TECHNOLOGY CAPABILITY ASSESSMENT - METHODS AND APPLICATIONS

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Abstract:

This paper is to review and evaluates the technology assessment methods and their expected results and then focus on an approach of technology assessment at national level. The paper ends with the proposal for selecting an appropriate method to meet the objectives of managers and policy makers.

1. Introduction

Many methods for technology assessment were proposed to meet practical and theoretical requirements. They may be classified by topics of application, namely technology assessment in transfer (may be called also appropriate technology assessment), technology capability assessment, technological environment assessment *(APCTT, 1996)*. They may also be classified by areas of application which include groups of businesses and enterprises, industrial sectors, regions, countries. The topic ß technology capability assessment attracts attention from researchers and authority agencies in Vietnam since the years of 80s, particularly since the years of 90s the last century and the early years of the actual century. Many provinces/cities conducted their local technology capability assessment. The demands come mainly from State authority agencies. Their targets are not only to know the actual situation of their technology capacity but also to know their relative position in comparison to other regions and countries. It seems, however, that the gained results did not meet the second target. This paper will consider the used methods and gained results from studies conducted by various research groups. Further, from macro-point of view, the author will present some assessment methods expected to help to compare technology capacities between regions/nations. The presentation will be focused on the method of technology capability assessment developed by the Technology Policy and Assessment Center (TPAC),

Georgia Institute of Technology, USA. It will be also accompanied with the analysis of applicability for Vietnam.

2. Technology capability assessment of businesses and industrial sectors

Many projects were conducted for technology capability assessment at the scale of province/city. The assessment, however, was based on data from businesses. The main research groups include Technology Management Department/BR&T Center (HoChiMinh City University of Technologies), Management Research&Consulting Center (CRC, Hanoi University of Technologies), HoChiMinh City Department of Science&Technology, Regional Center of Quality Research&Measurement. The methodology of these groups are based on the method of technology capability assessment developed by the concepts of APCTT (Aisa-Pacific Center for Technology Transfer). The method breaks down technologies into 4 companents: Equipment (Technoware), Information (Inforware), Human resources (Humanware) and Organization (Orgaware). The circle of their interests are businesses and the conducted surveys of businesses made for an industrial sector will reflect its technology capacity. Research groups set up the absolute scales (maximal marks would be 5 or 10) for assessment. Due to different stands of assessment, however, the studies can permit to make the comparison between sectors and businesses in one research project (see [6]). Therefore, the obtained results of these studies, as rule, can show only the actual situation of technology capacity of certain businesses or industrial sectors on the adopted absolute scale of measurement and cannot give the comparison to other provincves/cities or nations.

This micro-approach (based on *businesses*) and the 4-component method of technology capability assessment can give the initial analysis which would help the business managers to have a view of strong and weak points of their businesses and then to work out suitable solutions and development strategies. From the State management position, these results would help State agencies to issue supporting policies. However, these results are unable to give the comparison to other sectors and regions and, therefore, they would not help much to set-up their own development priorities or strategies. In addition, research results usually cannot give answers to the questions: where we are in term of technology capacity if the region and the world. In fact, this main question remains in the center of concerns of local administrations.

3. National technology capability assessment

We need to have another approach applied for comparable targets, particularly for regional and international context, where popular economic indicators can be used for easy calculation and comparison.

APCTT (Volume 4, 1989) presents some methods of technology capability assessment for sectoral and national scales such as the method of technology capability assessment by economic terms, method of technology capability assessment by isolation, method of strategic analysis, multi-index method, etc. Here, APCTT also gives the analysis of some shortages of these methods, namely:

- The use of many macro-economic indexes does not help to identify and synthesize the weakness of technologies. They do not give also any hints;
- The use of input data such as number of science-technological publications, number of patents and etc. can reflect partially the technology capacity. They cannot show the productivity and the rate of technological changes.

3.1. Method of Technological Atlas

The method of Technological Atlas is the result of the Project Technological Atlas started by the APCTT. The method compares the macro-economic indicators of many nations and the assessment is conducted annually. The method is based on the main concept that the technology is the deciding variable for socio-economic development and growth in the context of increasing economic globalization and international competition.

The method of Technological Atlas analyzes the assessment of technological indexes developed by the Project which include technological content, technological environment, technological level, technological capacity and technological need. The main purpose of Technological Atlas is to give a tool to support the decision making process. It is a set of methodological documents to unify the technological considerations during the set-up of development plans. With its advantages in the assessment, management and planning of technological strategies, the method of Technological Atlas is being used largely as basis for many technological projects, particularly for developing nations.

The method uses 4 typical components of technologies, namely Equipment (Technoware), Information (Inforware), Human resources (Humanware) and Organization (Orgaware) to assess the technology capacity. They would be capable to complete each other in the regular economical planning and the

technology-based planning for the scale of companies, sectors, provinces and nations. This method makes accents of assessment of changes of values in the total production accompanied with changes in technology capacity. The assessment includes 9 steps *(see APCTT, 1997, Vol. 4)*.

Althougth various studies of technology capability assessment refer to the method of Technological Atlas as leading methodology of their studies. But, in fact, majority of them were focused only on the first three steps and their main attention is focused on the TCC index which is the technological contribution coefficient of transfer means. The assessment of TCC is based on the complex rate of the 4 technological components of businesses where the technology capacity of the sector is assumed to be the average value of recorded TCC values [6]. Therefore, the further steps in the macro-assessment were ignored and it causes the weak points of results of the studies as mentioned above. The analysis of steps of the method of Technological Atlas fro industries *(APCTT, 1997, Vol. 4)* shows that this method does not permit the comparison of the technology capacity between nations. The calculations are found highly complicated but they can provide a comprehensive picture of an industrial sector where the capacity factors (input factors) include the technology capacity of businesses (reflected through TCC indexes) and the results (output factors) include the export and innovation content of products. The introduction of qualitative and quantitive analytical information in steps 4-8, without the indication of any method to synthesize these data, makes the results of studies qualitative, and the offered qualitative analysis and comparison, if any, remain the ones based on the results of step 3.

The author finds, however, that the method of Technological Atlas could not meet the purpose to assess and compare the technology capacity of any industrial sector or nations to others because of its complicatedness and it cannot give the desired final conclusions. Therefore, for purpose of comparison of technology capacity, it is necessary to have an organization to carry out the calculation and assessment on basis of a unified system of criteria which is applied for many nations, or to set up a unified system of assessment which is based on popularly available data in official statistic figures of almost all the nations.

Recently we have seen a popular assessment made by the World Economic Forum (WEF) named Global Competitiveness Report. The Report presents the full economic assessment of more than 130 nations (the number of nations varies from year to year) including Vietnam. Among many assessment indexes, there are some which reflect the technology capacity such as availability of latest technology, firm-level technology absorption,

capacity of innovation. The Report is issued annually and it permits to compare the competitiveness among nations.

In addition to this Report, there exists another method named the method of High Tech Indicators (HTI). The method was developed by the Technology Policy and Assessment Center (TPAC), Georgia Institute of Technology, USA and it is focused mainly on the assessment of technology capacity of nations. The study is conducted annually for many nations.

3.2. Method of High Tech Indicators (HTI) [10]

The Georgia Technology Policy and Assessment Center (TPAC) had set up the system of High Tech indicators for technology-based assessment and comparison of competitiveness of nations. The study receives the support from the American National Funds for Science and the HTI system is used also as science-technique indicators of nations. The study began in 1987 and it is made every three years. The last assessment had been made public in 2007 and it was conducted for 33 nations including the US, Canada and Mexico (North America); Brazil, Argentina and Venezuela (Latin America); Czech republic, France, Germany, Hungary, Ireland, Italy, Netherlands. Poland, Spain, Sweden, Switzelands and the UK (Europe); China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan and Thailand (Asia) and Australia, Israel, New Zealand, Russia and South Africa. Therefore this study covers all the continents and nations which are classified as developed (industrialized nations) and developing (emerging economies).

The HTI model considers the competitiveness at national scale where the technology is assumed to be the key for competition. This fact is confirmed also in almost all the related studies which were conducted before. The HTI-based assessment has two targets: (i) identification of the actual technological position, and (ii) forecast of the future technological position for 15 year later.

The HTI model is adjusted through the years of application. The most recent model of 2007 is shown in Figure 1.

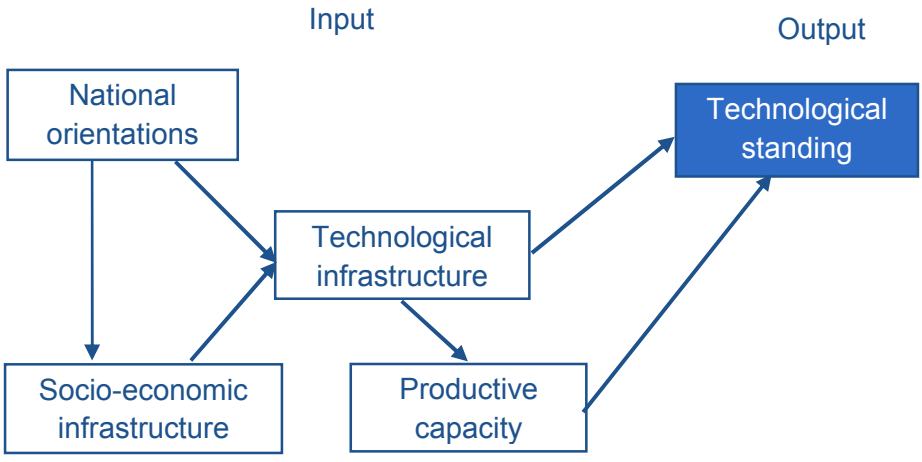

Figure 1: HTI Model [10]

As assumed by the research groups the nations build up their competitive advantages on basis of 4 input components, namely:

- National Orientation - NO;
- Socio - Economic Infrastructure - SE;
- Technological Infrastructure - TI;
- Productive Capacity - PC.

Then these components will define the output - Technological Standing - TS

3.3. Measurement and collection of data of the HTI method

For measurement and calculation of input-output components as presented in the above model the research group of TPAC had integrated statistic values and expertise. It is an interesting approach to combine the available data (statistic values) and the point of view of experts (for assessment non-quantitative factors or non-available data). In order to integrate quantitative and qualitative indicators, TPAC had set up formulas to compute indicators of TS, NO, SE, TI and PS based on the simple calculation of avarage value of the indicators.

The data for calculation of input and output indicators include quantitative and qualitative data. The qualitative data are taken from secondary sources such as UN Statistical Office, Yearbook of World Electronics Data and World Development Indicators of World Bank. Authors had consulted these sources and they were provided with the data of almost all the nations.

The qualitative data are collected through expertise survey and the collection had been conducted through the questionnaires established by TPAC. For purpose of this survey TPAC had set up a board of international experts. In the 2007 study the group had received 392 responds to their questionnaires (website and email). Averagely one nation is assessed by 12 experts. The experts selected by TPAC for the study are diplomatic officials, professors, experts, scientists and advisers of publishing houses whose activities are related to technological analysis and forecast. It is a strong position of TPAC that other research groups could not easily set up. Since the study is conducted for long periods of time TPAC can build up an extensive team of experts which may change from year to year (only 1/3 of the 2007 assessment team is retained from the 2005 assessment team). The experiences of TPAC in selection of experts and set-up of questionaires can make the obtained results credible.

For purpose of integration of quantitative and qualitative data with different dimensional units the collected data are transferred to the 100 point scale. For qualitative data the score of 100 points is assigned to the highest evaluation and the score of 0 point is assigned to the lowest evaluation for a question. For quantitative data the score of 100 points is assigned to the highest value and the score of 0 point is assigned to the lowest value in the set to values of indicators of the nations.

3.4. Outcomes from the HTI method

The results of input and output indicators were transferred to graphics to examine the relative comparison of technological competitiveness between nations. Since the study has been conducted for many years TPAC can show the change in relative positions between nations through years. For example, the 2007 study shows that China has a spectacular change in competitive advantages after 15 years (increased from 22.5 points in 1996 to 82.8 points in 2007, taking the first rank). The US passes from the top of 95.4 points in 1999 to 76.1 points in 2007. Japan passes from its top of 93.9 points in 1996 to 66 points in 2007. It is necessary, however, to note that these figures present only the relative position. They show only the increasing or descending trends in technology-based competitive advantages between nations.

4. Conclusion

The above presented analysis shows that ***the HTI method*** (Alan Porter *et al.,* 2008) can give answers to the questions of comparison of technology capacity between Vietnam and other nations. The application, however, of this method for self-assessment purpose is not simple. The methodology is

made public in details but the access to data is very tough without supports from TPAC. Therefore if Vietnam wants to get the similar assessment we should make the application for study and become a member of the group. In an immediate vision if we want try ourselves we can refer to some nations in the list of 33 nations (such as Thailand, Singapore, Malaysia, etc.) to set up a new group for purpose of comparison (which would have the same system of indicators of TPAC). Then we can compare Vietnam to the remaining nations in the selected group.

The following table summarizes the methods used for technology capability assessment. It may provide a global view to the methods of assessment and obtained results in term of technology capacity.

Assessment scale	**Assessment method**	**Strong-weak points and expected results**
Businesses	Calculations based on TCC term of the method of Technological Atlas. The criteria of assessment are adjusted by combination of fine measurements of technological components (according to Atlas) and the indicators of the MoST [6].	Applied largely already in Vietnam. Rich data exists. Simple methodology. Easy application. Criteria none unified then impossible to compare the results between provinces/cities (many research groups conduct studies) [6]. Results used to identify the technology capacity of businesses and compare businesses in the same sector. Orientations identified for businesses to enhance their technology capacity. Policies to be used to support businesses in enhancement of technology capacity (through improvement of T, H, I, O components).
Industrial sectors	Method of Technological Atlas for assessment of technology capacity including the calculation of technological content added (TCA) and the examination of export and innovation content *(APCTT, 1997, Vol. 4)*.	Complicated method requiring a rich detail information (quantitative and qualitative). Much information is not available in the actual context of Vietnam. Results, in majority, are qualitative then not easy to compare, even the same method being applied. Results describe a detail picture of technology for an industry then help to identify well the orientation of products and technologies and the development strategies. Not applied yet in Vietnam.
Nation	HTI method of assessment	Applicable also for industrial sectors Simple methodology with data available or

	developed by Georgia Tech [10]	easy to collect. Highly cost if we want to compare various nations (rich data and high expertise required). Results helps to compare the technology based competitiveness between nations, or to compare to its own changes in term of time... Results can make forecast for future (15 years later). Not applied yet in Vietnam.

Briefly, the actual method (Atlas-based) for assessment of technology capacity in Vietnam can give the assessment in micro-scale and help businesses to have a clear sight of their own strong and weak points and then figure out an adequate strategy. The obtained results can also help the State management agencies to issue policies to support businesses. It is necessaty, however, to be careful when we want to have the assessment of technology capacity of an industrial sector through the assessment of technology capacity of businesses in the sector. In order to have a more overall assessment of technology capacity of the industrial sector, it is required to add output indicators reflecting export content, technological changes and innovation under the Technological Atlas's method. For the macro-scale assessment the HTI model of TPAC can be taken to consideration. Vietnam would contact this organization for their assessment instead of efforts to seek for its own methodology and study./.

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