

Development of a Model for Technology Strategy Elaboration

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Abstract— Considering the role of industry in the economy, especially the developed countries and countries with automobile (automotive industry) seems to be necessary to develop technology development strategy. In this paper a model by choosing appropriate technology development strategy to how good we are. (So review existing models and evaluate their strengths and weaknesses of the measure applied in the industry with the closest model industry conditions is consistent with the practices were selected and other factors as the failure of this model was determined it developed a new model for strategy is presented)

Index Terms— Technology Strategy, Elaboration, Technology management

I. INTRODUCTION

TODAY, technology plays a crucial role in firms' competitiveness. It needs therefore, like other sources of competition, to be managed based on a strategic point of view. The first and most important step of technology management is to develop a long-term strategic plan which determines firm's investment priorities and preferences in the field technology development, called "Technology Strategy".

TS is concerned with, but not limited to, the following questions [Lindsay 1999]:

1. What are the technologies which the company's sustainable competitiveness depends on?
2. Are these technologies all available or feasible?
3. What are the appropriate ways of acquisition for those technologies should be acquired from outside?

4. How can we ensure that we make best ROI in technological assets/ capabilities/ competencies?

Different models and frameworks have been developed by practitioners as well as academicians in order to help companies' top manager in TS formulation. But, firms in different sectors, with different sizes and thus different characteristics may find it difficult to choose the proper model, the most pertinent to their own situation. This is because for majority of firms' managers is difficult to identify differences between models. While, for selecting an appropriate model, we should be able to compare different models and be aware of their strengths and weaknesses and their limits of applications.

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II. CONCEPT AND DEFINITIONS

A. Strategy

1) Assigning long time objectives of an organization and chose action for allocation sources in order to achieve goals [1].

2) A procedure of assigning organization objectives for long time, executive plan and priority in sources allocation [2].

3) A design and or plan in order to array fundamental objectives, policy, organization constant action drastically [3].

B. Technology strategy

1) Institute decision regarding to investment, development, applying technology of production and processes [4].

2) Assigning investment priority on technology development with considering long time objectives [5].

3) Technology strategy is an operation strategy and interpreted as organization general strategy on technology context, a prior situation or gaining long run objectives assigned by technology development [6].

According to Drejer who in 1996 presented historical classification of different procedures of technology management, generally, these procedures are:[16]

- R&D management,
- innovation management,
- technology planning,
- strategic management of technology

each of which has been considered by institution in different time intervals. Important point in examination of historical path of different views on technology in interactions of organizations.

C. Operation strategy

Operation strategy is organization general strategy in a specific segment, in other hand a way of fulfilling general strategy in the segment of organization [7].

D. Benchmarking

Finding other firms function fulfilled better in order to implementing them and or improves it [8].

E. Strategic planning

1) A process encompasses sources allocation for gaining organization and general goals and mission in competitive environment [9].

2) Assign and build organization mission and long run objectives and achieving a way to gain goals [10].

F. Technology

According to dictionary the meaning of technology is scientific study, engineering and scientific application use [11].

A scientific use of science in order to human needs provision [12].

Skill and science required for producing goods and or providing services resulting from mental ability and human perspectives and existed fundamental and phenomenal regulation combination [13].

Technology encompasses the whole factors which cause an idea to be changed to product. And lead to increasing income and entails factors such as reconstruction of main activity product technology, process technology, skills and know how, systems and experiences, data services, supporting, logistics, and management approaches [14].

In a simple language, technology is ability entails skills and science, and could be studied in here context: 1. Product technology, 2. Process technology and 3. Management procedures.

1. Product technology

A kind of technologies which are used in combination of goods and services and could be perceived via discipline and application contexts [15].

2. Process technology

A kind of technologies which are used in producing of a goods process could be perceived via four factors: hardware, info ware, human ware and or aware [16].

3. Management procedures

Contains techniques and procedures for handling administrative better, total quality management (TQM), just in time, risk management, and so on.

G. Technology selection

Technology as a major source of competitive advantage for manufacturing industries is widely accepted by practitioners, governments and academics. An enterprise can waste its competitive advantages by investing in wrong alternatives at the wrong time or by investing too much in the right ones (Torkkeli & Tuominen, 2002). A country can obtain its competitive advantages by investing in emerging technologies with comparative advantages (Lee & Song, 2007; Yu et al., 1998). In order to realize this competitive advantage, it is vital to understand both the specific technologies, and the ways in which organizations can best manage technology (Phaal, Farrukh, & Probert, 2001). Gregory (1995) has proposed that management of technology is comprised of five generic processes: identification, selection, acquisition, exploitation, and protection.

Among these processes, technology selection is defined as involving the choice of technologies that should be supported and promoted (Gregory, 1995). In the phase of technology selection, decision makers have to gather information from various sources about the alternatives, and evaluate these alternatives against each other or some set of criteria (Lamb & Gregory, 1997). Accordingly, Gregory (1995) separates the "identification" and "selection" phases where the former is concerned with gathering alternatives and the latter is concerned with the action to decide on an alternative. In contrast, Dussauge, Hart, and Ramanatsoa

(1992) define the technology selection process as identification and selection of new or additional technologies which the firm seeks to master. In sum, a key theme in these definitions is that technology selection is a "process" that is closely linked to organizational objectives and is associated with the broader technological and market environment (Shehabuddeen, Probert, & Phaal, 2006; Stacey & Ashton, 1990).

However, it is becoming more difficult to identify the right technologies because the number of technologies is increasing and the technologies are becoming more and more complex (Torkkeli & Tuominen, 2002). Additionally, decision makers need to face other challenges such the rising cost of technological development, abundance of technological options, and rapid diffusion of technologies (Berry & Taggart, 1994; Lei, 2000; Steensma & Fairbank, 1999). For example, technology accounts on average for more than one-third of all business capital spending (Bakos, 1998). The abundance abundance and complexity of technological options makes the task of accessing suitable technologies and selection of the most suitable option more difficult (Cantwell, 1992). Ronde (2001) selects 98 specific technologies of future possibilities in the field of biotechnology in France. Using the same foresight technique, Ronde (2003) respectively introduces 40, 51, 39 and 50 potential areas in the fields of elementary particles, energy, natural resources and environment for Germany and France. Lee and Song (2007) also provide 56 research areas in nano-technology field for South Korea.

Besides the increasing cost of technological development and the abundance of technology options, many studies have shown that companies fail to assess new technologies. Hackett (1990) and Greenberg and Canzoneri (1995) point out that projects to incorporate new technology in a majority of companies are failing or are not fulfilling expectations. Huang and Mak (1999) argue that the failure of a chosen technology often results from poor management and assessment. Some of the causes have been attributed to the inability to consider the wider relationship of technology to the industrial context and the technology investments (Schroder & Sohal, 1999). These studies demonstrate the necessity for a careful assessment to overcome the difficulties of technology selection before introducing a new technology (Efstathiades, Tassou, Oxinos, & Antoniou, 2000).

H. Four stages of process oriented

Generally firms apply their own procedures for process oriented and it in turn will effect on people separately. There are types of simultaneous and common pattern which could be applied in any environment. To be process oriented a firm should pursue the following stages:

a) Identify the processes and nominate them

This is a fundamental stage, some firms divide their main process to sub process that each of them including different functions.

Other firms declare their functional current activities as process.

The process pass through existed organizations and a rule of thumb instruction is the new process shall activate three people to be inferred as process. In order to identifying a process the organization function should be surveyed

horizontally and shall be prevented any up toward down attitude.

Nowadays due to importance of selecting process and communication correctly, firms, organizations, associations assign specific patterns in order to select and identify process in specific issues centralized on coordinated basis. This function driven to uniform the process in different activities.

b) Process and its importance should be introduced to all responsible

The key word "whole" is important, included, managers, staff, far and close representatives that should know well the process and their names, input, output and their relation to each other. Tendency to process oriented will change staff function immediately but their perceive will be promoted and consider to the whole activities.

Industrial revulsion presented the term worker that indicate new categories of farmers and craftsman, at present worker with limited functional view, is being substituted to processor; in the other word the staff knows that their performances will aid the process.

c) A criterion to appraisal and select of process in order to move toward process oriented

In order to understand that the process work properly, the function should be measured, in this case a criteria needed. Some of the criteria could be based on customers' tendencies, by surveying the customers view firm perceive that process cycle time should be preferred, working perfectly, related to organization other needs and other fiscal issues.

Criteria are for doing process right also for promoting and developing them any selected criteria should include at the whole process and all of the responsible should apply them and know them appropriately. It could be an important tool in order to shape people behavior and change them as tyrant group and lawful.

In process oriented, team role is outstanding. Team here does not means a group of people who works with each other, the likes each other and or the same idea. But team means a group of people who have common objectives and simultaneous criteria in function process; these in turn make them an integrated team forgoing close and or far away location. Some of the process might have been done lonely, but most of them performed by team working.

d) Possessing processor manager

As mentioned before tendency to process technology for solving firms' problems are important stage .besides it is a contentious function approach, so a processed oriented organization should improve organization permanently.

So most of managerial activities of such firms arraying the process right high caliber, applying opportunities in improving the process and pursuing the applicable opportunity. Process oriented is not a temporary proposal but could be a procedure in economic life. Process orientation affects fundamental and organization mission. and will affect the people view of their job, payment and appraisal method , managerial activities and their function, even format of the societies combined with process oriented organization.

I. Process approach

Any activity and or series of activities as source for changing input to out put could be a process. Organizations to perform effective, they should identify and array effective and relevant process. Usually output of a process causes input of next process directly. Identifying and systematic array of process in organization and esp. the process links recognized as process approach [18].

J. Organization function level

Romler in order to indicate the interior links of systems three levels, nominated as three levels of organization performance .according to Romler model, each organization included three main levels [19]:

a) Organizational and structural level in which objectives reason, strategies, macro policies, and general frame work of organizations and institute will be designed.

b) Level of process in which reason of existence, objectives and main process structure needed for the organization designed.

c) Organization design and executive in which objectives and organizing, organization structure details and main tasks of the organization will be assigned.

Systems structure and categories designed as: mechanical processes, physical, chemical and social ones.

K. Reengineering

Re-engineering analyzes organization's processes in order to identify the best way of performing a special set of actions. In order for resource planning system of an organization to be effective and useful for the organization, at least some business methods of the organization should be changed and new methods be developed. Hence, repeated engineering of business processes has a close relation with installation of the organization's resource planning systems. Repeated engineering of processes examines different methods of performing a special process and selects the best method [20].

L. Free Re-engineering:

In this method, repeated engineering is performed by a special technology and based on the organization's demands and without considering the system and there is no predefined limitation for reviewing and designing the processes. In this method, optimal processes for the organization are designed. Compared to repeated engineering method, this method has more technology cost but more flexibility for meeting organization's demands. Compared with repeated engineering, this method is based on slower technology and its installation is more difficult. Using this method, organizations could obtain competitive advantage since processes are produced exclusively for them and rivals have no access to these processes. If this method is accompanied with training, making culture and cooperation of employees, then in practice it will face fewer problems from employee's support view. Although in this method, processes with which users deal, may be changed completely [21].

M. Re-engineering based on technology

In this method, we first select organization' resource planning system and then based on this system, repeated engineering of processes is performed. Eliery calls this method limited repeated engineering. Compared to free

repeated engineering, this method is simpler and cheaper, because there is no need to system change and only organization's processes are changed considering the system. This method designs organization's processes based on system's capabilities. As an example, product processes of SAP Company are designed such that they perform the jobs in the best way. Companies which fully dismantle SAP products, design their processes such that they, along with post-war processes, created a new regime in the world. Industrial countries, after victory in war and predominance in economic field, obtained a major share of productivity capacity so that products based on technology, in addition to the inside of the county, could be sold all around the world easily [22].

III. LITERATURE REVIEW

A. Porter Model (1980)

Early in 1980s, Michael Porter examined relation between technology strategy and commercial strategy of an firm. Based on his view, competitive strategy and competitive advantage provide a **proper** and **effective** and for formulating technology strategy. In commercial strategy, competitive advantage is the characteristic for finding proper competitive environment, an environment in which institution of obtaining a stable competitive advantage. In Porter's examination, decision-making is based on commercial action's area and situation of that area's changes.[33]

B. Mogen model (1982)

In this model, technology strategy development process includes four main stages or steps, shown in the below figure. In Mogen model, after identifying institution's important technology, its necessary to perform evolution of this technology, Mogen specially considers two groups of: 1. basic criteria, technology' attractiveness evaluation criteria, 2. and criteria of ability evolution of proposed institution in identified technology's area.

C. Porter- Mogen composite model (1884)

Deficits of Porter model for not presenting a clear way to evaluate attractiveness and ability of identified technologies as well as developing technology strategy based on those evolutions are solved by use of tools presented by Mogen (attractiveness-ability matrix). In order to determine investment priorities and its proper methods. Identification of technologic changes procedure in key technologies of organization that was considered as one of critical steps in Porter model is also important indirectly in Porter- Marin composite model and performed in step of attractiveness evaluation of selected technologies for investment of the composite model.

D. Hax and Mazlov model (1984 and 1991)

- A valuable work to understand technology strategy
- Their conceptual and mental theme was based on Poter framework.
- Their theory specially made clear classification of the main decision- makings related to technology strategy [5, 31].
- In this model, institution considering its mission, strength & weakness points, strategic threats and

its competitive plans, should provide macro-strategy.. By developing this strategy, technological requirements field is specified in macro form.

E. Chaplet and Twistiga model (1984)

Chaplet and Twistiga model (1984) believe that technology development strategy of an organization should be developed considering key factors of success in the market (KFS). From their view, key factors of success are a set of needs, requirements and demands which are applied to the organization by costumers, suppliers, rivals, distribution channels, government and ect. Level of success or failure of organization, severely depends on their level of proper, timely and fast responsiveness to KFS s in the market.

F. Little model(1987)

Unlike chaplet & twistiga, some of other researchers believe that technology must be based on core competencies or in other words, basic capabilities of the organization. It's clear that paying attention to requirements, needs and demands of the market is necessary for survival of the organizations but organizations have different abilities in providing for demands and needs. In development process of technology strategy and making decision about that which technologies are important and what actions are required for their development, managers naturally tends to begin with technology without considering other considerations.

G. Booz - Alen & Hamilton (1981)

- a method for technology strategic management which is based on the following:[38]
- Path & time required for gradual development of required technology could be determined by pervious knowledge and anticipation.
- Technology should be seen as a capital asset.
- Homogeneity of investment in technology and commercial strategy fields is a necessary fact which leads to successful technology management.

H. Mc Kenzy model[1998]

In 1998, Foster presented another theory which focused on technologic changes and institution's ability to facing them. Base of analysis is S diagram behavior. In the beginning of a R&D progress in this stage is slow, then progress rate increases and finally, considering its limitations, technology is formed and progress rate becomes slow.

Now it's time to move toward another technology management which has more fluent changes. Foster suggests that finding technological decline (decadence) of existing technologies is very important. Technological decline effects in an institution are:

- decrease of R&D efficiency of the institution
- orientation of the institution toward losing last R&D opportunities
- change from R&D based on product to R&D based on process
- change in sell growth resources toward a little section of market share
- tendency toward important changes among rivals for investment on R&D

- dissatisfaction of performing an emerging R&D management

Orientation toward competition with smaller & weaker rivals in industries.

I. Parhald and hamel capacity theory (1989)

In 1989, Hamel and Prahalad named this as "strategic intent". Then, to obtain required objectives a path should be designed and its details should be specified. In fact, in defining these intents and important aspect which should be considered is that actions required for performing it as well as the path which should be followed should be considered. This action is named strategic architecture and makes capabilities which should be accumulated for competition and specify the way of obtaining them. Of course this (strategic architecture) should be designed with required freedom degree and flexibility any action should be based on meeting customers' needs and their satisfaction. Products are considered as a set of functions which are performed to response to costumers and make value for them. (Abel theory, 1980). Product functions are more stable than technologies and product itself. Therefore, functions of a product are basis of an organization that should be developed in long term strategy and lead the institution toward special actions which cause resources accumulation in this special direction.

J. D Aveni's ulro-competitive theory (1994)

In 1994, D "Aveni emphasized that dynamic property of competition is so intrinsically deep that it couldn't be considered as a secondary subject in strategic thinking. He emphasized that markets, are so changing and dynamic that evolution is the most basic power in strategic actions. In thoughts based on resources, the most important aspect of competition is not current situation of the institution but changes are made by dynamic interactions of competing firms.

K. Itami and Numagmi model(1992)

In 1992, Itami & Numagami performed an interesting examination about dynamic interaction between technology and strategy. Based on this, there are three kinds of interaction between strategy and technology:

- Interaction between current strategy and current technology
- Interaction between current strategy and future technology
- Interaction between future strategy and current technology

First case which is introduced as abilities of strategy in technology focuses on simultaneous consistency between institution's strategy and adoption of proposed technologies. Basic hypothesis is that technology could influence strategy in three ways:

- As an amour which distinguishes the institution from it's rivals.
- As a limitation with which institution should become consistent
- As a threat against which institution should protect itself

L. Chieza model. (2001)

Technology strategy formulation in dynamic environments of this section presents a structure of formulate technology in competitive dynamic environment. In the past section, basic principals and key characteristics of technology strategy formulation in dynamic environment were defined. Decisions are made based on data collected from future form of competition & industry, technologic advances prediction and evolution of internal & external environments. This data collection provides base of future scenarios, which is consistent with strategy foundation. This step is called future- recording of environment and is the key to enter decision-making step.

IV. PROBLEM STATEMENT

Today, technology strategy is considered as one of the most basic needs of industries & firms. Considering significant effectiveness of this strategy on other operational strategies. Increasing limitation of organizations' resource, specially in developing countries, has become a critical challenge for managers and hence made prioritization in technologies development & planning field very important. On the other hand, role and importance of proposed industry necessitates considering technology strategy development. Believing in this principal that the technology is the base of **add value** in a company creates necessity of developing technology strategy[10]. Coming of the newer technologies, changing of the sales markets paradigms, increasing of the competitiveness in local and international markets are the reasons for developing technology strategy in companies and firms. In order to define its future investment priorities needs to develop its own technology strategy determining its own activities domain for future [7] .

It is strongly necessary that local industries, which have good potential, should get into this business. So to get into this new business, the investment priorities and industry development should be determined which its requirements is developing technology strategy? (In regards to market conditions, customer requirements, and macro strategies) [7]

Technology as a source like many other sources like financial, Human resource is very important for organization.

In general, the goal of technology strategy is to define the priorities of investment in technology area.

Now a day's most organizations in order to keep their competitive position and have an effective presence in competitive markets are trying to establish their own strategy, especially progressive technology strategy. [24]

Since the subject of this research was developing progressing technology strategy for an specific industry, with consideration of conditions and specifications of that industry, the appropriate model for developing progress "technology strategy" has been selected (which is the HAX Model as a base model) which with some modification for specific industry can be used as an appropriate model to develop progress technology strategy. After analyzing the different solutions, the suitable strategy will be developed.

Speed and volume of technology changes in recent years were significant. Fast rate of technology innovation caused technology to be the main effective factor on economic growth and national power. Technology changes increase fast and widely and these changes influence industry capacity, employment pattern and social changes severely. At the same time as fast rate of technology changes, there are changes in market behavior. Now, costumers have selection right and expect to receive various and high quality products. Speed of technology changes along with new behavior of costumers provide for move from fixed production line toward flexibility and capability of fast response to changes. Relatively new competition of international market is becoming increasingly stronger.

Today, new countries such as Taiwan, Korea, Singapore and China are considered as powerful rivals and the way of competition is changing significantly. Countries are establishing commercial and merchant unions and rivals instead of one country, include several countries in the form of commercial unions

After studying all existing forums and models, evaluation of technology and different procedures for this evaluation have been performed, the results were indicating that the evaluation of technology will be carried out principally in two areas: The capability and Attractiveness of the technology in organization level.

The following questions must be answer in the presented model:

1. What are the technologies which the company's sustainable competitiveness depends on?
2. Are these technologies all available or feasible?
3. What are the appropriate ways of acquisition for those technologies should be acquired from outside?

Development of a model for: Assessment of TS, selection of technologies to be acquired (investment priorities), timing of introducing new technologies to the marketplace and exploiting

- Income gaining industry, local content, and preventing the outgoing of foreign currency.
- Increasing abilities of the industry through the existing technologies of Auto Industry.
- Making a competitive advantage for the industry.
- Development of the export market considering the situation of auto exporter countries.

Decrease of technology selection time

Increase of productivity and efficiency in technology selection

Increase of power competition firm in global market

Lack of specific model for Selection and assessment of technology strategy in auto industry.

It's clear that coordination between technology strategy and macro- strategy of this industry is very important and should be considered specifically .Considering characteristics of proposed industry, market condition, customer's variety and their various requirements; we used a proper model to develop technology strategy in this field. Key and strategic importance of commercial field of Auto industry in proposed because of:

- Its economic & strategic importance.

- Acquisition of technical knowledge and technologies related to design and manufacture of car industries is a stable and strong bed and basis for acquiring knowledge and technologies required for design & manufacture of other industrial.
- Existence of wide internal & external markets for final products of this business.

V. CASE STUDY: IRAN KHODRO POWER TRAIN CO.(IPCO)

A. Objectives

The main purpose of this research is to develop technology strategy in Auto industries by focus on business fields that generally results in obtaining investment priorities in the context of technology development and finding a proper way to supply, develop and exploit selected technologies.

- Finding a proper way to develop and exploit selected technologies
- Capability of evaluation their competitive position in technology
- Obtaining investment priorities in technology area

B. Contributions

- Plan and development of strategy, is one of the main need for industrial and companies.
 - ☞ Technology strategy
 - ☞ Proper investment
 - ☞ capability of competitive products in international markets
 - ☞ Future activity domain
- Deficiency of proper model that useable for in auto industry
- Develop a selected model for
 - ☞ Acquisition and assessment of available technology
 - ☞ Evaluating and Selecting
 - ☞ Planning for introducing new technologies to the marketplace and exploiting
- Preparing a developed model from selection till development of technology strategy

C. Methodology

The proposed methodology has been stated strategy in Fig.1. The model starts with a literature study and analysis of automotive production and relevant questionnaire based on the comparison of different models, and then consider their strengths and weaknesses of the model to choose the best acting ancestry to develop models chosen will act. Hax model is based on the model.

D. Outputs

- Determine investment priorities
- KFs identify specific industry standards
- Select the best model for developing technology strategies
- Take advantage of this strategy in developing the Road Map Company

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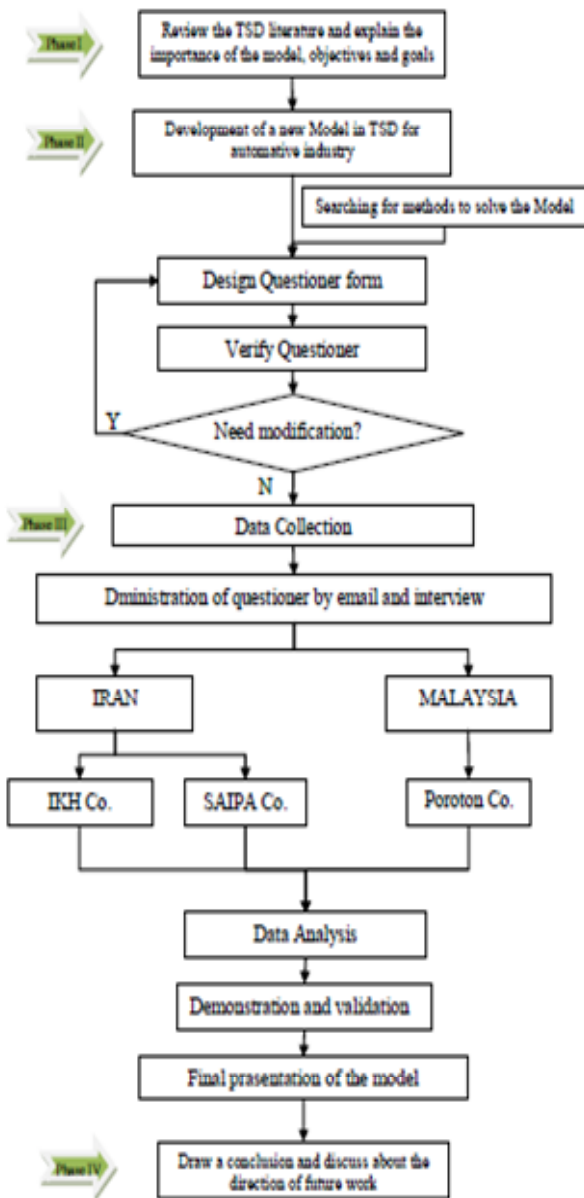


Fig.1. Proposed Methodology

VI. CONCLUSION

Considering the role of industry in the economy, especially the developed countries and countries with automobile (automotive industry) seems to be necessary to develop technology development strategy. Reviewing the existing literature on models of technology development strategies and their strengths and weaknesses is expressed. The base model Hax base model that developed the automotive industry due to the nature and conditions governing the intervention model with environmental factors, political and social were completed and presented.

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