and industry conferences are a valuable source of signals. Furthermore, industry publications, blogs, social media, patents, and patent applications can provide information about new products. The same applies for government reports because they contain hints about upcoming regulatory changes. Partnerships with universities are also an interesting source.

Name: **Hype Cycle**

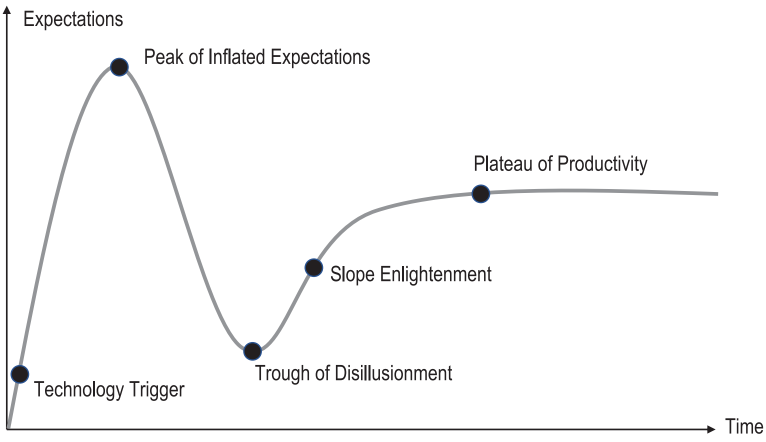

Figure 2.45: The classic pattern of new ideas which generate high expectations, till they reach a productive stage.

Discovery: Jackie Fenn at Gartner 1995
Application: Innovation, Tech Strategy, Long-term Planning

Description: the emergence of new technologies can be assigned to different stages: from the initial trigger, up to the peak of inflated expectations, down the through of disillusionment, upwards to the slope of enlightenment, it finally reaches the plateau of productivity. Its shape looks like an overshooting, goal-seeking curve. This heuristic can be combined with the Bass Distribution of Innovation, as it reflects the very early market penetration and the adoption rate of new a product or service.

Example: as this law has the quality of a universal natural law, weak signals are positioned to predict deviations from the idealized curve. The clue is to understand why an organization is over- or under-delivering innovation. On the one hand, customers do not perceive the problem yet. On the other hand, the added value delivered comes too late.

Name: **Little’s Law**

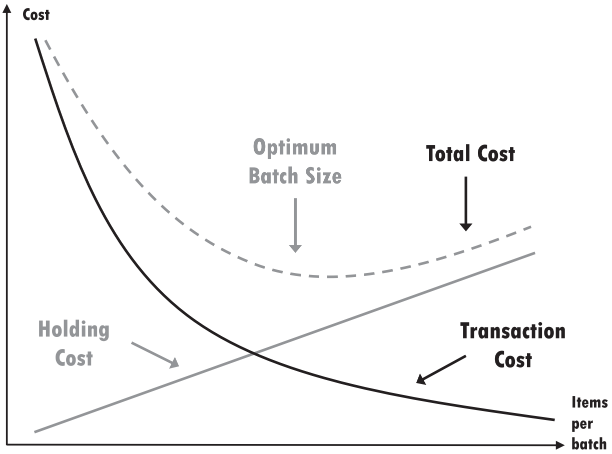

Figure 2.46: With this law we can find the sweet spot between holding and transactions costs to balance out the optimum batch size.

Discovery: Alan Cobham 1954
Application: Flow, Lead Time Optimization, Constraints Management

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Description: this law provides one of the most underrated insights in business: generate flow by limiting the work in progress, because cycle time and queue depend on each other. It is connected to the Theory of Constraints which explains how to create flow in a system by focusing on the bottlenecks. Please keep in mind: Little’s Law works only well for “relatively” stable systems. In complex environment, the math collapses exponentially.

Example: the detection of weak signals depends on the ability to reveal small changes in the grow rate of the queue in a production line. The potential impact of disruptions on its operations could be measured based on Little’s Law. This could involve estimating the average arrival rate of the disruption, as well as the average time it would take for the company to respond and adapt to it.

Name: **Three Horizons**

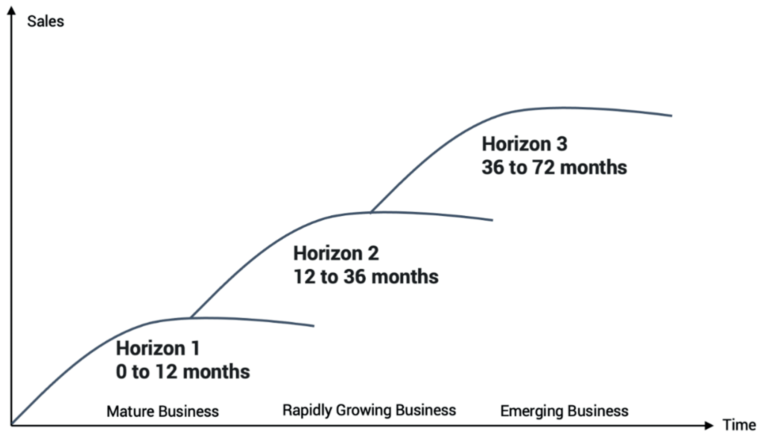

Figure 2.47: The visualization looks like a stacked version of the upper shapes of the disruption model of Christensen (S-curves).

Discovery: Baghai, Coley, and White 2000
Application: Innovation, Strategy, Business Development

Description: the horizon model could be interpreted as an extended version of Christensen's Disruptive Innovation S-curves. The three horizons represent three time-related perspectives: Horizon 1 focuses on the extension of the current value proposition (operators); Horizon 2 looks at the strategic dimension (builders); finally, Horizon 3 is reserved to visionary ideas to build viable options.

Example: the three horizons serve as a criterion to find weak signals for rapidly growing and emerging businesses. In each of the horizons it is possible to discover relevant hints regarding opportunities and threats. Again, this type of law is related to any other power law that addresses the competition and other environmental factors. The general question remains the same: what is happening around us that could accelerate or slow down the process of gaining a good position in the market in relation to "here," "later," and "one day," or "must," "should," and "could"?

Name: **Innovation Distribution**

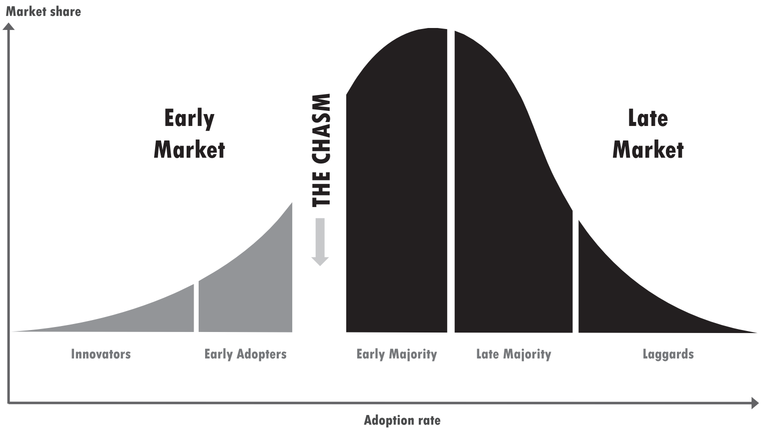

Figure 2.48: Typical phases of innovation adoption including the challenge of bridging the chasm.

Discovery: Geoffrey Moore, Crossing the Chasm, 1991
Business: Application: Trend Adoption, Innovation, Product or Service Development

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Description: the distribution of innovation depends on adoption rates across a given population. According to Rodgers it is the key to "bridge the chasm" between early adopters and the early majority in a market. According to this theorem it is critical to excite not only the inventors and "tech nerds" but convince customers close to the "average" (majority). This distribution is closely connected to the Gartner Hype Cycle. This also implies a different marketing message to the different types. Early adaptors prefer other messages than the late majority.

Example: since adoption rates are the distinctive criterion of this law, all weak signals must be connected to the perception of the value in use of a company's products or services. It is essential to differentiate between new, loyal, or lost customers to gain insights on how to stay ahead in the race for adoption rates of new solutions.

Name: **Zipf Principle of Least Effort**

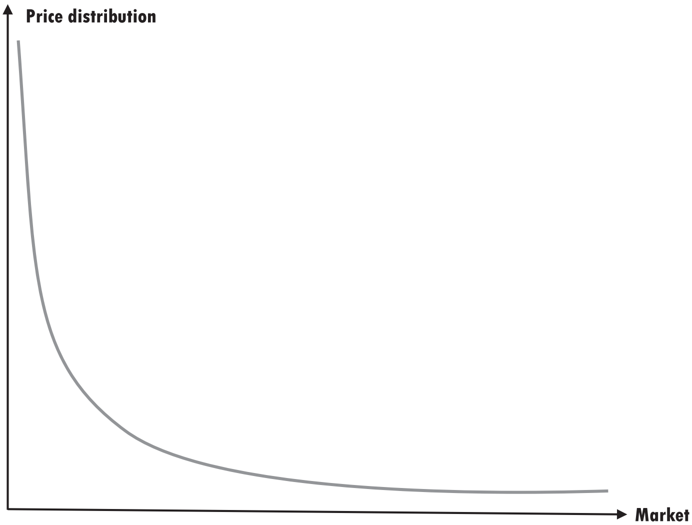

Figure 2.49: The typical shape of the Zipf distribution, as it can be found in the distribution of prices in a certain market.

Discovery: Zipf 1949
Application: Understanding harmonic distributions, Optimization

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Description: the Zipf Law originates from the examination of the word frequency in English. It states that in a given text, the frequency of a word is inversely proportional to its rank in the frequency table. In other words, the most common word will occur about twice as often as the second most common word, three times as often as the third most common word, and so on. It reminds us that nature tries to find the optimal balance between effort and outcome. This kind of distribution can be also found when examining city sizes, the structure of markets and industries, the distribution of prices or the distribution of wealth and income in societies.

Example: weak signals are related in terms of the relative frequency or prevalence of different types of signals within a dataset. If the distribution of signals follows Zipf's law, then this could suggest that a small number of signals are much more common or prevalent than most signals. In this case, the weak signals might be the ones that are less common or less prevalent and might be more difficult to detect or identify. If the distribution of signals follows this power law, then this could suggest that a small number of signals have a much greater impact or influence on the system being studied, while the majority of signals have a much smaller impact. In this case, the weak signals might be the ones that have a smaller impact or influence and might be more easily overlooked or discounted.

Technology Laws

The last set of power laws is devoted to constants of technological progress. Like the universal natural laws, this type serves to compare the company's performance with evolutionary forces of scientific and engineering progress. The detection of weak signals originates in an observed deviation from actual data and the trajectory predicted by the law, demanding an explanation for the gap.

Name: **Wright's Law**

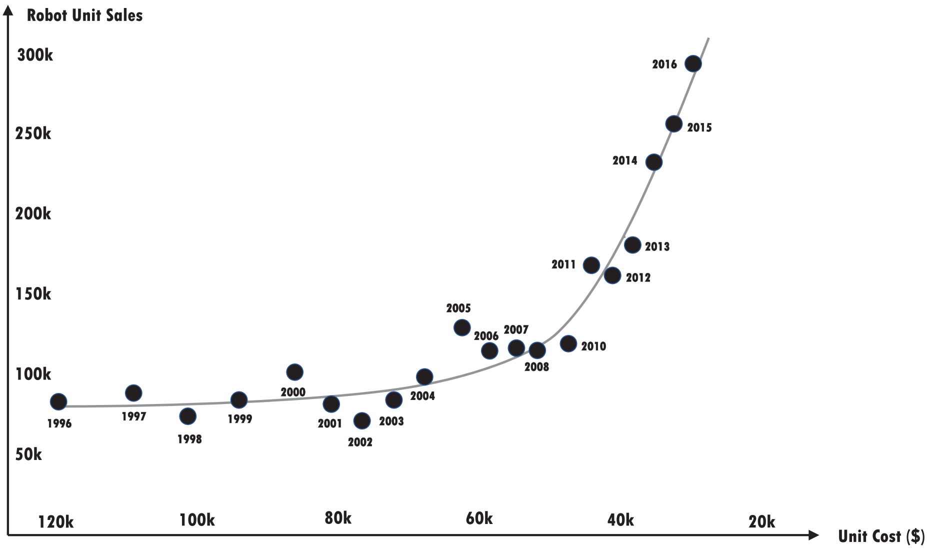

Figure 2.50: Wright's law in action in the context of robot unit sales and unit costs – the non-linear learning curve can be easily identified.

Discovery: Wright 1936
Application: Learning Curve, Diminishing Costs, Increasing Returns

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Description: this law is the origin of most other technology laws. It has proven to be more reliable than Moore's Law and helps to understand the exploitation of a given technology (or business model). The learning curve can be explained by scaling effects, new materials, or processes. It is closely related to the Laws of Increasing Returns and Marginal Benefit Function.

Example: Wright's law and weak signals are related in an indirect way. For example, an organization might use Wright's law to predict the future cost of a product or to anticipate potential trends that could impact the demand for this product. In this way, Wright's law and weak signals could be used together to inform strategic planning and decision making.

Name: **Koomey's Law**

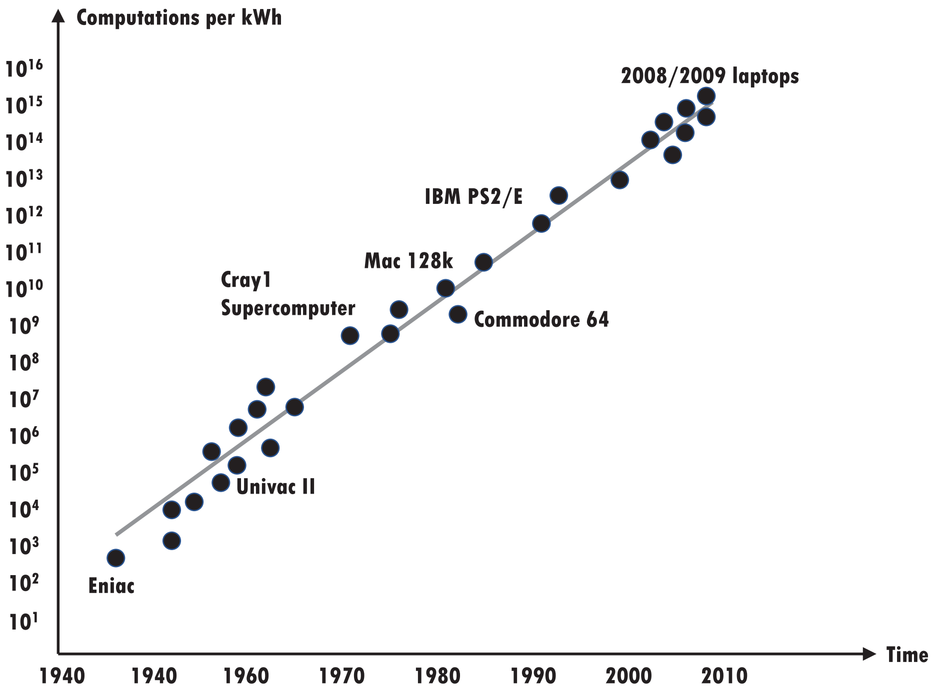

Figure 2.51: The exponential relationship between energy consumption and computation, demonstrated with some legendary computer systems.

Discovery: Koomey 2010
Application: Hardware Design, Energy Optimization, Technological Progress

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Description: while computational speed is important when assessing technological progress, it is also essential to optimize the energy consumption of computation. That is why Koomey examined the relationship of computations per kWh (or joule) over time. This law is even more precise than Moore's Law, even though the growth has slowed down since 2010.

Example: this law reflects the state-of-the-art technology to build computer chips. Any indication of a slowing pace indicates that technology is progressing beyond the known limits. This insight is useful to anticipate paradigmatic shifts. Koomey's law could be considered a weak signal in this field, as it provides an early indication of future developments in energy efficiency and computing power. With respect to better material properties, any signal pointing to new architectures could be worth following. While hardware topics are important, one should also focus on software, because it helps to ensure exponential growth.

Name: **Metcalfe's Law**

Visualization:

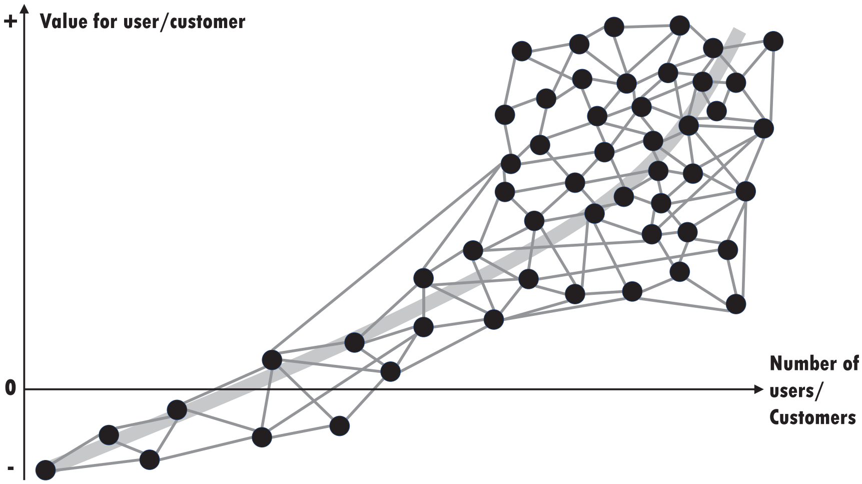

Figure 2.52: The higher the number of participants in a network, the higher the value for the participants.

Discovery: Metcalfe 1980
Application: Business Modelling, Creating Critical Mass, Growth Strategies

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Description: originally this law was developed to express the value of technology compared to the number of connected devices (here: fax machines!). Later it was applied to interpret social networks. It also explains why internet startups often take economic losses in the early growth phase into account to achieve the critical mass of users – and create some sort of social "lock-in effect." The costs to switch to a new platform are too high.

Example: this law is closely related to the concept of economies of scale, which depicts the dynamics of non-linear growth effects. A weak signal for this type of phenomena can be found in the adoption rate of new services and products, or the number of new users on a particular platform. The growth rate of connections between the users is also of importance. Other weak signals could be recommendations by influencers, or other types of early product reviews, e.g., social media "likes" or shares of a post. Overall, all metrics related to the attractiveness of new services, compared to competitors, are an interesting source of signals that help to understand if this law is acting in the background.

Name: **Keck's Law**

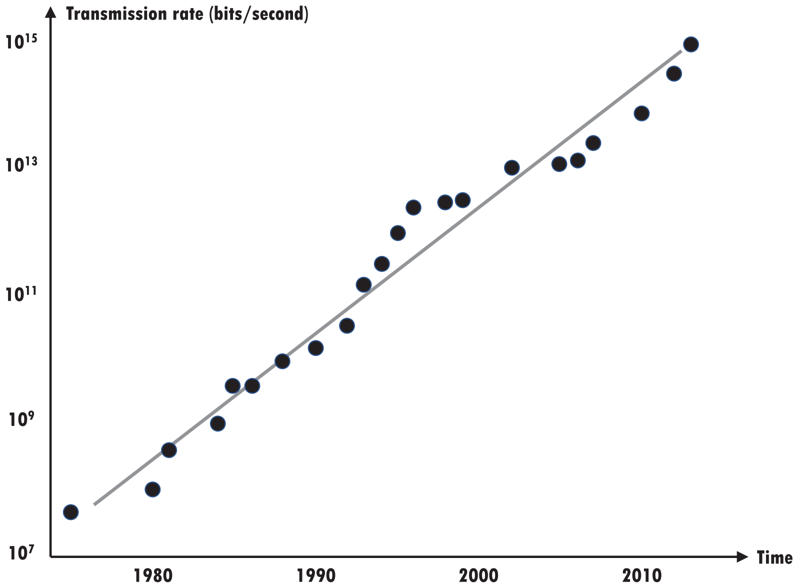

Figure 2.53: The exponential growth of the transmission speed in glass fiber systems.

Discovery: Donald Keck, early 1970s
Application: Communication Systems, Transmission Speed of Data

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Description: the exponential growth of the transmission rate in fiber optics reminds us of the ongoing technological progress (like Moore's or Koomey's Law). It enhances the idea of an evolutionary process which designates transmission of data as being of the same criticality as the computational power or the energy consumption of computation. A recent example of this trend is called "data center as computer" (scale every essential aspect as you need it).

Example: to understand this evolutionary heuristic, deviations from the ideal plot are examined, with special focus on the braking transmission speed: is it a design issue of the technical architecture, and is a specific product or service even close to physical boundaries? Is it possible to compensate physical constraints with an optimized technical structure? Weak signals indicate technical protocol issues to control the transmission of data. At a metaphorical level this law can be inspiring to discover signals about human-to-human communication and what it means to exchange information in times of technological acceleration.

Name: **Kondratieff Waves**

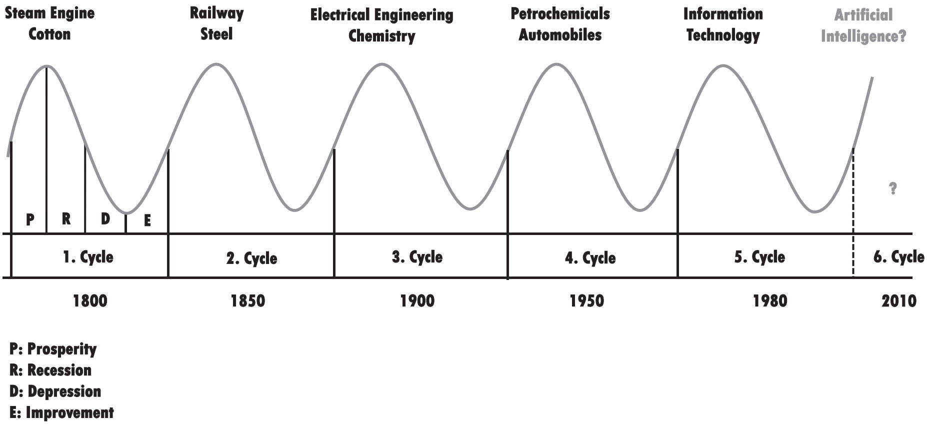

Figure 2.54: Scientific breakthroughs create long lasting economic cycles, but the intervals are becoming shorter and shorter.

Discovery: Kondratieff 1935
Application: Macroeconomic Understanding, Break-through Innovation

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Description: "Long waves" of technological advances can be observed and mapped towards the economic stages of prosperity, recession, depression, and recovery. Typically, each wave is about 50 to 60 years long. The big question (and opportunity for entrepreneurs) is: what will follow information technology? Is it "Green tech"? Synthetic Biology? Artificial General Intelligence? Or something completely different?

Example: here weak signals need to be explored along all possible scenarios and their respective trajectories. It is more about general futuring than applying a law with a specific scope. Structural changes in industries, in global trade patterns, and in the transformation of social or cultural norms typically indicate "long waves." The next wave will probably be dominated by Artificial General Intelligence (AGI) because this type of breakthrough is necessary to augmented scientific discoveries (by the factor 10 to 100). In return it opens the opportunity that fundamental crisis' topics like climate change or the breakdown of supply chains can be resolved. Therefore, any weak signal coming from AGI is significant to anticipate the future, e.g., the number of newly published papers, reduction of training costs for new algorithms, and multimodality (text, image, or video input for model training).

Name: **Moore's Law**

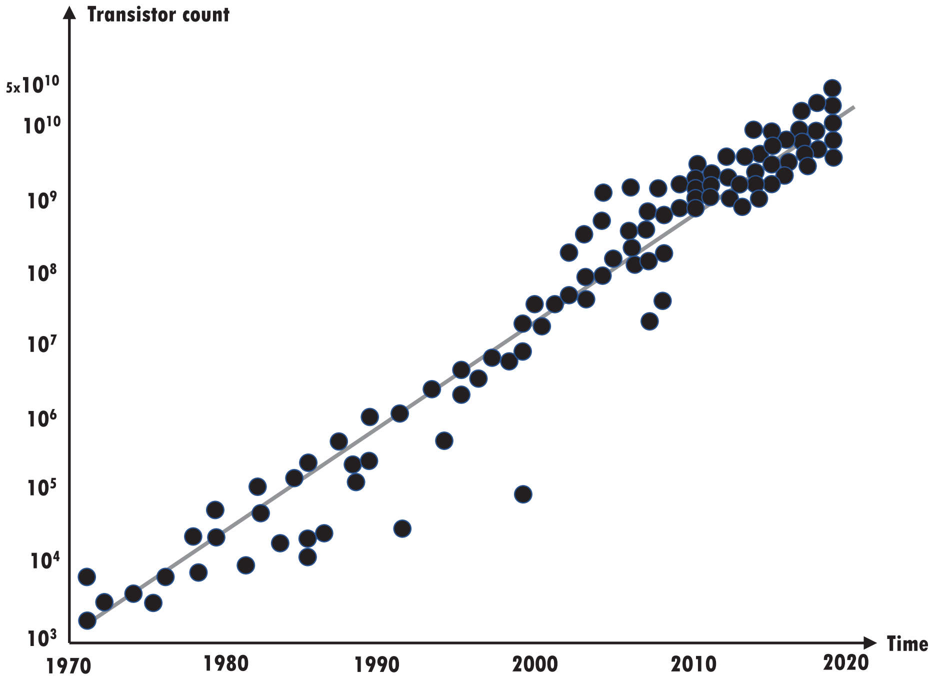

Figure 2.55: This law is often used to illustrate the technological progress.

Discovery: Moore 1965
Application: Hardware Design, Business Modelling

Description: faster computation allows more detailed models, no matter if they are of mathematical nature, or if it is a 3D-visualization. This law is useful to extrapolate upcoming technologies and it can be used to trigger the imagination of an entrepreneur. It fits Koomey's and Keck's Law and the underlying learning curve based on Wright's Law. Even if the growth is slowing down, the law as such is still applicable due to advancements in chip design and mathematical models.

Example: weak signals arise by comparing this curve with the performance of one's own products – and with that of the competition. They can be derived from the development of material science (alternatives to silicone), nano technology, or quantum computing. The occurrence of innovations and patents can serve as an indicator about ongoing improvements in those sectors, especially in the field of graphic chips, which are heavily used in the field of machine and deep learning.