

## PRODUCT LIFE CYCLE, TECHNOLOGY LIFE CYCLE AND MARKET LIFE CYCLE; SIMILARITIES, DIFFERENCES AND APPLICATIONS

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### **Abstract:**

The conference paper is a literature review for investigating three concepts: Product Life Cycle, Technology Life Cycle and Market Life Cycle. The aim of the research and comparing the three life cycles is promoting efficiency of strategic decision making in product development area. The concepts are exploring mostly based on the high tech industry specifications. Product Life Cycle illustrate the fluctuations of the product sales revenue over time, from the beginning of its design to the last phase of its ramp down. While, Technology Life Cycle demonstrates the cumulative product development projects of a technology or technology performance over time, which could represent the technology maturity level in various periods of time. Subsequently, Market Life Cycle represents appearance and developments of various market segments to market area of a technology. Apparently, each Technology life Cycle could contain various Product life cycles and each market life cycle could include different technology and product life cycles. Therefore market life cycle has more comprehensive view point and product life cycle is more detailed with specific product centric insight. But outcomes of each life cycle concept are different and making decision based on all of them together can lead to more optimized results.

*Keywords: product life cycle, technology life cycle, market life cycle, product development*

## 1. INTRODUCTION

Any phenomenon has an infinite life cycle, which could be considered from various aspects and could be classified by different categories. In the industry there are numerous defined life cycles that aim to classify the industry's existents to lighten up decision making directions.

The most simple life cycle in the industry and market area is product life cycle, which consider pathway of a product from the beginning of its birth to the last phase of its dead from sales revenue insight. Apparently such definitions are dependent on the industries and products, while as discussed in the study IT industry is the base of definitions. The stages of product life cycle are seen as: Introduction, Growth, Maturity, and Decline.

To invest in any product development project or any new product production, the company has to find out its technology stage in the life cycle. When the company is implementing any new technology, platform or even new product based on new technology should recognise if the technology is growing or disappearing to other trade-offs in accordance with technology future (Gao et al., 2012), mostly the S-curve of technology life cycle is based on Technology performance over time or cumulative development activities (Gao et al., 2013) Technology performance could be measure by various factors and indicators but some studies have suggested that different technology indicators should be taken into account and one single factor is not enough to build the S or double- S curve of Technology Life Cycle (Erst, 1997; Lee and Nakisenovic, 1989).

Market Life Cycle or Market Development Life Cycle is firstly present by Rogger (2011) then Moore made different models based on it (Moore, 1991, 1995, 1999, 2002, 2005, 2011). It describes the market behaviour with a new technology from the time that the first customer pays for it. The customers in various stages are classified from their behaviour against technology, their reasons for buying the technology and their satisfaction points. The model tries to find out the strategies to fulfill different groups of customers.

Therefore, if any technology development causes a life cycle, it will cause number of Product Life Cycles (Christensen and Rosenbloom, 1995). Apparently, PLC is based on an individual or limited series of Products while TLC points out life cycle of different platforms that each of them could introduce various products; therefore Technology life cycle is more based on macro level data than PLC (Kim, 2003). Moreover, PLC starts with the product introduction to the market, while TLC starts with the Idea creation of a new concept. Apparently, lots of ideas could not move from the first stage into the second, because the teams could not build the concept or some times when introduction stage takes a long time the team made to leave the whole technology or suspend it for future. (Callon, 1980; Abernathy and Utterback, 1978).

Market Life Cycle is based on Technology but it considers market situation and customer behavior other than R&D activities and patent creation models. Besides its insight is much more comprehensive than PLC. Any Market Life Cycle could include thousands of PLCs inside itself. The study looks at the strategic decisions which could be made from product development point of view in each stage.

## 2. PRODUCT LIFE CYCLE

Some authors believe that Product Life Cycle (PLC) is the fluctuation of a product sales from the beginning of its creation until the end of its ramp down (Cox, 1967), but some others look at the idea from macro perspective and describe it as: The most generic PLC is based on the market change during the product existence (Klepper, 1997) it could be the base of different strategic decisions inside the company (Rink and Swan, 1979). Hofer (1975) emphasized on the important role of PLC on strategic decisions by studying about the influences of PLC on business strategies. Additionally he found introduction, maturity and decline as the peak points of strategy renovation in any product life cycle. Additionally other authors like Cox (1967) mention that PLC is crucial factor in both product planning and control. Moreover, some other writers recommend the PLC as an applicable tool for management analysis (Forrester, 1961). Forrester is one of the first people who studied about product life cycle concept and he represents its applications in managerial modeling. He defines the scope of PLC in a way that the industry and products should be very homogenous from characteristics and customer view point to define the PLC stages and analyze them. It is helpful for developing new product and understanding market opportunities.

As mentioned before, determination of PLC stages is very dependent on the product and industry because the characteristics of product could illustrate the way that its PLC could be classified. While the most generic PLC classification is described below:

*Introduction:* The product is new in market and the customer is not very familiar with its concept or application, even sometimes the customers do not know their potential need to the product, but by the time the demand for the product is growing (Anderson, Zeithmal, 1984).

Cox (1967) categorises the PLC stages in ethical drugs industry that could be modified for most of the products and industries in some extents. He introduces two different lives for any product “Commercial Life” and “Catalogue or Market Life”. The “Catalogue life” begins with the first appearance of the product in catalogue of the company and “Commercial birth” begins when the product sales increase by 20% monthly trend. He defines the Introduction stage of PLC as the duration between “Catalogue and Market Birth” which the company begins to introduce the product to the customers and the “Commercial birth” that the product becomes popular.

In introduction phase that the result of product development is introducing to the customers the company keeps developing the product or at least tracking it heavily to find out the bugs. Therefore, product development according to the feedbacks in this stage is a crucial activity (Hofer, 1975), the product in the stage are mostly expensive and the company is trying its best to advertise the product and let the customers be aware of its benefits but as the number of sold product is not high the distribution centers are not numerous (Anderson, Zeithmal, 1984). Subsequently, there is high possibility for the new product to not pass the “introduction Stage” into the Growth stage, so some times the company have to use promotional strategies to keep the sales growing Cox (1967).

*Growth:* The product is introduced to the market so there is growing number of eager customers who want to have the product, the competitors are known with the product and they are trying to enter to the market as well, Therefore the company have to keep develop its supply chain, platforms, technologies and variations (Anderson, Zeithmal, 1984).

Cox (1967) defines the Growth stage as the duration between “Commercial birth” and monthly sales revenue peak point. Subsequently, demand for the product is growing therefore the company has to build a reliable supply chain, besides the competitors are coming to the market so the price should become reasonable by having better supply chain and efficient production line, additionally in this stage the company has acceptable amount of feedback so they can easily try to improve products performance (Rumelt, 1979).

The characteristics of advertisement in this stage changes completely, instead of training the product concept to the customer the company should emphasise on the advantages of its product in compare with the competitors’ (Hay and Ginter, 1979). Besides as the competitors are appearing the company has to build its own brand name in addition to increasing product variety (Oh et al., 2014)

*Maturity:* From Cox (1967) study, the peak of sales revenue is the beginning of “maturity stage” and it ends with “commercial death” which means the sales revenue reduction by 10-20% of the peak point in a monthly trend. In the stage the customers are completely familiar with the product and demand is almost constant. Though, product development, cost reduction, promotional strategies and better services or quality could gain better market share for the company, as there is still a big competition in the market area. (Anderson, Zeithmal, 1984).

The products variation should be increased, the production efficiency should be improved and the supply chain should optimized to cut the costs, moreover some marketing procedures like segmentation and customer classification could be helpful to keep the market share while the competition is high in this stage (Hofer, 1975; Hamermesh and Silk, 1979). The advertisement in this stage mostly belong to introducing variety of derivative products and lower prices of the company in compare with others, in addition the distribution channel should be lesson as the number of demands is going to be declined. (Hay and Ginter, 1979).

As mentioned before there are huge number of competitors in this stage, the company has to select one or both of the strategies to fight with them: cheapest price; by cutting the cost of supply chain (Hamermesh and Silk, 1979) and production or even providing acceptable but not perfect quality, or the

best quality of product and services to the customers (Hall, 1980; Buzzell and Wiersema, 1981) although having products with extraordinary high quality for some customer segments could be profitable. Moreover, the company could cut the costs by not investing on any R&D activity and advertisement.

*Decline:* Saturation or decline stage is between “Commercial death” and “ Catalogue/market Death” Commercial death is the time that the sales revenue decrease with 10-20% monthly and catalogue death is the time that company stop delivering the product (Cox, 1967). The product is in obstacle stage and the company and its competitors are trying to shift to new product with as less as possible lose.

In this stage the preference is to cut the cost to avoid from extra inventory level (Hofer, 1975), as the number of product demand is decreasing the supply chain and number of distribution centers should be decreased. (Hay and Ginter, 1979). The price and non-price promotions should help to speed up withdrawn the product and decrease inventory level (Cox, 1967)

## 2.1. Technology life cycle

There are various procedures to find out the technology life cycle stages in an industry and the stage of any technology, as an example FTA (Future –oriented Technology Analysis) (Martino, 1993) which has been applied from 1950, or the procedures of calculating Technology Readiness Level Which is very popular in US military. Different authors (e.g. Achilladelis, 1993 and Andersen, 1999) find out the models based on patent application in each technology, which could provide good information about not only various aspects of the technology life cycle but also it can lighten up the future product life cycles which came from the technology.

According to the Patent based Technology Life Cycle, the stages of the life cycle is the same as PLC and the x axis of the diagram is time as well, but the y axis is patent index. Moreover, founded patent based TLC has S-shaped in accordance with different studies in different technologies and industries almost the same as PLC Achilladelis, 1993 and Achilladelis et al., 1990) so the whole structure of stages is almost the same as PLC with introduction, growth, maturity and decline stages.

*Introduction(Emerging):* most of the product developments belong to fundamental definition of the technology rather than applicable ideas for products in real market, the scientist or other R&D teams are just trying to find out the concept of the technology, and they have long way still to be applicable. Therefore the application is low and as the risk of investment is apparently high there are not numerous companies who want to be inside of the circle. (Haupt et al., 2007) thus, the competitiveness is low and product integration does not exist (Little, 1981),

*BUG:* as mentioned there is a huge amount of uncertainty: the customers are not familiar with the whole idea, the technology cost is high and there is not a consolidated shape of derivative product from the technology. in the introduction stage, sometimes it takes long time for a technology to move from concept into application so it is decided to be decline or suspended (Callon, 1980; Abernathy and Utterback, 1978), additionally when the suspension happens the shape of TLC in accordance with the patent indices become double S shape that in a period of time the number of patents comes down and again it come up.

The Bug existence is very similar to the *chasm* in Market Life Cycle which will be discussed in the next chapter.

*Growth:* when the concept is discovered, and the tendency of findings went from radicals to applicable market useable products, the applications will increase. Risk of investment decrease and more companies will enter to the completion. And technology will enter to the growth stage (Haupt et al., 2007). Additionally, some more competitors are joining to the game and technology becomes “pacing”, but still there is not integration for products and processes. (Little, 1981).

*Maturity:* when the number of patent applications does not change any more, and the new patents belong to mostly major and minor enhancement instead of new products and features the technology arrived into its maturity. The risk of investment in the stage is low but the number of competitors is in its peak point (Haupt et al., 2007). The companies are still competing as the previous stage but the

technology is integrated into new products completely. Moreover, the "Pacing Technology" is known as "key technology". (Little, 1981).

*Decline (Saturation):* spontaneously, at the time that the patent applications take minus trend the technology left its climax point. The developments belong to minor and major enhancements and the direction of technical improvement (Haupt et al., 2007), the competitiveness decreases and the "Key Technology" will become "Base Technology". (Little, 1981).

But this procedure is not applicable for all industries, because firstly all the innovations does not become patent and secondly lots of private innovations in private companies does not release (Filson, 2002).

### **3. MARKET (DEVELOPMENT) LIFE CYCLE**

Market or Market Development life cycle is introduced by Roger (2011) then Geoffrey Moore (1991, 1995, 1999, 2002,) implemented technology adoption life cycle theory for high tech markets based on it. Later Moore tried to describe some more aspects of strategic decisions and he renamed the Market Development Life Cycle as Category Maturity Life Cycle (Moore, 2005, 2011). It describes the market situation in accordance with the level of technology and totally category maturity; from the beginning of a new technology or "disruptive innovation" appearance (Moore, 2005). The Market is seen as a group of customers, who actually or potentially, have similar interest in the product and they have interactions with each other which cause influences on their decisions (Geoffrey Moore, 2002).

In the model, there are three different markets: Growth market (which contains the Technology Adoption Life Cycle inside), mature market and declining Market. Each of the markets contains different customer groups from demographic reactions to the new technology creation. There are various watersheds in the Life Cycle that the companies have to shift their strategies according to them.

*Technology Adoption Life Cycle:* is the first stage in the life cycle; it starts at the time that the technology product the first product that any customer (even a single customer) want to pay for. It contains five different important points; Early Market (Innovators and Visionaries), the chasm, Bowling alley, Tornado and Main street. The life cycle is other than TLC that discussed before, technology adoption life cycle ends by the time that the product goes to the main market area and starts to be commoditized.

*Early Market: Innovators* are the group of customers who are interested in the technology. They could be known as "technology enthusiastic", they are the people who enjoy from new innovations and they enjoy from working and playing with new gadgets. As they buy technology for their own interest they care about the prices, but instead they do not need any services and they do not care about bugs and any error in the sold product.

The second known group of customers are early adaptors, which could be known as "visionaries". They grade the new technology in accordance with the degree of its "breakthrough" application in their industry. In the stage the company does not have to provide comprehensive services. Although early adopters are not interested in assembling and fixing the new technology by themselves (as the innovators) but they accept the product as a new and not institutionalized one. Moreover, they do not care about high prices, they know that they have to pay for newness; even sometimes they see the high prices as "prestigious" phenomena (Moore, 2002). The price in the stage is mostly "Value Based".

Totally the first battle of the company to attain early market is not about the products' characteristics but to changing the "operation mode", the company have to defeat the strong willingness of the market to keep using the former technology (Moore, 2005).

*The Chasm:* The CHASM is between early adopters and early majority customers. It is the shifting time for being "product centric" to "Market centric". In the crack the company should introduce "whole product" concept to the next level of customers, who are not visionaries any more. They need evident that the technology not only works well, but also will stay in the market. Shifting from "Product centric" to "Market Centric" decisions is more critical and harder than shifting from "Technology centric" to "product Centric" decisions, because in recent shift the company can provide the conditions of shifting

inter-organizationally, while in the crack they should build their ecosystem in addition to find out their location in their industry.

The early adopters are looking for an exciting new innovation that just change their industry and they could use it as a paramount, some bugs in the product or lack of services make sense for them. While, the early majority is not looking for a huge change, they are just seeking for one step forward to follow their industry; they do not like risky pathways. They prefer to wait until others complement about the product, then buy it. They do not have any ambiguous target therefore they do not trust to early adaptors so much as references.

*Bowling Alley:* It is both a momentum and technique to expand the market. The main suggested strategy for crossing the chasm is finding out niche market which needs to our product or technology. We should convince them that they are in need of the new technology. One of the most important priorities of pragmatists who are the main customer group of the mainstream market, in vendor selection is "leadership". In bowling alley the company has the opportunity to be leader of its own chosen segment.

The selected "niche" should have some special specification to let the company attains its strategic goals; firstly, the segment should not be occupied by other competitors. Being leader in a market that others have been there before is risky and hard. Secondly, the market should be matched with the size of the company and its capabilities. The third factor for selecting a segment is being in close connection with other segments that let us use "word of mouth" and implementing "bowling effect" techniques for finding the following segments one after the other.

New segments should have interactions, both from technical customization view point (to keep the R&D costs low) and benefiting from "word of mouth" which plays crucial role for absorbing pragmatists (Moore, 1998). Moreover, Bowling alley has another benefit for the company besides preparing pragmatists to come to the market; the company could prepare value chain, for the profitable and busy days of Tornado.

*Tornado:* After Bowling Alley, The IT administrators and directors become known about the new technology which is coming, they have controversy of being late for the piece of cake or coming too early for the party that others are not coming. Therefore, they come all with each (not to be too early for the party), they choose one same vendor all (to make the leader for the new industry and support "whole product" concept) (Moore, 1998) and they try their best to shift from former technology to new one quickly (supporting two systems concurrently in not efficient).

Thus, the tornado begins! With customers who invade to a single company with huge amount of demand and short lead time for having new "whole product". The only strategy that the fortune vendor could have in the lovely tornado is just shipping without any kind of segmentation. The vendor has to extent its distribution channel for this Tornado momentum (Moore, 1998). The target customers in Bowling alley were the "economic buyer", while in the Tornado the main target customers are "tactical and infrastructure buyers" (because there is a huge amount of demand, if the company could not potentially provide product and services for all the customers, they should select the group which could be known as "life time customers" to guarantee the future (Moore, 1998)

If bowling alley was the place of high amount of services for spoiled niche market, tornado is the place of limited amount of services shipped to anyone who is looking for it on the shelf (Moore, 1998).

*Growth Market:* After Tornado, the technology is known to the market, there are a lot of customers who made their decisions, the leaders of the market are known, although the Tornado is gone, and the sales revenue still is growing. Besides the risks of investment is apparently down. The price quality and services become more important to the customers. (Moore, 2005)

As discussed in the early market the company is trying to convince the customer to change their attitude by performing new technology and new product (Moore, 2005), in the mainstream the customers are somehow convinced by the technology benefits but still they have hesitations for shifting therefore the company should shift to compete against price, customization, flexibility and convenience (Christiansen et al., 2001).

*Mature market:* When the sales growth becomes completely flat and the company recognize the shortage of customers instead of supply channel, the mature market season comes. Good news is the absence of any risk in investment and bad news is for gaining more customers you have to produce products with big differences which the competitors' customers prefer them to the one which they own already.

The known strategy in this market situation is "Whole Product+1" (Moore, 1998). The customers know the product well, and they have the "whole product" expectation, the only reason which could differentiate you from your competitors is the "+1" difference. It could be any advantage like price, services, and availability.

*Declining Market:* The new technology is coming, but not in the Tornado yet. Although everyone is curious about new technology and pragmatist customers are waiting to see what is the next dominant technology. The sales growth is negative and companies cannot find much more capacities to innovate.

*End of Life:* New Technology is in Tornado, except laggard and conservatives nobody is interested to the technology. The technology platform stays in use sometimes simultaneously with the new technology; therefore the best strategy is harvesting the technology.

#### **4. SYNCHRONISE**

The result of any development for discovering new technology is finding out a "Paradigm" (Dosi,1982), each paradigm or concept could bear various Technology standards; and the standards could make different technology platform. Consequently, different products are plan, design and produce base on a technology platform (Kim, 2003). As the technology has a limited life cycle, it is develops, comes to the market, becomes popular , then a better technology replaces it and it dies, which is a similar story with product, the Technology Life Cycle classified similarly with Product Life Cycle (Rhyne, 1996).

Product Life Cycle is the evolution of a single product from its birth to death. Apparently a product is born in the market when it introduce to the customer and it promotes when becomes popular in the market area; therefore PLC in the generic level is based on the sales revenue. While, Technology Life Cycle in born when a new idea comes into the development teams, the idea will be promoted as a concept, the concept should be transformed into an applicable paradigm and numerous products are made based on the product (Winter et al., 2000; Godoe, 2000)

Subsequently, as the product life cycle is built in accordance with the sales revenue of a single company, TLC should be seen from more comprehensive view point. So TLC is based on the R&D activities and trends of patent application of an industry (Justman and Teubal, 1995), In addition, By passing through the Product Life Cycle, the Technology Life Cycle is going from growth to Maturity. (Anderson, Zeithmal, 1984).

As mentioned any TLC could produce various PLCs, but it is necessary to mention that the PLC generation begins mostly in Growth or maturity stage and in most of the case there is not any real product in introduction phase of TLC.

Market Life Cycle which discussed in the study is based on technology maturity. Apparently, the Market Life Cycle view point is much more comprehensive than the product life cycle insight. There could be thousands or billions of product life cycles inside a market life cycle. Moreover, Technology life cycle and Market life cycle viewpoints could be seen very similar but the technology life cycle is mostly seeks for the R&D activities but the Market Life Cycle is looking for the customer classifications, psychological behaviour of each group and the market behaviour. Besides the Market Life Cycle starts by the first sales, but TLC starts with the first idea generation point.

The hierarchy of appearance, growing, maturing and declining was almost the same in all three life cycles while the definitions each stage their characteristics and strategies are completely different.

## 5. CONCLUSIONS

The stages of the three discussed Life Cycles are almost the same, but the criteria of the investigations are completely different. They see the products from different viewpoints. Product Life Cycle consider the product sales revenue over time, while technology look at the technology maturity over time. If the technology becomes mature enough to come to the market it will come to the first stage of Market Life Cycle.

Different strategies for different stages of these Life Cycles were discussed in the study. Various aspects of each life cycle give a lighter pathway through making decision. Therefore using from all these three Life Cycle could give a better insight from the situation of a product in the market area.

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