The Role of Serendipity in the Innovation Management Cycle

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Abstract

This paper describes the importance of "lucky chance" in innovations and the marketing of inventions. It addresses the essence and role of models for managing innovation, using authentic examples of marketed products. The author presents an overview and analysis of factors that stimulate the processes leading to the emergence of innovations and circumstances that influence marketing success. When does an 'invention' become a 'product'? How do we identify the thin red line separating the effects of strokes of genius from inventions that never gained market recognition? For years, scientists have asked themselves to what extent chance generates innovation. Chance is the simplest and the easiest source of innovation. It is, however, challenging to determine when chance transforms from being a mere 'irritating disorganisation' and turns into a business opportunity. In all likelihood, there is no unequivocal answer to any of the above questions; however, it does not mean that such answers should not be sought.

Key words

lucky chance; innovation; model; management; case; innovation management; serendipity.

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Introduction

When does an 'invention' become a 'product'? How do we identify the thin red line separating the effects of strokes of genius from inventions that never gained market recognition? History has known numerous examples of brilliant technological solutions emerging by accident. For years scientists have asked themselves to what extent chance generates innovation. According to Peter Drucker, chance is the simplest and the easiest source of innovation (Drucker, 1985). It is, however, challenging to determine when chance transforms from being a mere "irritating disorganisation" (Tidd and Bessant, 2013) into a business opportunity. Probably there is no unequivocal answer to any of the above questions; however, it does not mean that such answers should not be sought.

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There are numerous models for the management of innovation. In Poland the so-called 'chance mode' is internationally referenced under the tag 'serendipity' ('lucky chance' or, in accordance with PONS dictionary, 'the faculty or phenomenon of finding valuable or agreeable things not sought for'). The serendipity model became famous in the 20th century when Nobel Prize winner Francis Crick considered chance to be "the only source of true novelty". The very concept of 'serendipity' explained as 'coincidence' has been frequently quoted in specialist publications. In the last decade of the 20th century alone, it occurred in almost 13,000 scientific works. The Google search engine allows us to find more than 3 million instances of the phrase "serendipity". However, as Campanario or Bandura have shown, research regarding this model is often unsystematic or even 'anecdotal' (De Rond, 2005). Why is the role of chance in scientific research so questionable and why does the assessment of values of inventions created by chance display so many extreme opinions?

The aim of this paper is to highlight how significant the impact of chance in the creation of innovations and technological solutions is, while recognising the complex context of business processes. Selected typologies of the 'serendipity' effect are illustrated by examples and sources of innovation. Particular attention is also given to practical aspects of the creation, utilisation, and significance of several selected scientific discoveries, as well as their evolution to commercial successes.

The authors claim that none of the established innovation management models meet modern demands. This does not result only from the fact that the "lucky spark" is undervalued in these models. Accidental innovations disputed in this paper still require the coexistence of many intertwined factors in order to evoke success in business ventures. Each factor can be described and measured in terms acknowledged in the management of innovation. The authors aspire to develop a new model for the management of innovation, particularly for science and research institutions, which would encompass significant external and internal factors determining the success of innovative projects and ventures.

1. 'To see bridges where others see holes' (R.S. Burt, 2004) – chance as a sources of innovation

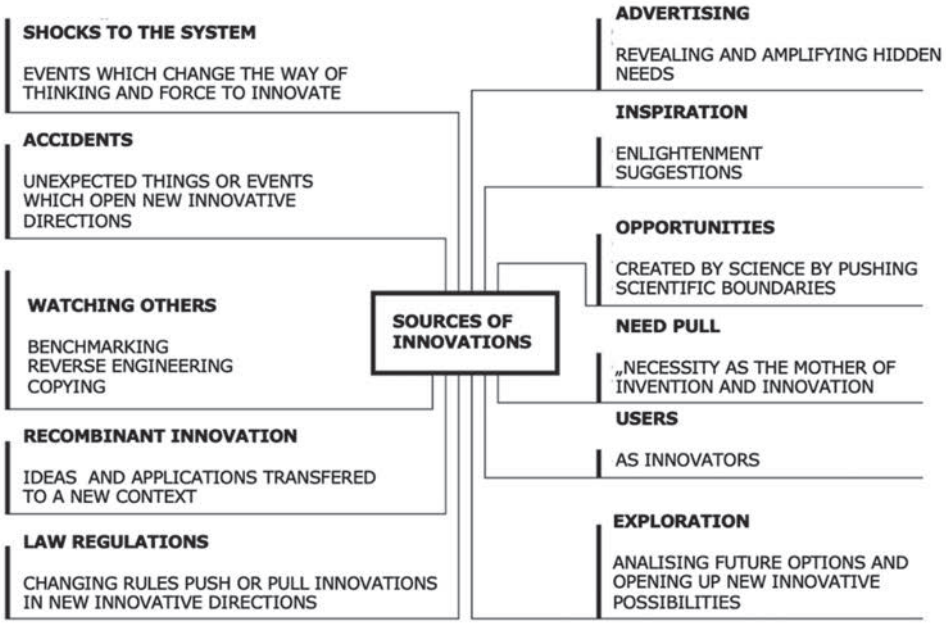
"I did not invent penicillin. Nature did that. I only discovered it by accident." This quote is attributed to Alexander Fleming, Scottish physician and bacteriologist, who is known as 'the father of antibiotics'. The 'discovery' of penicillin was indeed the result of Fleming's mistake, but also his perceptiveness. In September 1928, he was investigating the pathogenic bacteria Staphylococcus, but paused his work to go on vacation. Upon his return, he noticed that a sort of bluish and greenish mould had appeared on a Petri dish which had been left uncovered by accident. The area around the mould was free of bacteria. Fleming investigated why bacteria did not develop in the vicinity of the mould. It turned out that 'mould sauce' is characterised by bactericidal properties; this sauce is today known as penicillin (Letek, 2020). The bactericidal properties of penicillin helped to save many lives at the end of WWII, while to Fleming they brought the Nobel Prize in 1945 (Domosławski, 2007).

A melted chocolate bar in the pocket of Percy Spencer, a military expert specialising in radar devices, became the igniting spark for the discovery of technology applied in household microwaves. The self-taught engineer, who was researching magnetron use in radar technologies for military purposes, noticed one day that a chocolate bar hidden in his shirt pocket melted during consecutive experiments.

The observant scientist added two and two together and linked this effect to magnetron testing. The next day he conducted his usual experiments using some corn and one egg (which simply exploded under the impact of the microwave). The entire device was put into a metal enclosure for security reasons. Spencer received just two dollars for patent No. S2495429 from his employers. Microwave ovens revolutionised home cooking (H. Zhang, 2017) while for many years Mr. Spencer mostly enjoyed the respect of his colleagues employed at Raytheon, which became the first manufacturer of microwave ovens in the USA.

In the eyes of the public, 'chance' innovations are less appreciated. Less scientific attention is paid to them, even though they often constitute a popular topic in the daily press. The author does not wish to evaluate the sources of innovative solutions, but rather point out the ones that seem to be less noticed or even fully depreciated by the public. An array of impulses (stimuli) for initialising the search for innovation (Figure 1) was set and described by Tidd and Bessant (2013).

Figure 1. Array of impulses for initialising innovation



Source: developed by the authors based on Tidd J., Bessant J., Zarządzanie innowacjami – integracja zmian technologicznych, rynkowych i organizacyjnych, Wolters Kluwer SA (2013)

In the early 21st century we have access to modern research laboratories financed by corporations, highly trained staff, equipment, and research facilities at our disposal. It is difficult to imagine more suitable conditions for the emergence of innovation. However, even when innovation seems to be aimed at through a meticulously planned process, with great attention to detail, quite often inspiration comes from a very accidental breakthrough. Hence, is it justified to distinguish purely scientific approaches from the use of 'chance'? It does not seem reasonable to draw such divisions. Quite often,

discovery by chance simply constitutes an impulse for further research. If there is no place for further research, investigation, and modification of the invention, we cannot develop a product ready to conquer the market. On the other hand, the market itself often produces distinct impulses or inspirations to search for groundbreaking solutions. It has been said, and truly, that "necessity is the mother of invention". Anybody who knows anything about the market (be it only a one-time acquaintance) recognises the fact that without customers, any invention is to be shelved once and for all.

Searching for responses to market needs is also a complex and ambiguous process. While it seems safe to focus on the main group of customers, it might not be sufficient to maintain a competitive position. The concept of disruptive innovation (Tidd and Bessant, 2013) related to the requirements of entrepreneurs not present in the market mainstream shows that sometimes innovation is able to re-evaluate the reality. The beginnings of Apple and the rapid development of personal computers testify to this. Initially a niche product, PCs became a dominant trend in the technological market for decades. The example of Xerox, discussed later in this paper, proves that sometimes an innovation abandoned by one company is developed and commercially used by its competitors.

The participation of leading and niche users is inextricably related to the development of innovations, as well as the evolution of innovations. Examples showing that end-users become the inspiration for innovation are quite well-known. Polaroid cameras, medical/laboratory apparatus or sporting goods exemplify this trend (Tidd and Bessant, 2013). A great deal of credit goes to so-called boundary or extreme users; their requirements (many times of a niche type) influenced the dissemination of some solutions which are nowadays popular or even obvious (e.g. a system that prevents car wheels locking up during braking – ABS) (Tidd and Bessant, 2013). Among sources of innovation, authors also list the benchmarking method, which is popular today; comparison with other entities quite often brings about inspiration for corrections, changes, development, or generation of entirely new solutions. This trend may be used in many ways, of which one of the most popular is lean thinking, e.g. showing how to build values and maximise effects while waste and outlay are minimised. The source of this phrase may be traced back to Toyota. One of its directors, Mr. Taiichi Ohno, was a staunch opponent of waste (Japanese 'muda') (Womack and Jones, 1996).

The abovementioned examples show that inspiration for innovation may come from almost anywhere. It may be rational or not, it may be accidental, or it may result from a scientific process. It may be an original inspiration or an impulse from the market. Many innovations gain a second life due to changing life and technological environment. Sometimes, the development of some innovations is limited by legal regulations, while in some other cases, the rules effectively encourage the creation of innovations. All these spheres intertwine, and chance plays a remarkable role in the entire process.

Many researchers who analyse the factors determining the successful creation and commercialisation of innovations underline the role of management style aimed at harnessing an innovative entourage for experiments (Baruk, 2018). They also point out the necessity of changing managers' state of mind and their awareness of the demands of the future, not of the past, as well as viewing clients as a source of knowledge and experience, not only as a source of income.

The reshaping of mentality and companies being open to innovation can lead them towards continuous development and systemic innovation-based competition with others (Baruk, 2017).

2. Definition and the role of a 'stroke of luck' in the inventory process

As far as the process of creating innovations is concerned, can we equate 'luck' with 'chance'? The definitions of both concepts are not very accurate. Innovation by chance may not always be the result of pure luck. 'Luck' assumes passivity, while any search conducted within the 'serendipity' model should be considered an outcome of activity, commitment, and receptiveness to non-obvious results of research or investigations (Dew, 2009). A remarkably important aspect of this concept is the attitude of the researcher and his open-mindedness ('mindfulness'). The receptiveness of the innovator impacts the ability (among others) not to reject unexpected results (Kamprath and Henike, 2019), but to accept their potential value in the process of searching and interpreting the origin of new solutions. Apart from this type of approach, many authors indicate other key aspects in inventive pursuit such as motivation and life experience. In terms of the acquisition of different types of information such as historical knowledge, wisdom or basic knowledge (Kamprath and Henike, 2019), if we analyse them jointly – and only then – we are able to determine the significance of discovery or to assign to it a value significant from the novelty point of view.

The proponents of the chance model of innovation dissociate themselves from the thought of equating chance and luck. Still, it is worth dedicating some attention to the concept of 'meritocracy', which is defined somewhat ambiguously. Generally, it builds upon an assumption that the social status of the innovator depends solely and exclusively on his/her own merits such as achievements, work, competence, talent, or professed values. As such, luck is completely overlooked as a step on the way to success. We may debate whence this extreme need for stressing talent and hard work arises, while the significance of other factors contributing to the upward climb is totally excluded.

Robert Frank gives two reasons, one of which is strengthening the right to earn a significant amount of money or to attain a great deal of prestige, and the other is the conviction that if we believe that success is due to ourselves and our hard work and effort (it follows that we overrate our own abilities), we are more prone to striving for success. The attitudes which appreciate the importance of luck assume that even the greatest effort does not guarantee success; this might potentially tempt people to passively wait for events to turn (Frank, 2018).

Is there something wrong with being born into a prosperous family if one utilises favourable external conditions or mere coincidences, both in one's private life and for business decisions? Indeed, nobody likes it if the significance of his/her work is depreciated; this does not, however, mean that other circumstances allowing us to attain a set objective should be discriminated against. A broad outlook and complex approach to internal and external determinants allow us to maximise the potential effects and, what is most essential in the case of innovations, evade or minimise uncertainty in market-oriented decision making.

3. From chance to an innovation management model

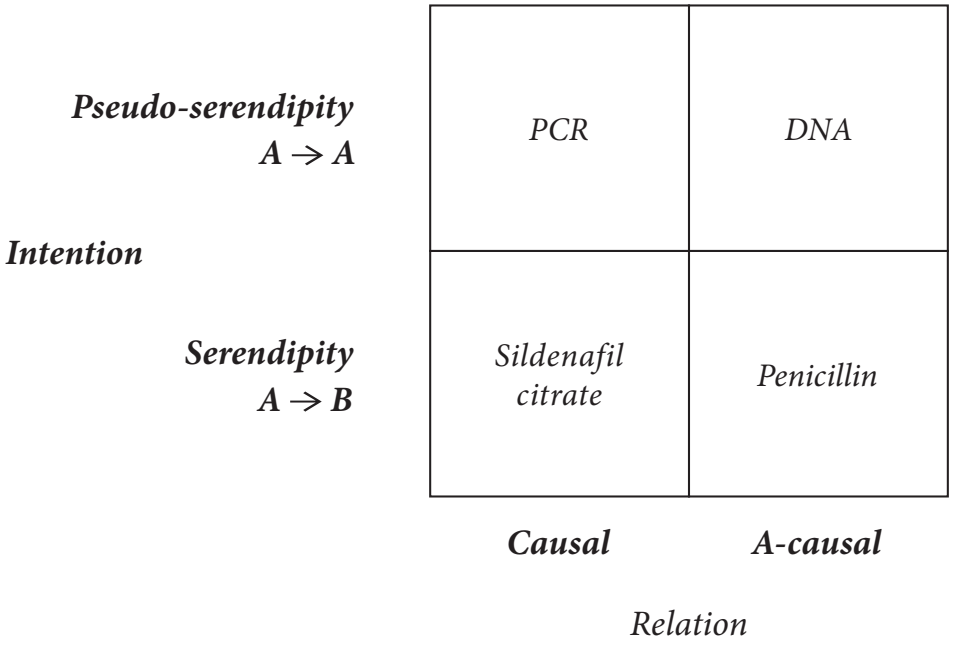
The 'serendipity' model imposes several standards (patterns), to which we may assign those innovations that were crucial in the history of mankind. The author will attempt to allocate and describe selected examples of innovations developed with chance as a factor using, to some extent, the classification offered by Kamprath and Henike.

Chance discoveries are based on several observed patterns that arise, e.g. being "in the right place at the right time" and from the perception of something potentially

novel. We might ask whether chance constitutes discovery itself or it is a key factor in the process of arriving at a discovery. Quite often, we cannot determine a time–place hierarchy since these two are closely related to each other (e.g. by Galileo's discovery of Jupiter's moons). History shows us that frequently something more than just these two indicated aspects have a key impact on chance discoveries.

In accordance with Kamprath and Henike's classification, innovation may also be created when two materials are joined together by chance (Viagra, X-rays, rubber vulcanisation), or when the right people cooperate with each other (vitamin C), or with unknown associations of data or as aftermaths of earlier inventions (spontaneous radioactivity) (Kamprath and Henike, 2019). This classification presents a simplified solution to all 17 patterns of coincidences provided by van Andel in one of his publications (Van Andel, 1994). Another classification, which is somewhat limited to medicinal inventions from the author's point of view, is presented by De Rond in 'Structure of serendipity'. Its author distinguishes the concept of 'pseudo-serendipity', where invention is the goal, but the way to discovery is accidental and unexpected (PCR and DNA). Another example in the classification is 'true serendipity', where the goal changes during the inventing process (sildenafil substance). De Rond (2005) furthers the research by differentiating between chance, as an unplanned consequence of the research process, and purely random coincidences, as shown below in Figure 2.

Figure 2. Structure of serendipity



Source: based on De Rond M., Structure of serendipity, Judge Business School, University of Cambridge (2005), p. 20

The predominant approach in Polish scientific publications on innovation management is that hardly any role is assigned to chance. Researchers focus on several classifications and categorisations, and very effectively omit any reference to 'lucky chance', even though its role is arguably significant. Fortunately, scientists from (mainly) the United States, the United Kingdom or Germany endorse the role of chance among innovation sources and, moreover, for years they have been trying to systematise it and include it in a coherent model of innovation management.

While analysing classifications of models for managing innovations, the lack of an unequivocal definition of the concept of a 'business model of innovation' (Ćwiklicki, 2015) becomes apparent. For A. Afuah, the key feature of such a business model is to set up an organisational framework for value creation purposes (Afuah, 2014). In relation to innovation, Afuah differentiates four models of managing innovations (Table 1) based on two criteria summarised in the table below.

Table 1. The innovation management model classification

	Low level of potential unsuitability	***High level of potential unsuitability***
High level of losing product competitiveness	Position-building model – present potential is used and products are rendered non-competitive	Revolutionary model – new resources are needed and products are rendered non-competitive
Low level of losing product competitiveness	Regular model – using present potential for innovations, while products remain competitive	Resource-building model – new resources are needed, while products remain competitive

Source: based on Afuah A., Business Model Innovation. Concepts, Analysis, and Cases, Routledge, New York and London (2014)

In principle, models evolve all the time; therefore. an exchange of models within the organisation may take place. The key notion is that selection of the model depends on the external environment where a given organisation functions.

An interesting typology of innovation management models was proposed by Taran, Boer, and Lindgren. It is based on the following criteria: radicalism, range, and complexity of innovations. Here we also encounter four models: open/proactive, characterised by low complexity of innovations, but with a high degree of radicalism and range; the opposite closed/reactive model; closed/proactive, where all three criteria are at a high level; and open/reactive, where only innovation range is at a high level (Taran, Boer, and Lindgren, 2015).

Many classifications presented in publications are based on a simple categorisation 'open/closed innovation'; they differ mainly in the approach towards the use of intellectual resources and the level of control that the organisation has over them. The latest theories emphasise the complexity of innovative processes and the impact of internal/external interactions (Kozioł-Nadolna, 2017) not only on the emergence of innovation, but also on its development and market implementation. The openness principle relates in this context mainly to sharing knowledge and using the achievements of other people to maximise the obtained

effects. At this point it is worth mentioning the research input of the Polish scientist A.H. Jasiński, who compared innovation to theatre: the foremost actors are science and industry, the supporting roles are played by infrastructure and transfer of technology, while customers become the spectators (Jasiński, 2006). Similarly, E. von Hippel (mentioned earlier in this paper) based his research on consumers as a source of innovation and its model solution. His investigations have shown the predominant role of users throughout the innovation process.

The examples quoted above are not an exhaustive list, in the author's opinion, since their focus is on the very structure of the organisation or on delineated directions of progress. In most cases, the wider background of innovation is not considered while it should include, on the one hand, the technological and general context, and on the other hand, mechanisms of chance in the model of innovation management. In most cases, these mechanisms provide an impulse or a starting point for further research and development work.

4. Xerox versus Pfizer – chance utilised, and chance wasted

Randomness in scientific research has always been controversial. Initially, it was considered chaotic and a contributing factor to work disorganisation; however, over time, it gradually gained prominence due to observation. Searching for standards and building models for innovation management became indispensable because we cannot regard a brilliant byproduct of research targeted in totally different directions or with a totally dissimilar goal as a failure. Henry Chesbrough aptly summarised this process as a "managing false negative" (Chesbrough, 2016). An analysis of the differences between success and failure can be showcased by two examples. The story of the invention of Viagra is one on how to transform failure into marketing success. The other is the story of the personal computer invented by Xerox and its market potential missed by the very same corporation.

Viagra was introduced onto the American market in 1998 and quickly became one of the bestselling drugs, simultaneously earning its place in popular culture. Sociologists even define 'the turning point', which was the airing of an episode of the popular series 'Sex and the City' (Akass and McCabe, 2004) in 1999. The script of this episode focused on the blessings offered by the 'blue pill' (Tiefer, 2006). The invention of Viagra occurred by chance, since the active component of the drug (sildenafil) was initially developed as a drug that counteracts arterial pulmonary hypertension and angina pectoris through relaxation of blood vessels causing an improved blood flow. A separate drug for hypertension, based on the same substance, was commercialised after all and sold as 'Revatio'. Even though the results of clinical trials for other diseases were not as satisfactory as the manufacturer could have wished for, nonetheless someone managed to appreciate the market potential in one of the side effects of the use of sildenafil.

Patients participating in the tests began to report that within several dozen minutes after the oral administration of the drug, they experienced a long-lasting erection persisting for four to six hours (Conrad and Leiter, 2004). The potential of the drug was observed by the Pfizer experts, but some changes in legislative definitions were necessary to market the drug. In the 1990s the problem of erectile disorders was redefined from a psychogenic effect to a medical phenomenon, called 'erectile dysfunction' (M. Wieczorkowska, 2016), which made it possible to introduce a drug containing sildenafil under the trademark 'Viagra'.

The promotional campaign was initially targeted at elderly men. Some statements uttered by well-known figures were used for the promotion of impotence cures – among

others, the then-US senator Robert Dole took part in some spots. Promising sales reports for this age segment inspired Pfizer to extend the advertising campaign. As a result Viagra became an exemplary solution that helps to improve the quality of one's sex life for the entire male population (P. Conrad, 2007). In a world where "there is a pill for everything", the accidental invention of sildenafil was a source of market success and became an important element of pop culture.

Xerox was previously famous for numerous remarkable innovations, although many of them were never used. An interesting point to note here is that in the world of technology, Xerox was renowned for its expertise in the protection of intellectual property. The inventor and first manufacturer of copiers is often portrayed as an ideal example of using synergy and organising work in groups (Op den Kamp and Hunter, 2019). In the market of document copying, Xerox was extremely successful, and it is no coincidence that today we speak colloquially of a 'xerox' when having in mind an exact replica of a document page, as the term is derived directly from the company's name. Yet, the fates of innovations that emerged incidentally while the main business line of Xerox was developed and strengthened were completely different.

To find new fields for market expansion, a different company called Palo Alto Research Center (PARC) was established in 1969 by Xerox, based on the company Scientific Data Systems (SDS) which had earlier been taken over. The management of the corporation, realising that the profits from foundational Xerox activity were falling, indicated a new direction for the company's development: 'Architecture of Information' (Chesbrough and Rosenbloom, 2002).

In the 1970s there were no 'personal computers'. In fact, the very concept of a 'computer' evoked associations with gigantic machines which barely fit into university laboratories. PARC workers accepted the challenge of creating a complete office computing system that could be handled by a single person and would occupy standard office premises. The idea drafted by the engineering team included an 875-line monitor, a keyboard with a 'pointing device', 'mass storage' of 2.5 megabytes, communication interface (ethernet), microprocessor and 16 (ultimately 256) kilobytes of operational memory (Thacker and McCreight, 1979). The hardware was supervised by the 'Star' environment, which automated office work. This 1981 environment used ideas which are common today: bitmap graphics, icons, windows, and interface controlled by a "mouse" (J. Johnson, T. Roberts, 1989). There was a real chance of these sets revolutionising office work. However, the market reception of the product was a failure. Fewer than 25,000 customers bought 'personal office systems', despite the fact that subsequent iterations of the product were supplemented by the first models of laser printers. The market fiasco was determined by the lack of coherent market strategy and internal rivalry within Xerox between representatives of the main business line, responsible for production and improvements of copying machines, and the team working on computer systems.

The PARC team, in fact, had invented the very first personal computer. In addition, they developed the ecosystem that connected the equipment with dedicated software, laying down foundations for the operating system applying the WYSIWIG philosophy ("what you see is what you get" (Smith and Alexander, 1988).

The ideas derived from the Star environment became hugely successful a few years later in the interfaces of operating systems ("OS") such as Windows or Mac OS. However, Xerox did not gain anything from these innovations: no one noticed them at the time and they were overlooked. They were, however, used at another time and in other business environments. The case of 'personal office systems' was neither the first nor the last commercial disaster for Xerox. Out of 35 abandoned (not implemented)

products, 11 began their new life elsewhere (Tidd and Bessant, 2013).

The case of 'omitted innovations' occurring in PARC shows that proper research and development (R&D) infrastructure and fantastic scientific ideas are not sufficient to turn them into a success story. To commercialise the inventions effectively, corporations need transparent processes, tools, and resources. but most of all, an accurate vision of how to utilise the original research.

Conclusions

"Fortune favours a prepared mind" – this simple travesty of the Roman saying "audaces fortuna iuvat" may be used successfully as a motto by all inventors. Keeping an open mind, being acquainted with innovation management models, and being able to adjust them to results of corporate work determine success in the commercialisation of inventions. The story of the 'sole inventor', who astonishes experts with his/her invention, is for the most part mythical (Lemley, 2012). Most significant inventions were created (and successfully commercialised) because of a planned process executed by an appropriately configured workgroup. A 'lucky break' can change the course of history and define new market roles for products. Still, apart from a 'lucky break', it is just as important to correctly plan how to transform innovations into products and to inscribe this process in an appropriate model.

The examples provided in this paper show how following routines shortsightedly and failing to notice changes and new market trends can damage business. These very same examples illustrate how courage and determination to absorb new trends and ideas can boost businesses.

Many more examples can be cited including, among others, the infamous Nokia case. Once the former leader of the mobile telecom devices market discarded the idea of a mobile phone with a touch screen instead of a keyboard, it took only a few months for Apple to take over the market with their flagship product. The iPhone took the market by storm and Nokia sank into bankruptcy. Failure to meet market demands and ignoring the "spark of luck" lead to the downfall of a market giant.

Innovation by chance is not a rare occurrence in science. In order to assess the market potential for commercialising innovation discovered by chance, it is crucial to properly analyse a variety of factors determining successful ventures. These include, apart from market demands and lucky chance, the regulatory environment, technological development path, and last but not least the charisma of the manager who decides to commercialise innovation for the benefit of the organisation.

The "spark of luck" should be included in innovation management models. Models described in scientific sources acknowledge serendipity as a factor but fail to fully notice its importance. Therefore, the authors of this dissertation claim that it is crucial to analyse it more thoroughly. Serendipity, or the spark of luck, merits inclusion in a management model that properly describes and measures the "spark of luck" factor, among others, determining the market success of innovation.

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