3 Innovation

The drama "Being Innovative" – Act 1, Scene 1

Inventor Thomas E., decision maker John G. and Walter K., management assistant at POLYM Inc., are in a meeting room. After the presentation of the idea the following discussion develops.

Inventor Thomas E.: *This new system will turn everything hitherto existing upside down. Never has the customer had a similar experience. The whole world is lying at his feet – of course not real, but virtual. With this system, we can only be successful!*

POLYM Inc. Walter K.: *Has anyone ever done such a thing? Are there any experiences? Did not YLMOP do something similar?*

Inventor Thomas E.: *That's just it. Never ever has anything like this been offered on the market. To my knowledge, it is light years ahead of the products that are already on the market.*

POLYM Inc. Walter K.: *Yes, I think it's conceptually highly interesting. But why should the customer want such a thing? Are there any studies on the subject matter?*

Inventor Thomas E.: *I haven't seen any studies on this. How could I? The idea is so new, nobody has ever thought into it – except me of course.*

Decision Maker John G.: *Have you ever thought about what it would cost to develop? Do we already have something we could reuse?*

Inventor Thomas E.: *The costs are marginal compared to the revenues that we will have, the profits will compensate the cost in no time. People will wrench it from our hands. Just think of Stephen J.; his products have sold like hotcakes. I have discussed this once – all confidential of course – with my sports friends – and they were all thrilled.*

POLYM Inc. Walter K.: *I'd happily believe you. But do you have an idea on how we could capture this a bit more specific?*

Decision Maker John G.: *I suggest that you investigate this in more detail. When can we expect further results?*

Inventor Thomas E. and decision maker John G. leave. Walter K. is alone in the meeting room.

POLYM Inc. Walter K.: *That's an interesting approach, and that it is new, I'll believe on the spot. Unfortunately, I myself do not have the time to make much use of it. If this invention is really as good as this Thomas E. claims it would be a great success for our company. But, what is at stake for us? Hmm, this Thomas E., he looks like an inventor, he could do with a haircut and a new pair of pants – these jeans all the time. Well, on the other hand Levi Strauss has built an empire with them and made a lot of money.*

3.1 Innovation: Selected Topics

At the beginning is always the idea – wouldn't it be great if something would work as you want it to work, this way and that way? You ponder with this question, this problem you identified, you mentally circulate and rotate it in all directions, you view it from different perspectives, you take into account additional aspects. Maybe eventually there comes the thought, what a solution might look like – yes, it could work that way. And again, you start pondering this idea, you mentally circulate and rotate it in all directions, you view it from different perspectives, you take into account yet more additional aspects, you consider potential obstacles that may hinder further development. Eventually if you are convinced that it could possibly work this way, then an invention is born.

And then again, you deal with your invention, you take more detailed aspects into consideration, resolve any obstacles or bypass them, develop the invention into a product.

With this product, you go to the market – hopefully, there are more people who find it great when something works, as they want it to work, this way and that way. When they become customers, use and deploy the product efficaciously, then the idea has become an innovation.

3.1.1 Hand-Axes: Example of an Innovation

These hand-axes (Figure 3-1) were discovered in the Turkana Basin in Kenya and are with an age estimated to 1.76 million years the oldest prehistoric tools yet discovered.[10,11]

Figure 3-1: Hand-axe (Source: picture alliance/dpa/P.-J. Texier/MPK/WTAP, Rights: picture alliance/dpa/P-J.Texier/MPK/WTAP)2

The traces of wear indicate that these devices were used for separating the hunting prey or for woodwork. These are specialized tools, the pointed hand-axes or splitting wedges having an elongated blade, typically shaped on both sides. The production of these tools requires a series of operations ranging from finding a suitable stone to hewing and shaping it in such a way that the desired tool emerges, as well as a significant degree of skill and strength. The hand-axe culture (Acheulean) has spread from Africa to Europe to Asia.

[10] Stuttgarter Zeitung: *Forscher entdecken älteste Faustkeile*, 1.9.2011
[11] MacGregor (2010): *A History of the World in 100 Objects*

"Homo erectus" populated large parts of Africa, Europe and Asia, between 1.8 million and 150 thousand years before our era. He was "*the first hominid type, who used fire, the first, who began hunting as an essential element to secure their food supply, the first, who could walk like a modern man.*" [12] In addition, he must have been able to imitate. The ability of imitation is one basis for developing a language; each generation must not repeatedly redeveloped language anew. The fact that homo erectus was able to walk upright modified the corresponding structures in his brain, enabling him to make better use of his hands and his facial expressions. Thus, it is quite conceivable that he could have had developed a sign language.

The hand axe also coined the name of this culture: the hand-axe culture. Hand-axes exhibit all the characteristics of an innovation – one homo erectus wanted to make himself independent of the fortune, chance or luck, to find a suitable hand-axe, and tried to form a hand axe by himself (**idea**). He invented a way (**invention**) to perform this formwork, and thereby improved his skills as needed and necessary. The manufacturing process was copied and exported, so that hand-axe production prevailed in the three continents of the old world (**diffusion**). Hence, the hand-axe culture dominated most of the hominid populated world for a very long time.

What may have been the thoughts of that homo erectus at that time, when he realized that he does not have to look for a suitable stone, but that he could form this useful tool all by himself and thus, that he could reproduce it? By today's standards, he should have felt an immense pleasure and satisfaction, and if he were able to speak, most certainly a *"Cool!"* would have slipped his tongue..

Homo erectus obviously had about 1.6 million years to establish hand-axes in his culture. To relate this period of innovation and usage to today's perspective, consider the development of the mechanical typewriter. The U.S. company Remington produced typewriters in large numbers by from 1874 onwards. The last production facility for mechanical typewriters was in India and was closed in 2011; in 2010, it produced just 800 pieces. In between, however, the typewriter was indispensable in daily life – hardly any office, hardly any household where a typewriter was not there to bring important documents on paper legibly for everyone. After all, the mechanical typewriter proliferated for 135 years. A much shorter product life was granted the videocassette systems. The companies Grundig and Philips brought the first devices for home use to market in 1971, which found in the following years a wide market acceptance. With the introduction of the DVD in 1997, consumers began to opt for this higher quality technology. Since 2006 videocassette recorders are no longer on the market – this technology was then just 35 years old.

3.1.2 Cycles of Innovation

The consideration of economic cycles, which relate to innovations, or which innovations even initiate, can shed some light on when and why some innovations are successful and others are not.

Kondratieff Cycles

In the 20s of the 20th century, the Russian economist Nikolai D. Kondratieff established based on empirical data from Germany, France, Great Britain and the United States, that the economic cycle follows a sequence of boom, recession, depression and recovery in long waves of about 40 to 60 years. He was able to forecast the third wave with the stock market crash, Black Friday and the world economic crisis of the late 1920s correctly from the analysis of the first two cycles he identified. Ten years later, Joseph Schumpeter recognized that fundamental technical innovations are the causes of these long waves – he called them Kondratieff cycles – and coined the concept of base innovations, which inspire or enable further innovations (see Figure 3-2).

[12] http://de.wikipedia.org/wiki/Homo_erectus

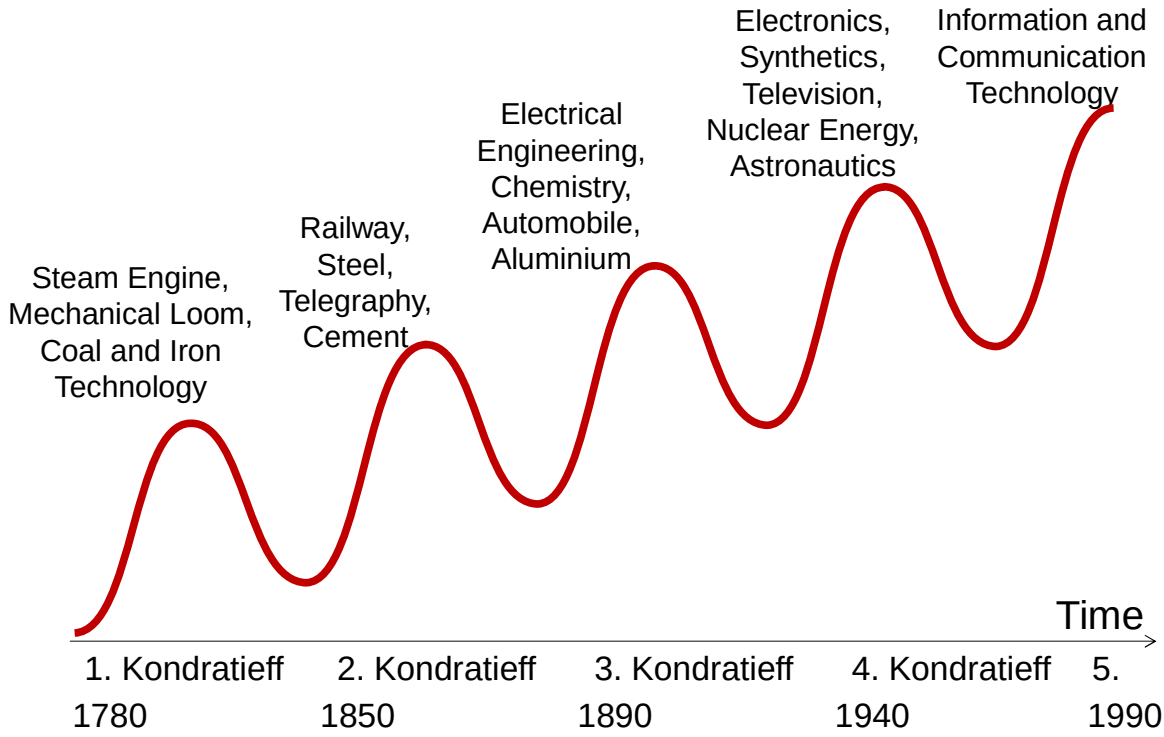

Figure 3-2: Kondratieff cycles (Source: Bernd X. Weis)

Fundamental inventions even change how a society organizes itself – after all, people want to make optimal use of any new base innovations. Therefore, new rules and success patterns arise on how to create wealth, with new educational content, new management and organizational concepts in the businesses. In the 19th century the British were not so rich and powerful because wages, government spending or money supply were high or low, but because they overcame the current shortage of resources first with the steam engine, then with the railroad.

The Austrian futurologist Hans Millendorfer[13] could established the link between economic development, innovation and motivation based on a valid social psychological investigation. In somewhat simplified terms, a new cycle begins with the dissatisfaction of the next generation with – technologically influenced – conditions of work and life of the previous generation. This dissatisfaction and discontent calls for a paradigm shift and leads to technical innovations, which also open up new social perspectives and have thus structure-changing influence on society. Growing prosperity and stabilization accompany this process. As a result, the change loses momentum and the resulting structures forfeit their flexibility and innovative power – they lose the ability to resolve the pending socio-economic issues and the motivating force for change resulting in an economic downturn. Then again, innovations and alternatives to what already exists initially develop in niches. Some of them establish themselves; they grow, stagnate, and eventually more suitable innovations will replace them.

And then it starts all over again..

Hype Cycles

At the American consulting firm Gartner Group[14,15] the consultant Jackie Fenn discovered that when introducing new technologies very often the same pattern develops with respect to public attention for this technology over time. This pattern consists of phases that

[13] Gaspari, Millendorfer (1978): *Konturen einer Wende. Strategien für die Zukunft*
[14] Gartner Group (2011): *The Gartner Research Process and Methodologies*
[15] Spiegel, 21.10.2006, http://www.spiegel.de/netzwelt/tech/0,1518,443717,00.html

technologies undergo until they are thoroughly established in the market. At Gartner, they gave these phases catchy names. Starting with the first attempts attention increases to the "peak of inflated expectations". Eventually, when it turns out that the technology still has to struggle with "teething" troubles and anyway cannot meet all its flowerily attributed expectations, attention falls into the "trough of disillusionment". With the resolution of the "teething" problems, the establishment of standards and the integration of complete solutions, a system of suppliers and service providers emerges that characterizes the phase "slope of enlightenment". On the "plateau of productivity", the technology has finally found its proper place (see Figure 3-3).

Analyses with hype cycles predicted in November 1999 the end of the dotcom boom within the following half year.

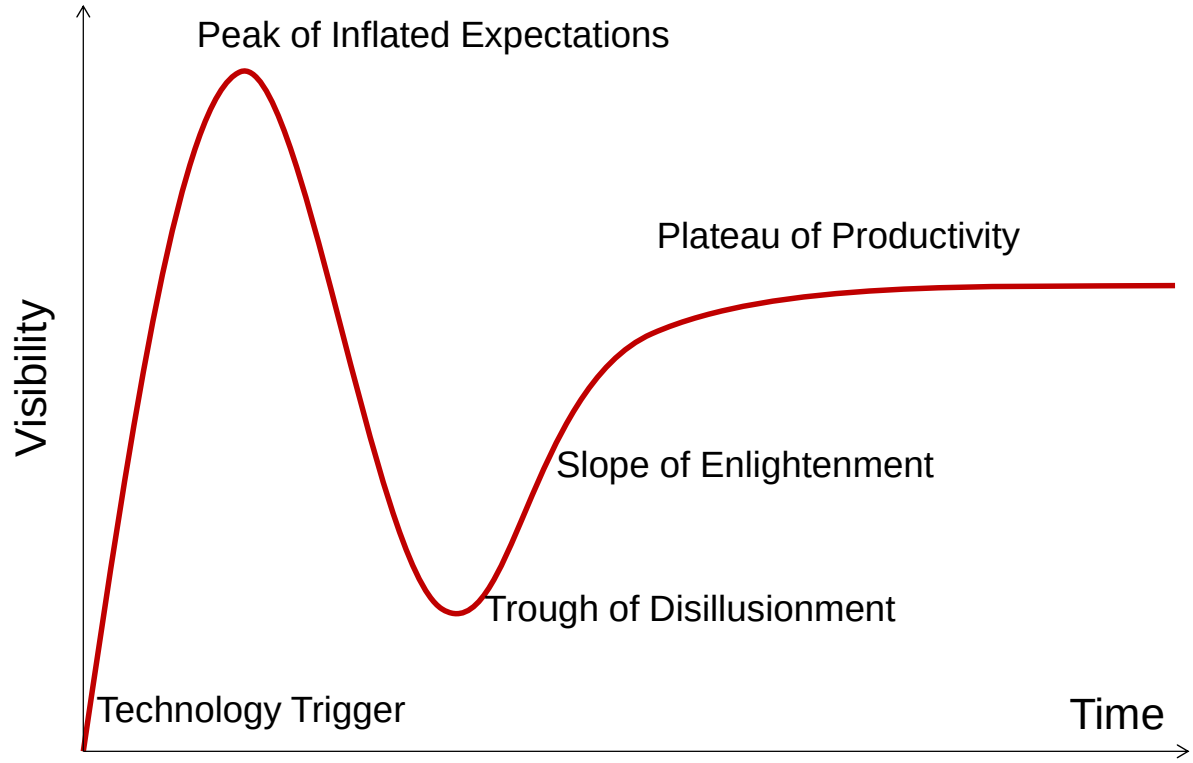

Figure 3-3: Hype Cycle (Source: Bernd X. Weis)

Companies that rely on a technological head start should think from the beginning a great deal about suitable applications knowing that probably they must endure a series of disappointments and setbacks over time. Eventually, if they reach the slope of enlightenment, they will already have products and know-how, while others have yet to deal with the technology. In general, the more important the technology is for the enterprise, the earlier it has to properly deal with it – and of course vice versa. There are also technologies that become obsolete even while on the way to market, that have not yet succeeded despite of renewed thrusts in public attention to make it to the market. And furthermore, in general, the estimates, where in the hype cycle a specific technology is, are subjective and can vary greatly depending on who does the assessment.

The value of hype cycles is to raise awareness of these cycles, among other things, that certain technologies, even if they – perhaps only for the moment – have escaped public attention, can come back with even stronger impact.

Both, the Kondratieff cycles as well as the hype cycles were conceptualized from the analysis of empirical data and observations of how people, businesses, markets and societies act and behave in the corresponding situations. From these analyses, instructions

for action may arise from the perpetuation from experiences.

3.1.3 Russell's Chicken and BLACK SWANS

The English philosopher and mathematician Bertrand Russell also asked himself whether it is possible to conclude from frequent observations of the same cause-and-effect linkages that the next occurrence of this cause again entails the same effect[16]. One usually expects that a carrot tastes like a carrot, because carrots have always tasted like carrots. He tells the following story referred to as Russell's chicken.

On a farm, there was a flock of chickens. One chicken started talking with another, remarking, "How good our farmer has been to us. He comes every morning to feed us." The other chicken added "and he has been feeding us here every day like clockwork, every day without fail since we were all just little baby chicks." Indeed, when queried, most of the other chickens clucked in agreement, about how benevolent their farmer was. But there was one chicken, intelligent but eccentric, who countered saying "How do you know he is all that good? I remember, not too long ago, that there were some older chickens who were taken away, and I haven't seen them since. What ever happened to them?" In the morning, the farmer came as usual, this time scattering even more corn around. The chickens loved it except one, which squawked in alarm, "He is just fattening us up! We are going to be slaughtered in a week's time!" But none listened, all just thought it was a troublemaker. A week later, all the chickens were placed into cages and driven to the slaughterhouse.

The chickens become accustomed, that the farmer feeds them daily. They deduced from these observations that this should continue to be so in all their conceivable future. The underlying "theory" of the chickens could have been that the farmer is a person who just liked chickens and therefore, fed them daily. Other concepts such as "chicken on the grill or in the pan" were so entirely alien to them; they just had no concept of it. If the farmer brought them food, it confirmed that every time that their "theory" was correct.

David Deutsch[17] even goes so far in claiming that it is altogether impossible to extrapolate observations without embedding them first in an explanatory framework. Thus, the chickens had the explanatory framework "benevolent farmer", and within this framework, they could predict well the daily feeding. Would the chickens have come up with the explanatory framework "barbecue or cooker", they would have also be able to predict the daily feeding well, but also the slaughtering feast at the end of fattening (see Figure 3-4).

[16] Russell (1912): *The Problems of Philosophy*
[17] Deutsch (1998): *The Fabric of Reality*

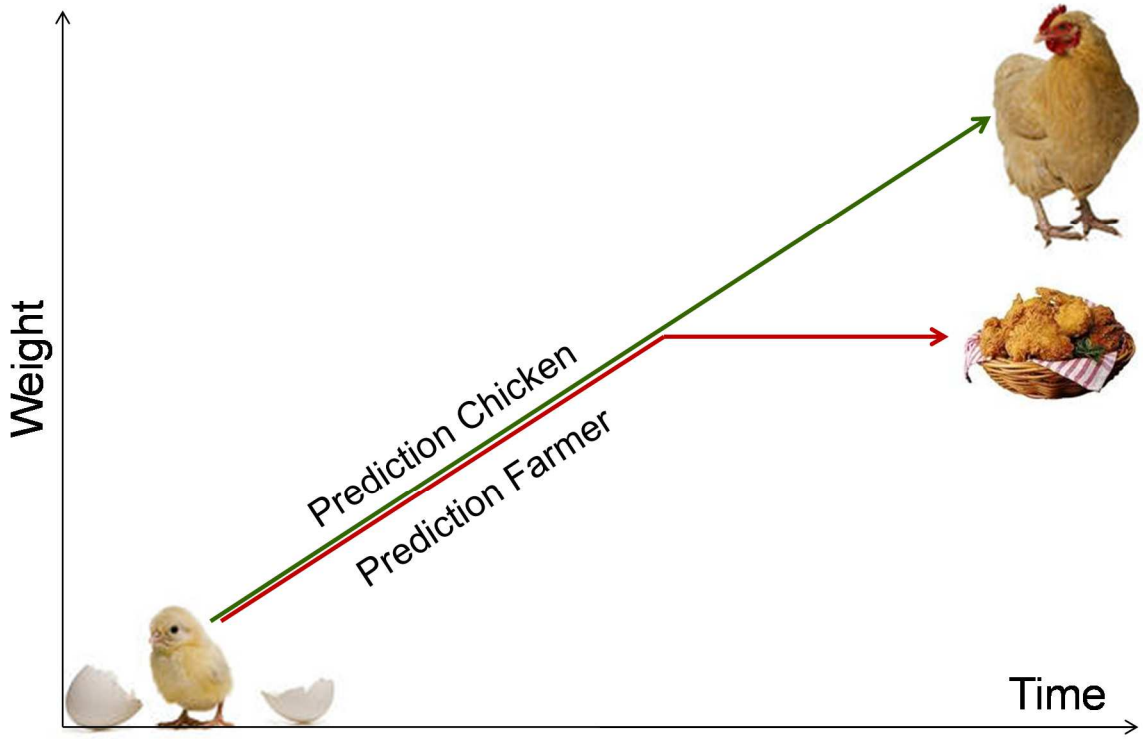

Figure 3-4: Predictions (Source: Bernd X. Weis)

Russell remarks somewhat tersely that it would have been quite useful for the chickens, if they had had a deeper understanding of the regularity of nature.

To dig even deeper the question could be asked which consequences the intelligent but eccentric chicken had drawn from its presumption. Would it have been happier in its last week? – But that would take us too far.

In various tests, series of numbers are to be continued logically, such as the series of numbers

0 2 4 6 ...

From the analysis of this number series, various hypotheses on the formation rules can be derived (see Table 3-1).

Rule – Explanatory Framework	Continuation
The following number is the last + 2	**0 2 4 6** 8 10 12 14
The following number is even and is not in the list	**0 2 4 6** 256 24 396 10532
The following number is greater than the last	**0 2 4 6** 7 99 396 123456
The last 4 numbers in reverse order added	**0 2 4 6** 6 4 2 0 0 2 4 6
Any 4 numbers and then only 1	**0 2 4 6** 1 1 1 1 1 1 1 1

Table 3-1: Continuation of number series: possible rules and explanatory framework

One can still think of many other rules that are not contradicting the original set of numbers.

In general, one can say that it is not possible to predict with absolute certainty from events experienced or observed in the past that these events will occur in the future. One can only suggest that these events are likely to occur.

Karl Popper considers it a mistake to conclude on laws from facts gathered by induction[18]. Theories, with how much creativity they may also have been developed, can never be verified by experiments. It is however possible but to falsify them. One counter-example may suffice to let a theory collapse. Ultimately, those theories will prevail that, despite all efforts, could not be refuted up to now. Moreover, these come probably closest to the truth. *"All swans are white."* Popper took this statement as an example to illustrate his theories. This sentence was a true statement until the discovery of Australia, where in the end of the 17th century swans were discovered that were black and the sighting of one single black swan sustainably repudiated the veracity of the all-swans-are-white-statement. However, the black swan has since then remained a metaphor for extremely rare events that are unknown or hardly predictable, but have a major impact and in hindsight great influence on our thinking and actions. A quip on the edge: In 1946, Popper met the philosopher Ludwig Wittgenstein in Cambridge to discuss these issues. It is said that in the heat of the debate Wittgenstein had threatened Popper with a poker.[19]

There are always such theories, rules, beliefs, dogmas, etc., which are derived from experience and observations, and which make believe that the world has to behave accordingly, or that it is structured agreeing with them. However, as shown above, this may, but need not be the case.

The management thinker Tom Peters says, "*Predictability is a thing of the past*."[20] The Lebanese-American ex-stockbroker Nassim Taleb adopted also the subject of uncertainty and predictability (or not). He takes the Popper's example of the black swan from above, when he asserts that the past can't be used to predict the future, at least not if one simply perpetuates the past into the future with a dash of naivety. He calls an event "BLACK SWAN"[21] when it shows the following three attributes:

(1) The event itself was unknown and thus unimaginable or was considered almost impossible. In terms of probabilities, the occurrence of almost impossible events is equivalent to the non-occurrence of almost certain events.
(2) When the event occurs, then it has implications and consequences that are enormous and extremely far-reaching.
(3) In retrospect, why this event happened or even had to happen is explicated with all sorts of explanations.

Often catastrophic BLACK SWANS evade prediction just because of their immediacy. Sometimes one knows that it can happen, but one does not know exactly when and to what extent – the ignorance –, other times one does not know anything, because a completely unknown and thus a per se unexpected event occurs – the unknown.

An example of events that were entirely outside the imagination of the majority of humankind are those of September 11, 2001, when in New York aircrafts were flown into the twin towers of the World Trade Center. The consequences that have grown from it were immense – many thousands of people died, the survivors are still traumatized in their fear of further attacks, the capital markets collapsed and more – and are still clearly noticeable in daily life. The Chernobyl accident in 1986 still has had devastating consequences in Ukraine; the tsunami following an earthquake in the Indian Ocean off the island of Sumatra in Indonesia in 2004 killed more than 200,000 people, the 2011 the tsunami following an earthquake off the coast of Japan killed over 10,000 people and caused the Fukushima nuclear disaster. It was known that the Chernobyl reactor was a security hazard, which was believed to be under control, that the Australian tectonic plate slides under the Sunda plate and thus, that a high risk of earthquakes prevails in Indonesia, that the east of Japan is a particularly vulnerable

[18] Popper (1934): *Logik der Forschung*
[19] Edmonds, Eidinow (2002): *Wittgenstein's Poker*
[20] Peters (1987): *Thriving on Chaos*
[21] Taleb (2010): *The Black Swan*

earthquake zone – all these facts were known. However, what was obviously not clearly conceived was the extent of the disasters these events resulted in. These most extreme earthquakes – the earthquakes had a magnitude of 9 and more – resulted in tsunami waves that were much higher and arrived with greater force on the coasts than the foreseen catastrophe scenarios ever predicted. Excessive demands on the ones involved in as well as the ones suffering from such extreme situations led to mistakes and failures made in combating the disaster.

According to Taleb[22], many people when assessing situations seem to take into account only the probabilities of events rather than the risks involved, i.e. probabilities AND consequences. Even if an event "on average occurs only every 100,000 years", it may occur tomorrow and the day after. However, the statement about the mean value remains correct.

Nevertheless, unforeseen and unforeseeable BLACK SWANS do not always have to be disastrous and fatal.

The discovery of America in 1492 by the Genoese navigator Christopher Columbus is one of the most important events in history. Columbus believed that the earth is spherical, and planned to find a sea route to India sailing west. For this plan, he found support amongst the catholic king Ferdinand and queen Isabella of Spain. With three ships on August 3, 1492, he set sail, and arrived at the Bahamas October 12, 1492. In total, Columbus made four voyages to the New World. It is interesting to know that Columbus did not realize even until his death that he had not come to the east coast of Asia, but had discovered an entire new continent. Sure, around the year 1000 Greenlanders under Leif Eriksson were the first Europeans who discovered the American mainland somewhere in the north of the east coast. They called the lands discovered Vinland – because of the many berries, from which they made berry wines. However, the lack of women and continuous battles with the natives made them abandon Vinland after few years. Eventually, they decided not to take possession of the new land and not to settle there.

At Sutter's Mill near Coloma at the American River in California the carpenter James W. Marshall found several gold nuggets on January 24, 1848 and started the California gold rush of 1848. In the next few years, several hundred thousand people moved to California seeking their fortune. Between January 1848 and December 1849, San Francisco grew from 1,000 to 25,000 inhabitants. A Californian newspaper had to cease publication because they had no workers, dozens of ships were mooring off San Francisco, because right after their arrival the sailors decided to move on to the gold fields and to try their luck, rather than to eke out a meagre existence as a sailor.

As it is, disasters are most memorable because the immediacy of the event itself and its consequences that appear directly and inevitably. From these consequences, there is no escape; one has to face them. The lucky BLACK SWANS – i.e. those events with positively assessed consequences – also have the immediacy of the event itself, but with the consequences, there always is the choice whether to accept them or not, as the examples above illustrate. Therefore, the consequences of the lucky BLACK SWANS have often a long "incubation period" until they fully unfold.

Examples of BLACK SWANS in the more technical fields – so-called disruptive innovation – are the development of telephony, computer, laser and the Internet. Like many of the technical BLACK SWANS these events are radiate a rather positive image.

"The horse does not eat cucumber salad" was the first sentence, the young teacher Philipp Reis transferred between workshop and garden with a device and a "talking wire". When in 1861 he presented to an illustrious group of German Physical Society his device, which he called telephone, with which one could transmit language over a distance, the renowned Professor Christian Poggendorf reprimanded him as "childish". The journal "Annals of

[22] Taleb (2004): *Fooled by Randomness*

Physics" rejected his contribution. Just 16 years later in the USA, Alexander Graham Bell founded the company Bell Telephone Company, from which then AT&T evolved being for a long period of time the world's largest telephone company. In 2010, telecommunications revenues in Germany alone were over 60 Billion Euros.

Although in the beginning of the 19th century the first attempts constructing a calculating machine were not really successful, in particular the construction of an analytical engine by Charles Babbage in England, they provided a fundamental understanding of computing machines even though. On May 12, 1941, the German engineer Konrad Zuse presented the calculating machine Z3 for floating-point calculations. In 1943 the former IBM CEO Thomas John Watson reportedly said, *"I believe that there will be a need in the world of maybe five computers."* After the Zuse Z4 in 1951, with the UNIVAC the second commercial calculating machine came into the market. From then on there was no holding back – in 2010, nearly 14 million PCs were sold in Germany alone.

When in May 1960 the young physicist Theodore Maiman presented the first working laser, news reported, *"Man from Los Angeles invents science fiction death beam."* Maiman succeeded after lengthy preparations, using a cylindrical ruby to generate a red point of light. Since then, medical, communications and consumer electronics without the high-energy, highly concentrated beams of laser light is no longer conceivable, the lasers themselves are getting smaller, faster and more powerful, and applied in ever-new areas. Around one billion laser diodes are deployed in drives to write or read data. Many thousands surgeries for vision correction are annually performed with lasers. The fiber optic cables installed all over the world, which enable transmitting data using lasers, reach a total length of 23,000 times the length of the circumference of the earth.

The Internet was launched in the fall of 1969, when the first four mainframe computers at the University of California, Los Angeles (UCLA), the Stanford Research Institute, the University of California, Santa Barbara (UCSB) and the University of Utah were interconnected.

On October 29, 1969, "lo" was the first successful Internet message sent in this experiment from UCLA to the Stanford Research Institute. In 1990, the Internet opened for commercial use. According to estimates, the Internet exchanged only one percent of the information flow in 1993, this share was 97 percent in 2007.

These technologies have produced fundamental changes. Martin Hilbert[23] of the University of Southern California has tracked 60 analogue and digital technologies for over ten years. He estimates that worldwide in 2007 memory capacity of 2.9×10^{20} byte (annual growth 23%), communication capacity of almost 2×10^{21} bytes (28% annual growth) and computing capacity of 6.4×10^{18} instructions per second on general purpose computers (annual growth of 58 per cent) were available. And there is no end to growth in sight.

How wrong have Poggendorf and Watson been with their predictions. Even the experts of that time did not foresee, could not foresee or did not want to foresee these developments.

For people with small tolerance for ambiguity, i.e. for people who can hardly withstand ambiguity or even contradictions, and who will do everything to rationalize when encountering them and thus, to provide some resolution, it is easier to not consider BLACK SWANS with their full implications. Because of them, they feel just stress and discomfort, and therefore, they try to restore order by either ignoring or making them fit to the rules. Today, in retrospect, everything seems clear and unambiguous; the developments were almost evident, inevitable and inexorable.

Actually, the occurrence of improbable events – of BLACK SWANS – can sustainably change entire structures. By definition, these events do not follow a plan, but occur more or less just by chance, they even might have been unknown to exist until they occur. In general, it can be

[23] Hilbert, López (2011): *The World's Technological Capacity to Store, Communicate, and Compute Information*

concluded that BLACK SWANS occur much more frequently than is commonly believed. The sociologist Niklas Luhmann[24] speaks of a normalization of the improbable, thereof, that it is not about a causality that follows some rule, or even a probable causality, but about improbable changes of structures – and these are contingent. I.e., they are as they are, but by chance, because they could just as well have turned out completely different.

3.1.4 Uncertainties and Probabilities

All BLACK SWANS have in common that it is uncertain if and when they occur. Therefore, a brief excursion to uncertainty is appropriate. In order to approach the subject, it is obvious to look at probabilities. Probability theory formalizes the concept of uncertainty and allows calculating with numbers. The Russian mathematician Andrei Kolmogorov founded probability theory with the help of concepts of set theory based on just three axioms[25]. By then, some experiences with probability calculus had already been made. Gambling and especially its analysis – in the hope of predicting the outcome – were extremely attractive even for great mathematicians like Geralomo Cardano in the 16th century, Blaise Pascal and Pierre de Fermat in the 17th century[26]. These studies and experiences of course influenced the formulation of Kolmogorov's three axioms. Kolmogorov defined elementary events, of which any arbitrary events can be composed. Take, e.g. throwing a dice, an example quite appropriate given its history. An elementary event is the result of one throw, an event could, for example be the result of ten consecutive throws. Now the axioms:

1. Every event E has a probability value between 0 and 1, i.e.
   $0 \leq p(E) \leq 1$.
2. The probability, that any event of all possible events occurs, is 1, i.e. with S the set of all possible events
   $p(S) = 1$.
3. The probability that one of two mutually exclusive events occurs is the sum of the probabilities of the two events, i.e., with $\varnothing$ the empty set (the impossible event), $\cap$ for the intersection (E_1 AND E_2) and $\cup$ for the union of two sets (E_1 OR E_2),
   $E_1 \cap E_2 = \varnothing \Rightarrow p(E_1 \cup E_2) = p(E_1) + p(E_2)$.

When playing dice, the probability to throw a 5 in one throw is 1/6 (1), the probability of throwing a number between 1 and 6, inclusive respectively, is 1 (2), the probability to throw a 5 or a 6 is 1/6 + 1/6 = 2/6 (3). It is interesting to note that there is no statement in probability calculus on how individual probabilities of events come about, but rather on how one can do calculations with them. Thus, the assignment of the probability 1/6 to the event "5 thrown" is the result of considerations which comprise the physics of throwing a dice and the symmetry of the cube and which exclude the results "dice on the edge or corner", although this not impossible, but rather unlikely.

Thomas Bayes was an English clergyman and mathematician, and gained great importance because of his investigations of conditional probabilities. Let H be a hypothesis, p(H) the a priori probability that this hypothesis is correct, D an outcome of observations and p(D) the probability of this outcome of these observations. Then, p(D|H) is the conditional a priori probability that, if the hypothesis H is correct, then outcome D is observed, and p(H|D) the conditional a posteriori probability that hypothesis H is true, if outcome D is observed. Then the following holds – and this is the Bayes theorem –

$$p(H|D) = \frac{p(D|H)\ p(H)}{p(D)}\ .$$

Example

[24] Interview mit Niklas Luhmann (1994): http://www.fifoost.org/user/luhmann.html
[25] Heinhold, Gaede (1972): *Ingenieur-Statistik*
[26] Mlodinow (2009): *Wenn Gott würfelt*

According to weather proverbs, a red evening sky's afterglow is a sign for fine weather.

Assume that the conditional probability that if on the evening before an afterglow has been observed the day's weather is going to be fine, is p(afterglow | fine weather) = 0.8. On the other hand the conditional probability of observing afterglow on the evening before, the next day brings no fine weather is p(afterglow | bad weather) = 0.3. Note that these two conditional probabilities do not need to add up to 1. Now assume further, that the probability of the hypothesis that the weather will be fine tomorrow, is p(fine weather) = 0.7.

The a priori probability to observe an afterglow is then

$$p(\text{afterglow}) = p(\text{afterglow} \mid \text{fine weather}) \bullet p(\text{fine weather}) + p(\text{afterglow} \mid \text{bad weather}) \bullet p(\text{bad weather})$$

$$p(\text{afterglow}) = 0.8 \bullet 0.7 + 0.3 \bullet 0.3 = 0.65.$$

Now the probability that the hypothesis "the weather is fine tomorrow" when afterglow is observed is true, can be calculated, namely

$$p(\text{fine weather} \mid \text{afterglow}) = \frac{p(\text{afterglow} \mid \text{fine weather}) \bullet p(\text{fine weather})}{p(\text{afterglow})}$$

$$p(\text{fine weather} \mid \text{afterglow}) = \frac{0.8 \bullet 0.7}{0.65} \approx 0.86.$$

Suppose one would not observe the afterglow. In addition, the conditional probability that no afterglow is observed on the eve when the next day brings fine weather, is p(no afterglow | fine weather) = 0.2 (= 1 - 0.8). On the other hand, the conditional probability that we observed no afterglow on the evening before, when the next day brings bad weather, is p(no afterglow | bad weather) = 0.7 (= 1 - 0.3). The probability of the hypothesis that weather is fine tomorrow, is unchanged p(fine weather) = 0.7.

The probability of the hypothesis if no afterglow is observed can now be calculated,

$$p(\text{fine weather} \mid \text{no afterglow}) = \frac{p(\text{no afterglow} \mid \text{fine weather}) \bullet p(\text{fine weather})}{p(\text{no afterglow})}$$

$$p(\text{fine weather} \mid \text{no afterglow}) = \frac{0.2 \bullet 0.7}{0.35} = 0.4.$$

The conditional a posteriori probabilities add up to the a priori probability for fine weather once multiplied by the respective probabilities of the observed outcomes. .

The evening's view out of the window increases the subjective probability of fine weather. As this example shows, probability calculus allows supporting hypotheses with corresponding empirical observations. It also shows that the results are just only probabilities and thus remain uncertain, even if empirical data support them (see Russell's chicken). It should be noted that the American mathematician and electrical engineer Claude Shannon with similar considerations developed the entirely new concepts of information theory[27,28].

3.1.5 Anomalies and Fallacies

Up to now, humans have not been taken into account – and apparently, they give a twist to these considerations. The two Israeli researchers Daniel Kahneman, Nobel Laureate for Economics in 2002, and Amos Tversky have investigated how people assess uncertainties focusing on which distortions facilitate that sometimes they are assessed erroneously. Here are some results of Kahneman and Tversky[29,30] describing these cognitive anomalies and

[27] Shannon (1948): *A Mathematical Theory of Communication*
[28] McEliese (1984): *The Theory of Information and Coding*
[29] Kahneman, Slovic, Tversky (1982): *Judgment under Uncertainty*

fallacies, as they call it.

They identified three very simple heuristics that people apply to make assumptions about the relevant situation: availability, representativeness and anchoring heuristics. And these may at the same time be the cause of the anomalies.

The **availability heuristic** states that the frequency of a set of events is estimated by the ease with which one remembers relevant examples that are vivid, unusual, or emotionally charged. Therefore, the decision process will not incorporated all the essential information, but only those most recently or easily remembered.

Events from real life or that have received attention in the media are perceived to occur with higher frequency with respect to those that are difficult to remember or seen as mere statistics.

Representativeness heuristic is based on the fact that individuals pay too much attention to more noticeable, palpable features, and disregard information about probabilities of occurrence of events. For example, most people overestimate the likelihood that someone exercises a certain profession, as soon as he looks like a typical representative of this profession. Given the choice, whether a shy person is a librarian or rather a sales person, most persons will assume, he is a librarian, because this property “shy” is considered representative of that profession. In fact, however, there are far more sales persons than there are librarians. The base rate probability of someone exercising these professions are often neglected (see below base rate error).

The **anchoring heuristic** states that people often use a temporary, convenient estimate for the evaluation of a situation – the anchor – to adapt subsequently when additional information becomes available. Experiments show, however, that people tend to stick to their initial estimate and that they refuse to adapt later on or that they only adjust very inadequately their assessment.

Example

Groups of students were presented the following multiplication problems with the instruction to estimate the product of the eight numbers within five seconds.

1. Group: $8 * 7 * 6 * 5 * 4 * 3 * 2 * 1$
2. Group: $1 * 2 * 3 * 4 * 5 * 6 * 7 * 8$

Since a complete calculation in such a short time is impossible, most do a multiplication by the first two to four numbers from the beginning (their anchor) and then estimate the final result. The resulting distortion yields exactly the predicted result: the median estimate in the first group was 2.259, in the second group only 512 (the correct answer is 40,320).

Typical sources of error or cognitive fallacies are base rate errors, conjunction errors, the gambler’s fallacy, overconfidence effect, ambiguity aversion and hindsight bias briefly discussed hereafter.

Base rate error: People intuitively tend to ignore the base rates and to rely on the case-specific information, even when the base rates are explicitly stated.

Example

For the example above: Suppose an afterglow is not observed. Many persons would then state the probability of fine weather with 0.2, although the probability is 0.4 if the base rate information "likelihood of (no) fine weather" 0.7 (0.3) is considered. One factor for this is the cognitive and emotional significance that is attributed to case-specific information.

[30] Jungermann, Pfister, Fischer (2005): *Die Psychologie der Entscheidung*

Conjunction error: *Linda is 31 years old, lives alone, talks frankly and is very smart. She studied philosophy. As a student she was very much involved in issues of social discrimination, she also participated in various demonstrations. Which statement do you think is more likely?*

- *Linda is a bank teller.*
- *Linda is a bank teller and active in the feminist movement.*

The vast majority of the probates believed the second statement to be more likely. However, the set of women who are both, bank employee and active in the women's movement is certainly a subset of the set of women who are bank employees. If statement b. is true, then certainly statement a. is also true. Therefore, statement b. can never have a higher probability than statement a. This error derives from the fact that the description strongly suggests a causal relationship between the events. The stronger the assumed causal relationship is, the more plausible the common occurrence of events becomes.

The gambler's fallacy: *A regular, fair coin, i.e. a coin, for which, when thrown, the probability of heads or tails on top is 50/50, is thrown 99 times and the result is 99 times head. On which result of the next throw would you put money – heads or tails?*

A majority of subjects relies on tails, because it is simply time that tails "must" come. Anyone who is somewhat familiar with probability theory will argue that each throw is independent of the previous ones and therefore the probability of tails remains unchanged at 50%.

Taleb[31] tells a nice story to illustrate that one could also question the assumptions. His Fat Tony, a real skeptic and obviously well acquainted with the abysses of human behavior came to a result of about 1%. He argued that the coin is not fair, that it is more likely that the assumption of a regular, fair coin is wrong than that head shows up 99 times ($< 10^{-30}$).

Overconfidence effect: *Which city has more inhabitants Berlin or Paris? How sure are you that your answer is correct, 50%, 60%, 70%, 80%, 90%, 100%?*

The answers of 80% of the probates who were 100% sure that their answer is correct, were wrong, the answers of 75%, who were 90% sure, were wrong, etc.

The certainty in relation to the correctness of the answers is consistently higher than the relative frequency of correct answers. People are too confident of the correctness of their answers and overestimate the quality of their own knowledge.

Ambiguity aversion: *You have the choice between two games. With both, you win 10 Euros if you draw a white ball from the urn. Game 1: The urn contains 5 white and 5 black balls. Game 2: There are 10 balls in the urn, each of which is either black or white.*

Most probates prefer Game 1 because of the precise definition of Game 1. Here the probability to draw a white ball is 50%. In the Game 2, this is not clear, but because of not knowing any better, the assumption of 50% is also justified. Ambiguity emerges from a lack of information and refers to the uncertainty about the uncertainty, the cognitive feeling of "I know that I do not know something." The impression of ambiguity is greater, the less one believes to know about an issue one needs to decide, assess or appraise.

Hindsight bias: (see definition of BLACK SWAN) When a certain event of several possible events has occurred, most probates find very good reasons in retrospect, why exactly this event had to occur, even if the information available doesn't permit to distinguish the probabilities of the possible events.

There are still a number of other phenomena, affecting human (mis)judgments on

[31] Taleb (2010): *The Black Swan*

probabilities.

Think of the many success stories told – be they from economy, science, or politics – from which the special abilities of the protagonists were condensed to be courage, risk-taking, optimism and perseverance, it seems that if one only possesses those abilities, success comes about almost certainly. On the other hand, in the cemetery of failed endeavors there lie buried many whose protagonists have had and have shown courage, risk-taking, optimism and perseverance. Some of the cognitive fallacies described above coincide. These are base rate error – e.g. there are many attempts to create successful businesses, of which not all but only a few are successful and on those attention is directed – and hindsight bias – these abilities and characteristics have made success possible.

However, if it is not only these abilities, then what is it that makes the difference? Taleb believes that success is not only the result of these special abilities, but also very significantly sheer and mere luck is needed for this.

3.1.6 Perpetuations and False Inferences

"It was never like this!"
"We have never done that!"
"We've already tried it!"
"This has never worked!"
"That never works!"
"Nobody wants this!"
"It's there already!"
…

Every creative, inventor, innovator knows these sentences only too well – they all are factual, and exude a certitude, which probably is not justified. In any case, such sentences are evidence that it pays to dig deeper and go into more detail. They are often more an expression of a *"Noli turbare circulos meos"*[32] or that one has fallen into one of those traps that have been set by all the above perpetuations, projections, cognitive fallacies and anomalies.

Uncertainties characterized the way from idea to innovation – and whether it will be a flop or a lucky BLACK SWAN is not easy to predict with certainty. Also, fortune that one – possibly – needs for success, requires an object that it can make fortunate: only those who attempt something may also have luck – nothing ventured, nothing gained. This statement however, is definitely true.

[32] "Do not disturb my circles", the last words of Archimedes of Syracuse (212 BCE)

3.2 Innovation: Concepts and Contexts

There is hardly any published corporate strategy, in which the credo of the necessity of innovation for the company's development does not appear in a prominent position.

After all, innovation is the lifeblood of an organization. Only with innovation, an organization can grow and compete: become even better, venture in new directions. Only with innovative products with new features, an organization can increase the demand for its products/services or its market share. With innovative new business processes, an organization can optimize its cost structure and thus sustainably position products/services more economically and/or more profitably in the market or reach customers better and respond better to their needs. The ultimate goal is always to prepare the organization for the future, to maintain and improve competitiveness and ultimately to operate profitably.

On the other hand, innovation decisions are always decisions pointing to the future. Will the market accept these novelties? Will the cost savings actually be achieved? Will the innovation fulfil expectations? Often, large investments are at stake.

3.2.1 What is an Innovation?

Yet, a good idea is not an innovation. First, the idea must be elaborated to make a new product, a new service or a new process (invention) eventually possible. If this invention is then successfully positioned in the market (diffusion) – be it in form of products, services or business processes – then, this idea has become an innovation.

Idea + Invention + Diffusion = Innovation

Thus, an idea, an invention becomes an innovation then when it is successful in the market. Innovations can be new to the company, new to a market or industry, or can be entirely new, "from scratch", i.e., this innovation has neither been implemented nor applied anywhere else yet.

The innovation funnel illustrates how ideas become inventions, how the inventions generate products/services, which then have to prove themselves in the market. In each of these steps, there are losses. Not all ideas make it to become inventions. Some are so "over the top" or technically so challenging that they have no chance of realization for the time being, and are therefore discarded immediately. Others do not fit into the market, in which the organization operates, or into the corporate landscape so they are discarded for those reasons.

In any case, the multitude of ideas reduces to a few, which then become inventions and receive further consideration. For many of them one will already in the concept phase discover, that it is not worthwhile to pursue these. For them, maybe resources are needed that are not available within the organization and cannot be procured or require prohibitive financial expenditures.

However, on the other hand other inventions have such a great potential for success that the organization decides to develop a product and provides resources necessary. Nevertheless, again history shows that not all innovative products are successful in the market, so that ultimately, only very few remain which have successfully completed the entire process – and these eventually are the innovations (see Figure 3-5).

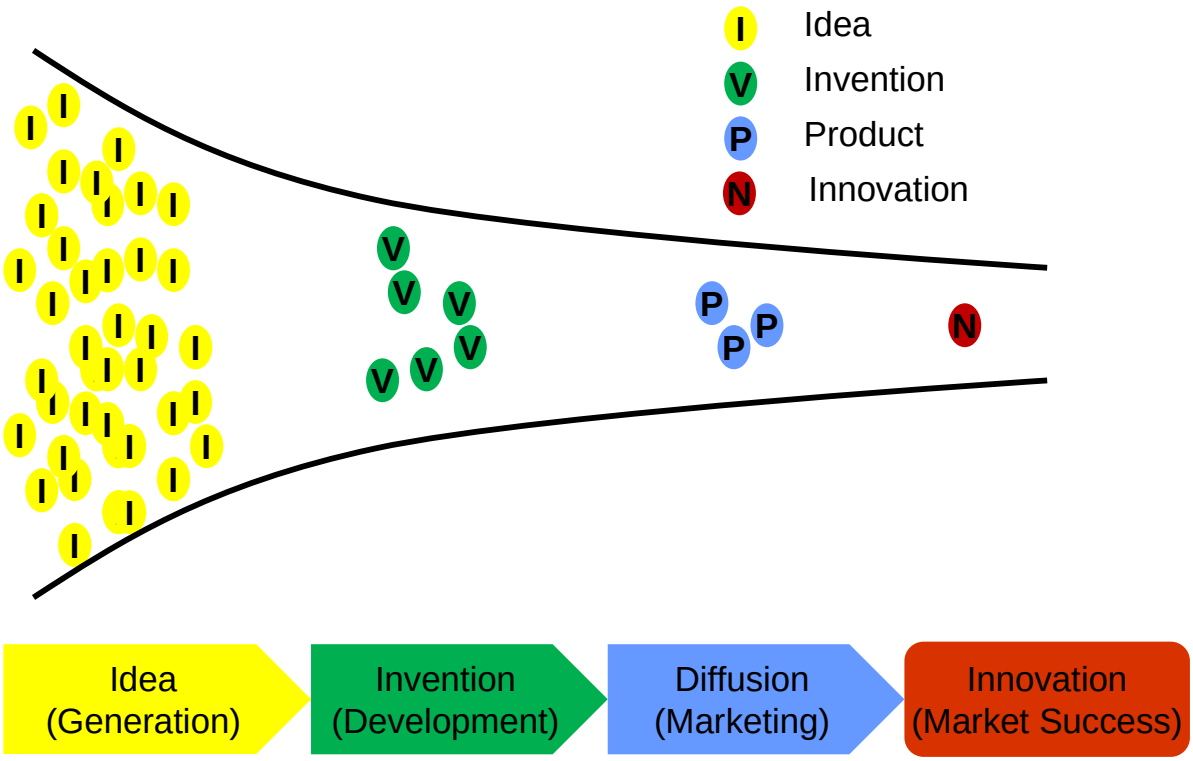

Figure 3-5: Innovation funnel (Source: Bernd X. Weis)

3.2.2 Innovation Typology

Here innovations are typified accordingly to content, creation and impact. The content of an innovation describes the "what" of an innovation, i.e., what exactly is the goal of the innovation. The Organization for Economic Cooperation and Development (OECD) defines differentiating factors and uses them for their surveys. The creation of an innovation answers the "how" question, i.e., it describes how the innovation has been created. In general the type of impact answers the "why" question, i.e., the innovation's impacts and effects.

Please note that here and in the following products refer to both, goods and services.

3.2.3 Innovation Aspect Content: Definitions According to OECD

According to the dictum "What you can't measure, you can't control", in 1992 the OECD has started to develop guidelines for the assessment of the innovativeness of enterprises. The Oslo Manual "Guidelines for Collecting and Interpreting Innovation Data" compiles these guidelines. The manual was revised in 1997 and is now in its third edition (2005). In this manual, different types of innovation are defined also used in the following.

The OECD distinguishes in its Oslo Manual "Guidelines for Collecting and Interpreting Innovation Data, Third Edition" of 2005[33], four types of innovation: product, process, marketing and organizational innovations. In the sequel because of its ever-growing importance business model innovation is also defined here.

> *A **product innovation** is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.*

Product innovations can serve an existing market better, easier and/or more demanding, or

[33] OECD (2005): *Guidelines for Collecting and Interpreting Innovation Data*

develop an entirely new market (see Figure 3-6).

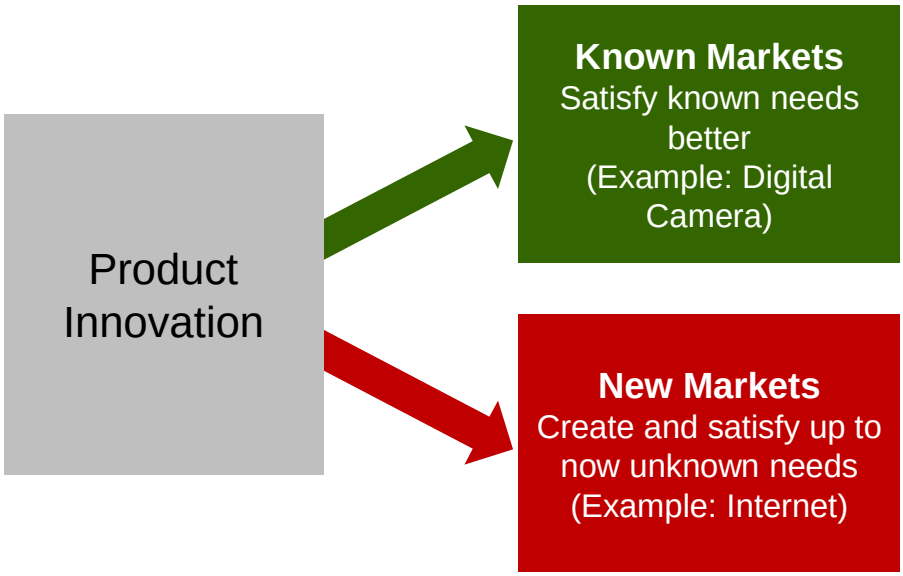

Figure 3-6: Targets of product innovations (Source: Bernd X. Weis)

New products are goods or services that differ significantly in their characteristics and features or in their areas of application from the enterprise's existing products. On the one hand, they deploy new technologies or on the other hand, make use of already existing technologies, but in a novel combination. Digital cameras are such new products that use new technologies in the photographic market. MP3 players newly combine already known technologies in a developed market already formed by the various technical variations of the Walkman.

It is also a product innovation if a product that is already established in the market enables an entirely new application with only minor changes to the technical design. The Post-It products of 3M are examples for these. Both, pieces of paper and adhesives were well known, but by an appropriate combination made a completely new application possible.

Significantly improved products originate mainly from changing materials, components or other properties that improve the performance of the products. Many product innovations in the automotive sector are typical. With new components, vehicles get improved driving, comfort and/or safety properties. Functional outfits as widely used in sports, which have with new, modern materials significantly improved properties, are yet another example.

In the service sector, product innovations arise mainly in that services are provided easier and/or faster and/or more effective. For this, services linked to the Internet offer an abundance of examples, such as online and Internet banking, Internet shops and many more.

> *A **process innovation** is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.*

Process innovations typically have three targets (see Figure 3-7). These are

- reducing unit costs in production or in distribution and delivery of products,
- improving product quality,
- facilitating the production of new or significantly improved products.

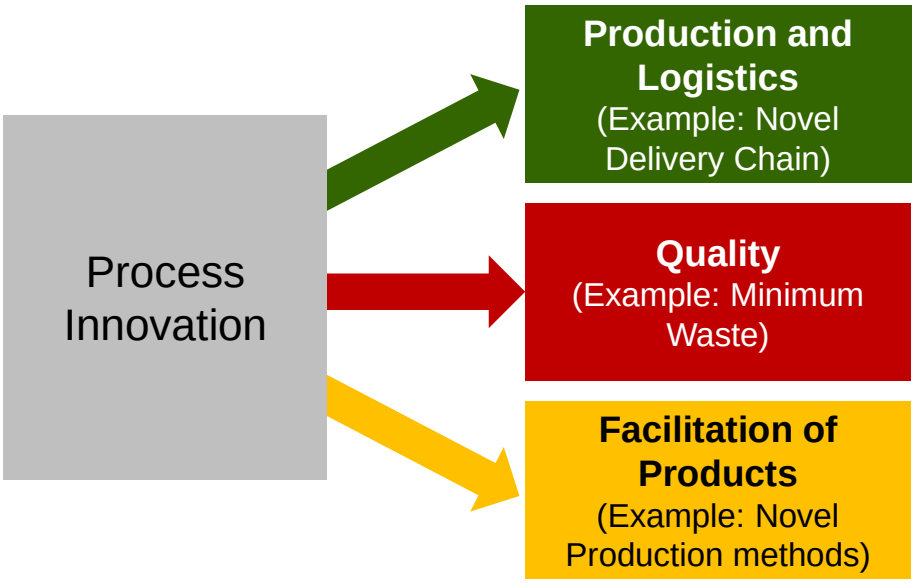

Figure 3-7: Targets of process innovations (Source: Bernd X. Weis)

The application of computers and computer programs has enabled a multitude of process innovations. Through the automation of production processes, the procedures became leaner, simpler and therefore faster with the corresponding positive impact on unit cost and quality. Computer-aided design can now be found almost anywhere; hardly any development department can do without those tools. Barcodes and the new Radio Frequency Identification (RFID) chips allow to easily tracking goods, and thus enable a seamless trace of the product's route from producer to consumer. Avoiding unnecessary human intervention in these processes eliminates many sources of error, thereby significantly improving product quality. The services sector benefits from significant improvements through process innovations. Automatic reservation systems reduce waiting times; Enterprise Resource Planning (ERP) systems allow a significantly improved coordination of internal processes and the processes between enterprises and their suppliers, buyers and customers.

> *A **marketing innovation** is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.*

Marketing innovations (see Figure 3-8) aim to improve the way customer needs are addressed, to develop new markets or customer segments or to realign the enterprise's positioning in the market – all under the proviso to increase the enterprise's product sales. It is essential that the enterprise has not yet been deploying this marketing method, where, however, it is irrelevant whether the enterprise has perfected this method itself or has copied it from some else.

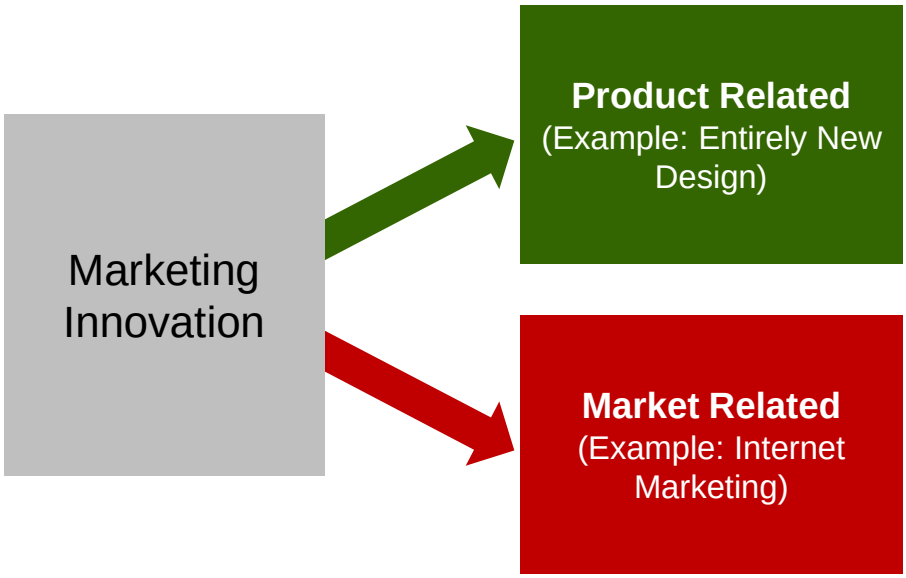

Figure 3-8: Targets of marketing innovations (Source: Bernd X. Weis)

In this context, product design refers not to the functional or technical product characteristics, but rather to shape and appearance of the product. Especially design heavy lifestyle products make use of innovations in product design. A good example of this is Apple's iPhone, which is extremely successful on the market not only because of its technical innovations, but also because of its marketing innovations of captivating product design and of simplified handling in significant elements.

In this context product distribution is meant to be the ways how the enterprise's products are delivered and sold to customers, not the logistical measures by which mainly an increase in efficiency is achieved. These ways include the introduction of new distribution and sales channels such as introducing a franchise system or an online shop, the launch of new products, substantially modified decor of stores, and much more.

An innovation in product communication is e.g. a new brand concept. For instance, Sony has been successful for a long time with the slogan "It's a Sony" regardless of the product being advertised. Further examples of innovative brand management are the brand differentiation efforts of mobile communications operators. Today each operator has – along its standard product –at least one lower priced product brand on the market, taking care not to create cannibalization effects between the individual brands.

Pricing of a product is always a touchy topic. New pricing schemes are for example flat rates for telephony, film distribution, cinemas and for many other products. Pay-as-you-grow models open up rather popular pricing options e.g. in capital-intensive equipment. In addition, Michael Dell has gone new paths when he enabled the option to configure PCs at home on the computer coming with an instantaneous price quotation. This marketing innovation is likewise based on a process innovation, namely to directly manufacture the PCs on demand in the manufacturer’s premises and deliver it from there to customers.

> *An **organizational innovation** is the implementation of a new organizational method in the firm’s business practices, workplace organization or external relations.*

Organizational innovations (see Figure 3-9) aim at increasing the performance of a company by reducing the administrative or transactional costs by improving employee productivity through access to intangible assets that are not traded, such as non-codified external knowledge, expertise and know-how. Typical examples are improving operations through easy access to the existing, passed on knowledge on how to decide and to act best in specific situations. For example, writing down and codifying the knowledge, know-how and

experience in in-house databases can achieve this. Lived empowerment is an example of innovation in the workplace organization. The mode of cooperation with e.g. research institutions or universities is an example for innovation in the external relations of a company.

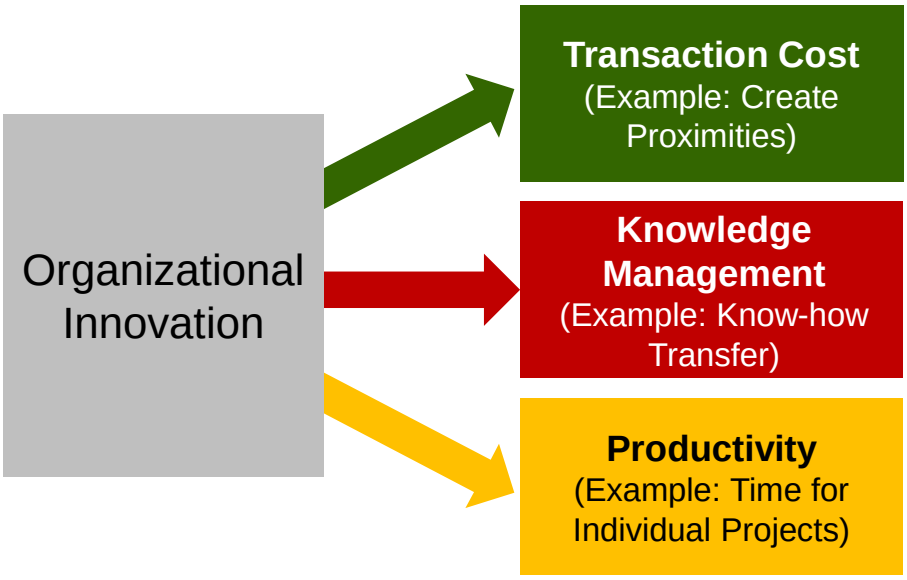

Figure 3-9: Targets of organizational innovations (Source: Bernd X. Weis)

> *A **business model innovation** is the implementation of a new business model or the new implementation of a significant proportion of the existing business model.*

A business model innovation is the consciously intended change of an existing or the creation a new business model that will satisfy customer needs in a novel and superior way. It is about creating a competitive advantage through differentiating from competitors. Business model innovations are profound, strategic innovations since they change the fundamentals of the structure of a business (see Figure 3-10).

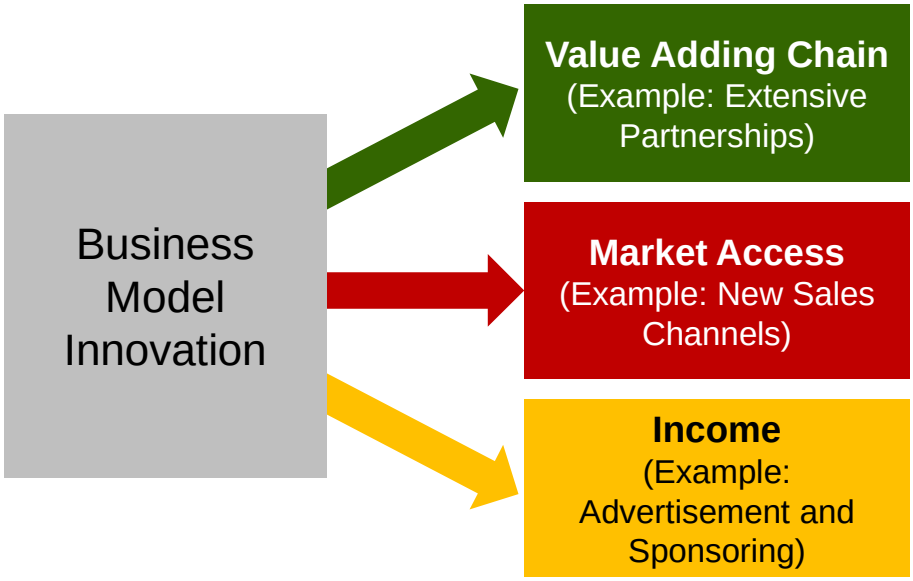

Figure 3-10: Targets of business model innovations (Source: Bernd X. Weis)

OECD did not specifically list this innovation type, but because of its growing significance, it is defined here.

An example is the Amazon bookstore, which completely abstains from retail shops and sells exclusively via Internet and parcel services. A most interesting and also surprising business model innovation, is the "Local Motors" company in the United States, which produces in a variety of local production facilities cars that exactly match customer requirements, either custom-built or in mini-series. Business models will be discussed in detail in chapter 4.

3.2.4 Innovation Aspect Creation

Closed and open innovations are distinguished by the way, how innovations are created.

> *A **closed innovation** is developed in a self-contained environment – typically an enterprise or other entity.*

The underlying belief that innovation can only be successful if know-how, technology, processes, and intellectual property remain under the control and the property of the innovating organization, characterizes a closed innovation process. In the past, organizations have invested heavily in expanding their research and development capabilities. Ultimately, the intention is to reap the fruits of this investment in terms of innovation. In addition, a strong research and development position builds a barrier that competitors or would-be entrants cannot easily overcome by due to the high investment and related expenditures.

At first glance, these arguments in favor of closed innovation are understandable and comprehensible, since the organization wants to gain a competitive advantage and additional income with these innovations. The so-called "Not Invented Here" syndrome provides additional assistance for this perspective; everything coming from the outside is cautiously considered assuming that it may not be adequately accurate or reliable.

> *An **open innovation** is created by the interaction of both internal and external contributions of ideas, technologies, processes and distribution channels with the aim of the organization, to develop at the same time their own technologies further.*

Open innovation and distributed innovation (mass innovation, "crowd innovation") are used synonymously; they closely relate to other concepts such as user innovation and know-how trading. Here the term open innovation is used.

The view that individual organizations cannot afford to rely solely on their own internal innovation capabilities characterizes the paradigm of an open innovation process. Too highly distributed are knowledge and skills throughout today’s world. Therefore, many organizations, in particular large ones, are already progressing to acquire the necessary licenses and patents from other organizations or even to buy entire innovative organizations with a correspondingly innovative portfolio. The big advantage for these organizations is that they save the expenditures in research and development and that the portfolio purchased is already to some extent tested in the market. Another option is that organizations join forces in joint ventures, to elicit a particular potential for innovation. If this procedure of open innovation has solid anchors in and is consistent with the organization’s culture, then the organization can offer on the market also proprietary inventions, which it does not immediately require. Through this type of collaboration, intellectual property wanders between the involved parties back and forth, and eventually the origin of an invention often cannot accurately be determined (see Figure 3-11).

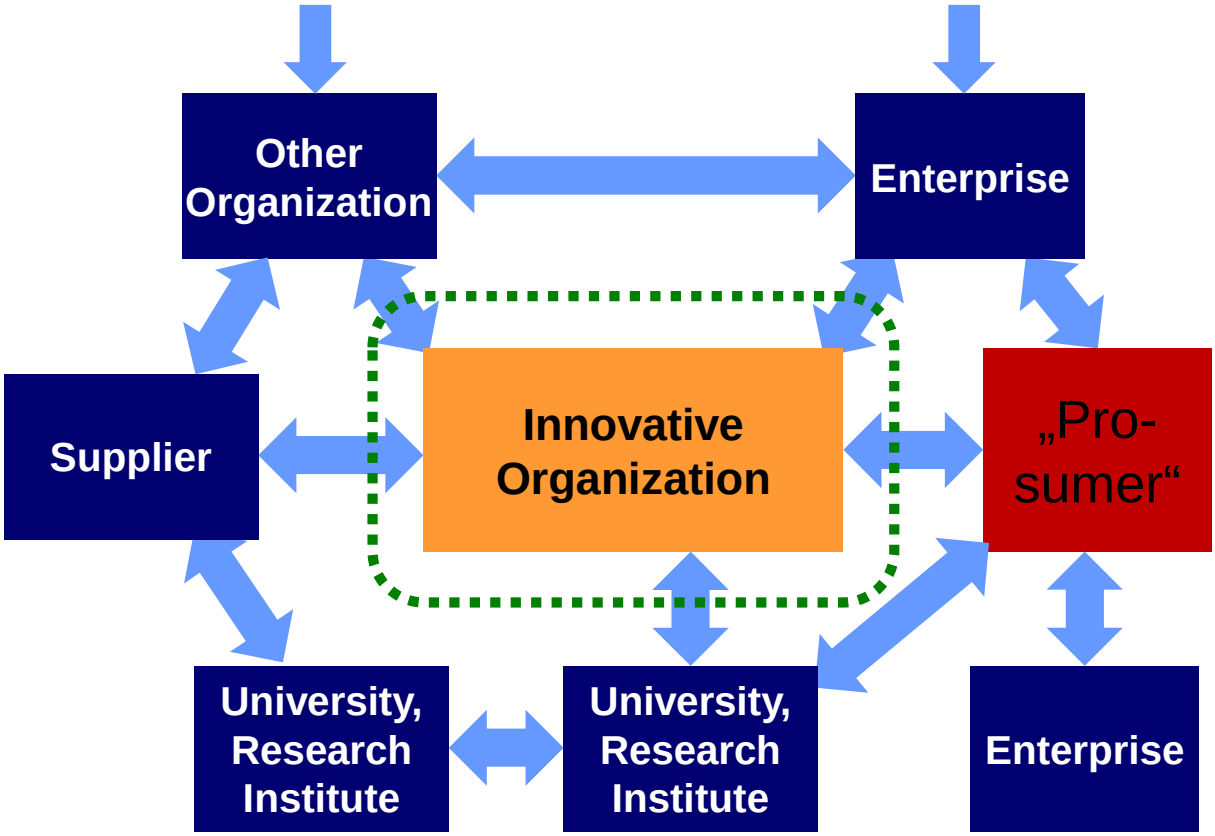

Figure 3-11: Closed versus open innovations in a network (Source: Bernd X. Weis)

The concepts of open innovation require functioning marketplaces for know-how. In these marketplaces, knowledge, know-how and expertise can be traded for money. Usually very specific, often complex problems are disclosed. The suitable solution is remunerated accordingly.

Yet another type of open innovation collaboration is involving customers in the development process. Customers want solutions that precisely meet their wants and needs. To facilitate this, good and direct communication with customers is mandatory, so that their requirements are incorporated in the solutions quickly and smoothly. In his research, Tuomi[34] found that the developers often did not intend the key applications, which users virtually invented anew, thus fundamentally expanding the possibilities of the invention. Then, the customer is not only consumer, but also producer. The made-up word "prosumer" expresses these two roles of the customer.

The Cologne Institute for Economic Research (Institut der Deutschen Wirtschaft Köln)[35] has collected in a survey data on cooperation behavior. According to these data, the customer plays the central role in the innovation network, 93 percent of respondents consider the customer’s role as important or somewhat important, followed by suppliers, with 68 percent, universities, colleges and other research institutions with 54 percent, and other enterprises are far behind with 29 percent. From these results it is evident that cooperation with enterprises are considered with quite some skepticism, although right there is a huge potential for increasing competitiveness.

At this point, the difference of open innovation and open source is briefly commented on. The basic difference is that the use of open source is within wide limits unrestricted, whereas in the open innovation concept the rights of use and intellectual property are definitely traded.

[34] http://en.wikipedia.org/wiki/User_innovation
[35] IW (2006): *Das Innovationsverhalten der technikaffinen Branchen: Forschung, Patente und Innovationen*

3.2.5 Innovation Aspect Impact

In the 90s of last century, Clayton Christensen[36] developed another important distinctive feature of innovation. He distinguishes innovations based on their effect, their impact. An innovation is continuous, incremental, sustainable or groundbreaking, revolutionary, disruptive.

> *A **sustainable innovation** ("make it better!") improves a product or service in a way that the market already appreciates. Most organizations sufficiently to excellently developed processes for these types of innovations.*

The organizations in the market are actually doing everything important right. They invest in the improvement of their products. However, it often happens that products are improved beyond the point at which further improvements do not really make sense and are thus useless. The customers and the market do not reward this by an appropriate purchasing behavior. They may have no interest in even better quality, a possibly even more expensive product, when preceding model has already fulfilled and maybe even exceeded all needs.

These organizations have more or less shaped this market and have developed up to now successful corporate cultures, which are similar in the fundamental values and the expected margins. Accordingly, they behave rather more cautiously, reluctantly or hesitantly towards innovations that could shatter and change their traditional markets in the foundations.

> *A **disruptive innovation** ("do it differently" or "do something different!") creates an entirely new market with the introduction of a completely novel type of product or service. It penetrates new market segments and uses technological innovations or new business models. Most organizations have no or only insufficiently developed processes for these types of innovations.*

The market is not immediately accepting disruptive innovations, but eventually they can change and shape markets fundamentally. Often entirely new customer segments will be addressed that were previously not served, or customer segments, which the "old bulls" consider unprofitable. In these segments, the innovators must make a special effort to address the corresponding need, to raise the demand and to meet the requirements of quality and/or price. The margins are lower, the market is smaller, and perhaps the products may be a little easier. However, in due course these products improve. As a result, customers previously not interested will also become aware and now discover that with this innovation a need is favorably satisfied. The innovation works its way up with the market (see Figure 3-12).

[36] Christensen (2000): *The Innovator's Dilemma*

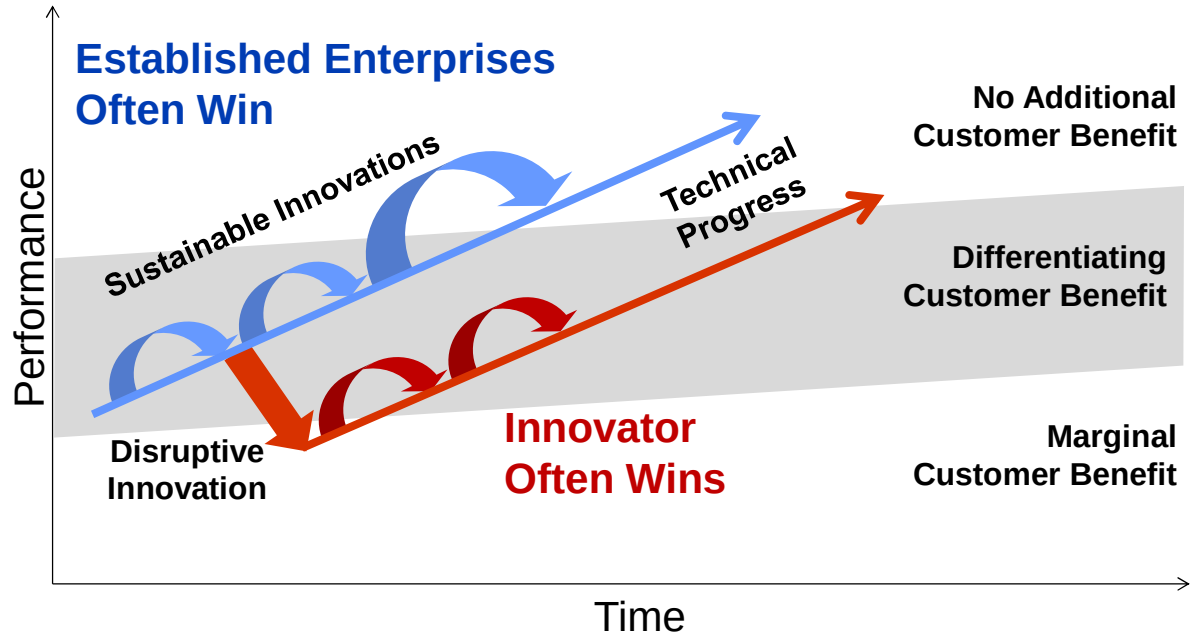

Figure 3-12: Sustainable and disruptive innovations (according to Christensen) (Source: Bernd X. Weis)

Often incumbents cannot really keep up, although they discovered or invented many disruptive innovations, but their traditional customers often have no interest in these novelties. Moreover, because the organizational culture is geared towards the above-mentioned optimized processes, organizations find it difficult to diversify into a new technology and/or market segments because of these adversities. It just does not fit right.

If disruptive organizations i.e., one with a disruptive innovation, challenge these established organizations in their traditional market, they are often too ponderous to withstand the competition. Therefore, large companies have begun to buy the disruptive innovations if and when they have proven themselves in the market with some success, and hence, market uncertainty is low. Figure 3-13 shows a typical curve of market uncertainty and capital requirements for the acquisition of a disruptive innovation. This graph is only qualitatively since in each case a number of factors need to be assessed.

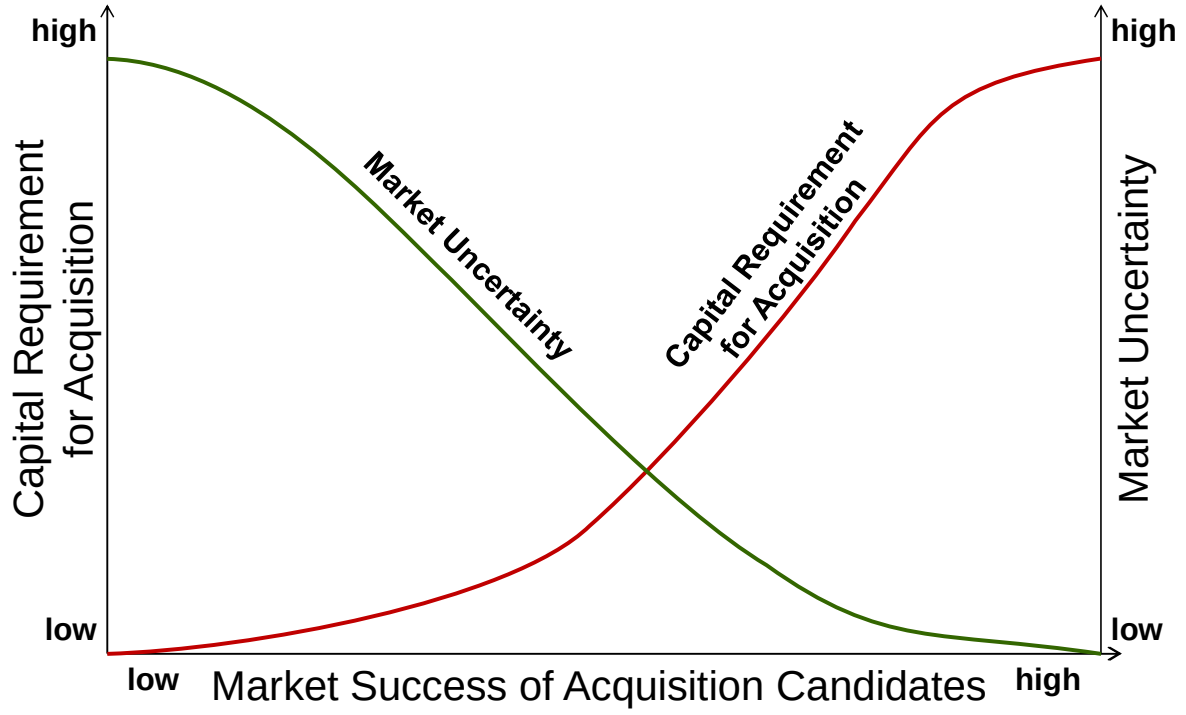

Figure 3-13: Acquisition of innovations (Source: Bernd X. Weis)

A nice example of a disruptive innovation is mobile communications, now even preparing to replace fixed line communications completely.

3.2.6 Life Cycle Models of Products and Technologies

Innovations rarely "happen" on the green field. In general, they are competing from the beginning with other products and need to prevail against them. For the analysis and the description of the environment as well as enabling classification of innovations in terms of market relevance, life cycles models of products and technologies are briefly introduced.

The **product life cycle model**[37] assumes that every product and every service undergoes a life cycle from launch to discontinuation of the offer, which characterizes the profiles of sales volumes, sales revenues and profit expectations over time. The typical cycle consists of four phases: introduction, growth, maturity/saturation and decline. They differ in the relationship between volume (number of products sold), revenue (income from products sold) and profits as shown in Figure 3-14. In each phase, the organization faces different challenges, opportunities and problems and thus, requires different strategies for marketing, finance, production, purchasing, supplies and personnel.

[37] Kotler, Keller (2009): *Marketing Management*

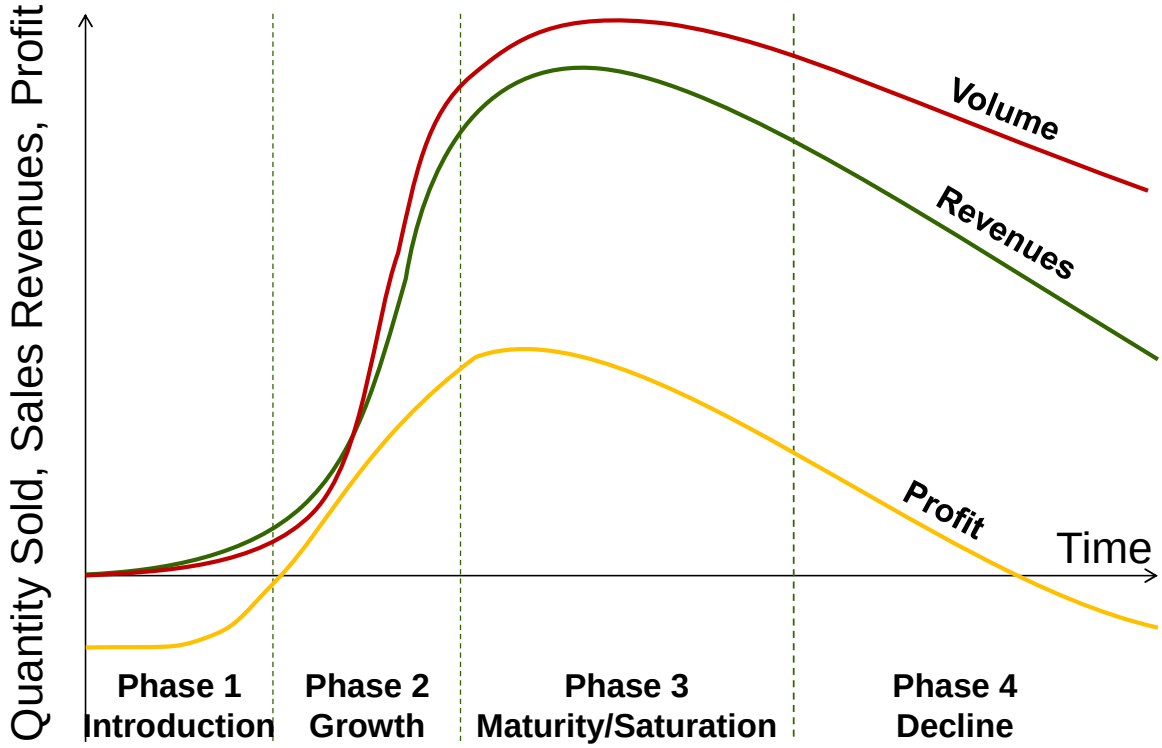

Figure 3-14: Product life cycle (Source: Bernd X. Weis)

In the **introduction** phase, the product is new and almost unknown in the market. In this phase, the most important tasks are to increase the awareness for the product and to overcome technical start-up problems and market resistance. Only those consumers particularly excited by new products usually buy the product. Its price is not yet optimal, since no effects of mass production are exploited. However, pricing is crucial at this stage: a price point must be found at which on the one hand a sufficient number of buyers are found, i.e., as economical as possible, and on the other that the customers' engendered price expectations do not jeopardize profits at a later point in time.

In this phase, it is eventually determined whether a product idea has eventually become a marketable product. Despite the often very high expenditures that have already been incurred for the product up to this point (development, investments in the manufacturing and marketing for market introduction), many products do not reach the critical growth phase. Often products cannot prevail against alternative offers, do not set technical de-facto standards or do not offer enough possibilities of usage and application. This phase lasts approximately until break even.

Once the product has convinced a critical mass of buyers, it reaches the **growth** phase, in which the product passes over the threshold from a niche product to mass-produce. Generally, the price level will still be high, and therefore, this phase allows for the highest margins. However, since the market is now very attractive first competitors/imitators emerge in the market. It is essential to exploit the benefits from the acquired customer awareness level and differentiate very clearly with respect to alternative products.

Intensified competitive pressure characterizes the **maturity** stage where further growth can be only partially achieved or at very high expenses. The market is saturated and the level of profit margin decreases. Now the strategic goal becomes to maintain and stabilize the market share achieved, to leverage the cost benefits of mass production, and to differentiate the product by augmenting the offer with appropriate services.

In the phase of **decline** sales volumes of the product decreases. By now the product is

outdated with respect to both, technology as well as fashion, and buyers are more interested in new offers that are at the beginning their life cycle. With new models, technical upgrades, a repositioning of the product image, changes in the distribution system, or by addressing new customer groups this point in time may be delayed. Ultimately, however, the product is discontinued when sales volumes, revenues and profits as well as their perspectives fall below an economically acceptable level.

Nevertheless, products can be profitable even in the phase of decline. Namely, if the competitors already have retreated from the market, and hence, without competition, without major investments and by leveraging efficient production means the remaining market can well be served at a profit. This process is called "milking".

Table 3-2 summarizes the phases and their characteristics.

	Introduction	**Growth**	**Maturity / Saturation**	**Decline**
	Properties			
Sales Volume	Slowly rising	Further increasing	Slightly increasing to decreasing	Decreasing
Sales Revenues	Small	Increasing quickly	Slowly increasing to decreasing	Decreasing
Profit	Negative	Increasing quickly	Decreasing	Decreasing
Cash Flow	Negative	Medium	High	Medium
	Strategy			
Goal	Market entry	More Market share	Maximize profits	„Milking“
Measures, Customers	Win new customers, „pioneers, early adopters“	Win market segments, „mainstream“	Defend market share, “late adopters“	Reduce cost, „laggards“
Competitors	Few	Increasing	Many	Decreasing
Differentiation	Product	Brand	Price/service	Price

Table 3-2: Characteristics of the different phases of the product life cycle

The product life cycle describes the empirically established sales performance of a product or the expected trend in sales during the period in which the product is on the market. Thus, the product life cycle considers only the period of time, in which the product is actually on the market. This is different, perhaps substantially, from the time in which the product is or can be used. Thus, the product life cycle model does not express a general law, but rather it may be advantageous as a thought pattern. The course of a product's life cycle is not predetermined and fixed. E.g., the product of an internationally operating enterprise can be in different phases in different markets.

The **technology life cycle model of Arthur D. Little**[38] (see Figure 3-15) implies that a technology with increasing degree of exploitation of its competitive potential traverses through the four phases of development, growth, maturity and obsolescence. Depending on

[38] Little (1991): *Management der F&E Strategie*

competitive importance, each phase represents a technology category:

- **Pacing technologies** will (probably) prevail in the market in the future and promise high (latent) competitive advantages for the enterprises involved, and will (probably) have a major impact on the performance of products or the cost structures;
- **Key technologies** are already established in the market and outstandingly influence the competitiveness of the enterprises mastering them, and also strongly influence the options and possibilities of product and/or cost differentiation;
- **Base technologies** are already established in the market and mastered by the relevant competitors without explicitly offering further benefits of differentiation;
- **Obsolete technologies** are (almost) completely replaced by substitution technologies.

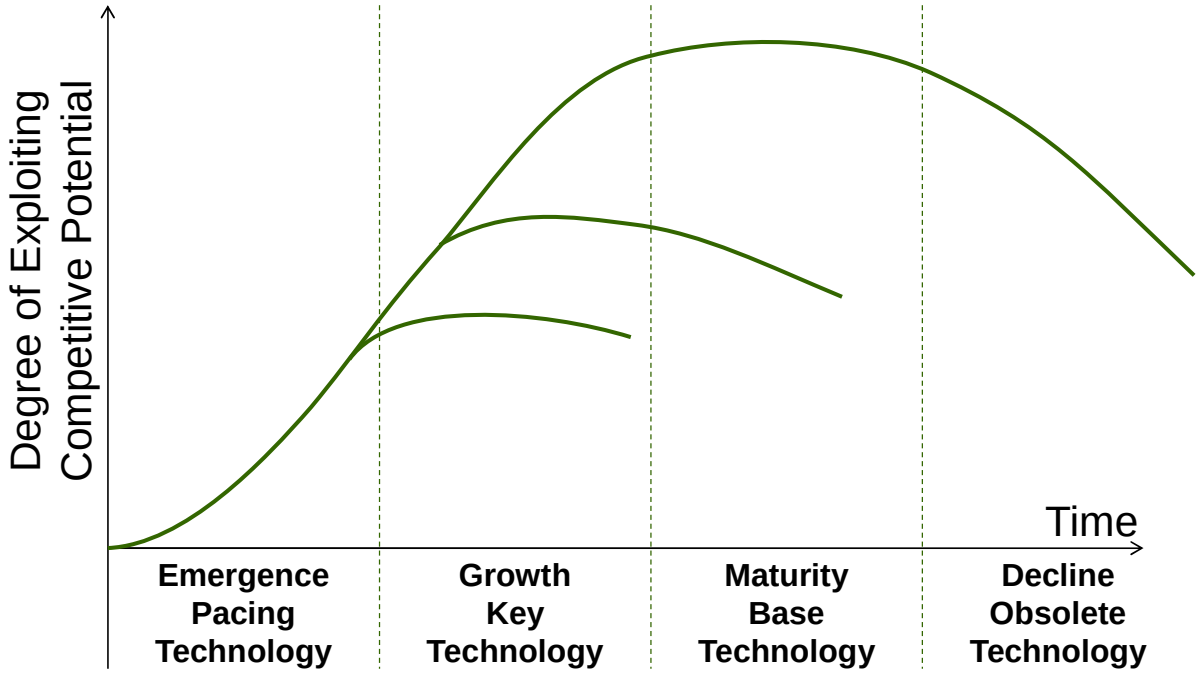

Figure 3-15: Technology life cycle by A. D. Little (Source: Bernd X. Weis)

Table 3-3 compares the essential characteristics of the technology phases.

	Pacing-Technology	Key Technology	Base Technology	Obsolete Technology
Uncertainty about performance	High	Medium	Low	None
Development investments	Low	Maximum	Low	Negligible
Potential deployment areas	Unknown	Large	Established	Decreasing
Development requirement	Scientific	Application oriented, maximum	Application oriented, marginal	Cost oriented
Impact on cost-performance ratio	Secondary	High	Decreasing	Marginal
Strategic role	High		Low	None
Patents	Conceptual, increasing		Process related, licenses	
Availability	Very limited ——————————————> High			

Table 3-3: Characteristics of the different technology phases

For the early identification of technological advances and of the point in time at which one should seriously analyze and consider using a new technology, the **McKinsey S-curve model** suits well. It assumes that every technology eventually reaches its limits. As in the model of AD Little the curve is divided in phases: firstly, emergence, secondly, highest growth and thirdly, maturity, substitution implicitly models the fourth phase obsolescence. As Figure 3-16 shows, there is a point at which a change to a substitution technology makes most sense, even if it has not yet revealed its full potential.

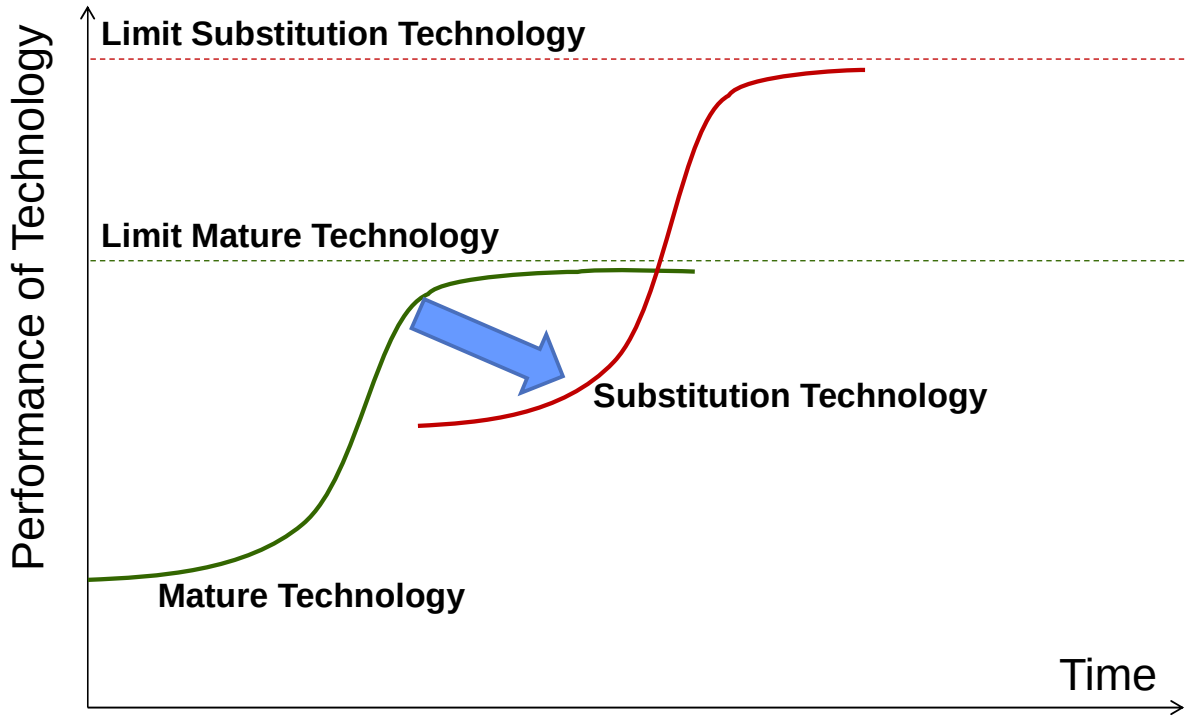

Figure 3-16: Technology life cycle according to McKinsey (Source: Bernd X. Weis)

In this context, an interesting effect can be observed. The conviction that the prevailing technology is superior, and the belief that development potentials are not yet being fully realized, often result in increased development efforts that somewhat push the performance boundary of the technology. This is called the "sailing ship effect" since – as a historical note

– with the advent of steamships shipyards resumed development efforts to improve sailing ships (see Figure 3-17).

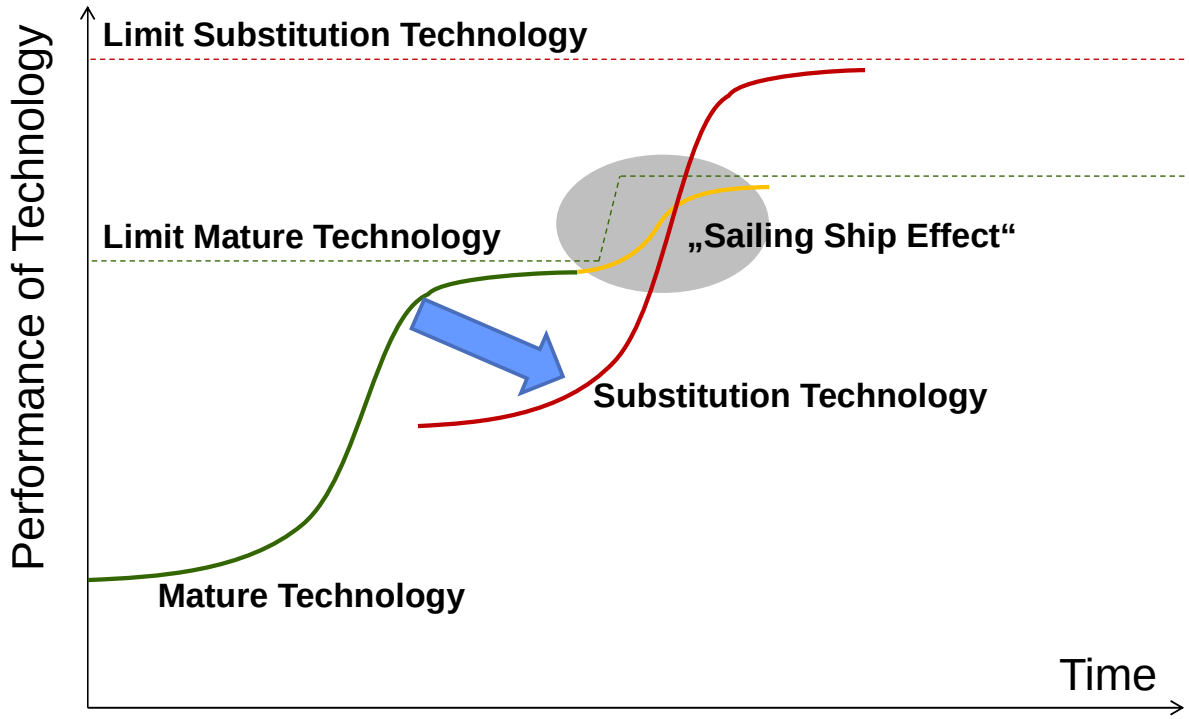

Figure 3-17: "Sailing ship effect" (Source: Bernd X. Weis)

The "sailing ship effect" often supports the arguments to stick to an outdated technology – the technology is known and mastered, and one always discovers further development potential.

3.3 Innovation: Tools

Below some questionnaires are listed that support the analysis around an innovation project.

3.3.1 Around an innovation project: Questionnaires

Goal and impact of innovation (Table 3-4)

	Assessment				
Competition, demand, and markets	relevant		partially relevant		not relevant
Replace products, which became obsolete					
Enlarge scope of applications					
Increase market share					
Enter into new markets					
Improve response time to customer needs					
Improve visibility or presentation of products					
Develop environmentally friendly products					
Production and supply	relevant		partially relevant		not relevant
Improve quality					
Improve flexibility					
Increase capacity					
Reduce unit labor costs					
Reduce resources consumption					
Reduce design costs					
Reduce set-up times					
Reducing operating costs					
Catch up with industry standards					
Increase delivery efficiency and times					
Improve use of IT					
Organization	relevant		partially relevant		not relevant
Improve communication and collaboration within the organization					
Increase of exchange of knowledge and experience with other organizations					
Increase the adaptability to different customer needs					
Develop stronger customer relationships					
Improve working conditions					

Other	relevant		partially relevant		not relevant
Minimize impact on health and environment					
Increase safety and security					
Comply with regulatory requirements					

Table 3-4: Goal and impact of innovation

Reasons that hinder or prevent innovation (Table 3-5)

	Assessment				
Expenditures	relevant		partially relevant		not relevant
Costs too high					
To large perceived risk					
Insufficient internal funds					
Insufficient external agents such as venture capital, public funds					
Know-how	relevant		partially relevant		not relevant
Inadequate potential for innovation (R & D, design, etc.)					
Not enough qualified staff in the organization and the labor market					
Inadequate knowledge of the technologies					
Inadequate knowledge of the markets					
Inadequate availability of external services					
Difficulties in finding suitable partners for product or process development					
Marketing	relevant		partially relevant		not relevant
Organizational barriers within the organization					
Staff attitude to changes					
Management's attitude towards change					
Management structure of the organization					
Inadequate staffing of innovation activities					
Markets	relevant		partially relevant		not relevant
Uncertainties in demand for innovative products					
Dominance of the "top dogs" in the potential markets					

Institutional factors	relevant		partially relevant		not relevant
Lack of appropriate infrastructure					
Legislation, regulations, standards, taxation					
Legal uncertainties					
Other reasons	relevant		partially relevant		not relevant
No need for innovation					

Table 3-5: Reasons that hinder or prevent innovation

Open or closed innovation

Table 3-6 summarizes the major principles of closed and open innovation. The answers to the statements may be different from innovation project to innovation project. Depending on the type of innovation sometimes, it is more appropriate to pursue it in a closed context; sometimes it is better to pursue it in an open context.

Principles of closed innovation						**Principles of open innovation**
We are the real experts in the field.						Not all specialists in the field to work with us. We must work together with other specialists.
We need the entire value creation chain under our control.						Others can contribute significantly to value creation. However, we must ensure our contribution.
We are faster to market with our own inventions.						We do not need to invent everything ourselves in order to benefit from it.
We need to invent the best inventions in our industry ourselves.						We optimize the benefits of our own, as well as of external inventions.
We need control of our intellectual property.						We sell licenses of our own intellectual property, and we buy licenses of intellectual property of others.

Table 3-6: Open or closed innovation

3.3.2 Key indicators of innovativeness

Table 3-7 presents the key indicators of innovativeness.

Income	
Total Sales Sales(period) = Sales Market Novelties(period) + Sales Generic Products(period) + Sales Standard Products(period)	
New or significantly improved products that have been introduced during the observation period which were new in the market $\frac{\text{Sales of Market Novelties(period)}}{\text{Total Sales(period)}}$	
New or significantly improved products that have been introduced during the observation period which were new for the company, but not new for the market (generic products) $\frac{\text{Sales of Generic Products(period)}}{\text{Total Sales(period)}}$	
Standard products, which were not or only marginally changed during the observation period $\frac{\text{Sales of Standard Products(period)}}{\text{Total Sales(period)}}$	
Sales that result from marketing innovation projects to total sales $\frac{\text{Sales Resulting from Marketing Innovation(period)}}{\text{Total Sales(period)}}$	
Sales that result from business model innovation projects to total sales $\frac{\text{Sales Resulting from Business Model Innovation(period)}}{\text{Total Sales(period)}}$	
Profits	
Cost savings through process innovation projects to total sales $\frac{\text{Savings through process innovations(period)}}{\text{Total Sales(period)}}$	
Cost savings through other innovation projects (marketing, organizational and business model innovation) to total sales $\frac{\text{Savings through other innovation projects(period)}}{\text{Total Sales(period)}}$	

Expenditures	
Research and development expenses (product and process innovations) to total sales $\frac{\text{R\&D Expenditures(period)}}{\text{Total Sales(period)}}$	
Expenses of other innovation projects (marketing, organizational and business model innovation) to total sales $\frac{\text{Expenditures of Other Innovation Projects(period)}}{\text{Total Sales(period)}}$	
Number of closed innovation projects to total number of innovation projects, $\frac{\text{Closed Innovation Projects(period)}}{\text{All Innovation Projects(period)}}$	
Financing closed innovation projects	
Own resources (equity) $\frac{\text{Own Resources(period)}}{\text{Total Funding(period)}}$	
External funds (venture capital, loans) $\frac{\text{External Funding(period)}}{\text{Total Funding(period)}}$	
Public funding (national Projects, EU Projects etc.) $\frac{\text{Public Funding(period)}}{\text{Total Funding(period)}}$	
Number of open innovation projects to total number of innovation projects, $\frac{\text{Open Innovation Projects(period)}}{\text{All Innovation Projects(period)}}$	
Financing open innovation projects	
Own resources (equity) $\frac{\text{Own Resources(period)}}{\text{Total Funding(period)}}$	
External funds (venture capital, loans) $\frac{\text{External Funding(period)}}{\text{Total Funding(period)}}$	
Public funds (national Projects, EU Projects etc.) $\frac{\text{Public Funding(period)}}{\text{Total Funding(period)}}$	
Safeguarding	
Number of confidentiality agreements	
Number of patent and utility model applications	
Number of granted patents and utility models	
Structure	
Number of R&D employees to total workforce in percent	

Table 3-7: Key indicators of innovativeness

3.3.3 Innovation Platforms

A number of platforms rely on so-called crowd sourcing. The following describes two of them as examples.

Quirky (www.quirky.com) brings ideas to life

The company Quirky specializes in the successful implementation of product ideas. For a fee of $ 10 a product idea can online be registered (as of September 2011), and for a successful idea one receives a certain proportion of global sales revenues. The target price of the product should be less than 150 U.S. dollars.

The Quirky community (65,000 members and rapidly growing) is evaluating the idea. They vote on whether they would buy the product later, and if so, at what price. This feedback further completes all the other market research results available. Then Quirky decides whether to pursue the product idea. In each further process step the community is decisively involved; so-called "influencers" contribute to the emerging product with their own ideas and proposals e.g. for a name, a logo, proposals for industrial design.

At its own risk and on its own account Quirky evaluates the idea, calculates production costs, sets a competitive selling price, seeks and finds a suitable manufacturer, evaluates the distribution channels and develops and sets up the supply chain. In return, Quirky reserves 70 percent of sales revenues through its own Quirky shopping portal, 90 percent of sales revenues for sales through retail partners, and eventually the creator of the idea and the influencers split the remains between themselves.

The involvement of the community through social media in the exploratory phase of a product decision saves money and protects against many erroneous decisions.

InnoCentive (www.innocentive.com) teams up the ones that have a task and the ones that solve the task

InnoCentive is a challenge-driven organization. A challenge is a well-formulated task whose solution has a value for an organization. It can be formulated both as a vague question to stimulate new ideas, and as one that requires higher accuracy of the solution, e.g. physical characteristics of materials. By definition, a challenge is specific, detailed and executable. In a stringent process, a challenge is formulated, prioritized and published on the platform. The results are tracked, evaluated and rewarded. The protection of intellectual property is an essential component of the process.

The InnoCentive Challenge Platform (ICCP) is the first innovation management system for businesses. It enables organizations to solve the most important challenges by quickly and easily involving various internal and external innovation communities. The platform is the focal point for open innovation that allows commercial, public and non-profit organizations to find easy access to the right people, communities and networks. Thus, new ideas are created, major problems solved and innovations created faster, more economical and with less risk.

3.4 Innovation: Summary

Forecasts of future customer behavior and market development often avail the perpetuation of past and present experience. However, it is impossible to conclude with certainty from in the past experienced or observed events that these events will occur in the future. The only conclusion to be drawn is that these events are likely to occur. The occurrence of actually improbable events (BLACK SWANS) can alter structures sustainably. These events do not follow a plan, but more or less just happen by chance, until they occur they might even have been unknown.

Probability theory allows supporting hypotheses with corresponding empirical observations. However, the results are just probabilities and thus uncertainties remain.

People assess uncertainties heuristically, where various distortions cause a sometimes incorrect assessment. People use three very simple heuristics to make assumptions about the relevant environment: availability, representativeness and anchoring. These heuristics often lead to false conclusions.

An idea must first be elaborated to enable a new product, a new service or a new process (invention). If this invention is then applied successfully (diffusion) – be it in products, services or business processes – then this idea becomes an innovation: **Idea + Invention + Diffusion = Innovation**. Thus, an idea, an invention becomes an innovation when it is successfully placed in the market.

The OECD distinguishes four types of innovation according to content: product, process, marketing and organizational innovations. In addition, today business model innovations are important.

Closed and open innovation are distinguished according to how innovations are created. Closed innovations are created in the organization under its control, open innovation are developed in collaboration with partners.

The impact of innovations distinguishes on the one hand incremental, continuous, sustainable and on the other ground-breaking, revolutionary, disruptive innovations. Sustainable innovations satisfy a customer need better than it has been before, and are advanced developments of existing products. Disruptive innovations satisfy a customer need differently than in the past or a customer need, which has hitherto been present only latently.