Technolife 2035

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How Will Technology Change Our Future?

By

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Dedicated to our wonderful herd.

CONTENTS

DEAR READER

Congratulations. You have just opened a book that stands the test of time very well. However, the book functions differently in different times, but this is what makes the book so versatile. When the book comes to the market in 2015, reading the book may raise confusion and interest among the readers. This is due to the wild technologies that are being developed in laboratories and corporate research centres. That's what this book is about. The book also describes different futures in 2035—in twenty years—by retelling the famous Renaissance story, William Shakespeare's *Romeo and Juliet*. These may also cause amazement, annoyance and even some awe. Is that the kind of future we will live in?

If you, Dear Reader, will keep this book somewhere at the bottom of your drawer for the next twenty years, it will open up to you in a completely different way—and not only because books will then be in electronic form, or because the book has been written by two humans instead of an algorithm. We promise that reading the book will most likely provoke bursts of laughter: how silly were they back then—how could they not predict this or that? And what kind of a view is that? It never happened! Ha!

Exactly—predicting is impossible. We do not have—anymore than the reader—a crystal ball that would paint a clear picture of where technology will take us in twenty years. "He who predicts the future is lying, even when he is right," an old proverb says. We admit our limits in terms of being able to tell you what will happen in twenty years in terms of technological development (or life in general—technology is only a part of a larger whole).

Then why did you write this book, a clever reader may ask. The answer is ambiguous. We writers hoped that this book would raise discussion about what technology can bring with it—both the good and bad. Like a coin, technology always has two sides. A new technology can solve a difficult problem in our society, but it may cause a bunch of new problems in the future (that another even newer technology aims to solve). The advantages and disadvantages of new technology are worthy of careful consideration. We always need discussion and creative visions for what technology can

bring with it. New technologies do not develop in a vacuum, but there are forces and counter forces related to their emergence. Often political decisions accelerate the progress of an area of technological development (for example, car emission taxes have made low-emission cars more popular). Also consumer attitudes have an impact on the adoption of technology.

The purpose of this book is also to provide an extensive analysis regarding new innovations that are being developed in different areas of technology. These current innovations may be the same ones that have a significant impact on our lives in the future, in 2035. Due to the extensive subject matter, we must warn the reader that we could not deal with all the interesting areas and research in technology within the scope of this book. The technologies that we have selected as a part of this book have been selected based on the writers' interests, background material and their potential social significance. We wish to apologize in advance if the reader feels like an important subject area has been excluded from the book.

There are also a few personal reasons that have led to writing this book. The two Finnish writers of this book are technology enthusiasts; Elina has a master's degree in technology and Kari has a PhD in technology. We have both been through years of education in the former Helsinki University of Technology, the current Aalto University School of Chemical Technology—one of us for a bit longer than the other.[1] We have both conducted research in the field of bioplastics. In research work, the development of technology can be seen on a practical level, and we have also encountered issues—stumbling blocks of development—that a layman may not have access to. Both of us have also worked for the technology company Nokia—one for longer than the other. In addition to the development of technology, we have also accumulated views regarding production, commercialization, acquisition, and preparation of technology strategy. We wish to share these experiences that we have accumulated over the years, as well as our views.

We are extremely interested in new technology and the possibilities it brings. We are also avid science fiction fans, and this book is an excellent opportunity for us to produce literature in this genre in small doses. Science fiction is an art form that also steers the development of science. Technological innovations that only appeared in science fiction at first—

[1] Indeed, this is where the writers met for the first time. And yes, they are still a couple (Kari is the husband and Elina the wife), even after this writing process.

such as Jules Verne's submarine—have inspired engineers. "Go and see the Harry Potter movies—you'll get some inspiration," a product manager of a technology company once told his employees.

In the third part of this book, we provide some views on how new technology might influence people's everyday lives in twenty years—in the form of a science fiction story. As we mentioned earlier, the future will be examined through the old love story of Romeo and Juliet. Now they live in worlds where technology has either (1) failed, (2) developed as expected or (3) developed faster than expected. We admit that it may be foolhardy to combine a romantic story with a technology book. We made this choice so that the reader, if they dare to embrace the love story, can also activate the right side of their brain. Most of this book mainly concerns the left side of the brain.

The reader may also be interested in how a technology book such as this one is born. The book was born in a very similar way to most technology forecasts. In practice, the writers reviewed hundreds of different magazine articles and online links. Similarly, reading different books related to the topic, watching documentaries and interviews with experts were an essential part of the writing process for this book. The forecasts have therefore been constructed by reviewing extensive amounts of material, and with the help of imagination (and, in this case, large amounts of caffeinated drinks).

As is the case with any other major work, this book could not have been written without the help and support of different parties. We would like to thank Sam Baker from Cambridge Scholars Publishing for being open to our idea for the book. We would also like to thank science journalist Marko Hamilo for reviewing and commenting on the script, and Marja-Liisa Helenius and Rebecca Mills for translating the book. We are also extremely grateful to the many people who agreed to be interviewed by the writers and to share their valuable insights. We would like to thank:

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We also wish to thank Heimo and Liisa, who have done a wonderful job taking care of the writers' little herd. Most of all, the writers would like to thank the most important people in their lives: their children.

By a frozen lake, surrounded by silent nature, in our little summer cottage in Eastern Finland,

Elina and Kari Hiltunen

Note: This book was published in Finnish in February 2014 by Talentum. The name of the book in Finnish is *Teknoelämää 2035: Miten teknologia muuttaa tulevaisuuttamme?* This book is an updated and revised version of the Finnish book.

FOREWORD

A lot has happened in technology since Gutenberg invented the printing press in 1436. A lot has also happened since the beginning of the 1970s, when the writers of this book were still in primary school.

The changes that technology has brought about in our everyday lives since the 1970s—over the last forty-odd years—has been astonishing. Let's look at a few examples. School children from the seventies have a memory of a stack of warm handouts fresh from the photocopier. Back then, copy machines used rubbing alcohol, which meant that the first handouts in the pile were smudgy from the ink, but in the last copies, the text was barely visible.

If we, the writers, compare our own schooldays to those of our own parents and the generations that preceded them, we already see progress. When our parents were kids, no one had even heard of copy machines; they used notebooks, and their parents used slates and slate pencils.

In schools today, new technology is represented by a different sort of notebook—tablet computers that have already been adopted as personal digital boards for each pupil in some more progressive schools. School books are starting to be produced in electronic form, and each teacher can shape the content of the book however they wish. Actually in many cases, school books are more applications or games that allow the kids to learn in an enjoyable way.

What about communication technology? In the seventies, telephone tables were a fixture in the hallways of households; now they're entirely futile pieces of furniture. Back then, this table served as an altar to communication, holding a plastic box with a round rotary dial. Finnish families usually had an Ericsson model, which was owned by the local telephone company. No one had even heard of wireless technology. The cable for the device was twisted like a corkscrew, and always tangled, which significantly reduced its operating range. If you wanted to reach someone by phone, that person had to be near a telephone with a certain number. If the person was not there and the matter was urgent, in the worst emergencies they could be sought via radio.

When on the move outside the home or office, it was best to have a pocketful of coins for the phone booths on the street. As time passed, pre-paid phone or credit cards replaced coins. Telephone booths with these public phones were made of glass, were often victims of vandalism, and often smelled of urine. There was a thick catalogue next to the telephone where you could look up numbers, even though at the time people usually memorized their most important numbers—back then, memory was located between the ears.

In the 1990s, mobile phones began to proliferate appeared. At first, they were the crown jewels of business people, and no wonder, as they cost quite a lot. In the beginning they were clumsy, heavy, and expensive; the reception was weak, and battery life non-existent. Nevertheless, they were carried or, rather, dragged from one place to the next.

Technology evolved. Prices decreased year by year. The size of mobile phones became more convenient, and their properties more versatile. Mobile phones became everyday devices for every Jack and Jill. Landline phones started to disappear from people's houses and the number of public telephones diminished. In 2014, mobile phones—or smartphones—are an extension of every person's personality. They mean more than a landline phone ever did, or could.

The most important task of mobile phones is no longer making phone calls—they contain a person's life, in terms of technology. They contain a calendar, phonebook, entertainment, TV, e-mail, camera, health applications such as a pulse meter, a comprehensive encyclopaedia—i.e. the internet. Even school kids get their own mobile phones so that their parents can keep in contact with them. When the writers were young, children would walk their own paths, and parents had little knowledge of where they were. Nowadays, parents can use information technology to pinpoint their child's whereabouts in an emergency.

Technology evolves, usually slowly and insidiously—but always just as surely. Things that are now being developed in laboratories will be in our midst as different products and applications perhaps as soon as in a few years' time, and as more refined versions in ten years' time.

However, not all new inventions enter our everyday lives. Some perish, perhaps in the impossibility of business operations or through the stringency of legislation. Sometimes humankind is not ready to receive a

new technology, for one reason or another, and postpones its arrival to the last moment. On the other hand, a crisis situation may further the development of a certain technology by giant leaps.

This book deals with the future of technology and how new technologies may influence our lives within the next twenty years. The book has been divided into three parts. In the first part, we go into technological development and the forces and counter-forces related to it. We also review how to forecast technology, what kinds of parties make these forecasts and what kind of forecasts have been made for the following decades. The second part of the book reviews different areas of technology and trends related to them. We will review current studies which may have concrete results in our lives in a few decades, for example in the fields of energy, biotechnology, materials and robotics.

The third part of the book introduces the writers' visions of how technology may develop by 2035. In the third part, we present three different scenarios, or future worlds. These will demonstrate where technological development can take us. The scenarios are introduced through two main characters, Romeo and Juliet. Even though the technology around us changes, the writers believe that even years into the future, the significance of human relations will remain the greatest influence on our lives.

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PART 1:

ABOUT FORECASTING TECHNOLOGY

HOW DO WE DEFINE TECHNOLOGY AND ITS DEVELOPMENT?

The mobile phone, the car, the computer: these are perhaps the first things that come to mind when talking about modern technology. The concept itself is, however, quite wide. These products are, of course, today's technology, but the term has a much wider significance.

In addition to objects, technology encompasses the methods and processes used to manufacture or process different products and things (such as energy). Advanced technology is often hidden from people, or we become blind to the properties that make our lives easier and less complicated. Technology keeps our houses warm and fills our pipes with clean water. We move from one place to another with the help of technology, whether it be by car, bicycle or sneakers. We wrap our offspring in high-tech products—diapers—which are, in fact, a miracle of material development, involving many patents.

And how many readers consider traffic lights to be high technology? Because they are; they're built of different sensors and microchips, and they know how to grant buses right of way, for example.[2] Technology has spread into different areas of life in our society, closely and permanently. We can presume that in the future it will be even more tightly knit into our lives.

When we talk about technology as a concept, it is interesting to check how the word has been defined in different contexts. Let's start with the dictionary: The Oxford English dictionary defines technology simply as "applying information to practical purposes—especially in the industrial field."[3] Brian Arthur, who works at the Santa Fe Institute, presents three definitions for technology in his book *The Nature of Technology*:

1) It is a a means to fullfill a human purpose. As a means, technology may be a method or process or device: a particular speech recognition algorithm, or a filtration process in chemical engineering, or a diesel engine.

2) It is also as an assemblage of practices and components. This covers technologies such as electronics or biotechnology that are collections or toolboxes of individual technologies and practises.
3) It is also as the entire collection of devices and engineering practices available to a culture.[4]

With the help of Arthur's definition, we see that technology encompasses individual devices and processes (car, injection moulding), wider research areas (electronics, biotechnology), and a cultural perspective on technology. In this book, we attach nearly the same meanings to technology as Brian Arthur.

The subject matter of this book examines different perspectives and theories regarding how technology usually develops and the interesting issues that are related to this development. The development of technology happens in at least a few dimensions. *First*, technologies themselves develop, or—more precisely—are developed. For example, the first cars ran on steam and electricity, and then the combustion engine was developed in order to increase the functional range of the vehicle. The famous Ford Model T, from the beginning of the 20th century, could be driven at a maximum speed of 70 km per hour. The modern car is significantly more efficient than its older brother from the early twentieth century.[5, 6]

Technological innovations, whether they are radical new solutions or improvements to old technology, are born in laboratories, universities, research institutions, corporate research centres, or inside the heads of individual inventors. The development of technology is often related to exploiting and combining already existing technologies (technology products, units, materials, processes) in new ways.

Brian Arthur connects the concept of "combinatory evolution" with the development of technology. This daunting term contains the idea that new technologies are born from the combination of already existing technologies.[7] In practice, old technology is combined in laboratories in new ways, and this produces new solutions. This is the basic principle behind research work.

According to Brian Arthur, the evolution of technology is also based on another element: capturing new natural phenomena and harnessing them for different tasks. For example, reflecting electro-magnetic waves and nuclear magnetic resonance form the basis of radar and magnetic scans

(MRI).[8] If we refer to the previously mentioned combinatory evolution as applied research, we can describe the explaining of natural phenomena as basic research. Basic research aims to solve different mysteries in the natural sciences, based on the assumption that when you can understand natural activities in more depth, natural phenomena can be used in different applications.

In the eyes of a layman, the hunt for the Higgs particle may seem very abstract and useless (and extremely expensive), but the benefits of finding the particle may become more concrete after several years or decades, via innovations or series of innovations. This has happened, for example, with the understanding of quantum physics that has accumulated since the 1930s. Understanding this phenomenon has enabled the creation of the transistor, the laser and the entire digital revolution.[9, 10]

Second, the development of technology is also connected to how a certain technological innovation is adopted in our society. There are different views (theories) on how a technology or technological innovation becomes a part of our every-day lives. These are, for example, theories such as the adoption of innovation, the taming of technology, or path-dependency. All these different theories or views examine the integration of technology into our society from slightly different perspectives.

One perspective on the integration of technology is related to the "diffusion of innovation theory," developed in 1957. According to this theory, different people have their own roles in the adoption of innovation into society. The theory was presented in 1957 by researchers Bohlen and Beal, who examined how farmers adopt new technical innovations. The researchers discovered that people have different ways of dealing with novelties. A small percentage of people adopt novelties easily; they are called innovators. Early adopters follow the innovators, and are the next ones to adopt and innovate. The early majority is the next group. As time passes, the novelty is adopted by the majority. However, there are always those who refuse to adopt novelties at all.

Phases for becoming familiar with novelties are often connected with the diffusion of innovation theory. At first, a person becomes aware of the new technology (*awareness*). After this, he or she perhaps becomes interested in the novelty (*interest*), and starts looking for more information about the matter. In the evaluation phase (*evaluation*), the person evaluates the functionality of the novelty and its suitability to him/herself personally, and decides whether to try the novelty. In the trial phase (*trial*), the person

acquires the product and tests it on a small scale. Based on this, the person finally decides whether to permanently start using the product or not (*adoption*).[11, 12] From the point of view of a technology anticipator, the innovators and early adopters are the ones to follow. These groups can often be distinguished because they have "gone crazy" over some technological innovation.

The Finnish consumer researcher and futurist Mika Pantzar talks about "taming technology" when he describes how we adopt new devices into our daily lives. In taming technology, the use of a technological innovation changes its nature in the course of time. At first, the new technology product may be a toy-like, exciting object. In time, this toy or ego-booster perhaps becomes an essential part of our daily lives. This has happened to many familiar devices. For example, at the beginning of the twentieth century, the telephone was considered a miraculous device, and in the 1950s it became an everyday object—and these days the telephone is a necessary commodity, at the very least.[13]

When the development of the telephone was in its first phases, it was intended for a different use than what we are now used to. The telephone was planned as a more or less official information channel conveying, for example, the news—therefore, in modern language, it was intended to work like the radio. In North America, there were at first attempts to restrict the use of the phone so that it would not be used in the "wrong" way. Women in particular were considered to use the phone inappropriately for gossiping, and this was seen as a great risk to the device's more "noble" purpose, writes Pantzar.[14]

According to Pantzar, new technological commodities are often rejected in the beginning—even feared. The radio was at first seen as a dangerous device because "it had so much electricity"; people in the United States were afraid that television would weaken the quality of housewives' work; it was feared that the video would turn young people into "vidiots." In the beginning, there was a man waving a red flag running in front of cars, so that this dangerous machine would not go unnoticed among the public.[15]

This fear of new technology has not abated. The potential threats of nanotechnology and genetic modification are discussed in 2015. New technologies have been known to cause fits of anger throughout history: an industrial spinning machine, the Spinning Jenny, developed in 1767, caused enough resistance among the spinning profession that it was sabotaged.[16] Now genetically modified crops, for example, have replaced

the Spinning Jenny as an object of techno-fear, and activists resisting GMO have destroyed plenty of crops in the process.[17]

Path-dependency theory deals with how some technologies prevail in the market and others—perhaps better ones—do not. The theory centres around the idea that with a group of solutions—or even coincidences—that seem insignificant, we lock ourselves into a certain path that we follow, even when it is not the most sensible one. According to path-dependency theory, moving from one path to another results in great costs and can lead to locking into worse technological solutions; at the very least, switching to another path can be slow and expensive. In particular, if the technological system connects many parts (such as rails and train carriages, cars and gas stations), changing to another technology or standard is slow.

An example often mentioned by path-dependency theorists is the battle between the QWERTY and Dvorak keyboard standards. The QWERTY keyboard was originally developed for a typewriter because when typing quickly, the key stems often got jammed. The purpose of the QWERTY keyboard was to slow down typing to avoid this problem. Nowadays we use the QWERTY keyboard with computers, even though there is no problem with key stems getting jammed. Dvorak was another competing keyboard arrangement, which is said to be more efficient than QWERTY (but, on the other hand, there are differing opinions regarding Dvorak). However, this keyboard did not prevail, because QWERTY had already been taken widely into use.[18]

The concepts *increasing returns* and *networking effect* are also important to path-dependency theory. The networking effect refers to cases where the adopted technology becomes more useful for the individual the more people adopt the technology. The telephone again serves as an example. The buyer of the first telephone did not have much use for the device, but the more people acquired this novelty, the more useful it became to own one. At least there were people to call. The same phenomenon can be seen with e-mail, Twitter and Facebook, to name a few.

On the other hand, the networking effect also functions as a counter-force to the spreading of a particular technology: when the number of users becomes too vast (e.g. traffic, use of the internet), too much networking has negative effects on the users (traffic jam, slow internet connections). In the long run, the networking effect may cause locking into a particular

technological solution, which has happened in the case of the QWERTY keyboard, and somehow also with Microsoft products.[19]

Increasing returns, however, refers to the fact that the more a product is used and bought, the greater the numbers that are produced, and this, in turn, lowers the expenses. When the product becomes less expensive, the number of users increases further, which leads to locking into the technology.[20]

THE FORCES AND COUNTER-FORCES OF TECHNOLOGICAL DEVELOPMENT

Technological development is very rarely, if ever, fast. New technologies are not born overnight. Rather, the development is evolutionary, time-consuming and gradual. New technologies that are currently being developed in laboratories will come to the market after many years or decades, if at all. During this time, the technologies and the products made from them will change quite a lot from the first versions; they are developed to be more suitable for production, more efficient and lower in cost, as well as compliant with legislation and standardization. Consumers themselves also shape technology and its use.

For a technology forecaster, it is tempting to examine these technological novelties developed in the laboratories today and scale them according to the use of future consumers. When, for example, a brain-computer interface is being developed in a laboratory, we can assume that perhaps in twenty years time, it will be in general use by consumers. If its development advances quickly and the technology is universally approved, perhaps cars will also be steered by the power of thought, and teachers' lessons smoothly transferred into students' minds. Nintendo's *nunchucks* will be in technology museums next to *joysticks*: all you'll need is to pull a device over your head when you want to play, and it will read the electrical signals in your brain and obey the gamer's thoughts. (In fact, there are already such devices on the market.)

However, technology does not develop in a vacuum: it is a dialogue with many factors, such as societal norms, consumer attitudes, the market, legislation and politics. All of these factors determine which technology catches on and how and to what extent it spreads into our society. We have divided the factors influencing the development of technology into the three subject areas of the market, technology, and society, and then in addition to these, chance can affect the spread of technology.

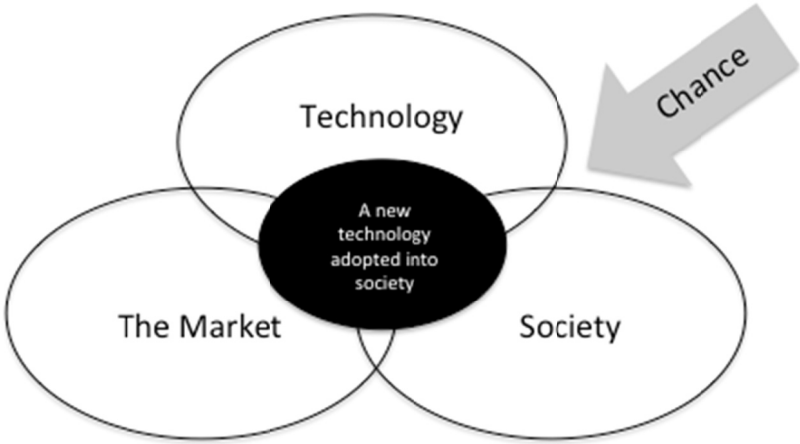

Figure 1. Subject areas affecting the development and spreading of a technological novelty

In the following sections, factors related to different subject areas are reviewed—factors hindering or accelerating the development of technology (development here being defined as developing technology as well as adopting technology in our society). Classifying factors into these three different subject areas is not always simple, as many forces are related to several areas, but here we have classified one transformative force under a single subject, even if it belongs under several. Similarly, a force affecting the adoption of technology may simultaneously both advance the development and adoption of the technology and slow it down. One example of this is the patent process.

The market

"Money talks, and bullshit walks" declares the coarse proverb, which refers to the idea that money is what eventually makes things happen. In terms of the development of technology, money—or, phrased more eloquently, market factors—have a great impact on what technology becomes predominant in our society and which developments we invest in. Market factors that advance the arrival of some technology into our society, include for example new market needs (*market pull*), consumer choices, values and attitudes, standardization, and rich supporters. Market forces that, on the other hand, slow down the adoption or development of

some technology include standardization, the wrong time for entering the market, lack of money, high price, and low demand in the market place.[21]

New market needs may be related to changes in people's courses of action, changes in consumer attitudes and values, or problems related to the use of existing products. Market needs can be discovered through market surveys, for instance. New products based on market needs include the digital camera. There were many different problems related to the old-fashioned film camera: loading the film was difficult, there was a limited number of pictures that would fit on a film, it was not possible to see whether the shot was a good one when taking the picture, developing the film took time and the film had to be taken to a photo processing shop before you could see the pictures. Taking photos was an expensive business, especially if you had a sensitive trigger finger. These consumer problems were solved with a new innovation: the digital camera.[22]

When new technological innovations come to the market, this awakens new needs in the consumers. For example, when the iPhone and iPod came to the market, music became more digitalized than ever. In order to be able to listen to music better, a completely new product category entered the market: speakers with a small attachable digital device, which often also charges these players.

Sudden crises may also awaken market demand; for example, when swine flu started to spread globally, pharmaceutical companies quickly developed a vaccine that could vaccinate a large number of people. A company that profited from the influenza was pharmaceutical company Glaxo-SmithKline, which sold hundreds of millions of doses of its vaccine during the outbreak.[23]

Consumer values and attitudes strongly guide the selection of technology products. Lately the emphasis has been on the environmental values of consumers, which has lead to companies having a moral duty to guide their product development in a more environmentally friendly direction. For example, electricity companies offer "eco electricity" and "green electricity," which has been produced with wind energy. Similarly, the development of cars is no longer determined by increasing power but reducing emissions and fuel consumption, although there are other factors that have lead to this, such as taxes and rising oil prices.

There are also certain deeper consumer preferences related to the proliferation of a certain technology product, such as the product brand, image, ease of use, price, design, compatibilities with other products and further services (business ecosystem). Recently, it has become possible to monitor changes in consumer preferences in the mobile phone and tablet market. In recent years, a clear "mental" forerunner in smartphones and tablets has been Apple. The insight of Apple's first iPhone,[24] which entered the market in 2007, was the ease of use and clear design. It struck a chord with consumers, who were ready to pay significantly more for this cool product in comparison with competing products. When Apple in 2010 launched its first tablet computer, the iPad, the company's reputation as an innovator was secured, and there was even a queue for the products.[25, 26] Competitors quickly followed the new market need Apple had created with their own tablets.

The AppStore, provided as an additional service to the mobile and iPad, gave Apple a great advantage over its competitors. The store offered thousands of programs developed by consumers and approved by Apple, which could be downloaded to diversify the properties of the iPhone and iPad at a very low cost. Similarly, Apple's innovative iTunes, which provides content such as music and movies in an easy (and legal) manner for a low cost, advanced the hype of Apple products in the market.

Apple formed a certain business ecosystem connected with mobile electronics, and its competitors have now tried to acquire it for their own operations. (A business ecosystem refers to a network connected to a product or service, which includes agents in different fields, consumers, competitors, distributers, state administration personnel etc).[27] On the other hand, Apple's place in the hearts of many consumers is not guaranteed in the future, as lately other companies, such as Samsung, LG and HTC, have excelled in the smartphone business in particular.

As we already mentioned, consumer preferences change constantly. Something that can also be seen as a market force, supporting the development of a certain technology, is the enthusiasm of wealthy forerunners. These people are not only interested in a particular field or innovation but they also see vast market potential in it—even if it may not be possible to profit from it for a long time. However, these people's funds and ability to draw in enthusiastic people and financiers usually ensure that the technological development they prefer takes a leap forward.

Examples of such technology investors include Elon Musk and Richard Branson. Elon Musk established the PayPal service some time ago. After selling the service to eBay in 2002, Musk received a stack of money that he has invested in space technology (SpaceX), electric cars (Tesla), solar power (SolarCity) and, his latest frenzy, ultra-fast tube trains (Hyperloop)[28, 29].

Millionaire and adventurer Richard Branson, the owner of multi-trajectory company Virgin, is also interested in conquering space. He has been involved in building the first space airport and his goal for the future is that the Virgin company would offer tourist trips into space.[30, 31] It is not always necessary for a celebrity to invest funds in order to advance the adoption of a technology. When the talk show star Oprah Winfrey started using the Twitter service in 2009, the number of Twitter users and messages increased dramatically.[32]

Not all research projects awaken the interest of investors. If there are no investors for the research, it does not advance. Fortunately, thanks to social media, we now live in a very democratic world in terms of technology funding. New crowdfunding services, such as kickstarter.com, banktothefuture.com, indiegogo.com, and crowdfunder.com offer opportunities for those whose technology ideas are not backed up by the likes of Musk or Branson. With crowdfunding, interesting small projects are able to fund their research and, at the same time, obtain a ready customer base through their funders. This is market economy at its best.[33]

Development is also driven by different technology prizes, such as competitions organized by XPrize, where the team or company that first reaches a specific technology goal wins a big stack of money. Competitions going on in the fall of 2014 include, for example, the Lunar XPrize sponsored by Google, which will be won by the team that succeeds in landing their own robot on the surface of the moon, moving 500 meters and sending recorded video from the surface.[34] The winners will receive 30 million US dollars. Another ongoing competition is the Qualcomm Tricorder XPrize, which awards a sum of money to teams who are able to produce a light health analyser, which can be used for mobile analysis of state of health.[35]

Other positive market forces advancing the development of technology include standardization. The problem with new technology products may be that each agency brings their own products to the market. This leads to the effect that the products and their plug-ins and accessories are not compatible with competing brands. Standardization aims to establish

common “game rules” for the products of different parties, setting a standard for characteristics, quality, safety, and compatibility that is agreed by different parties in the field. The standards can be commercially set, or the law may require the implementation of certain safety standards, for example.

It is difficult to imagine that our technologized world would operate without these standards. They determine the magnitude of the mains current, the shape of the plug and the socket, the sizes of the bases of light bulbs, the thickness of a screw and the shape of its base, the diameter for gasoline pumps (and the gasoline pump access hole in cars), the width of rails, the tyre size for cars and bicycles, the shape of the USB plug, and so forth.[36]

There are both positive and negative aspects to patenting, in terms of competition and development. Patent documents are public and they provide valuable information for competitors about how certain things work. Patenting drives development forward by disseminating information regarding the innovation. One of the aims of competing companies is to produce similar technology with methods that work around the existing patent. At the same time, it is of course possible to aim to develop a cheaper, more efficient and ecological alternative for the patented technology. If the company’s own alternative technology cannot be developed for some reason, it is always possible to turn to the owner of the patent and try to make a licence agreement that enables the use of the patented technology, in return for compensation.

Patents therefore fit under market forces that advance development by making research information open and accessible. On the other hand, they also slow down development. Patents are generally considered to protect a technical innovation that a company uses in their product. In practice this is what happens, but patenting is also carried out for strategic reasons. According to one technology leader, patents are used to build a strategic mine field. The intention is to prevent competitors from using a specific technology, even though the patentee him/herself would have no use for it.

Currently, a discussion is going on regarding what can be patented. Recently, the patenting of genetic material has been brought to public attention. In the summer of 2013, the US government prohibited the patenting of human genetic material. The discussions were being held because a company had wanted to patent the breast cancer gene BRCA that they had discovered.[37]

Therefore, patenting has its pros and cons in terms of technological development. Many other factors that advance the development of technology also have their downsides. Standardization advances progress, but can also, in the worst case scenario, hinder or slow it down. When selecting a standard, it is not necessarily the best technology that is selected; there is often a negotiation where different parties present their views regarding good technological practices. Something is selected as the standard, and the selection depends on many factors such as the skills of the negotiators, affordable price, execution potential and licence agreements. Path-dependency theory addresses the negative effects of standardization. When a standard has been selected, moving to another, perhaps better standard is often slow and expensive.

The development and adoption of technology can also be prevented by (usually secret and illegal) agreements between companies operating in the market. For example, some pharmaceutical companies were caught in Europe collaborating on quotas for manufacturing different products, and even destroying medication and obstructing some parallel medication from entering the market. Danish pharmaceutical company Lundbeck received a staggering fine of EUR 94 million from the EU: the company had paid its competitors to not manufacture parallel products to their anti-depressant. It had also bought and destroyed the parallel medication of its competitors.[38]

Other counter-forces for technology development include the high price of technology, which slows down demand. This has happened, for example, with electric cars. If technology comes at the wrong time for consumers, development can slow down. Sometimes the market is simply not ready to receive a novelty, and it remains on the shelves. This happened to Apple's first pad, Newton, which was announced in 1993, and to the Friendster community service in 2003.[39]

Consumer attitudes also affect how technology is received. If consumers have, for some reason, decided to oppose a new technology, it is difficult for companies to push it out on to the market. For example, the negative attitude of Europeans towards genetic modification has slowed down the usage of GMO technology for agricultural purposes in EU countries. In the summer of 2013, GMO giant Mosanto announced that they were abandoning their dream of bringing new GMO products to Europe due the great opposition they are facing.[40]