USEFULNESS OF TECHNOLOGY LIFE CYCLE IN TANZANIA: THE CASE OF THE IPI DEVELOPED TECHNOLOGIES

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This study sought to identify the adoption rate of technology innovations developed by the Institute of Production Innovation (IPI) at the University of Dar-es-Salaam since 1984 to 1997 using a sigmoid shaped curve (S-shaped curves) to predict the life cycles of the respective technologies. Depending on the stimuli imparted to the specific technology, some of such technologies for instance, cinva ram and block making machines with hollow/spacer/louver exhibited longer life period as indicated by a series of inter-connected S-curves. Other technologies including but not limited to sunflower oil processing, kit-winnowers, scorcher with one stove, seed roller, standard wheelbarrow, and manual decorticator had reached saturation level of technological advancement within single life cycle (that is, the sales of the respective technologies stopped years back). A decision should had been made to whether to impart new research initiatives based on market research results or be discarded as no longer met any target market. Potential technologies for advancement within the technology shelf are also highlighted and discussed.

Keywords: *S-shaped curves, stimuli, technology life cycle, adoption, innovation*

INTRODUCTION

Sales often begin slowly as the market for the new technology (product) is developed. With customer acceptance and design improvement, the technology sales grow rapidly and its use becomes more widespread. As the market becomes saturated, sales may stabilise for a time and perhaps even for many years. Eventually based on the market demands, the technology may be modified or superseded by new technology and substitutes. At this point, the usefulness of the old technology is outdated by the new technology or its substitutes.

Good business practice is often based on the realization that successful technological development requires the presence of effective demand. The greatest factor in determining the success of firm's innovation efforts is its understanding of its potential customer requirements (i.e. from its very inception, a new product or process have to be developed with an eye towards meeting the need of potential customers). Commercial failure of many inventions is due to inability to realistically evaluate the extent of the dynamics of the market.

When the technology (or the product for that matter) has reached saturation point, it is possible to extend its life cycle by giving a new stimuli, namely creating new range of applications or increased frequency of use for existing purchasers, or by attracting new purchasers or finding new applications for the same basic technology. In most cases, attempting to extend the life cycle is, in itself, less risky than introducing an entirely new technology. What has been found to be extremely important is the timing of this extension (Martino, 1993).

In the world of business and dynamics of competition, it is crucial for a company to know which technologies are about to become obsolete if it is to remain competitive and thus, at least stop pouring money into something that can not be improved. Once technological saturation is reached, it becomes increasingly expensive to make progress to catch the eyes of the market once again.

It is therefore crucial for all technological based-business firms to have a well-documented scientific method that will enable the management to monitor the technological development and seek all opportunities that are in their disposal before technological saturation is reached. This can be achieved through monitoring the technology life cycles by using a scientific method called sigmoid (S-shaped) curve (normally called S-Curves). The S-Curves when applied provides a solid base for thinking about what will happen in the future and doing what is necessary to capitalize on opportunities (Harold, 1976).

This paper attempts to use the experiences endowed with the then Institute of Production Innovation (IPI) at the University of Dar-es-Salaam in assessing technology usefulness in Tanzania by using the S-curves method. The IPI was established in May 1979 and on 15th December 2001 merged with the Faculty of Engineering to form the currently known as College of Engineering and Technology. The mission and functions of the IPI have been entrusted to the newly formed organ named as Technology Development and Transfer Centre (TDTC). The findings of this research would be beneficial to TDTC and other technological business oriented institutions.

OBJECTIVES AND RESEARCH METHODOLOGY

The purpose of the study was to investigate the application of the S-curves for the product portfolios developed and promoted by IPI and now TDTC so as an informed TDTC management be able to take appropriate action in due time to offset any adverse impact associated with the adoption of the respective technology. In order for the TDTC to remain competitive and be relevant to the Tanzanian society in terms of its technology development portfolios, TDTC is required to address continuously the following questions:

- What technology business it should plan to withdraw from over the coming years?
- At which year should it withdraw from the specific technology business?
- What measures and strategies can be used to elongate the technology useful period in order to increase the sales of the respective technology?

Objectives

Therefore, the objectives of this study that took the three questions on board and provided guidance for the future focus of TDTC technology development and dissemination are specifically spelled-out as follows:

Assessment of the technology portfolio that IPI has developed over the years

- Determination of the technology life cycle of the respective developed IPI technologies.
- Analysis of the technology life cycle status for the selected IPI technologies.
- Recommend future prospects and course of action for the selected IPI technologies.

Research Methodology

The study focused on technologies developed, promoted and disseminated by the IPI since 1984 - three years after the IPI existence. Technology selection was made by assembling IPI historical data on technological performance for the various research and development (R&D) results that were developed by IPI over the period until 1997.

Apart from literature review in the conversional and electronic libraries, the data collection at the IPI was collected through records that were documented by the IPI in the Department of Promotion and Services where sales records of various technologies were kept. Furthermore, observations and interviews were done where it was appropriate. Interviews were made to the IPI management and technical staff. Data analysis in terms of compilation of all sales and sorting was analysed through percentages, mean scores, and cumulative sums of occurrences and eventually, graphic presentations of various technologies were made.

LITERATURE REVIEW

Definition of Technology

Ramanathan (1994) and Chungu (1996) have analysed in depth the various definitions of technology, which they have found to be more than 25 efinitions. When all the technology definitions are analysed, both Ramanathan (1994) and Chungu (1996) found that the technology in its broader definition do consist of four components namely; the techno ware (object-embodied form of technology – physical facilities), human ware (people embodied form of technology - human abilities), inforware (documented embodied form of technology - records), and orgaware (institution embodied form of technology - organizational arrangements). This broader definition of technology embodied in four components that provides desired products and services demanded by the users is adopted in this paper.

Concept of Technology Life Cycle

According to Harold (1976) and Khalil (2000), the process of technological advance (technology life cycle) can be portrayed using a graph in which the horizontal axis represents time and the vertical axis represents any aspect of technological advance. The plotting of one against the other produces a sigmoid (S-shaped) curve or a normal, bell shaped curve when plotted over time on a frequency basis (Figure 1). The S-shaped curve is obtained when cumulative number of adopters is plotted over time. The S-curve or a family of S-curves are described as the graph of relationship between the efforts put into developing and improving the technology (product or process) and the result one gets back for that investment within a given time period. Figure 2 shows associated stages of the technological advancement at any particular time in the S-shaped curve.

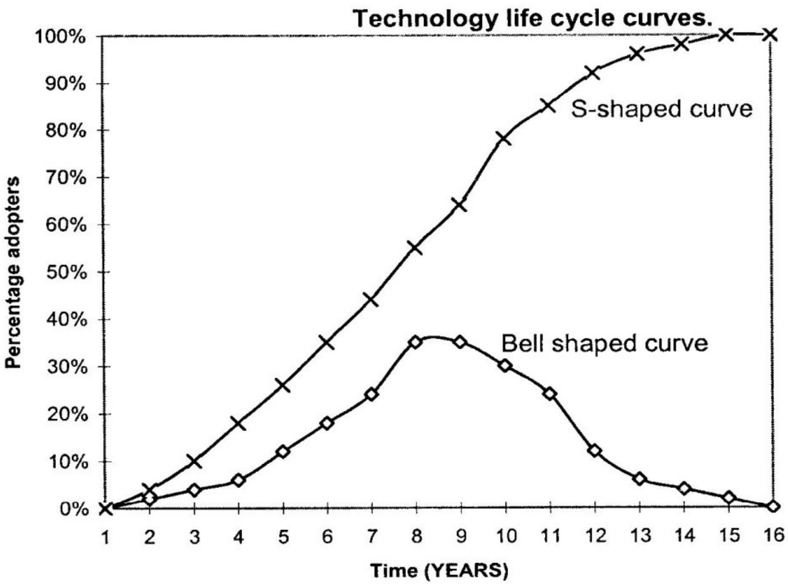
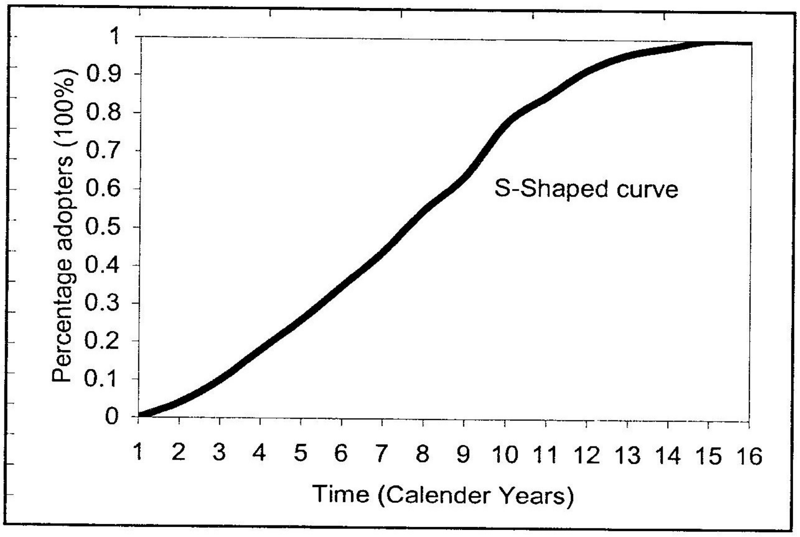


Figure 1: Bell shaped (frequency) and S-shaped (cumulative) curves.



Legend:

1. Period of slow initial growth (Introduction)
2. Rapid exponential growth (Growth range)
3. Growth slows as performance approaches a natural physical limit (Decline)

Figure 2. S-curve showing the various stages of the technology life cycle.

Harold (1976) and Khalil (2000) further explain the main difference between the two curves. The bell-shaped curve shows the data in terms of number of individuals that are adopting the technology each year, whereas the S-shaped curves shows the same data on a cumulative basis. However, the two curves are similar in that one observes a slow initial growth, followed by a rapid rise of approximately exponential growth, which for S-shaped curve slows down as it approaches asymptotically upper limit set by physical property and for the bell-shaped curve starts declining towards zero technological advance (Rogers, 1983).

In this study, the S-shaped curve will be used because the study is in search of knowing the cumulative units of each of the selected technologies at any particular time after its introduction in the market and subsequent development trends.

Usually, users adopt a new technology slowly during the first few years after introduction because of various initial market related teething problems. At first instance, a new technology is unknown to would be users, its reliability is uncertain, spare parts are hard to obtain, skilled personnel are scarce, the process or product may need improvement and its potential users have not learned how to use it. The lack of continual change or improvement of products or processes of the technology to meet the market demands hamper the competitiveness of the new technology. Ngahu (1999) points out that the major obstacles hindering the continual improvements of the technology may be one or a combination of having lack of finance, market information, technology information, management skills, and technical support.

Once the initial learning period is over and the new technology proves to be technically and economically competitive, the technology is now required by many users and rate of adoption increases much more rapidly and gradually displaces its competitors (stage 2 in Figure 2).

Harold (1976) argues that the technology reaches the point when technological improvements are not that significant and thus approaches saturation of its natural market when it is substituted by a new technology. However, there will remain a few applications for which the old technology is particularly well suited in a different context where market demands will suit it much better than where it has been substituted by a new technology.

Technological Innovation

Cooper (1991) defines technological innovation as the acquisition, use or development of firm specific technological skills, which lead to technical improvements. It covers the efforts of differentiations at the firm level aimed at obtaining competitive advantage in the market by developing new products and processes. Innovation is the act that endows resources with a new capacity to create wealth (Drucker, 1985).

In this study, technological innovation is viewed as including new processes (new ways of using existing resources to produce existing products); new products (the use of existing processes and materials to produce completely new or changed versions of existing products) and the use of new sources or types of materials (Stoneman, 1987). The focus is on development of ideas into marketable products (technologies) that are adopted by the relevant target market.

APPLICATION OF THE S-CURVES TO IPI TECHNOLOGIES

IPI over the years has been able to develop the following technologies that reached to the target users:

- Cinva ram
- Chicken feed mixer
- Chicken feed mill
- Hullers
- Small, medium and large size maize mills
- Electric decorticator
- Electric KIT winnower
- Sunflower Oil processing Equipment
- Manual KIT winnower
- Manual decorticator
- Standard wheel barrow
- Seed rollers

Block making machines with spacer/hallow/louver and standard ones

Table 1 shows the number of units on a yearly basis and corresponding cumulative values of each of the selected technologies, which were sold directly to the customers for the period 1984 to 1997. The data from Table 1 was used to plot the S-curves for the selected technologies and the results are indicated in Figure 3.

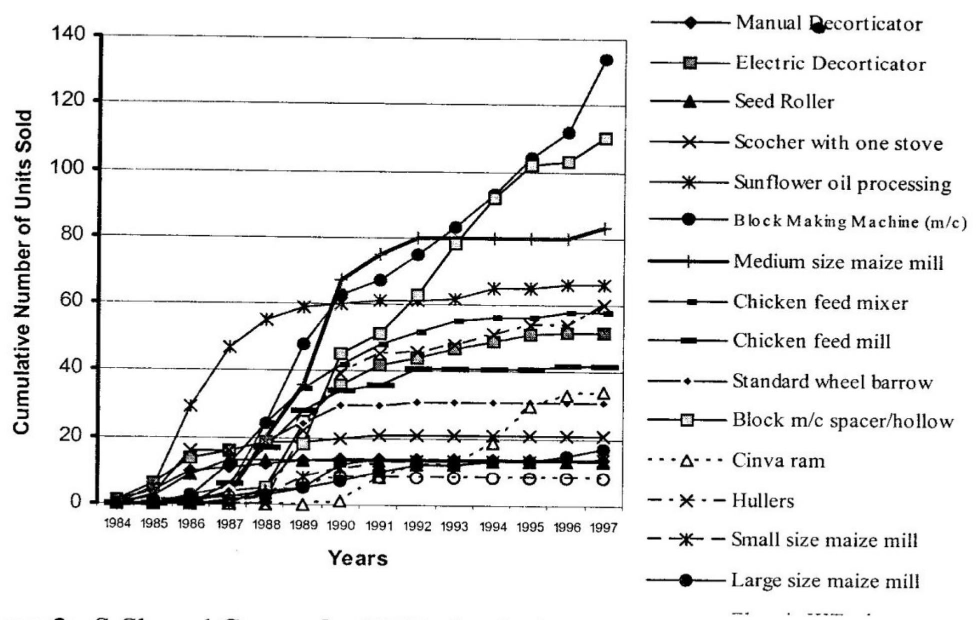


Figure 3: S-Shaped Curves for IPI Technologies

Table 1: Annual number of various technologies and corresponding cumulative values for the IPI units that were adopted each year

Type of Technology	Sales	Year													
		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Manual Decorticator	Units	1	3	6		1	1	1	0	0	0	0	0	0	0
	Cumulative	1	4	10	10	11	12	13	13	13	13	13	13	13	13
Electric Decorticator	Units	1	5	8	2	3	6	11	6	2	3	2	2	1	0
	Cumulative	1	6	14	16	19	25	36	42	44	47	49	51	52	52
Seed Roller	Units	0	2	7	4	0	0	0	0	0	0	0	0	0	0
	Cumulative	0	2	9	13	13	13	13	13	13	13	13	13	13	13
Scorcher with one stove	Units	0	3	13	0	3	0	1	1	0	0	0	0	0	0
	Cumulative	0	3	16	16	19	19	20	21	21	21	21	21	21	21
Sunflower oil processing	Units	0	5	24	18	8	4	1	1	0	1	3	0	1	0
	Cumulative	0	5	29	47	55	59	60	61	61	62	65	65	66	66
Standard Block	Units	0	0	3	2	19	24	15	4	8	8	10	11	8	22
making machine	Cumulative	0	0	3	5	24	48	63	67	75	83	93	104	112	134
Medium size maize mill	Units	0	0	1	2	17	16	31	8	5	0	0	0	0	3
	Cumulative	0	0	1	3	20	36	67	75	80	80	80	80	80	83
Chicken feed mixer	Units	0	0	2	10	12	11	7	6	4	3	1	0	2	0
	Cumulative	0	0	2	12	24	35	42	48	52	55	56	56	58	58
Chicken feed mill	Units	0	0	0	6	11	11	6	2	5	0	0	0	1	0
	Cumulative	0	0	0	6	17	28	34	36	41	41	41	41	42	42
Standard wheel barrow	Units	0	0	0	4	1	19	6	0	1	0	0	0	0	0
	Cumulative	0	0	0	4	5	24	30	30	31	31	31	31	31	31
Block making machine	Units	0	0	0	0	5	13	27	6	12	15	14	10	1	7
with spacer/hollow	Cumulative	0	0	0	0	5	18	45	51	63	78	92	102	103	110
Cinva ram	Units	0	0	0	0	0	0	1	7	4	0	7	11	3	1
	Cumulative	0	0	0	0	0	0	1	8	12	12	19	30	33	34
Hullers	Units	0	0	0	0	0	22	17	6	1	2	3	3	0	6
	Cumulative	0	0	0	0	0	22	39	45	46	48	51	54	54	60
Small size maize mill	Units	0	0	0	0	2	6	3	1	1	0	0	0	0	1
	Cumulative	0	0	0	0	2	8	11	12	13	13	13	13	13	14
Large size maize mill	Units	0	0	0	1	2	2	2	3	2	0	1	0	2	2
	Cumulative	0	0	0	1	3	5	7	10	12	12	13	13	15	17
Electric KIT winnower	Units	0	0	1	1	2	1	7	2	0	0	0	0	0	0
	Cumulative	0	0	1	2	4	5	12	14	14	14	14	14	14	14
Manual KIT winnower	Units	1	0	0	1	1	3	2	0	0	0	0	0	0	0
	Cumulative	1	1	1	2	3	6	8	8	8	8	8	8	8	8

DISCUSSION OF THE RESULTS

All the IPI technologies as indicated in Figure 3, exhibited S-shaped curve as portrayed in the literature review. Many of these technologies followed a one-life period designated by the S-curve, meaning that, the said technology beyond that period became obsolete to that target market. Apparently, few of the IPI technologies have a slightly different S-curve shape; portraying a double serial S-curves such as for cinva ram technology (Figure 4) and triple serial S-curves for block machine with spacer/hollow/louver (Figure 5). These curves seem to look as if they had approached saturation many years back but eventually they picked up and start to rise again forming a series of S-curves for the same technology. This is due to the fact that as these technologies were approaching saturation, a stimulus through technological innovation took place, which initiated their adoption rate once more. This stimulus was influenced by either addressing a technical, social, economic, political factor or a combination of these factors to meet the needs of the users of the technology. An interview with

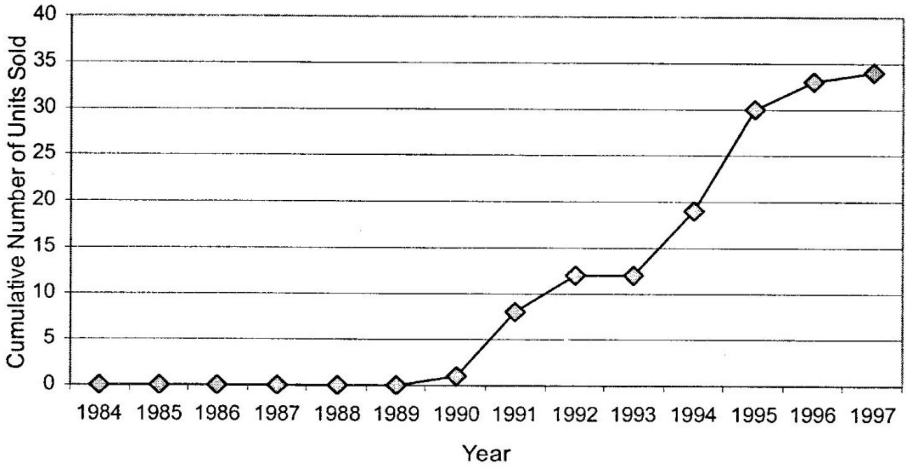


Figure 4: Double Serial S-Curve for IPI Cinva Ram Technology.

the IPI personnel indicated that the stimulus was mainly through design modifications that took into account the requirements of the user in terms of value for the money (economic) and social acceptability of the respective technology. An example to this phenomenon is illustrated by the family of S-curves as exhibited by the cinva ram, standard block making machine, medium maize mill, and block machine with spacer/hollow/louvers as shown in Figure 3.

The double serial phenomenon of S-curves as exhibited by the cinva ram technology started in 1988 when it was introduced as a new technology. Sales continued until 1992. This segment as from 1988 to 1992 forms one S-curve. In 1993 there were no significant sales and the technology started reaching saturation. Investigation done showed that customers were complaining that the machine had low compression strength and the arms were bending after short use. As a response to the problem, the IPI increased the length of the stroke, which resulted in high compression strength, and also the arm, which was originally made of 6mm plate, was replaced by 10mm plate, which did not bend easily. Tests and promotions were performed to restore the confidence of the

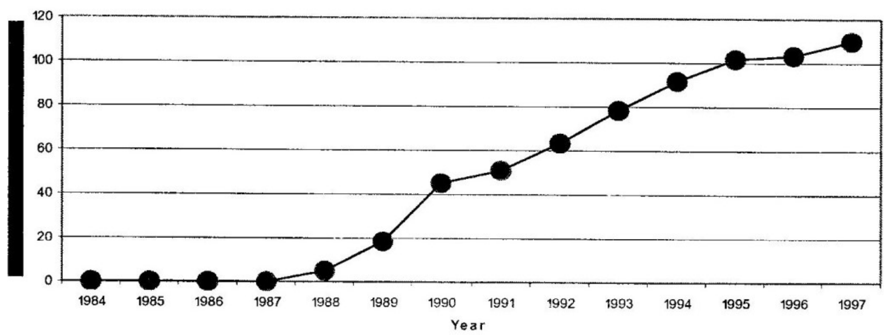


Figure 5: A Possible Triple Serial S-Curve for the IPI Block Machine with Spacer/Hollow/Louver

customers with regard to the improved technology, on how strong the bricks made by the IPI technology compared to the ones made by other competitors. Sales picked up immediately and the curve started to rise again. Therefore, the segment as from 1992 to 1997 formed another S-curve. In this way, the life span of the cinva ram technology was prolonged beyond the year 1997 instead of being obsolete in 1992.

Likewise, the triple serial S-curves for block machine with spacer/hollow/louver in Figure 5 shows that from 1984 to 1990 exhibits the first S-curve, from 1990 to 1995 a second S-curve and from 1995 onwards, is the third level S-curve. The growth noticed in the years 1988 to 1990; one would expect the trajectory to continue at same pace in 1991 and 1992 which was not the case due to changes in the market requirements. That called for improvements of the technology to meet the market demand and hence a new product life circle (the S-shaped curve).

The IPI technologies that reached saturation level of technological advancement (that is, the sales of the respective technologies stopped years back), include electric kit winnower, manual kit winnower, scorcher with one stove, seed roller, standard wheelbarrow, manual decorticator, sunflower oil processing equipment (Figure 3). The IPI should had made, though a painful decision, for the technologies that have reached saturation point whether to impart new research initiatives based on market research results or be discarded as no longer met any target market within the country and even the neighbouring ones.

There are some technologies within the technology shelf of the IPI that had some potential of increasing the rate of adoption in case they were given sufficient stimuli. Most of these technologies had already approached saturation point of technological advancement, but after sometime have started picking up due to external factors that have influenced their adoption. For instance, the maize mill technology whose sales stopped in 1992 started to rise again in 1997 without any additional design modifications (Figure 3). One of the main reasons among others was that in 1992 many people shifted their consumption pattern with regards to flour preferences to packed maize flour such as Chapa Jogoo, Nguvu, etc., from the normal flour obtained directly from the milling machines. However, in 1997 many people once again reversed their preferences and stopped using the packed flour because of its price that was relatively high and also the quality of the flour was not as good as it used to be in the earlier days. This category of technologies includes small maize mill, medium maize mill, large maize mill, and respective hullers. Potentials are also observed within the chicken feed mills and mixers. The adoption rates of these technologies started in 1992, which were highly influenced by the macro-factors and were beyond the IPI capabilities. These factors were governed by the liberalization policies that Tanzania adopted in order to drive the country towards a market economy. Poultry industry is still on the increase. However, the growth of the industry does not provide much incentive for importation of the machines, as the demand for such machines is not that big enough.

Figure 4 and 5 exhibits IPI technologies that are still under growth. The standard block-making machine falls also under this category (Figure 3). The sales of these technologies have been rising and their saturation points seem to be far ahead. Despite the economic hardships, these technologies have indeed impacted on the building industry in Tanzania.

CONCLUSION

Though the S-curves results indicate the past trends of the IPI technologies, they do provide significant information for the future adoption of those technologies. Based on the S-curve theory, one can determine the future trend of the said technology and determine its substitution time or appropriate period for transferring to another place where the target markets has similar requirements as provided by the technology. With this kind of results, other institutions that are in the technology development will be in a position to make good and informed decisions in order to take proper course of action to maximize the market potential and minimize wastage of resources.

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