Management Science Letters 2 (2012) 1385–1396

Contents lists available at GrowingScience

Management Science Letters

homepage: www.GrowingScience.com/msl

Utilizing TOPSIS intensified with adjustment similarity factor to determine price of technology

Arnoosh Shakeri[*], **Mohammad Ali Shafia** and **Seyed Mohammad Seyedhosseini**

Department of Industrial Engineering, Iran University of Science & Technology, Tehran, Iran

ARTICLE INFO

Article history:
Received October 15, 2011
Received in Revised form October, 30, 2011
Accepted 20 January 2012
Available online 6 February 2012

Keywords:
TOPSIS
Factor Analysis
Technology Pricing
Adjustment Factor

ABSTRACT

Technology transfer has been a very frequent activity in the industrial world nowadays. Technology valuation, and in particular technology pricing, has played a considerable role in these transactions, in spite of a huge amount of limitations in the pricing methodologies applied. Making a sound, traceable and reliable means for applying the price evaluation procedure, seems as a technological requirement to be traced for. The objective of delivering this paper is to introduce a new numerical technology pricing method to provide the two transacting parties a unique compromised price. A three-dimensional model for technology pricing is proposed and The TOPSPS algorithm has been utilized to select the most similar technologies to the intended one and the constructed scoring system is applied to calculate the final technology price accordingly.

1. Introduction

During the past three decades, there have been tremendous efforts on providing efficient methods to choose an appropriate method for pricing technology (Hultén et al., 2009; Jafarnejad, 2007). Several valuation and pricing methods have been proposed and examined during the last decades. Anderson (1992) categorized valuation methods of invisible assets into three methods which are cost, market value and economic value. Smith and Parr (1994) introduced three methods to evaluate patents, namely cost-based, market-based and income-based methods. Yongtae and Gwangman (2004) designed a new method for technology valuation in monetary value based on defining technology influencing. Razgaitis (2003 divided technology valuation and pricing methods into six categories which are Industry Standard, Ranking Method, Rules of thumb, Discounting Method, Advanced Method and Auction Method. Leino et al. (2005) at Helsinki University utilized Razgaitis methods to arrange new product manufacturing methods. Stevens (2005) initiated a dividing valuation methods based on their focus on past or future periods. Following Razgaitis researches, Chiu and chen (2007) divided influencing factors of patent value into four groups, which are essence of technology, cost dimension, product market and technology market. In a recent research, Tabatabaeyan and Gharibi

* Corresponding author. Tel: +98-21-22565390
E-mail addresses: shakeri@iust.ac.ir (A. Shakeri)

doi: 10.5267/j.msl.2012.02.080

(2008) separated technology valuation methods into quantitative and qualitative methods. Finally, in a comprehensive conducted academic research, the technology pricing methods were summarized in three groups of *Traditional Mathematical* methods, *Innovative Mathematical* methods and *Empirical Qualitative* methods, which are illustrated in Fig. 1.

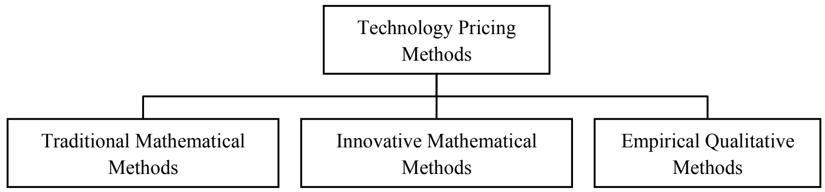

Fig. 1. Technology Pricing Methods

As mentioned above, several pricing methodologies have been developed by different researchers of the costing field during the past years, but there are new emerging methods being generated now and then, since the technology is complicated itself in nature and nobody can restrict the factors influencing its price in different situation. In this paper, a new pricing method is developed for situation that there exists similar technologies in the market.

2. Developing a three-dimensional technology pricing model based on factor analysis process

Identifying influencing factors on the price of technology is one of the most important issues in determining the relationships between know-how and market expectations. In this new proposed method, field studies and expanded literature review have been utilized to determine affective factors on technical knowledge pricing.

2.1 Applying FA to determine technology pricing factors

While all impressive factors are identified, the factor analysis process is utilized to refine them and specify the most critical items. This process is a statistical method used to describe variability amongst observed variables in terms of a potentially lower number of unobserved variables called factors (Child, 1973). In other words, it is possible, that variations in three or four observed variables, as an example, mainly reflect the variations in fewer such unobserved variables. The information gained about the interdependencies of observed variables can be used afterwards to reduce the set of variables in a dataset.

Given a set of p observable random variables, $x_1,...,x_p$ with means $\mu_1,...,\mu_p$ and unknown constants l_{ij} and k unobserved random variables F_j, where $i \in 1,...,p \;\&\; j \in 1,...,k$, when $k < p$, we have $x_i - \mu_i = l_{i1}F_1 + ... + l_{ik}F_k + \varepsilon_i$.

Here ε_i is independently distributed error terms with zero mean and finite variance, which may not be the same for all i. Let $Var(\varepsilon_i) = \psi_i$, so that we have $Cov(\varepsilon) = Diag(\psi_i,...,\psi_p) = \Psi$ and $E(\varepsilon) = 0$. In matrix terms, we have $x - \mu = LF + \varepsilon$.

If we have n observations, then we will have the dimensions $x_{p\times n}$, $L_{p\times k}$ and $F_{k\times n}$. Each column of x and F denotes values for one particular observation, and matrix L does not vary across the observations.

In addition, the following assumptions holds on F,

1. F and ε are independent,
2. E(F) = 0,
3. Cov(F) = I.

Any solution of the above set of equations following the constraints for F is defined as the *factors*, and L as the *loading matrix*.

Let Cov(x − μ) = Σ, then we have,

$$Cov(x-\mu) = Cov(LF+\varepsilon), \text{ or:} \quad (1)$$
$$\Sigma = LCov(F)L^T + Cov(\varepsilon), \text{ or:} \quad (2)$$
$$\Sigma = LL^T + \Psi. \quad (3)$$

Note that for any orthogonal matrix Q if $L = LQ$ and $F = Q^T F$, the criteria for being factors and factor loadings still hold. Hence, a set of factors and factor loadings is identical only up to orthogonal transformations. In order to provide required information for FA, a panel of experts from related industry and also scientific institutes is constructed.

FA is an appropriate tool to extract affective factors from a set of different ones. FA usually is used as a statistical method to categorize observations in smaller groups, which has been broadly applied in social and management science. The method assumes if there are several indicators or factors in observations, 'p' factors for example; it is possible to categorize them in some smaller groups of affecting factors, i.e. 'm' categories. According to Rencher (2002), FA has the following three steps,

- Construct the 'correlation matrix' of all factors or variables, which is a square matrix of correlation coefficients of variables,
- Extract main factors, based on correlation coefficients of variables (by calculating Eigenvalues),
- Rotate matrix factors to maximize the relationships between factors and variables.

Due to dispersion and huge number of factors affecting price of a technology, a questionnaire on identification and prioritization of price factors is designed and consequently fulfilled by a certain numbers of technology and pricing specialists. Cronbach's alpha test was used to assure reliability of the questionnaire, which yielded 0.88 and it is well above a desirable level of 0.7. Validity of the questionnaire also is determined by using expert judgment method. In this mentioned questionnaire specialists were asked to evaluate the impact of each factor on price in a range of 0 to 10. Then data were gathered and refined to reach the final outcome.

Table 1

Results of Factor Analysis to determine Technology Pricing Factors (Shafia & Shakeri, 2010)

No.	Factors	eigenvalues	Variance Percentage	Cumulative Percentage
1.	Degree of Monopoly	5.43	6.52	6.52
2.	Profitability	5.34	6.39	12.91
3.	Reducing Operational Cost	5.10	6.08	18.99
4.	Market Attractiveness	4.92	5.92	24.91
5.	Technology Completeness	4.67	5.59	30.50
6.	Age of Tech.	4.24	5.06	35.56
7.	Raising GDP	4.05	4.86	40.42
8.	Application & Development	3.83	4.56	44.98
9.	Speed of Income Generation	3.47	4.15	49.13
10.	Risk of Income	3.23	3.88	53.01
11.	Access to Tech. Owner	3.18	3.79	56.80
12.	Ease of Market Entrance	2.97	3.56	60.36
13.	Market Stability	2.46	2.94	63.30
14.	Supporting Documents	2.15	2.58	65.88
15.	Standardization Level	1.96	2.33	68.21
16.	Increasing Buyer Reputation	1.73	2.04	70.25
17.	Degree of Job Generation	1.51	1.81	72.06
18.	Simplifying Working Process	1.36	1.66	73.72
19.	Environment-phile	1.23	1.45	75.17
20.	Ease of use	1.06	1.24	76.41

It is obvious from the results of Table 1, these 20 factors represent over 76% of the overall variance. By recognizing the main factors via factor analysis, it is possible to construct a mathematical model for pricing the technologies with great degree of reliability to encompass most influencing elements or costing ingredients. To illustrate this model, the above mentioned factors are categorized in three main clusters, based on their specification, including ‘Inherent Factors’, ‘Internal (effect on market) Factors’ and ‘Market Situation (external) Factors’. This model is named as ‘Three-dimensional Technology Pricing Model’ which is illustrated in Fig. 2.

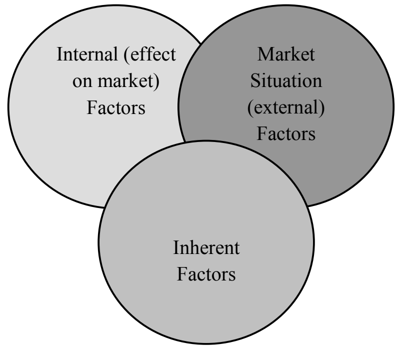

Fig. 2. The Three-dimensional Technology Pricing Model

Therefore, we have,

$$P_t = f(I_h, M_a, M_s), \tag{4}$$

where P_t is the price of technology, I_h is the Internal (effect on market) Factor and M_s is the Market Situation (external) Factor. The aim here is to build objective function f calculated for the proposed model through using TOPSIS algorithm and information about the price of similar technologies.

2.2. Introducing sub-factors of Three-dimension Technology Pricing Model

The goal of defining ‘inherent factors’ is to determine potential values existed in the soul of technical knowledge, which has two subdivisions, ‘principal indicators’ and ‘application indicators’. ‘Principal indicators’ are remarkable attributes of the technology, meanwhile ‘application indicators’ are the factors that affect the degree of technology applicability. Sub-indicators of principal and application indicators are listed in Table 2.

Table 2
Sub-indicators of Inherent Factors

Factors	Sub-factors	Definition
Principal Indicator	Standardization Level	Compatibility with related technical standards
	Environment-phile	Compatibility with environmental regulations
	Age of Technology	Passed years from invention of technology
	Degree of Monopoly	Degree of exclusive control on technology in a particular market
Application Indicator	Application & Development	Possibility of developing technical knowledge and its application in other areas
	Supporting Documents	Access to the technical documents required to applying technology
	Access to Tech. Owner	Ease of access to technology developer to get more technical assistance if required
	Market Attractiveness	Volume of earlier technology demanders
	Technology Completeness	Degree of readiness to be commercialized
	Degree of Job Generation	Power of technology in generating job opportunities
	Raising GDP	Preventing imports and raising domestic production by means of technology
	Profitability	Chance of achieving high rate profit
	Ease of use	Simplicity of buying, transferring and applying technical knowledge
	Simplifying Working Process	Decreasing workforce and working stages

Internal factors indicate values created in the organizational trough inherent attributes of the technology, which have been applied in the market and proven their effects. Sub-indicators of internal indicators are listed in Table 3.

Table 3
Sub-indicators of Internal (effect on market) Factors

Factors	Sub-factors	Definition
Internal (effect on market) Factors	Reducing Operational Cost	Amount of saving in cost of production stages, material, manpower, maintenance, working time, etc.
	Speed of Income Generation	Required time to market, from achieving technology to break-even point
	Risk of Income	Probability of detriment in using technology
	Increasing Buyer Reputation	Effect level of technology on increasing sales and market share of buyer, customer satisfaction, diversity of product, etc.

Market situation (external) factors refer to the market attributes or desirability of the market in which the technology will be applied in. Sub-indicators of external indicators are mentioned in Table 4.

Table 4
Sub-indicators of Market Situation (external) Factors

Factors	Sub-factors	Definition
Market Situation (external) Factors	Market Stability	Number of existing competitors in the market with close competition in quality and prices, that leads to increase bargaining power of customers and distributors, possibility of entering new competitors or substitute products
	Ease of Market Entrance	Obstacles of market penetration like number of competitors, substitute products, scarce raw material, level of know-how, required investment, etc.

2.3. Applying relationships among price indicators to calculate factors' utility degree in objective function

To calculate the score of each technology in this method, an analytical hierarchy method has been implemented. In order to prioritize similar technologies in TOPSIS,'real amounts of quantitative factors' and 'utility degree of qualitative factors' are needed (Yongtae & Gwangman, 2004). In case of scoring and prioritizing indicators, relationships amongst the price factors can be utilized; when there is no access to the real amounts of quantitative factors, like Reduced Operational Cost, and to determine utility degree of qualitative factors, such as market effect factors. For example as 'inherent factors' and 'effect on market factors' are interrelated (VanWyk, 2010), the degree of utility for each qualitative or quantitative indicators of market factors can be calculated by estimating utility degree of each inherent factor and calculating average utility degree of sub-indicators related to each market factor. In the other word, for each market factor, utility degree assigned to its related inherent factors are summed up and their average are calculated to reach the utility degree of that market factor. These degrees are assigned by Decision Makers (DMs). DMs are industry specialists with sufficient knowledge regarding technology, market and pricing process and some relationships are shown as Table 5.

Table 5

Sub-indicators of Market Situation (external) Factors

Effect on market factors Inherent factors	Reducing Operational Cost	Speed of Income Generation	Risk of Income	Increasing Buyer Reputation
Standardization Level			√	√
Environment-phile			√	√
Age of Technology			√	
Degree of Monopoly			√	
Application & Development	√		√	√
Supporting Documents				
Access to Tech. Owner		√	√	
Market Attractiveness			√	√
Technology Completeness		√	√	
Degree of Job Generation			√	√
Raising GDP			√	√
Profitability			√	√
Ease of use	√	√	√	
Simplifying Working Process	√	√		√

Qualitative sub-indicators of 'market situation' factor also could be converted to the numerical quantitative indicators utilizing the similar method. Then they are utilized to score and prioritize indicated technology and other similar technologies accompanied by 'internal factors'.

3. Identifying and selecting similar technologies

As the influencing factors of technology price are determined, finding the most similar alternative to the under-discussion technology is determined as the next step. At least two similar technologies are selected at this step by industry experts to calculate the scores for each item of 'three-dimensional indicators' which have been introduced earlier. The scores have been calculated for under-review technology and all similar ones. Then calculated scores are used to decide which of them is the most comparable to the mentioned technology.

3.1 Refining similar technologies group with AHP

In order to calculate the score of each technology and to have a more precise result, the analytical hierarchy process (AHP) will be utilized after selecting industry expert's trough a statistical rational method. Table 6 demonstrates a sample of technology assessment and scoring based on some of the pricing indicators, i.e. principal inherent factors.

Table 6

Scores of technology Alternative on the basis of AHP

Factors	Sub-factors	Units	Weight	Score (10)	Weighed Score
Principal Inherent Factors	Standardization Level	points	6	0.8	
	Environment-phile	points	7	0.7	
	Age of Technology	years	5	0.9	
	Degree of Monopoly	points	7	1.0	21.2

After each expert assigned the scores to a certain alternative technology, average score are computed to determine the final scores of technologies. Then alternatives with distant scores comparing to the new technology is neglected and remaining alternatives are prioritized using TOPSIS algorithm.

3.2.Prioritizing Similar Technologies using TOPSIS Algorithm

TOPSIS, Technique for Order Preference by Similarity to Ideal Situation, has been widely accepted method in the context of multiple-attribute decision making, MADM. An ideal solution is detremined as a collection of ideal levels, or ratings, in all attributes considered.

An MADM problem with *m* alternatives, which are evaluated by *n* attributes may be viewed as a geometric system with *m* points in the *n*-dimensional space. Hwang and Yoon (1981) developed the TOPSIS based on the concept that the chosen alternative should have the shortest distance from the positive-ideal solution and the longest distance from the negative-ideal solution. Lately, this principle has been also suggested by Zeleny (1982) and Hall (1989), and it has been enriched by Yoon (1987) and Hwang et al. (1993).

TOPSIS is usually used to prioritize alternatives through comparing them to the best and the worst solutions. Possibility of incorporating qualitative and quantitative factors is one of the benefits of this technique. Another benefit of this method is the ability of separating indicators into cost or profit categories.

In other word, in the $m\surd n$ Decision Matrix (DM), if the factor has the profit effect, the greater the assigned value is, the more utility will be allocated to the technology alternative. On the contrary, if the factor has the cost effect, the lower utility will be assigned to the array with higher value in DM matrix.

All values assigned to the factors in TOPSIS algorithm should be in a quantitative manner, hence we should convert qualitative data to number types with some suitable means. Table 7 could be used to this alternation.

Table 7
Converting qualitative to quantitative factors

Cost Effect indicators	values	Profit Effect indicators
Very high	1	Very low
high	3	Low
Medium	5	Medium
Low	7	high
Very low	9	Very high

After identifying more close alternatives to the intended technology based on the calculated scores, they would be prioritized with TOPSIS to identify imagined ideal technology, i.e. the most similar technology, based on the shortest distance from the positive ideal alternative and longest distance from the negative ideal alternative. Below steps are passed to this aim:

1. Normalized decision making matrix (technology alternatives-price factors) is constructed.
2. Weighted matrix is defined.
3. The best alternatives among similar technologies are identified.
4. Distance between ideal solution and technology alternatives are determined.
5. Relative closeness to the ideal solution is calculated.
6. Alternatives in an ascending order are arranged.

At the first step, decision matrix are made with numerical values of quantitative indicators –i.e. inherent factors– and utility grades of qualitative indicators –i.e. effect on market and market situation factors– using relationships between price factors which was already mentioned in the previous section. Then normalized matrix are organized by removing dimensions of the matrix arrays through below equation:

$$R_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}^2}}, \quad i = 1,2,\dots,m \quad j = 1,2,\dots,n \tag{5}$$

where x_{ij} is the array values of decision matrix, and R_{ij} is the normalized values. Since importance of price factors are not equivalent, a set of weights are introduced by decision makers to weighting the matrix values. To create this weighted matrix, all arrays of *R* matrix are multiplied to the column matrix of weights, i.e. W_j. The normalized weighted matrix is known as *V* while we have:

$$V_{ij} = W_j R_{ij}, \quad i = 1,2,...,m \quad j = 1,2,...,n \tag{6}$$

$$\sum_{j=1}^{n} W_j = 1, \tag{7}$$

In this step to identify extreme technology alternatives, two virtual parameters, T^+ and T^- are defined as below:

$$T^+ = \{(Max V_{ij}; j \varepsilon J); (Min V_{ij}^-; j^- \varepsilon J^-); i = 1,2,..,m\} \tag{8}$$

$$T^- = \{(Min V_{ij}; j \varepsilon J); (Max V_{ij}^-; j^- \varepsilon J^-); i = 1,2,..,m\} \tag{9}$$

In which $J = 1,2,...,n$, is a set of factors that have positive role (profit effect, shortest distance to the intended technology) and J^- belong to the set of negative (cost effect) factors. In another word, T^+ is the most similar assumed technology alternative and T^- is the most distant technology alternative to the intended technology.

The distance between each technology alternative and two above mentioned virtual alternatives will be calculated through n-dimensions Euclidean distance, i.e.:

$$S_i^{\max} = \sqrt{\sum_{j=1}^{m} (V_{ij} - V_{j\max})^2}, \tag{11}$$

$$S_i^{\min} = \sqrt{\sum_{j=1}^{m} (V_{ij} - V_{j\min})^2}, \tag{12}$$

In which $S_i^{\max}$ is the distance between technology *i* and the best technology alternative, T^+; and $S_i^{\min}$ is its distance with the worst technology alternative, T^-. In this step, 'relative closeness' of each *m* technology alternative would be calculated as below:

$$C_i^* = \frac{S_i^{\min}}{S_i^{\max} + S_i^{\min}} \quad i = 1,2,...,m \tag{13}$$

Technology alternatives then are subject to organize according to their importance through C_i^*, which is a number between 0 and 1. Higher C_i^* shows that the technology has more priority to be considered as the similar technology to the intended alternative.

Thus the best actual technology alternative are identified after these mentioned steps of TOPSIS algorithm. Now it seems that defining the price would be the next step.

4. Calculating the price of intended technology

4.1 Defining the Adjustment Factor

To reach the price of a technology trough similar alternative, 'adjustment factors' could be applied (Yongtae & Gwangman, 2004). Therefore, after finding more similar technology alternative trough TOPSIS algorithm, score deviations between intended technology and most similar technology are calculated based on the scoring system we had developed in the hierarchical analysis step before. The results of multiplying score deviation to the price of selected technology are utilized to define the adjustment factor:

$$AF_T \approx \Delta S = (S^{AHP}_{TOPSIS} - S^{AHP}_{Tech}) \ \ AF_T \varepsilon \left[0, \infty\right], \tag{14}$$

$$\Delta P = AF_T * P_{TOPSIS} \,. \tag{15}$$

Since the score deviation between two technology alternatives depends on the weights and scores assigned by decision makers, upper extreme of weighted score is not limited. For example, it was shown that the weighted score of a technology alternative reached 21.2 just for its inherent factors in our previous sample in Table 6. Therefore, it is required to convert this value to the centric value between 0 and 1. Some alternating tables could be helpful in this regard. For instance, if the maximum deviation between scores in terms of weight and number of factors reaches 35, below table could be applied:

Table 8
A sample table to define Adjustment Factor

Weighted Score	0-5	6-10	11-15	16-20	21-25	26-30	31-35
Adjustment Factor	0.7	0.8	0.9	1.0	1.1	1.2	1.3

The coefficients are calculated more precisely by interpolation computations.

4.2.Calculating the Price

Adjustment factor equals to the extra-price that should be added to the price of TOPSIS-selected technology. Therefore, we have:

$$P_T = \Delta P_T + P_{TOPSIS} = P_{TOPSIS} * (1 + AF_T), \tag{16}$$

In which P_T is the price of intended new technology, AF_T is the adjustment factor, and P_{TOPSIS} is the price of similar TOPSIS-selected technology.

If the price of selected technology does not belong to the present time, it first should be converted to the present value trough NPV or similar methods, then adjustment factor could be utilized. In addition, if the score of intended technology is less than TOPSIS-selected alternative, the price of the similar technology could be considered; or the result of multiplying adjustment factor to the price of selected technology could be reduced from the price of that similar technology to define the new price. It should be noted that at the minimum, the calculated price should cover the costs of R&D and intended profit of technology owner.

4.3.Assumptions of the Proposed Model

Win-win situation is an important principal in sustainable economical transactions. To reach to a fair logical price for a new technology in the proposed model, these assumptions have been incorporated:

1. Owner and buyer of new technology should compromise on the similar technologies.
2. Decision makers are educated in the intended field of technology and pricing methods and have no bias in their judgments.

On top of that, below general assumptions had been considered during designing of model:

- No limitations in finding similar technologies for the intended technology. Note that similarity here is not in forms of shape, process or component of technology, but in function is intended.
- No limitations existed in finding experts to judge about technologies.

In addition, it should be noted that type of industry and technology –i.e. hardware, software, know-how, patent, etc.– would have effect on selecting experts, influencing factors and finally the price of new technology. Therefore, introduced factors in this proposed model are not general factors; hence they are subject to change in each certain area of technology.

5. Results and discussions through practical application

To confirm results of the proposed model, it has been applied in a famous Generator Manufacturing company, which is a subsidiary of a powerhouse project contractor company of Islamic Republic of Iran. Let us identify this generator manufacturer as 'GEMA' which has made a plan to purchase an insulator technology from 'Alestom', a Swiss generator manufacturer. GEMA is aware of the market price of two similar technologies, which are 'Resin Rich Insulator' of 'Ansaldo', and 'Vacuum Pressurized Impregnation' that belongs to 'Siemens' company.

At the first step of implementing the model, three experts of insulator field were determined to build the DM team. Their opinions have been summarized in Table 9.

Table 9
Experts' judgment regarding market factors for three similar technologies

Factors/Indicators	Siemens Tech.	Ansaldo Tech.	Alestom Tech.	Average weight
Reducing Operational Cost	650.000 €	500.000 €	700.000 €	0.1
Speed of Income Generation	High	Medium	High	0.15
Risk of Income	Medium	High	Medium	0.15
Increasing Buyer Reputation	Medium	Medium	High	0.2
Market Stability	High	Medium	Very high	0.2
Ease of Market Entrance	Medium	Low	High	0.2

Since in TOPSIS all factors should be homogenous in type, i.e. profit or cost, by changing 'Risk of Income' factor to 'Confidence Margin'; and 'Ease of Market Entrance' factor to 'Difficulty in Market Penetration'; all factors have been altered to profit type factors. Now the more the degree of utility is, the better alternative would be selected as the similar technology. Indeed, number of obstacles for entering market will prevent competitors to imitate the technology or introduce a higher-level one, which could outmode the technology and squander the investment.

Initial cost of Siemens and Alestom technologies are higher, but their maintenance costs are low. Vice versa Ansaldo technology has a different situation. Since Siemens and Alestom are more recent technologies, they are more dependent to their own support and their risk of income is higher, hence confidence margin will be lower. On the other side, Alestom is the just innovated alternative; therefore its market is more resistant and has more obstacles in front of competitors. All three technologies are applicable for generators and electrical machines, but Ansaldo technology has less application easiness because of its need to special manufacturing tools, diversity in production and development capacity. Therefore, its speed of income is less than two other ones. Also transferring of Siemens and Alestom technologies is more time consuming, because they are more complicated; but possibility of easy development and usage in different products compensate this weakness. Calculations to find the price of new technology are as follows.

Table 10
Calculations of Alestom technology price

Technology Alternatives Factors	Siemens	Ansaldo	Alestom
Scores in AHP	0.3415	0.3013	0.4218
Relative Closeness to Ideal Solution	0.812	0.735	-
Price (in euro)	22.000.000 €	15.000.000 €	-
Score deviation between selected technology and Alestom	0.0803		
Adjustment Factor	1.766.600 €		
Calculated Price (by model)	**23.766.600 €**		
Owner Price	24.500.000 €		

As it is shown, finally Siemens technology was selected as the most similar technology since it is the nearest alternative to the ideal solution. Therefore, it is used to calculate price of Alestom technology based on the proposed model.

It would be mentioned that to validate model components and produced results, not only pricing factors are endorsed by industrial and collegiate experts in powerhouse projects, but also ELECTRE, another MADM technique, has been utilized to confirm prioritizing similar technologies. Siemens technology was the answer to the most similar technology question using ELECTRE too, and it has placed in a higher position comparing to the Ansaldo technology once again. Table 11 summarizes final analysis to define a price technology in this model.

Table 11
Decision analysis to define technology Price

Technology Alternatives	Relative Advantage	Price
Ansaldo Technology	0.3013	15.000.000 €
Siemens Technology	0.3415	22.000.000 €
Extracted Price (using model)		**23.766.600 €**
Alestom Technology	0.4218	24.500.000 €

Since the price proposed by technology owner is higher than the calculated price based on this model, now the technology buyer should decide if he wants to accept seller price or he may decide to start a negotiation process with technology owner.

6. Conclusions

In this new proposed model to define a price for an intended technology, it is tried to define indicators and factors that affect the price of technology, using field studies and interview panels of related experts. Extracted factors were refined trough Factor Analysis and categorized via expert judgment into three clusters of factors that are Inherent Factors, Internal (effect on market) Factors and Market Situation (external) Factors.

Internal relationships among these factors and effect of each of them on the price of technology were examined in a certain technology industry by means of expert judgment technique. AHP and TOPSIS decision making techniques applied to prioritize and select most similar technology in the next steps and an adjustment factor designed to tune the price of most similar alternative and define the price of new intended technology.

The results of applying this new proposed methodology in calculating the price of an insulator technology was promising and confirmed this model to be used in such similar situations.

In addition, as the nature of this model is a general concept, it can be used to calculate the price of different types of technology, i.e. equipments, hardware, software, technical knowledge, know-how, patents, etc.

Acknowledgements

Authors appreciate academic and industrial experts who assisted in processes of identifying and prioritizing factors affecting price of technology. They also would like to express their special thanks to GEMA company R&D center that provided them with the required information that was needed in selecting most similar alternatives to define the price of new intended technology.

References

Anderson, A. (1992). The Valuation of Intangible Assets. Special Report No. P254, the Economist Intelligence Unit, London.

Bandalos, D. L., & Boehm-Kaufman, M. R. (2009). *Four common misconceptions in exploratory factor analysis In Statistical and methodological myths and urban legends: Doctrine, verity and fable in the organizational and social sciences. Lance, Charles E. (Ed.); Vandenberg, Robert J. (Ed.)*. New York: Routledge. pp. 61–87.

Child, D. (1973). *The Essentials of Factor Analysis*. Holt, Rinehart & Winston, London.

Chiu, Y.J., & Chen, Y.W. (2007). Using AHP on Patent Valuation*. Mathematical and Computer Modeling*, 46, 1054–1062.

Hultén, P., Viström, M., & Mejtoft, T. (2009). New printing technology and pricing. *Industrial Marketing Management*, 38(3), 253-262

Hornby, A. S. (2010). *Oxford Advanced Learner's Dictionary of Current English*. Oxford University Press, 10th ed., Oxford.

Hwang, C. L., & Yoon, K. (1981). *Multiple Attribute Decision Making Methods and Applications*. Springer, Berlin Heidelberg.

Jafarnejad, E. (2007). *Engineering of Information Technology.* Computer Science Publication, 1st ed., Tehran.

Lai, Y. J., Liu, T. Y., & Hwang, C. L. (1994). TOPSIS for MODM. *European Journal of Operational Research*, 76(3), 486–500.

Leino, L., Antila, M., Beletski, A., & Isola, T., & Janhonen, H. (2005) *'IPR Valuation and Pricing'*, Final Report, Mat-2.177 Seminar on case studies in operation research, Case: Asperation Oy, Helsinki University of Technology.

Parr, R. L., & Smith, G.V. (1994). *Quantitative Methods of Valuing Intellectual Property*. In: M. Simensky and L. G. Bryer, The New Role of Intellectual Property in Commercial Transactions (pp.39- 68), John Wiley & Sons Inc., New York.

Razgaitis, R. (2003). *Valuation and Pricing of Technology–based Intellectual Property*. John Wiley & Sons Inc., New York.

Rencher, A. (2002). *Method of Multivariate Analysis*. Wiley Series in Probability & Statistics, 2nd ed., John Wiley & Sons Inc., New York.

Shafia M. A., & Shakeri, A. (2010). *Developing a Combined Model to Fair Pricing of Technology in Commercialization Process*. Proceedings of the 4th National Technology Management Conference, Iramot, Tehran, Iran, 396-410.

Stevens, A. (2005). *Intellectual Property and Technology Transfer.* Presentation at the Bill and Melinda Gates Foundation Symposium on Challenges in Translational Research, School of Management, Boston University, MA.

Tabatabaeyan, H., & Gharibi, J. (2008). A review on concepts and quantitative methods of technology valuation. *Journal of Incubators & Technological Parks*, 13, 11-19.

Van Wyk, R. J. (2010). Technology assessment for portfolio managers. *Sciencedirect, Technovation*, 30, 223–228.

Yongtae, P., & Gwangman, P. (2002). A new method for technology valuation in monetary value: procedure and application. *Technovation*, 24, 387–394.