International Journal of Knowledge *www.ijklp.org*
and Language Processing KLP International ⓒ2016 ISSN 2191-2734
Volume 7, Number 3, **2016** pp.28–42

A Review of the Research on the Advanced Evaluation of Technological Value and Technical Performance

Qian Zhang

School of Software & Microelectronics, Peking University
24th Jinyuan Road, Daxing Industrial District,
Beijing, China
zhangqianblu@pku.edu.cn

Received May 2016; revised June 2016

ABSTRACT. *The advanced evaluation of technology is based on technical assessment, and it focuses on evaluating whether the technology is in line with the development trend and the improvement of the performance and value compared with the similar technology. This paper studies the two aspects of advanced evaluation - technological value and technical performance, and summarizes the application of these research methods, then analyzes the limitations, and put forward several major problems which need to be solved.*

Keywords: Advanced evaluation, Technological Value, Technical Performance, Evaluation methods

1. **Preface.** The advanced evaluation of technology comes from technology assessment. The research of technology assessment began in the 1970s during which the United States established professional technology assessment agencies and the Western European countries have also set up technology assessment agencies. Joseph F. Coates[1], the American futurist, defined technology assessment as following: a class of policy studies which systematically examine the effects on society that may occur when a technology is introduced, extended, or modified, which emphasis on the unexpected, indirect and hysteretic effects. Above is the most cited definition of technology assessment. In 1993, Xiong [2] published a paper on "Technical Assessment (TA)" in the Journal of Future and Development, and introduced the origin and importance of the technology assessment. Since then, Chinese scientists began to study technical assessment officially.

Therefore, the research of advanced evaluation of technology has also appeared late. Xiu [3] regards the advanced evaluation of technology as part of the technology assessment. It is considered that the advanced evaluation index of technology should include the following parts: time, space, degree of automation and precision complexity, but these indicators are not specified. After 2000, more and more literature is based on the evaluation of specific technology, and the advancement of technology is usually regarded as part of the technology assessment system. But there is no literature to give a clear definition of advancement of technology, only a few literatures established some indicators in technology assessment system. Zhai [4] believes that the advanced evaluation of technology is to measure the advantages of the technology and compare it with the performance of existing technologies. He put forward four indicators to measure the advancement of technology: novelty, otherness, reliability and maintainability, and described the calculation methods of these indicators.

In paper[5], the concept of advancement of technology is given for the first time, and its system and evaluation method are also established. The research shows that the advancement of technology refers to whether the technology has significant effects in reducing cost, improving performance, improving quality and so on by comparing with general techniques, and whether it is in line with the development trend of industry. Compared with similar technology, if it is to improve product quality and performance, reduce production costs and increase product functionality and price, it is advanced.

It can be seen that the value and performance are important parts of advanced evaluation of technology, because the advancement of technological value determines the economic performance of technology such as cost reduction, and the technical performance affects quality of products and efficiency of technology. Therefore, this article will study the advanced evaluation of technology from two angles: the advanced evaluation of technological value and technical performance.

2. **The Advanced Evaluation of Technological Value.**

2.1. **Traditional Evaluation Methods.** The traditional methods of advanced evaluation of technological value are generally based on three kinds of ideas: cost-based, market-based and future-earnings-based, corresponding to the cost, market and net present value methods.

Cost Methods. The cost method is a method of assessing the present value of the sum of intangible assets technical costs which of the costs appeared in the development process. The basic idea is to deduct the devaluation of the actual replacement costs of the assessed assets, in order to determine the value of the assessed assets.

The basic formula: valuation = replacement cost - physical devaluation - functional devaluation - economic depreciation

Or valuation = replacement cost×newness rate

The key method of assessing technical intangible assets by cost method is to determine the replacement cost of technology. The replacement cost refers to the total amount of money spent on the re-creation or acquisition of a new intangible technical asset under current market conditions. However, due to the characteristics of the production of technical intangible assets such as disposable, can't be repeated or reset, the replacement cost of the intangible assets of technology is the adjustment of the cost of the original R & D production process according to the current price and expense. The replacement cost of technical intangible assets can be achieved in two ways:

Based on historical cost, adjust the replacement cost. Generally, the national fixed base price index is used to adjust.

The formula is: replacement cost= book historical cost×price index at the time of evaluation / price index at construction time

The replacement cost calculated by reset accounting method, which are living labour and materialized labour occurred in the process of the formation of technical intangible assets, can be estimated by market price and cost.

The formula is:

replacement cost=$\sum \text{Materialized Labor} \times \text{Current Prices}$

+$\sum \text{Consumption of Active Labour} \times \text{Current Cost}$

When using the replacement cost method to assess the technical intangible assets, the first is to get historical data, and second, to calculate the cost of forming the value of the technical assets, which should reflect the social or industry average

Market Methods. The market method is to find the latest transaction price of the technical asset similar to the non-patented technical asset to be evaluated through the market. And on the basis of analyzing the homogeneity and difference between the two, the current transaction price can be adjusted, which is close to the assessed non-patented technical assets trading price. The formula is:

Technical asset valuation = similar technical asset transaction price ± correction value

However, due to the current technical market conditions in China, such as not perfect rules and not active trading, it is difficult to collect the relevant transaction information, so in the actual assessment, the market method is less used.

NPV. The NPV method is the algebraic sum of the present value of the net cash flows calculated at the industry basic discount rate or set discount rate. It is a dynamic absolute index which reflects the investment effect. The formula is:

$$\mathrm{NPV}(i, N) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t} \tag{1}$$

If NPV> 0, which indicates that the yield of the project can not only reach the basic level, but also to obtain the excess present value, the project is feasible;

If NPV = 0, which indicates that the project investment rate of return is just equal to the basic yield, the project is feasible;

If NPV <0, which indicates that the project investment rate of return can't reach the basic yield, the project is not feasible.

The limitation of traditional methods is as follows: For the new technology, there is a great deal of uncertainty and risk in the whole process of the technology life cycle, and using a discount rate to represent all risks in the future do not reflect the true level of risk and its changes.

2.2. **The NPV Methods.** In response to the shortcomings of traditional methods, Myers [6] and Ross [7] pointed out that the potential investment opportunities of risk projects can be regarded as another form of option - a real option.

The real option pricing models, which are applied to the evaluation of new technology value, are mainly compound options and hybrid real options.

In terms of technology pricing, there are two main models of compound real options: One is the compound option pricing model proposed by Geske (1979) with the firmative execution price, which is widely used in the calculation or investment decision. The second is the compound swapping options model proposed by Carr, which is widely used in the calculation of stochastic investment costs and earnings or investment decisions. Miller[8] uses the compound real option method to evaluate the MRO of the aviation industry and considers that the analysis of the compound real option is superior to the DCF (Discounted Cashflow Model) method. Chang Kai[9] used the compound real option method to evaluate the CCS (Carbon Capture and Storage) of coal-fired power plants in order to solve the problems, that the uncertainties of some factors hinder the assessment of the value of technology, such as thermal power price, coal price, carbon price, carbon capture and storage technology and so on.

The idea of hybrid real options based on the model presented by James E. Neely and Richard de Neufville[10]. The model separately collects and analyzes the data of the project itself and the market risk, then calculates the future income of the project with the real option model, after that substitutes it into the decision tree model to calculate the present value of the project and finally put the result into the relevant analysis of option and decision. Sun Shangtong [11] used an R & D project of a bio-pharmaceutical company to verify the use of hybrid real options model for the specific use.

The value evaluation of projects is mainly based on Weeds' real option model. Marcus Hartmann and All Hassan[12] investigated the application of real options in the pharmaceutical industry. The survey results show that, in the pharmaceutical industry, the real option pricing is not very accurate, and it can’t replace the NPV method. Fathi Abid and Dorra Guermazi[13] used the Berk, Green and Naik’s models to evaluate the multi-stage information technology projects by comparing the results of the net present value method with the real option method to show that the real options were valued at the flexibility of the project Which is more accurate than the net present value method, especially when the cash flow of the project is negative, the net present value method tends to underestimate the value of the project. Steffens and Douglas[14] compare the NPV, real option and decision tree method to the calculation of the value of the technical project, and think that the method of the real option takes too much consideration of the market risk, and does not consider the specific risks of the enterprise, so they put forward the idea of applying the real option. The use of decision-making tree method to price technical projects, not only can simplify the calculation, but also closer to the actual situation. In the life-cycle evaluation of the technical project investment, J.Da[15] proposed the evaluation in two aspects: the risk and the value. In value evaluation, each stage of the technical project cycle is evaluated by real option method. At the seed stage and growing stage, the binary tree model was used, and NPV method was used at maturity, besides simple empirical calculation was also carried out.

In general, the real option method is widely used in the field of technical value evaluation. But the real option method also has some limitations in the practical application, because the mathematical model of the real option method is complicated, the hypothesis is difficult to meet and the parameter estimation is not accurate enough. As a result, there are some comprehensive methods combined with real option.

Comprehensive Method. At present, the method of fuzzy real option is paid more and more attention to the evaluation of new technology value. J.Chen and Q.Liu believe that the traditional real option methods have some shortcomings, especially the managers are difficult to estimate the expected cash flow accurately, and the real option pricing model with the combination of fuzzy theory and real option theory can overcome this defect, the assessment of project value can reflects the actual situation better. It can estimate the scale of the present value of the expected cash flow, so the fuzzy real option method is consistent with the actual situation. They take the electric power project as an example to carry on the empirical research. Juite Wanga and B.Hwang combine the real options with fuzzy sets to apply to the R & D portfolio.

Real option method can also be integrated with quantitative and qualitative methods, for example, combined with AHP. Yu—Jing Chiu and Yuh—Wen Chen [16] argue that the option pricing method only evaluates the value of the patent quantitatively and does not take all the factors into account. Therefore, they establish the index system of patent value to evaluate it. In the established index system, it also includes quantitative Real option method, and the calculated results as one of the indicators for reference. Georgios N. Angelo and Anastasios A． Economides [17] use qualitative and quantitative methods to combine real options (RO) with Analytic Hierarchy Process (AHP) to form ROAHP methods, and perform multi-scale decision analysis, then study with broadband technology options as an example.

3. **The Advanced Evaluation of Technical Performance.**

3.1. **Technical Performance Measure.** The TPM (technical performance measure) is defined as an indicator to measure whether the technical performance used in system meets the requirements. When the system into the development stage, you can follow the development progress to define the reflection system to achieve the level of its performance requirements of the indicators.

The classic TPM indicator is to evaluate the technical performance of the system from a certain point of view, and then combine the different indicators to get the performance measurement of the system, so as to have a global understanding of the progress of the whole system. In order to meet the demand, some technical performance of the system require higher value, while others require lower value. According to this feature, the technical indicators can be divided into two categories[18-19]: A class for the higher value, and vice versa for the B class. Although some of the indicators in the requirements need to be as high or low as possible, but they can’t be infinitely high or low, so the index value can only meet the performance requirements of tasks. For class A technical performance indicators, you can specify a threshold to meet the needs of the task, which can be given according to the needs of the task, and if the index value is higher than the threshold, it meets the requirements; Similarly, if B class indicators are lower than their threshold, it meets the requirements, as the graph shown below:

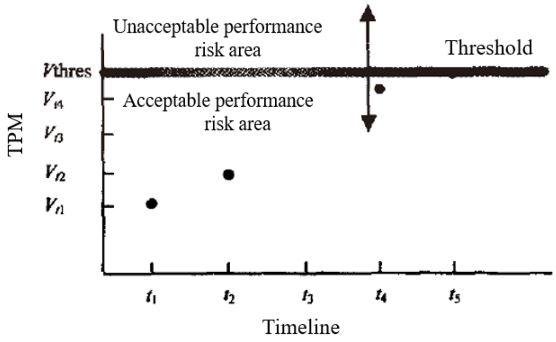

Figure 1 Class A

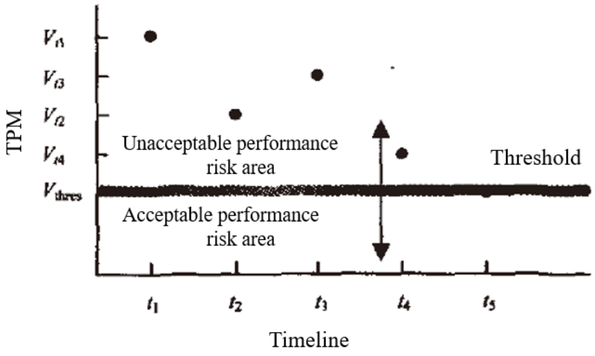

Figure 2 Class B

In Figure 1 and Figure 2, the horizontal axis represents the time of the indicators, that is, the time at which the technical performance measure is obtained; the vertical axis is the corresponding technical performance measure, V_{thres} represents the threshold of the system performance requirement, and is the critical value of the technical performance measurement, which is the boundary value of the system performance acceptable and unacceptable area.

In addition to the above measures, there is another situation: the technical performance requirements of the system should be within the specified range, higher than the upper limit of performance or below the lower limit values both do not meet the requirements, which indicators are class C. This is similar to the number of pulse of the human body, the number of healthy pulse should be within a certain range, too fast or too slow pulse, are unhealthy signs.

The class C indicators should satisfy the upper and lower thresholds, which can be given according to the task requirements, as long as the index value in the class C is between the upper and lower thresholds. $V_{up\text{-}thres}$ represents the upper threshold of system performance requirements, and $V_{low\text{-}thres}$ represents the lower threshold of system performance requirements. as the graph shown below:

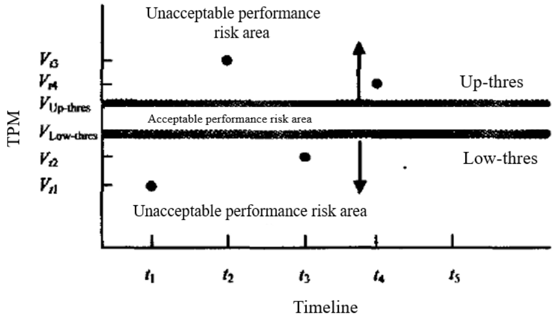

Figure 3 Class C

As there is no unified standard and unit of measurement between the TPM indicators, the raw data can’t be compared directly. Therefore, the raw data should be normalized first. After the normalization of the index, they are all in the range of 0 to 1, When its value is 1, it indicates that each TPM indicator in the system meets the requirements. When the index is much smaller than 1 (close to 0), it means that each performance does not meet the requirements. The smaller the value, the farther the requirement from the requirements, and we should take the appropriate measures to improve it.

In the integrated aspects of indicators, you can use conventional systems to evaluate. According to the importance of each TPM indicator in the system requirements, we can determine the weight of each index, such as expert scoring and AHP, in combination with the method of determining the weight coefficient, and then synthesize the comprehensive results as a comprehensive measure of technical performance

In general, the technical performance evaluation can also refer to the TPM method. The indicators that measure technical performance can be classified into A, B, and C, and can be calculated by different methods. The closer the value is to 1 or equal to 1, the more advanced it is, the closer to 0, indicating that it is less advanced.

3.2. **The Complexity.** The The complexity of the technology determines the generalization of the technology. For manufacturing products, the versatility of product design techniques, components, manufacturing equipment, etc. can bring many benefits to the enterprise, such as reducing R & D time, development risk, inventory and costs of component management, the complexity of production line, and increase production capacity, and these benefits can represent the advanced nature of a technology. Follows are versatility evaluation indicators of common manufacturing product technology:

The Product Line Commonality Index

PCI sets some penalty functions to penalize designs that are supposed to be generic components that do not. PCI can be calculated as follows:

$$PCI = \frac{\sum_{i=1}^{P} n_i * f_{1i} * f_{2i} * f_{3i} - \sum_{i=1}^{P} 1/n_i^2}{P * N - \sum_{i=1}^{P} 1/n_i^2} * 100 \quad (2)$$

In the above formula, P refers to the number of the universal parts; N is the number of products; n_i means the number of products containing the parts i, f_{1i} is the shape and size factor of the component i, f_{2i} is the material and the manufacturing factor of the component i, f_{3i} Is the assembly and the fixing factor of component i . PCI has a fixed numerical boundary: 0 ~ 100. When PCI = 0, either no part is shared, or even if it is shared, but the shape, size, manufacturing process are not the same. When PCI = 100, all components are shared, and the dimensions, manufacturing, assembly, material, and installation methods are same. PCI provides a simple measure of the versatility of the product family, but it focuses on the entire product family, thus ignoring a single product.

Commonality Index

CI is mainly used to calculate the number of special parts in the product family[20]. CI is a variant of DCI, and its formula is:

$$CI = 1 - \frac{u - \max p_j}{\sum_{j=1}^{v_n} p_j - \max p_j} \tag{3}$$

U refers to the number of special parts; Pj is the number of parts included product j; Vn is the number of products. CI is in the range of 0 to 1, the greater the CI value, the less the number of dedicated components, the higher the versatility. In the case of a product family consisting of five printers, assuming that each printer contains 20 parts, the denominator in the CI formula is 80 (= 5X20-20). If all parts are special parts, that is, the number of special parts is 100, then the CI of the product family is 0 (= 1- (100-20) / 80); if the product family contains the total number of different parts is 60, then CI is 0. 5(=1-(60-20) / 80)。 CI characterizes the ratio of the number of dedicated parts to the number of all components.

Component Part Commonality Index

CI (C) is the DCI upgrade form, based on the DCI, taking into account the product sales, quality and parts of the cost, the formula is as follows:

$$CI^{(C)} = \frac{\sum_{j=1}^{d}[p_j \sum_{i=1}^{m} \phi_{ij} \sum_{i=1}^{m} (V_i Q_{ij})]}{\sum_{j=1}^{d}[p_j \sum_{i=1}^{m} (V_i Q_{ij})]} \tag{4}$$

In the formula, d refers to the total number of different parts in the product family; j is the part number; Pj is the cost of the part; m is the total number of products; i is the product number; Vi is the sales of the product i, Φij is the the number of direct parent parts of the product i; and Qij is the total number of parts in product i.

Commonality Performace Index

The above indicators only evaluate the generality and ignore the difference. In the product family design, the high degree of versatility will inevitably sacrifice the performance and personality of the product. If the product personality is reduced, its advancement will also be affected, therefore, D.Jin put the C-PI.

Set a product family contains n products, P1, P2 ... Pn, in the absence of platform design, product Pi only optimized design can achieve the best performance for the PP_i, in the platform j can achieve the best performance PP_i^j, with PVI_i^j to characterize the amount of changes of the product Pi in the platform j, the formula of PVI_i^j is:

$$PVI_i^j = \left| \frac{PP_i^j - PP_i}{PP_i} \right| \tag{5}$$

If the C-PI of product family j is CI^j, then the $C\text{-}PI_j$ of product family j is:

$$C - PI_j = \sum_{i=1}^{n} \frac{CI^j}{PVI_i^j} \tag{6}$$

Suppose there are m product family design scheme, the larger the C-PI value, the more versatility of the design scheme can be achieve when sacrificing the same performance

3.3. **Technology Readiness Levels.** Technology Readiness Levels (TRL) Is a standardized evaluation method proposed by NASA in the 1990s to evaluate the technical maturity of the project. The levels of the technology readiness are based on the fact that any new technology are bound to have a mature process from 0 to 1 or from appear to be applied. In general, the maturity and development of various technologies follow a similar rule. The US Department of Defense (DOD) has established its own TRL rating on the basis of NASA's, as the table follows[1]:

Technology readiness level	**Description**	**Supporting information**
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development (R&D). Examples might include paper studies of a technology's basic properties.	Published research that identifies the principles that underlie this technology. References to who, where, when.
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are limited to	Publications or other references that outline the application being considered and that provide analysis to support the concept.

---

[1] "Technology Readiness Assessment (TRA) Guidance" (PDF). United States Department of Defense. April 2011.

	analytic studies.	
3. Analytical and experimental critical function and/or characteristic proof of concept	Active R&D is initiated. This includes analytical studies and laboratory studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.	Results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical subsystems. References to who, where, and when these tests and comparisons were performed.
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that they will work together. This is relatively “low fidelity” compared with the eventual system. Examples include integration of “ad hoc” hardware in the laboratory.	System concepts that have been considered and results from testing laboratory-scale breadboard(s). References to who did this work and when. Provide an estimate of how breadboard hardware and test results differ from the expected system goals.
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Examples include “high-fidelity” laboratory integration of components.	Results from testing laboratory breadboard system are integrated with other supporting elements in a simulated operational environment. How does the “relevant environment” differ from the expected operational environment? How do the test results compare with expectations? What problems, if any, were encountered? Was the breadboard system refined to more nearly match the expected system goals?
6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a	Results from laboratory testing of a prototype system that is near the desired configuration in terms of performance, weight, and volume. How did the test

	major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.	environment differ from the operational environment? Who performed the tests? How did the test compare with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before moving to the next level?
7. System prototype demonstration in an operational environment.	Prototype near or at planned operational system. Represents a major step up from TRL 6 by requiring demonstration of an actual system prototype in an operational environment (e.g., in an aircraft, in a vehicle, or in space).	Results from testing a prototype system in an operational environment. Who performed the tests? How did the test compare with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before moving to the next level?
8. Actual system completed and qualified through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation (DT&E) of the system in its intended weapon system to determine if it meets design specifications.	Results of testing the system in its final configuration under the expected range of environmental conditions in which it will be expected to operate. Assessment of whether it will meet its operational requirements. What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before finalizing the design?
9. Actual system proven through successful mission operations.	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation (OT&E). Examples include using the system under operational mission conditions.	OT&E (operational test and evaluation) reports.

In recent years, technology maturity measurement in China has been promoted to application gradually. In line with China's "Twelfth Five-Year" works of project approval and demonstration in basic national defense scientific research projects , the State Commission of Science and Technology for National Defense Industry issued a document, *the Review Procedure of Technical Maturity Evaluation Report of Military core competence major projects*, in which the technical maturity evaluation report is the important basis for the preparation of major project guidelines and project proposals The General Armament Department has formulated the national military standards, such as *Classification and definition of the technology readiness levels for materiel* (GJB7688-2012) and *Procedures of the technology readiness levels for materiel* (GJB7689-2012). Standardization Administration of China and General Administration of Quality Supervision, Inspection and Quarantine o of China issued *General rules of science and technology research projects evaluation*，which is based on the technical readiness (ie, technical maturity), and provides a quantitative management method for the input-output efficiency evaluation of three types of projects, basic research, applied research, and development research. As follows:

TABLE 1 BASIC RESEARCH PROJECT TECHNOLOGY READINESS LEVEL

Rating	Description	Supporting information
1	Generate new ideas and express them as conceptual reports	Reports
2	Identified as a direction can be explored free	Thesis
3	Identified as a specific target worth exploring	Plan
4	Simulation results are established in laboratory environments	Simulation results
5	Semi - physical simulation results are established in laboratory environments	Semi - physical simulation results
6	The physical functional indicators in the laboratory environment can be tested	Test report
7	The test results match the theory	Identification conclusion
8	Published papers, volumes and books	Papers, reports and books
9	Papers are cited, research reports are adopted	Quote and proof of adoption
Note 1: Fundamental research is a transcendental or theoretical study of new knowledge about the basic principles of phenomena and observable facts (revealing the nature of objective reality, the laws of motion, the new development, and the new doctrine)., It does not have any specific application or use for the purpose, but generally has a wide range of application prospects。 Note 2: The main objective of the basic research project is to acquire new knowledge, The 9th level of its technical readiness level should be recognized for new knowledge and accepted.		

TABLE 2 APPLIED RESEARCH PROJECT TECHNOLOGY READINESS LEVEL

Rating	Description	Supporting information
1	Discover new uses and create thoughtful reports	Report
2	Make a specific target application plan	Plan
3	Key functions were analyzed and experimental conclusions were established	Function results
4	Key simulation results are established in laboratory environments	Simulation results
5	Key features in the relevant environment are validated	Performance Conclusions
6	In the test environment, the initial performance index meets the requirements	Prototype Sample
7	In the test environment, the regular performance index meets the requirements	Sample
8	The sample get the users'recognition	User identification conclusion
9	Positive samples, proprietary technology, patented technology are transferred	Pantent、
Note 1: Application research refers to the practical research in order to explore the possible new use of basic research results, or to achieve new goals or new uses in order to achieve the intended goal, to solve the practical problems in the transformation of the objective world； Note 2: The main objective of the applied research project is to acquire new uses, new methods, new products, between basic research and development research, and to approach development research.		

4. **Conclusions.** The current technological value evaluation has the following limitations: the traditional methods, such as NPV, are relatively simple and can't truly reflect the technical risk level; ②There are a lot of real option pricing model, and if the assumptions of model can't be satisfied, it will cause some deviation. Therefore, if the real option method can be applied to the advanced evaluation of technology, we can combine it with the net present value method to enhance the applicability of the evaluation and to reflect the real risk level in the future.

The current technical performance evaluation has the following limitations: ① evaluation methods are not classified by the characteristics of different industries. The indicators are not flexible and can't be applied to a variety of situations in the measurement; ② These methods do not attach importance to the measurement of technical performance, the evaluation formula of the technical performance is relatively simple. In this regard, we can try to evaluate the indicators with different industry characteristics, and according to the characteristics, we can adjust the indicators, and use the formulas comprehensively to enhance the integrity and systematicness of the evaluation.

From the above two aspects, we can draw that the current advanced evaluation methods of technological value and technical performance is too simple. These methods are not integrated and can’t learn from each other. The versatility of some methods are not high, therefore, we need to generalize related methods by organizing different characteristics of different industries.

REFERENCES

[1] Coates J F. TECHNOLOGY-ASSESSMENT-TOOL KIT [J]. Chemtech, 1976, 6(6): 372-383.

[2] B.Xiong, The Introduction of Technology Assessment, *Future and Development*, vol.2, pp.33-34, 1983.

[3] G.Xiu, Study of Eenterprises Technology Assessment Method, *JOURNAL HARBIN UNIV. SCI&TECH*, vol.3, no.2, pp.59-62, 1998.

[4] X.Zhai, G.hao, Z.Cai and P.LiConstructing the Technology Assessment System with the Sustainable Development Concept, *Science of Science and Management of S.& T*, vol.25, no.8, pp.92-95, 2004.

[5] Y.Gao, J.Yang, and F.Yang Research on the Construction of Advanced Evaluation Index System of Technology, *Science & Technology Progress and Policy*, vol.30, no.5, pp.138-142, 2013.

[6] Myers S C, Determinants of corporate borrowing. *Journal of Financial Economics*，vol.5, no.2, pp.147-176, 1977.

[7] Cox.J.C，Ross.S.A，Rubinstein.M, Option pricing：a simplified approach．*Journal of Financial Economics*，vol.7, pp.229-263, 1979.

[8] Nikolaj Malchow-Miller, Repeated real options：optimal investment behaviour and a good rule of thumb. *Journal of Economic Dynamics＆Control*，vol.29, PP.1025-1041, 2005.

[9] K.Chang, W.Wang and Z.Meng, Investment Evaluation in Carbon Capture and Sequestration Technology of Coal-fired Power Plant Based on Compound Real Options, *Science and Technology Management Research*, vol.32, no.24,PP. 39-42, 2012.

[10] James E Neely，R de Neufville, Hybrid real options valuation of risky product development projects International Journal of Technology，*Policy and Management*，vol.1, no.1, PP.29-46,2001.

[11] S.Sun．Real Option Pricing of Hybrid Real Options in R & D Projects, Master 's Degree Thesis of Hunan University，2008．

[12] Marcus Hartrnann, All Hassan Application of real options analysis for pharmaceutical R&D project valuation--Empirical results from a survey, *Research Policy*, vol.3, no.35, PP.343-354, 2006.

[13] Fathi. Abid,Dorra. Guermaz, Multi—stage IT proiect evaluation：The flexibility valueobtained by implementing and resolving Berk, Green and Naik(2004)model, *Journal of Computational and Applied Mathematics*, vol.233, no.1, 2009.

[14] Steffens P R, Douglas E J, Valuing technology investments: use real options thinking but forget real options valuation, *International Journal of Technoentrepreneurship*, vol.1,no.1,PP.58-77, 2007.

[15] C.Dai, Evaluation of High-tech Project Investment Based on Life Cycle, Beijing Jiaotong University Master degree thesis，2008．

[16] Yu—Jing Chiu，Yuh—Wen Chen．Using AHP in patent valuation Mathematical and Computer Modelling[J]．46(2007)1054—1062．

[17] Georgios N Angelou，Anastasios．A compound real option and AHP methodology for evaluating ICT business alternatives[J] *telemetics and informatics* 2009．

[18] Garvey.P.R, Cho Chen-Ching, An Index to Measure a System’s Performance Risk, *Acquisition Review Quarterly,* vol.2, no.10, PP.189-199, 2003.

[19] X.Qi, J.Lv, A System Evaluation Method for Combined Technical Performance Measure Based on TPM, *Microcomputer Information*, vol.22, no.12, PP.90-93, 2006.

[20] Martin，M．V, and Ishii.K, Design for variety：A methodology for understanding the costs of product proliferation ，*Proceedings of the ASM E Design Engineering Techmocal Conferances and Computers in Engineering Conference,* 1996.