TECHNOLOGY ACCEPTANCE MODEL FOR COMPLEX TECHNOLOGIES IN A PERIOD OF RAPID CATCHING-UP

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Technology Acceptance Model (TAM) was developed to explain computer usage behaviour. This concept later found applications in studying adoption of consumer products like Cellular phones. In this paper an attempt has been made to understand the importance of user motivations and perceptions in determining his behaviour to use indigenous technology using the TAM concept. Cases of new product technologies that were developed by Indian firms with R&D grants from the government under PATSER scheme of DSIR were examined. These products were developed by commercial organisations with an intent to profit from the development. However, despite their closeness to market, their experience with user adoption of these technologies is mixed, some were accepted with excitement and some others are struggling to find acceptance from the targeted users. Examinations of various factors indicate prior experience in handling innovations and purchase practices to have significant effects on user's extrinsic and intrinsic motivations.

Introduction

Policy makers noticed that many technologies developed in publicly funded academic/ research institutes (like CSIR, IITs) remain unutilised by the industry for reasons such as technology obsolescence, up-scaling limitations, engineering drawbacks, absence of complimentary assets, easy leakages. Similar problems were noticed even in sectors like Steel and defence where both the lab and production units were under the administrative control of same ministry. Now, to ensure seamless transfer of technology from lab to industry, lab scientists are encouraged to involve industry partners from the onset of project formulation by way of sponsored research, consortiums, advisory councils etc. Also several coupling mechanisms like Home Grown Technology (HGT) of TIFAC and Technology Development Board (TDB) of DST were started to provide soft loans for up-scaling lab technologies and commercialise indigenously developed technologies. On the other hand, PATSER (Programme Aimed at Technological self Reliance) of DSIR provides R&D grants to industry to meet part of product/ process development costs. These R&D project were conceived by industry, funded mostly by industry and results fully exploited by industry. These were market led projects. There was perfect fit between the R&D project and the business strategy. This arrangement resulted in seamless transfer of technology from in-house R&D units to production units. However all the technologies developed by the industrial units with clear intention of profiteering from the innovation have not resulted in user acceptance of the technology. This article addresses the issue of user acceptance of technology.

Why involve users in the development process?

First the basics, why involve users in the development process? In a product development cycle there are 2 main types of information flows:

1. Synthesis
2. Abstraction.

Synthesis focuses on the downward information flow where alternatives are systematically created and selected. On the other hand, downstream concerns such as performance and manufacturability determine constraints on possible alternatives. These constraints need to be accessible at every stage of the product creation cycle where they may influence the synthesis process. This second information flow thus represents an abstraction process, since very detailed downstream information needs to be presented upstream in a compact and usable fashion. It is only the manufacturing industry and users who can provide that abstraction type of information flows to the lab scientists and engineers. They bring real world problems, processing and manufacturing constraints.

The development cycle depicting these work flows is given below:

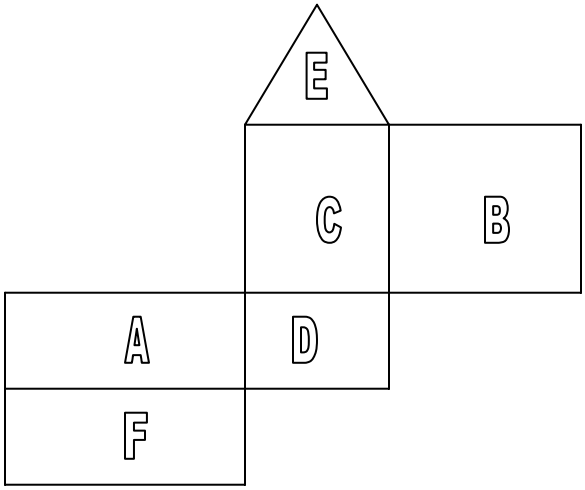
Some of the innovations like lab instruments have traditionally originated from users. The scientists developed one or two for their use and manufacturers entered later for mass production. Many farmers, housewives are custodians of traditional knowledge. One of the popular technique that places user feedback as central to a R&D project is the QFD house.

QUALITY FUNCTION DEPLOYMENT (QFD)

QFD, originally developed in Japan is a conceptual organisational framework for enhancing communication and coordination between engineering, marketing and manufacturing personnel. It is based on the premise that Innovations do not fail in the end - they take the road to disaster in the beginning with incomplete understanding of user's requirement. The organising framework for QFD is the concept known as the house of quality (HOQ), a matrix that maps customer requirements against product attributes. The starting point is to identify customer requirements. The completeness of customer requirements must be checked.

Section A of figure below contains a list of the customer wants and needs. Sometimes it is also called the `*voice of the customer*' or `*whats*'. **Section B** is the planning matrix which usually includes the following information; importance to customer, competitive benchmarking, sales point and final priorities. **Section C** lists the technical characteristics of a product or `*hows*'. **Section D** is the relationship matrix

which indicates how much each `*how*' affects each `*what*'. **Section E**, the roof of HOQ contains the technical correlations that capture the trade-off between pairs of `*hows*'. **Section F**, considered as the last room contains the technical matrix with information on technical priorities. Sometimes it also includes technical benchmarks, technical difficulties, estimated cost, targets and other related information.



The great strength of the house of quality is that it provides a common language and frame-work within which the members of a project team may fruitfully interact. The house of quality makes the relationship between product attributes and customer requirements clear, focuses on design trade-offs, highlights the competitive shortcomings of the company's existing products, and helps identify what steps need to be taken to improve them.

Technology Acceptance Model

A better mouse trap will not always have a ready market despite need and innovative features. To understand the user's behaviour towards new innovation, one must learn the technology adoption process. The technology acceptance model (TAM) consists of two beliefs, *perceived utilities* and *perceived ease of application*, which determine attitudes to adopt a new technology. The attitude towards adoption depicts the prospective adopter's positive or negative orientation/ behaviour about adopting a new technology. Attitudes are determined by relevant internal beliefs. Attitude towards adoption is influenced by factors such as :

(1) perceived ease of adoption;
(2) apprehensiveness
(3) perceived utilities of technology (extrinsic motivation)
(4) enjoyment (intrinsic motivation)

In addition, individual characteristics like age , qualification , their prior experiences in adopting technology; technology suppliers' commitment ; compatibility with existing technology and enhanced value are important factors. Social pressure is another important factor.;

Perceived Ease of Adoption (EA)

EA is operationally defined as "the degree to which the prospective adopter expects the new technology adopted to be free of effort regarding its transfer and utilization". This measures reflects the potential difficulty for the adopting firm to utilize the new technology, as well as that of the individual if he is required to learn to use the new technology. Improvement in ease of adoption can be instrumental to the utilization of technology, contributing to increased profitability for the adopting firm (through reduced transfer costs, greater

concordance with installed based technologies, and/or more effective application of the technology), or improve work performance of individuals. Perceived ease of adoption can also affect attitude directly. An innovation that is easy to implement and transfer can considerably reduce the time and effort a recipient needs to invest in the project. There is also a perceived probability that, the less complicated the transfer and application are, the more likely they will be successfully accomplished.

Hyundai initially received technology from Ford for assembly of cars. While plant construction was underway, teams rehearsed operations by dissembling and reassembling two passenger cars, a bus and a truck over and over to routinise procedures, internalise production manuals. When plant is ready, the workers had sufficient knowledge to assemble cars with minimum trial and error.

Apprehensiveness

It refers to the anxiety of using a new medium or technology. Even telephones in the early years of their adoption aroused apprehension. How can a firm take a chance with an indigenously developed catalyst, consequential costs in the event of technology failure are enormous. Simulation modelling , demonstration in pilot scale address the issues of observability and trailability. These do not provide solutions to apprehensions about adopters capability and preparedness to accept new technology. Draftsmen are worried about introduction of CAD, Bank employees about computerization of data, middle level management by talk of de-layering with BPR and ERP.

Perceived Utilities of Technology (PU)(extrinsicl motivation)

PU is operationally defined as "the prospective adopter's subjective probability that applying the new technology from outside sources will be beneficial to his personal and/or the adopting company's well being". This construct comprises two dimensions: perceived utilities for the organization and perceived utilities for the individual. To the adopting organization, utility usually means economic benefits resulting from adopting a new technology. These benefits may consist of increases in productivity, enhancement of product quality, cost savings, improvement in market share and entry of new market. To an individual in the adopting organization, utility is most likely the result of improved job performance and the associated intrinsic and extrinsic rewards. When technology threatens earnings through corrupt practices, then utilization is perceived as negative.

Intrinsic motivation

It induces activities where there is no apparent reward except the activity itself. Intrinsically motivated behaviour arises from people’s need to feel competent and self-determining in dealing with their environment. There is an inner drive to learn, which manifests clearly in the case of young recruits. Learning is an investment for them. This enthusiasm tapers with age, no wonder software engineers burnout by the time they reach forty.

Adoption experiences

Adoption experiences can be a function of the accumulated technical knowledge of the adopters and the augmented working relationships with the technology suppliers through previous experiences. Previous experiences with the technology provides an excellent opportunity for the adopting firm to collect important information regarding the technology and provides the needed personnel for similar future engagement. Moreover, the adopter is in a better position to evaluate the needs and requirements of the technology more accurately and can develop an understanding of the level of support required from the suppliers of the technology. Knowledge accumulation is cumulative for most technologies.

Technology Suppliers' commitment

The adoption of new technology carries a high risk. The level of perceived commitment from suppliers can help reduce this perceived risk through the transmission of adequate information from the suppliers to the adopters. Supportive commitments from suppliers are expected to be the most critical in the area of resources support. In many cases, resource commitment by suppliers can often affect the recipient's ability to absorb the technology. The more extensive the support, the more positive is the degree of perceived supplier's commitment. When technologies are changing rapidly, buyers are worried about shelf-life of the technology they are acquiring. This concern is addressed by technology suppliers with commitment to upgrade their product (software on site and hardware through buy-back) for a specific period of time.

Compatibility

The compatibility of a new technology is to a large extent the subjective judgement of the decision-makers. The more a new technology is perceived to be compatible with existing technology, the higher is confidence of mastering the new technology and the more positive the attitude that can be derived. Open standards have evolved to address this concern of compatibility between various technologies. More common are the non-compatibility of the operating practices.

Enhanced value

In addition to the benefits derived directly from the technology itself, there could be some other forms of benefit relating indirectly to the adoption of the technology such as the generation or enhancement of a quality image or a novelty perception from adopting the technology. Such benefits can generate extra value as perceived from the user's point of view. Hence, the attitude towards adopting the technology may not only be related to the firm's utilisation point of view, but also incorporate the firm's perception of the extra (enhanced) value carried by the new technology to the users. The more experience a perspective adopter has, the better the understanding the adopter will have of the new technology. A better understanding of the technology will allow the adopter to better appreciate the additional value carried by the new technology.

Social pressure

Social norms have significant effects on system usage. Norm is the most frequently occurring pattern of overt behaviour for the members of a particular social system. For certain innovations, the social prestige that the product conveys to its user may be the sole benefit that the adopter receives.

Cases from PATSER

1.Improved Air Circuit Breakers

JSL Industries had taken up a project to upgrade the short circuit breaking capacity of their existing air circuit breaker from existing 32kA to 50 kA by optimising contact dynamics/ parameters. ERDA (Electrical Research and Development Association), successfully redesigned arc contacts based on know-why studies (study of bounce, bounce duration, time difference between main and arcing contacts and opening speed) and benchmarking (Korean, German). The contact dynamic parameters were improved with optimum selection of closing torque, contact spring pressure and contact gap. The improved ACB (1250A, 50kA) uses less material (32kg in place of 56 kg) and reduced production and inventory costs because of modular construction (in place of profile design). The product was readily accepted by the user. No changes need to be made by SEBs (State Electricity Boards) in system specifications or in his purchase practices. This contrasts with the challenges Shyam and ARDEE face in selling their systems to utilities. These examples highlight the importance of trailability, and observability for technology adoption.

2. Remote energy Metering System (REMS)

REMS is developed by Shyam telecom with the following components; energy meter (class 0.5, 3 phase, Trivector) with built in radio modem (9.6 kbps), area control station (radius of 3 km) and master control station . The energy metering unit coupled to a radio modem is installed at the customers premises. The consumption data is transferred (transfer time 5 sec) over the wireless link to the area control station(every 30 minutes) and from there on to the central control station. The data at central station is processed for billing, load profiling and analysis and energy audit. The pilot system with 50 meters, 2 area control stations and 1 master control station was erected, commissioned and demonstrated in Mayapuri with active involvement of Delhi Vidyut Board.

Though the system has the potential to reduce non-technical losses of power distributing agencies, there are difficulties in seamless transfer of technology. First it needs to be demonstrated together as working system. Second there are no national standards for REMS and BIS was roped in to formulate specs based on PATSER supported system. In the absence of national standards, MNCs have offered their own competing systems (based on GSM and others) and adoption of those systems by SEBs is fraught with danger because of network externalities. Third issue is whether transfer from energy meter to area control station by radio should be an open standard or proprietary standard. As on now the firm is using their own standard but experience of other countries show that an open standard will lead to faster diffusion of technologies. All our firms use open standards as free riders and there is no mechanism to agree on an open standard, when not thrust on them.

Installation of Energy Meters at user premises and Area Control Station in DVB office called for customers understanding but no modification to their existing system. Case of dry beneficiation project explains the issues of trailability and observaalbility made more complex because of the need for users to make modifications to their existing systems.

3. *Dry beneficiation of coal.*

The technology currently employed globally is wet beneficiation using heavy media to separate floats (clean coal) and sinks (rejects). The existing coal washeries of CCL, BCCL employ this technology, but it is a capital intensive technology. The coal industry tried to encourage private industry to set up these coal washeries but the response was not satisfactory again due to high capital investment. De-shaling plants have also been set up, for manual removal of stones from a slow speed flat conveyor. Bradford breakers were used to separate coal and non-coal particles. These simple methods did not produce satisfactory results. The coal users continue to receive coal with high ash content in addition to stones and other extraneous matter.

RAMDARS is the acronym for the RAdiometric Mass Determination cum Automatic Removal of Stone/ Shale. In this system the coal moves uniformly in a single layer over a conveyor belt. An on- line measurement system employing the principle of attenuation of radiation when it passes through a bed of coal and stones, measures the bulk density and identifies the nature of the material that composes the bed. Rejects are pushed away by air jet. The system is integrated in such a way that material that is of a higher density than the set threshold can be removed from the stream as it reaches the point where solenoids are located.

This RAMDARS system has been jointly patented by ARDEE with ANATEC of Germany, both in India and in Germany. ANATEC, is a small company with employee strength of 6 in Germany(part of east Germany) but with an accumulated knowledge base in on –line coal ash measurement . The concept was demonstrated in a small lab scale plant set up in the company (ARDEE) premises in 1996, with a single channel detector. Representatives from coal industry visited the lab scale plant, appreciated the work but felt demonstration on a full conveyor size at site is essential to prove the system before they could consider use on commercial scale.

In U.K they use sorting system adapted from agriculture and in Germany they use part of the system- on-line detection, there after they stop the conveyor and remove the stones. With support from PATSER the firm had taken up the project for development of a mobile 4 channel RAMARS system for demonstration of technology in different coal mines. The system has been developed and installed at Yellandu mines of SCCL.

The department is encouraging the firm to look at non-traditional ways of business partnering with coal mines, like supplying the system on wet lease basis, BOT method , linking payments to increase in cash flows etc, as Indian coal mines had no prior experience of adopting any major Indian innovations, which necessitates changing their purchase practices.

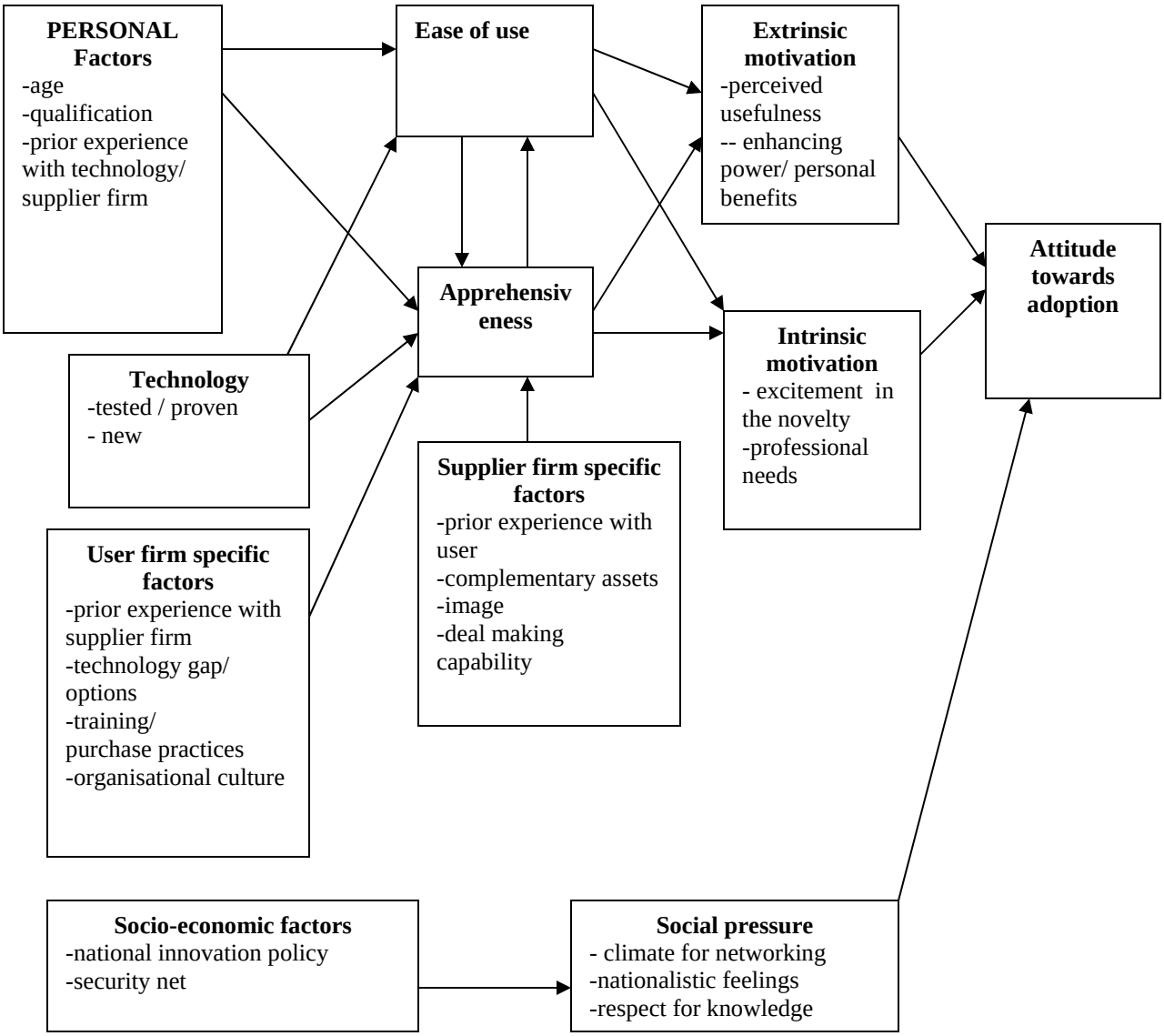


Fig1: Technology Acceptance Model

Summery

From the literature, one notes that large government buyers like Defense, Space, Health services, Telecommunications, Aviation, Mines have driven innovations in Triad (US, EEC, Japan) countries. In India the situation is more complex. Excluding those sectors where technologies are denied, in other areas, the primary concern of service provider is upgradation of technology to catch-up fast with other global players. Given the technology options, innovative merit becomes a basic need but not sufficient to clinch a deal. QFD technique provides a systematic framework to capture the users attributes. TAM provides a wider perspective to understand customers behaviour. This was based on the foundation of Motivation theory and Theory of Reasoned Action. Davis.F.D developed this theory in 1989 to explain computer usage behaviour. It theorizes that customers actions are determined by behavioural intentions which is influenced by the persons attitude toward using the system and perceived usefulness. From analysis of R&D project supported under PATSER, it appears simple technologies (stand alone, add-on) that require least effort in modifying adoption behaviour of buyer find ready acceptance. Complex technologies (systems) need to address apprehensions by providing observability and trailability. Many firms are now taking up development projects, which are in the early stage of Technology Life Cycle. For firms coming up with such technologies , success in networking (at various levels)with enlightened users decides the outcome. If Indian users are laggards in technology adoption, can Indian firms take up product/process development for global market ?

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