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Systematic Method for Roadmapping Disruptive Innovation on the Fuzzy Front End of New Product Development

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Abstract

As an effective innovation method, disruptive innovation (DI) can be applied in a new firm to achieve leaping-over development. Based on technology evolution theory, the necessary conditions for DI are put forward. To forecast and realize disruptive technologies during the process of product development, the basic laws and principles of DI are summarized. The paper offers a kind of innovation method for the fuzzy front end (FFE) stage of new product development (NPD). The method highlights effective disruptive technologies in the end mostly relies on disruptive innovation and presents it as the final high quality idea of FFE. The adoption of this method makes the objectives of the initial stage of product development clearer, which improves the effectiveness of innovation and success rate of product development. It is particularly fitting for new product development process of new enterprises entering a mature market.

Keywords: Disruptive Innovation, Fuzzy front end (FFE), Systematic method.

1. Introduction

Disruptive Innovation (DI) is a technological innovation theory put forward by Christensen (1997) in 1997 and also consummated by him (Christensen, 1996, 2000, 2003). DI has several characteristics used for attracting unimportant consumers or new users. When these products are gradually becoming stable not only in the low-end market and the new market, but they can also take the place of the products which finalized the design in the mainstream market, enterprises that have these products, in other words, radical enterprises will replace current ones so as to achieve DI.

The development of DI product requires brand-new values to be brought into the existing market. Therefore, the development process of DI product involves an integration of a series of procedures. The integration contains various contents which include field selection of initial products consumer demand analysis, forecast of disruptive technologies opportunity, realization of disruptive technologies, the research and development production plan, design administration that can ensure each plan is carried out effectively. Sometimes the integration even includes the selling channel for preparing the new product and other promotion arrangements etc. Product design is included in the process of product development and is made up of each technical activity in accord with market development and commercial operation. It contains the development that conforms with the technical manual requirements for conceiving of the product, the development of new thinking and blending technological factors in the new product.

The initial stage of product innovation is called fuzzy front end (FFE). Recently, the products lifecycle has been shortened because of fierce market competition with new products coming out continuously to replace existing products. The success rate of product design must be greatly improved for adapting to this situation. Reliable and effective design constraints must be implemented from the front end of the conceptual design of product and the FFE stage, to achieve an effective innovation process. To improve the success rate of the DI process, the FFE stage of the DI process should be studied.

2. Literature Review

Disruptive Technology (DT) is the technology used in the process of the realization of DI. DT is technology which doesn't match the typical needs of mainstream consumers of enterprises and the improvement of it doesn't take place on the continuous evolutionary track of mainstream capability. DT might be the innovation technology that could not fulfill the needs of mainstream consumers of enterprises. The performance of DT is usually lower than that of the mainstream in the initial stage. It will surpass the mainstream technology before long and replace the mainstream technology. Successful DT can offer extra product characteristics for existing market consumers to meet their uncovered needs. The extra characteristics of these products are usually in the improvement directions of being small, light, cheap, function, ease of use, high reliability, high efficiency and energy saving (Kostoff and Boylanb, 2004). To some extent, the process of DI is just the process of forecasting and searching of DT. Therefore, the forecasting and searching method of DT has been a focus of studies, many scholars have their own definition of DT.

Abernathy and Utterback (1988) described DT as the technology for creating bran-new technology product—market pattern, DT will bring new concept to the whole world which may be difficult to understood for consumers.

Bower and Christensen (1995) believed that the kind of technology can be regarded as having the characteristics of being disruptive, when the service or entity commodity produced by this technology has the capability that was ignored by existing consumers. For instance, when 8-inch rigid disk drives appeared for the first time, consumers couldn't see the value from its "small volume" on the rigid disk drive market whose mainstream product is 14-inch (for mainframe computer market) in size. The consumers then took no account of the size attribute. We can define that the technology for 8-inch drive is a DT then.

Walsh and Linton (2000) regarded that DT was the combination of existing technologies and some new technologies. These new technologies would lead to momentous reform of product technology pattern or creating a sort of new product when they were used in the problem field or commercial competition.

Lewis, Cosier and Hughes (2001) hold the view that the S curve which was the tradition way to study technological evolution could not describe DT any more. They believed that a structural plane of social intention definition should be added, so the DT can be described fully.

Walsh, Kirchhoff and Newbert (2002) thought DT was the technology which didn't support the fundamental manufacturing operation of existing enterprises. In other words, DT is the technology that isn't consistent with the fundamental manufacturing technology of existing enterprises.

Kassicieh, Walsh and Cummings etc. (2002) brought forward that DT was a kind of discovery of scientific knowledge and this discovery would surpass the capability of common products or technology. DT would become the base of new apotheosis competition, and a change brought by the technology can be used to distinguish DT between common technologies. DT would bring changes in three aspects in general: altering science and technology, shifting market structure, changing consumers' benefit.

3. Methodology

3.1 FFE during the process of new product development

Figure 1 is the process model of product innovation process. FFE is the initial stage. The stages afterwards are new product development stages (NPD) which contain conceptual design, detailed design and product manufacturing. The last stage is the product commercialization. Tan (2008) divided ideas of innovation of stage FFE into three types: raw ideas, possible ideas and high quality ideas. Possible ideas is acquired by estimation of raw ideas, high quality ideas will be got through the estimate of possible ideas. In the shape of the output of FFE, high quality ideas are just the input of NPD. The idea of the output of FFE turns into product by means of NPD and is put into market from which benefits the enterprises (Tan, Yang and Zhang, 2008).

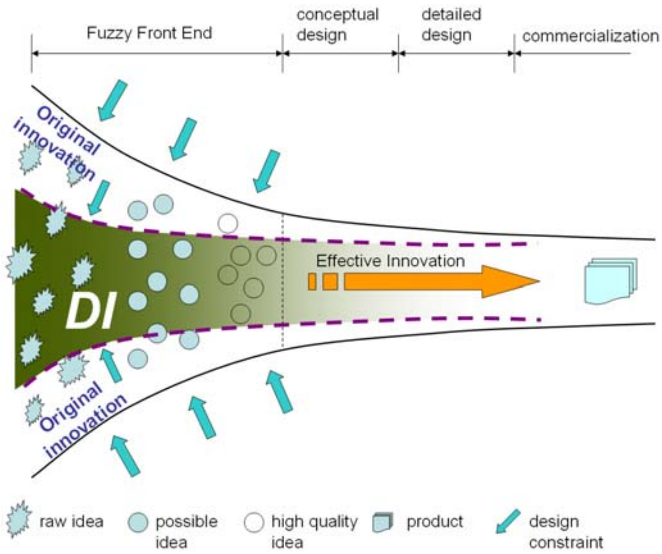

Fig. 1. The process of product innovation

Finding and applying the method of using knowledge in different fields becomes the bridge for designers to produce high quality ideas of stage FFE, through this method, producing just several ideas which contain materials of high quality will be all right. It is unnecessary to form many ideas. As a result, not only the evaluation of idea gets easier but also conquered the obstacle of producing high quality ideas. However, as the original technology innovation is aiming at innovating system knowledge of antetype, high quality idea is hard to be acquired. It is necessary to master a number of knowledge in each field, but to DI or sustaining innovation (SI) process, because the existing of many design constraints that are known, the transpiration extent of FFE falls greatly, so the difficulty of acquiring high quality idea is knocked-down greatly and small FFE area is formed in figure 1.

3.2 The model of DI products development face to FFE

Figure 2 shows the FFE process of DI product development based on TRIZ framework. "TRIZ" is the (Russian) acronym for the "Theory of Inventive Problem Solving." G.S. Altshuller and his colleagues in the former U.S.S.R. developed the method between 1946 and 1985. TRIZ is an science of creativity that relies on the study of the patterns of problems and solutions, not on the spontaneous and intuitive creativity of individuals or groups. Millions of patents have been analyzed to discover the patterns that predict breakthrough solutions to problems.

Firstly, according to the history and actuality of enterprises themselves and the analysis of market condition, choosing a kind of product which is already available in the market to be the object of DI. Using forecasting tool of technology maturity which is supported by TRIZ predicts the technology maturity of target product. If the result of technology maturity prediction is that the technology lies in maturity phase, the main function of product has been evolved fully and has stable, mature market, so it can begin forecasting process of DI. If the result of technology maturity prediction is that the technology lies in decline phase, new substitutable technology should be found and radical innovation process is entered. If the result of technology maturity prediction is that the technology lies in child or growth phase, then incremental innovation is needed because of the evolutionary insufficiency of main function of the product. Technology evolution law and technology evolution route and method in TRIZ are needed in searching for DT opportunities then ensuring possible evolutionary direction of technical subsystem which is waited to be improved, the state of technology that is on certain evolutionary route, after that finding potential state and putting forward innovative idea according to it. Applying the conflict, effect and canonical solution and other tools in TRIZ and analogical method (Tan, 2007) to fix on innovative idea for the settlement of field problems as the product of innovative idea will bring relative field problems. Computer aided innovations (CAIs) offers tools and acts as repository in the process which is showed in Picture 2. CAIs contains all kinds of TRIZ tools and the corresponding repository, so it can support the generation of product innovative idea expediently.

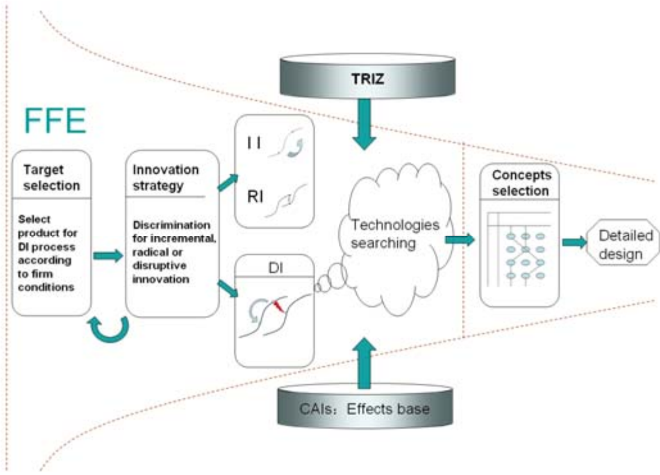

Fig. 2. The model of disruptive product development

3.3 Disruptive technologies forecasting based on technological system evolution theory

Product is a kind of complicated entity which is made up of different subassembly and which has unitary function and comprehensive performance. The technical system which composes the product is built up by each subsystem and it can be analyzed as an integrated technical system. Tree decomposition method as shown in figure 3 is usually used in foregone decomposition of system. To avoid over complication of the technical system decomposition hierarchy, each outsourced unit can be limped as one unit. Moreover, design constraints (volume, price, operative accessibility, energy consumption etc.) can be listed in all subsystems.

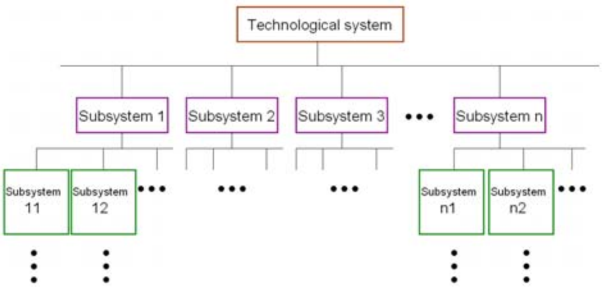

Fig. 3. Hierarchies of technological system

Refers to Figure 4, the evolution of product technology is not a single technical evolvable process. The product evolution appears as evolution of various aspects such as needs, overall technical system and the constituent technical subsystems. Evolution of needs is made up of different demands of user groups. The needs of each technology of products vary to different user groups. Cooperative technology refers to the technology that coevolves with some sub-function, which usually is the technology in another field that affects some technological level of the product.

Figure 5 shows the development process model of new product based on DT, and it can be divided into the following procedures.

Part 1:

1. Project selection
2. Function analysis
3. IFR definition
4. Decomposing technological system
5. Technological evolution analysis

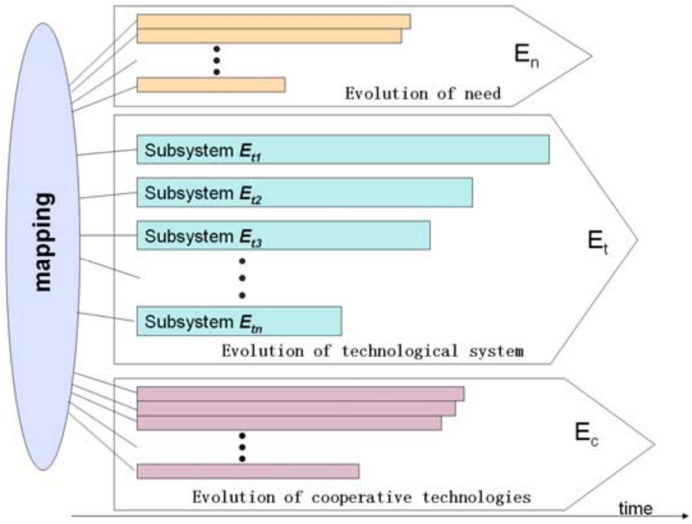

Fig. 4. Technologies system evolution model

Part 2:

Before technologies forecasting, there are two judgment problems: Are the customers' needs over satisfied? Is the technological system evolution unbalance? The questions determine the types of innovations, such as low-end DI, new-market DI and sustaining innovation. After that, according to features of different innovations, latent technologies are forecasted based on TRIZ technological evolution theory.

Part 3:

The Managers need to understand the feasibility of these obtained technologies. To achieve this objective, a robustness evaluation for the obtained technologies will be given. If result is not ideal, the former forecasting process will be carried out anew by selecting a different TRIZ technological evolution path till an ideal robust evaluation is contained. Then, the following 4 steps proceed:

1. Technical design
2. Detailed design
3. Blueprint
4. Put into production

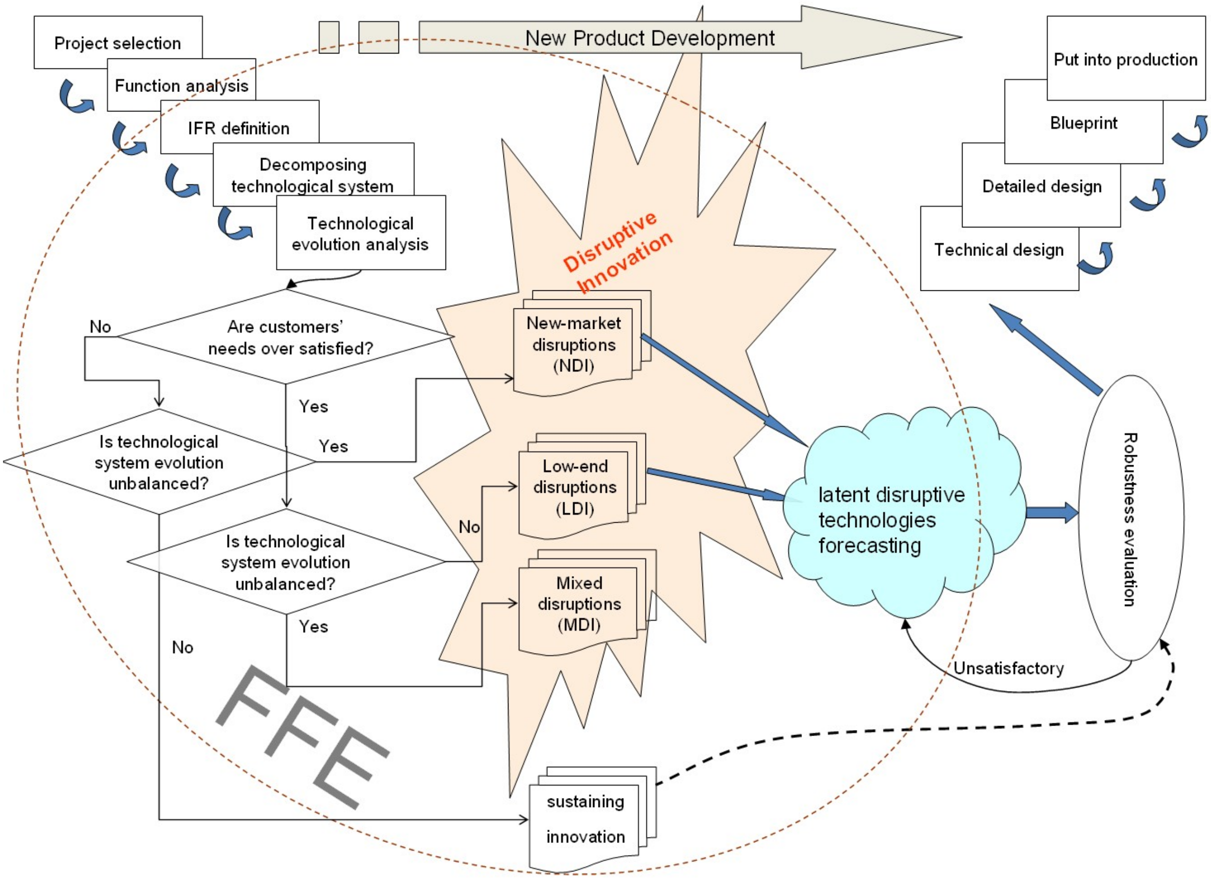

Fig. 5. Model of disruptive technologies roadmapping

4. Results

The innovative ideas of DI includes the raw ideas of DI, possible ideas and high quality ideas. As shown in Figure 6, the product of the three ideas makes the stage of FFE in product development of DI.

Product design starts from the market and ends in the market too. The first problem of new product development is to decide what to develop, what kind of innovative method should we choose—Incremental Innovation, Radical Innovation or DI? The production process of raw idea of DI product contains the choice of object product and the forecast of innovative opportunities. The contents and time of DI are restricted by means of the choice of object product and the forecast of innovative opportunity. After that, more specific procedures are followed and the evolutionary state of product technology system is acquired through technical system decomposition of chosen object product. And then making the decision, which one to choose, Low-end DI, New-market DI or Mixed DI by the method shown in Figure 5 and the survey of market user requirements so as to form possible idea of DI. Afterwards, searching and fixing on the technical measures which should be chosen to realize DI.

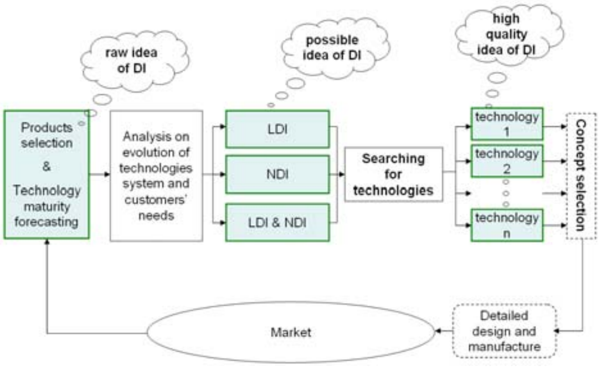

Fig. 6. Raw, possible and high quality ideas during DI

5. Case study-mobile phone for pupils and elderly

With the development of modern science and technology, mobile phones have been used in many fields as a convenient means of communication. Mobile phone has developed from the initial stage of doing telephony only to a transportable and multimedia unit that collects communication, entertainment and business in one. It is doubtless that the mobile phone market has been taken by several mainstream enterprises, such as Nokia, Samsung, Apple, Motorola and so forth. Low-end market has also been taken by a lot of 'imitating' enterprises. Hence, it will be quite difficult for new enterprises to enter mobile phone market, develop mainstream mobile phone product and compete with mainstream enterprises in the market directly. Therefore, DI policy has to be adopted and we should do DT searching in the FFE of product developing.

Mobile phones become more and more advanced and will be more abundant in functions. For instance, the functions include: listening to music, watching movies, playing games, browsing the webs and so forth. Meanwhile, the prices of them are quite high, such as iPhone. But not all of the customers need these functions. To some customers, certain advanced functions are unwanted. On the contrary, some unimportant functions which may be easily ignored are always of interests to them. DI got the opportunity to develop.

As the manufacturing technology of mobile phones becomes more and more mature, the prices get cheaper and cheaper too. And this situation makes more customers join in. According to the survey, we may find out that: the mobile phone market of the young pupils and the elderly enlarged gradually. Aiming at this market, DI can be adapted and disruptive technology will be searched according to the analyzing result.

As displayed in figure 5, the phases of the DI process are:

Phase 1: Products selection and technology maturity forecasting

In December of 1947, Douglas H. Ring and W. Rae Young, Bell Labs engineers, proposed hexagonal cells for mobile phones in vehicles (Tom, 2007). By the end of 2007 there were 295 Million subscribers on 3G networks worldwide, which indicated that mobile phone are popular worldwide. According to the market investigation, the conclusions can be drawn that mobile phone is at its maturity stage. The evolutionary timing of mobile phone is suitable for DI process.

Phase 2: Technology system decomposition

As shown in figure 7, the technology system of mobile phone is decomposed into several units, including more than 3 sub-function technologies and 4 constraints. Through data collection, processing and analyzing, 2 circular radar diagrams are shown in Figure7.

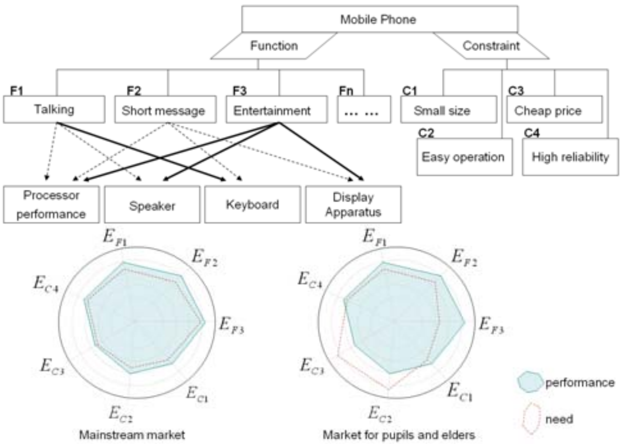

Fig. 7. Decomposition and analysis of mobile phone technology system

Phase 3: Technology sub-systems analysis

From the radar diagrams, we can draw a conclusion as shown in the table of Figure 8. For pupil and elder customer, the complex entertainment functions of mobile phone are unnecessary, and even harmful to pupils, but it is demanded that mobile phone is cheaper and ease to use.

Sub-technology	Evolution state	Disruptive technologies
E_{F1}	Optimal Performance state, OPS	
E_{F2}	Optimal Performance state, OPS	
E_{F3}	Over-satisfied need state, ONS	Reduce entertainment functions
E_{C1}	Optimal Performance state, OPS	
E_{C2}	Dissatisfied need state, DNS	Simplify operation
E_{C3}	Dissatisfied need state, DNS	Cost reduction
E_{C4}	Optimal Performance state, OPS	

Fig. 8. Disruptive technologies face to the market of pupils and elders

The display panel of mobile phone for kids has only seven key-presses as the figure shows, which doesn't have digital input key-press and can just dial five pre-stored phone numbers. The five pre-set phone numbers can be set as the phone numbers of most conversant guardians such as parents and grandparents to avoid inappropriate usage of mobile phone for kids. It has simplified the usage of mobile phone too. The display screen takes up with simple alphanumeric display so as to prevent kids using mobile phone for entertainment. Mobile phone for the elderly has bigger key-pad which is good for dialing and its cost has been reduced owing to the simplified display design and the deletion of other entertainment functions.

Phase 4: DI strategy formation

At this phase, technologies of sub-functions are adjusted according to the results of technology system decomposition (Sun, 2011). All of the over-satisfied need state (ONS) technologies will be reduced and the dissatisfied need state(DNS) items will be increased. As shown in Figure7, to simplify the operation process of telephone number input, instead of the full keyboard , only 4 shortcut keys in that 4 relative's telephone numbers preset are designed on the panel of mobile phone for pupils and a special keyboard with extra large key is designed for elders. Meanwhile, the display designs of the two mobile phones are simplified for reduced cost.

6. Conclusion

Stage FFE is quite important in the process of NPD, the innovative result of this stage decides directly whether the development of new products is successful or not. DI is an effective innovation method, the roadmapping of DT is the applied result of DI. DT enables designers to produce high quality idea in stage FFE. With the help of the production process of DI, not only does the imaginative estimate gets easier but the obstacle which is produced in the creation of high quality idea is also be conquered. Relative to original innovative technology, because the existing of vast design constraints which are known, the radiation extent of FFE will be reduced greatly owing to the application of DI. Therefore, mission success rate of product development will increase greatly and new product will be accepted into the market more easily.

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References

Abernathy, W. J. and J. M. Utterback, *Patterns of industrial innovation,* in Readings in the Management of Innovation, 2nd ed., M. L. Tushman and W. Moore, Eds. Ballinger, 1988: 25-36

Bower J. L. and C. M. Christensen, *Disruptive technologies: Catching the wave*, Harvard Business Review, 1995

Christensen, Clayton M. and Bower, Joseph L. *Customer Power, Strategic Investment, and the Failure of Leading Firms.* Strategic Management Journal, vol.17, no.3, pp. 197-218, 1996.

Christensen, Clayton M. *The Innovator's Dilemma. When New Technologies Cause Great Firms to Fail.* Boston, MA: Harvard Business School Press, 1997.

Christensen, Clayton M. and Overdorf, Michael. *Meeting the Challenge of Disruptive Change.* Harvard Business Review vol.78, no.1, pp.67-76, March, 2000.

Christensen, Clayton M. and Raynor, Michael E. *Innovator's Solution.* Harvard Business School Press, Boston, 2003.

Lewis, A. V., G. Cosier and P. M. Hughes, *Dimensions of Change-a better picture of disruption,* BT Technology Journal, 2001, 19(4): 15-23

Ronald N. Kostoff, Robert Boylanb, Gene R. Simons, *Disruptive technology roadmaps*, Technological Forecasting and Social Change, 2004, 71: 141-159

Sun Jianguang, Tan Runhua. *Product innovative design methodology based on disruptive technologies.* Journal of Engineering Design, 2011, 18(1):1-11.(in Chinese)

Kassicieh, S. K., S. T. Walsh, J. C. Cummings, *Factors differentiating the commercialization of disruptive and sustaining technologies*, IEEE Transactions on Engineering Management, 2002, 49(4): 375-387

Tan Runhua. Process of Two Stages *Analogy-based Design Employing TRIZ.* International Journal of Product development, 2007, 4(1/2): 109-121

Tan Runhua, Yang Bojun, Zhang Jianhui. *Study on Patterns of Idea Generation For Fuzzy Front End Using TRIZ.* China Mechanical Engineering, 2008, 19(16): 1990-1995

Farley, Tom. *The Cell-Phone Revolution*. American heritage of invention & technology New York, 22 (3): 8–19, 2007

S. Walsh and J. Linton, *Infrastructure for emerging markets based on discontinuous innovations*, Eng. Manag. J., 2000, 12 (2): 23-31

Walsh, S. T., B. A. Kirchhoff and S. Newbert, *Differentiating marketstrategies for disruptive technologies*, IEEE Transactions on EngineeringManagement, 2002,49(4): 341-351

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