Research Article
Research on a New Approach of R&D Budgeting based on Value Chain

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Abstract: The aim of this study is to introduce value chain and uses stage-gate model, which is widely used in programming, to find a new approach of R&D budgeting based on value chain. The expense of R&D of contemporary enterprises is taking larger and larger part of the whole production cost, so R&D budgeting, as a forward feed management mode, has been paid great attention to. R&D budgeting model is a management system that contains relevant basic concepts, procedures and methods correspondingly. The present model most enterprises are using follows the budgeting method in the field of manufacturing, which is more difficult to adapt to the characteristics of R&D activities, leading to adverse effects on R&D budget slack, as well as low management efficiency. Actually, the process of budgeting is the allocation of scarce resources to organize all kinds of work.

Keywords: Index system construction, R&D budgeting, state-gate model, value chain

INTRODUCTION

Nowadays, the competition among different firms in the same industry is getting more and fiercer. In any forms of production mode, resources are scarce, thus the necessity and core of enterprise management lies in the efficient allocation of limited resources. People share resources and natural resources to make profit and enterprise nature is no doubt for an understanding of this point, thus the competitiveness of enterprises is how to effectively use the resources competition. However, the resources did not begin with the production process, which is fundamentally in R and D. With the transformation of the enterprise target to the maximization of enterprise value, in order to drive value creation, more and more enterprises into the value chain in the management idea of management (Rayport and Sviokla, 2001). The idea of the value chain was first proposed by Porter (1985). Potter thought that the enterprise value chain is composed of various different but correlative value chain activities in a specific way linked together, the source of its competitive advantages to form the value chain of differences between different enterprises (Dunk and Kilgore, 2009). Enterprise value chain can be divided into vertical value chain, horizontal value chain and internal value chain.

The core competitiveness of hi-tech enterprises is the comprehensive competition ability to R&D as a starting point. An R&D activity directly bear the value creating function, is important value-added enterprises and their products. R&D budgeting is an important part of management of R&D of high-tech enterprises, determines the development effect of budgeting. The traditional budgeting is profit oriented, to cost control as the objective, the premise of management is to have

a reasonable, accurate standard costs, according to this standard to the implementation of budgeting. However, the management plan for the R&D budget and there are obvious defects (Shank and Govindarajan, 1993). First of all, for how the strategies reflect not clear in the R&D budget, may cause the enterprise strategy and R&D budget does not coordinate; secondly, due to the various links of R&D activities of value creation is not analyzed, R&D resources allocation may result in unreasonable, significant investment, output of small does not meet the business objectives phenomenon of some R&D activities. These budget and enterprise value creations from the situation not only make the budget function failure and greatly reduce the R&D activities and economic effect. R&D budgeting is used with multiple methods to evaluate the cost and resource demand behavior (Cooper and Edget, 2007).

According to the related literature review and model building, this study is trying to establish a kind of simple and intuitive and practical evaluation analysis model on R&D budgeting based on value chain using stage-gate model.

The main problems:
- **The lack of R&D project management process:** R&D activities from the innovative thinking, through investigation and study, the preliminary project screening, decided to try, trial production, development, testing, project approval, constitute a complete R&D project life cycle. Especially for large and complex project, the cycle may be as long as 3 to 4 years (Cooper and Kleinschnidt, 2011). But as seen from the R&D management practice, China's enterprises to develop the project management mainly focus on project management,

especially the feasibility and identification of acceptance, the middle is only concerned with how to apply engineering techniques, such as concurrent engineering and the lack of phase of the audit, in the implementation process, evaluation, modification and adjustment process management (Sorder, 2009). These two, as light process R&D management mode, the development process is regarded as a "black box", which is full of unseen internal operation and resource consumption (Rothwell, 2012; Shyamala and Rajagopalan, 2006).

- **Insufficiency on information basis of R&D budgeting:** R&D activities at the forefront of technology and market, is the innovation and development of knowledge, R&D projects may not have the exact same precedent, very difficult one-time access to all information related to the project. On the other hand, the information obtained with the change of the lost value, causes the appraisal consumption which is expected to be R&D project resources and the evaluation is very difficult (Yan, 2007). When R&D project, is not only a financial personnel, even the technical staff for its success, value, the final funding situation difficult to grasp, the lack of information about the uncertainty and make the budgeting is very difficult (Guha et al., 2000). Even if the overall budget of R&D projects may also be due to environment and information mutation, the budget constraint is meaningless (Zhang and Yin, 2006).

- **No distinction among different functions of R&D budgeting:** A significant feature of R&D activities, unlike the production and sales activities, it is also an investment activity, independent of the value creation function, which makes the R&D budgeting for different purposes, belonging to the category of different budget (Kao and Wu, 2008). When it comes to the feasibility of R&D project and investment decision, it is seen as an investment project, the overall value of the analysis, the R&D budget function belongs to the category of capital budget. When R&D project implementation, the need for R&D project implementation process of resources into different stages, responsibility center, the details of the project cost allocation, control and evaluation, R&D budget functions belonging to the operating budget, called the capital control budget. Enterprises in the budgeting without function and use to distinguish different R&D budget, budgeting effect will be greatly reduced (Yu, 2009).

- **Taking no consideration of value chain's impact on R&D budgeting:** The business activities of enterprises mainly involve three value chains: vertical value chain, horizontal value chain and internal value chain. Vertical value chain is to connect the value chain of the enterprise and the supplier, customer; horizontal value chain is between the enterprise and the industry competition relationship. From the whole process of the production and operation of enterprises, R and D, production and sales to achieve business objectives, this is an indivisible, complete value chain; at the same time R&D activity itself is also a value chain and independent, each stage of development is a fundamental value adding activities.

Characteristics of value chain in different longitudinal position in the value chain and the competition and its own internal value chain of R&D project creation has the important influence, namely any R&D project value are influenced by the upstream and downstream enterprises, enterprises and enterprise production and management situation (Bradley et al., 1998). But at present the majority of enterprises in R&D budgets often lack the value chain analysis. This leads to that the value of R&D project is not accurate, may choose the actual value for the negative items; on the other hand, to create a budget target is usually not in the value orientation, but the profit oriented budgeting, more emphasis on cost reduction and not enough attention to value increase, which leads to the decrease of the efficiency of resource allocation.

The model method:

- **The combination of value chain and R&D budgeting:** The concept value chain of enterprises is one of the core concepts of modern enterprise management, by which creating value is the target of an enterprise. To value management as the center, all the management activities around the value creation and value management thought and how to combine the management activity, therefore, the value chain theory provides a way for us. The value chain theory was first proposed by USA scholar Porter (1985), according to the basic theory of Potter, "every enterprise is a collection of various activities for the design, production, marketing, delivery and plays a supporting role on the product. All these activities can be represented by a value chain." He believes that the value chain is the basic tool for the analysis of the competitive advantage of enterprises and the value of the business activities are divided into basic activities of the creation of value and indirect value creation support activities in two categories (Zeleznikow and Nolan, 2001).

The value chain theory stressed the need to follow the value chain to carry out the activities of enterprises and the starting point of enterprise's value is the R&D,
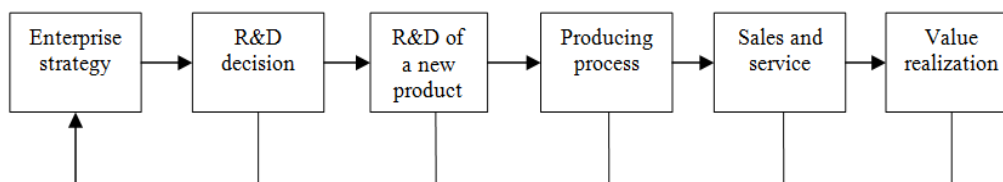
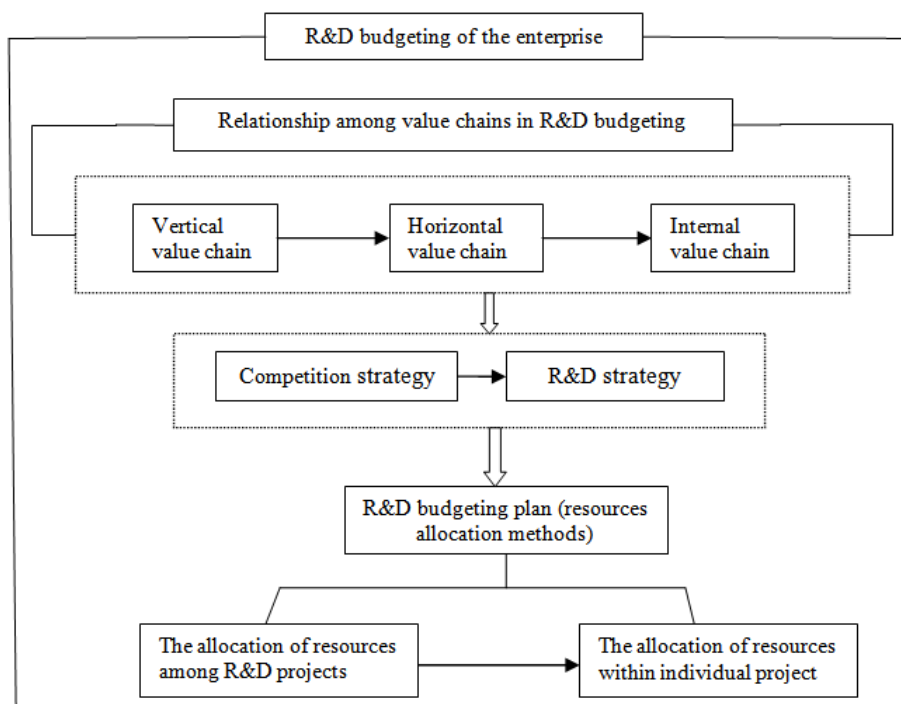Fig. 1: Procedure of an enterprise creating value starting from R&D

Fig. 2: R&D budgeting relationship based on value chain

is to make decisions decision of enterprise value chain in specific form as well as the enterprise to create value, there was a strong relationship between the value of the business activities (Fig. 1 and 2).

In fact, compared to other production links, the thought of value chain in the R&D budgeting is more important. R&D project once gets determined successfully, the formation of a decisive influence on the production. On the formation of value, one is in the design phase determines the product cost, including type and quantity, consumption of materials required for the production of human, sales and services (after sale service); on the other hand, the project development phase input into the will of the final product market the value of the impact. These are manifested in R&D for the value chain relations and R&D for new products to market has important value influence.

- **The stage-gate model:** In view of the current R&D budget reasons, the poor effect of the R&D budget, not only should be combined with value chain analysis, more important still deal with the

R&D process to implement process management stage, partial function of budgeting, thus the introduction stage, stage gate management thought. Stage gate management, is (Cooper, 1988) a process management of new product development technology was founded, the basic idea is to process the entire R&D activities into stages one and, at the same time the cross function at each stage of a predetermined by a group of R&D activities, the establishment of project evaluation, decision stage between the project behavior decision points, i.e., or stage-gate. When R&D project come to the barrier, the project managers to convene the relevant personnel to review progress, if the project achieve the intended objectives and requirements, the project to continue to the next phase, otherwise cause analysis, to find countermeasures or termination of the project.

No matter what kind of R&D management mode an enterprise uses, according to the way of management ideas, any development project can be important
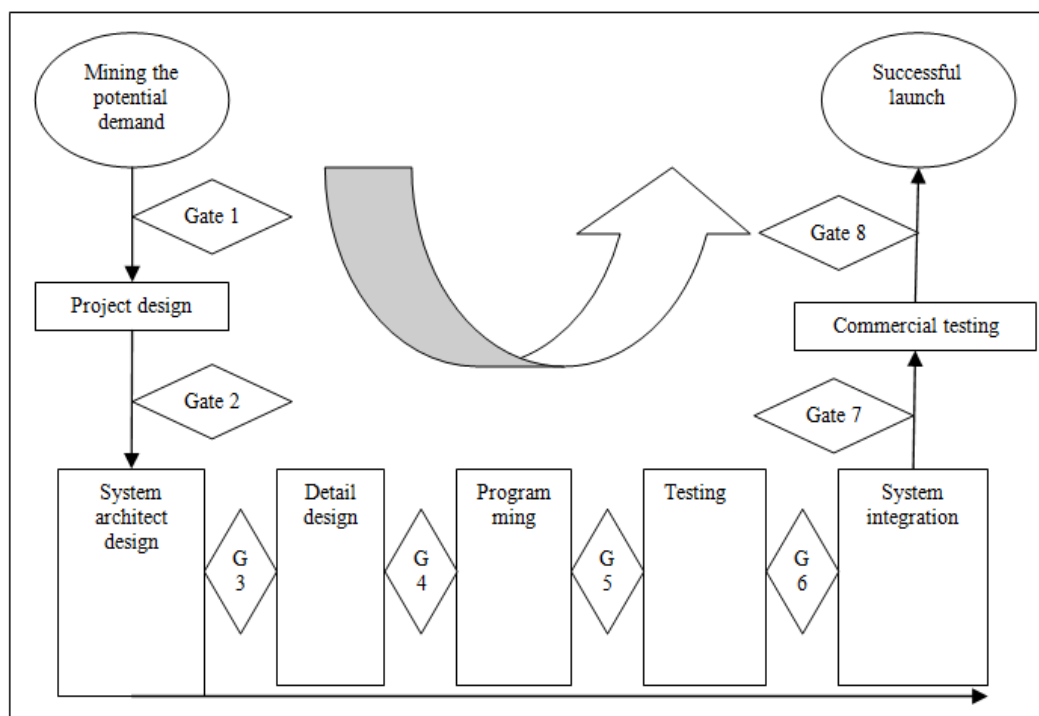
Fig. 3: The flow chart of stage-gate development of software

milepost event in the development process as method, process management stage of development projects. It can be decided that according to the complexity of development projects and development cycle length on the number of gates in the R&D process settings, synchronization and technology management activities, in order to facilitate the access point review. For example, a software project according to the R&D sequence is divided into 10 stages, such as the formation of the flow chart shown in Fig. 3.

The proposed method:
- **The basic framework:** By introducing the cause and stage gate management thought to the R&D budgeting problem, this study has constructed the value chain of gate type R&D budgeting mode based on. The basic idea is: will be important to mark important events in the process of development or in the course of the project as the R&D process approach, on the R&D budget implementation stage management. Based on the value chain analysis, the capital budgeting decision of R&D project investment decision and the gate line/check decision; before and after each method according to the information, take the capital control budget review on a stage of the investment and the preparation of the next phase of the budget, until finally the way. Each gate is increased the amount of information has been the implementation of the project and so on line/check decision, so as to realize the project phases,

dynamic budget control. Its basic frame is shown in Fig. 4.

- **The characteristic of the model:** As seen from Fig. 4, the new approach of R&D budgeting based on value chain has the following characteristics:
  - **Strategy oriented:** The business strategy of the day is to create more value, no matter what the strategy must meet the basic requirements of value creation. R&D as important value activities must comply with the goal of maximizing the value of enterprise. The R&D budget should take the strategy as the guidance, mainly reflected in two aspects: one is the must obey the requirements of enterprise strategy determine the R&D budget target; two is the distribution of R&D project selection and resource should be in accordance with corporate strategy.
  - **Including analysis of value chain:** Value chain budgeting increases the value chain analysis in the allocation of resources based on the research and production link. Value chain analysis is the identification of business activities classification and it can optimize the whole process. R&D value chain analysis aims to determine the relationship among different R&D projects and their activities, value and recognition of R&D project value distinction between activities, value-added and non value added, eliminate non value added activities, improve the efficiency value added activities and grasp the value of the link between activities, the
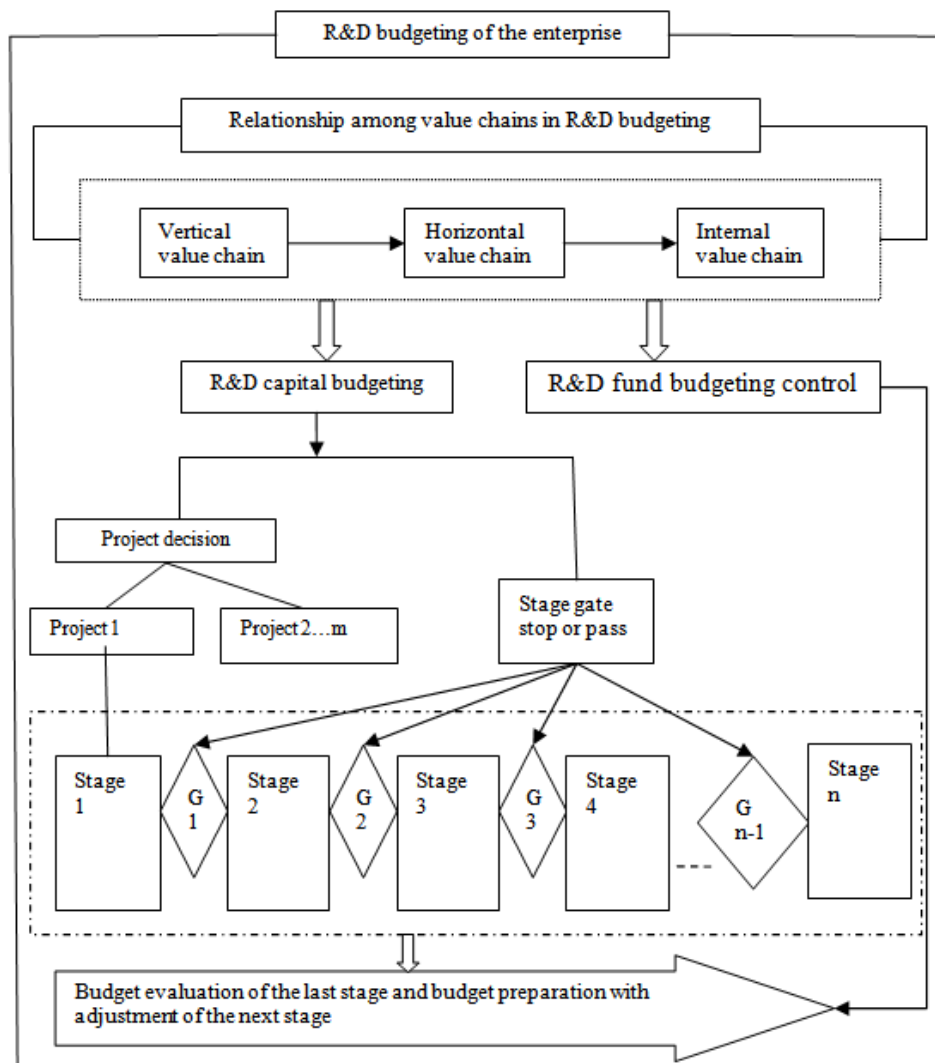
Fig. 4: The framework map of the model of R&D budgeting

development of the value chain the highest overall efficiency.

o **Using multidimensional budget system:** The traditional budget system generally includes two dimensions of budget and budget target and multidimensional budget system, according to the need to set the budget period, budget index, value activities, metering and responsibility center dimensions. R&D budgeting based on value chain is the implementation of the development of value chain management, its R&D budget requirements reflect the resource allocation for the development of value activities, control and assessment of the value for R&D activities.

Compared with the traditional methods, the new approach of R&D budgeting based on the value chain is better for resources distribution and optimize enterprise resource to enhance the use efficiency of R&D resources can play an effective role, which is directed by the strategy. R&D budgeting fully reflects the enterprise strategy; cost driver analysis of R&D activities based on the value chain analysis, provide an effective basis for resource allocation. However, the R&D budget model than the traditional budget method is more complex, budgeting, cost is higher, it is important, the quality and ability of the value chain of the R&D budget mode on R&D budget staff enterprises based on the higher requirements are put forward, so as to push the development of budgeting level of enterprises to improve.

RESULTS AND DISCUSSION

• **The R&D budgeting procedure:**
  Circulation system design of R&D budgeting: A scientific R&D budgeting mode shall at least meet the following requirements:
o How to enterprise strategy of clear thinking in the R&D budget

o The allocation of resources within the enterprise resources and ability range. To meet above requirements, we designed the R&D budget cycle system based on value chain in earlier paragraph (Fig. 4): R&D budgeting to the strategic direction, strategic decomposition R&D budget target, choose to reflect the strategic R&D projects, R&D budget target for R&D activities of the constraints of resource allocation; resource allocation based analysis in the value chain and can coordinate the relationship between R&D projects, R&D value activity and enterprise resources and ability ", resulting in the equilibrium of supply and demand of resources situation, which is the target of R&D budgeting.

Determine the budgeting target: R&D budget goal is to realize the goal of enterprise, in the budget period on the allocation of resources to achieve the goal of the R&D activities. Determine the R&D budget target, which is related to the rationality of science resource allocation, but also to realize the goal of enterprise. Enterprises determine the value chain research budget targets based on should take the strategy as the guidance, preparation for the R&D budget strategy provides a basic framework. The relationship between enterprise strategy and R&D budget goal should be: the strategic goal of guiding the development budget target, R&D budget target reflects the enterprise strategic target. The value chains of the R&D budget objectives include three levels: the first is based on determining the total budget target, this is the enterprise strategic target in the concrete embodiment of the budget period, is also the budget period umbrella R&D resources scale. The second is to determine the individual R&D budget target, this is the total budget target decomposition to various R&D projects; the project is on different stages of the budget target, according to a single project budget target, Resources allocation R&D resources include human resource, equipment, materials and capital etc., The allocation of resources is not random combinations of different types of resources, but the destination will organize all kinds of resources

to support value activities. Otherwise, all these resources getting together will be losing meaning. For example, the R&D project, test, acceptance of these activities in the value of human resources investment and industrial test pilot, need a large number of materials, equipment support resources, the enterprise according to the resource demand characteristics of reasonable organizational resources, can help to create value.

According to the value chain analysis results in the R&D project to allocate resources among enterprises, to support the competitive position of enterprise value creation contribution, or other important project, its resource requirements should be given priority to meet the. The allocation of resources to a single project, with the help of multidimensional budget system, budget index as the core, to meet the needs to meet the resource allocation of the value chain by setting the value dimension.

- **The index system building:** How to make limited resources optimal allocation is the major problem in evaluation of R&D budgeting. To solve the problem, the main factors involved in R&D budgeting must be clearly defined. A scientific and reasonable evaluation should take into account the complexity of R&D project and innovation, complexity and innovative cover index is based to construct evaluation model. The R&D project evaluation factors into two dimensions of complexity and innovation, from the two dimensions to select one of the appropriate indicators as evaluation factors, as shown in Table 1.

After the main factors are determined, the weighting of each factor also needs to be confirmed. Determining the factor weight, according to the complexity and innovation index design expert scoring table, gave m a consulting expert, by experts according to their subjective experience important scores of each index, the most important is the 100 points. In order not to be

Table 1: The index system of the evaluation

➢ Complexity index A1	➢ Creativity index A2
A11 Quantity of personnel	A21 Quality of ideas
A12 Sustainable competition advantage	A22 Probability of test success
A13 Core technology	A23 Evaluation of related institutes
A14 Fitness to the strategic plan	A24 Frequency of technical exchanges
A15 Technical success probability	A25 The expense of creation
A16 Business success probability	A26 The investment of technology
A17 Cost to finish the project	A27 The new product life cycle
A18 Time to finish the project	A28 The degree of new technology
A19 Importance of the project	A29 Technical monopoly
	A210 Knowledge and tech difficulty
	A211 Novelty of technique
	A212 The quantity of patents

Table 2: The specific indexes of the new product

| 1st Class	2nd Class	W	Level	Score
A1	A11 Quantity of personnel	4	4	0.16
	A12 Sustainable competition advantage	7	2	0.14
	A13 Core technology	7	3	0.21
	A14 Fitness to the strategic plan	5	4	0.2
	A15 Technical success probability	4	3	0.12
	A16 Business success probability	6	4	0.24
	A17 Cost to finish the project	12	5	0.6
	A18 Time to finish the project	10	4	0.4
	A19 Importance of the project	2	2	0.04
Sum of A1		57		2.11
A2	A21 Quality of ideas	2	3	0.06
	A22 Probability of test success	3	4	0.12
	A23 Evaluation of related institutes	3	2	0.06
	A24 Frequency of technical exchanges	2	2	0.04
	A25 The expense of creation	6	4	0.24
	A26 The investment of technology	6	3	0.18
	A27 The new product life cycle	4	4	0.16
	A28 The degree of new technology	4	2	0.08
	A29 Technical monopoly	3	2	0.06
	A210 Knowledge and tech difficulty	4	3	0.12
	A211 Novelty of technique	4	4	0.16
	A212 The quantity of patents	2	2	0.04
Sum of A2		43		1.32
Total		100		3.43
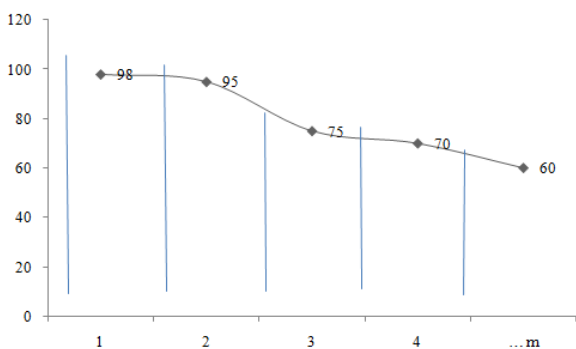
Fig. 5: The weighting coordinates of the model

confined to the expert evaluation results, combined with the original calculation method of expert statistical method and Newton iteration method and the score for calculation of each factor score area to replace the original method of factors, finally the expert scoring table for statistical processing, in order to improve the precision of the. The process is as below:

o Listing the data in the statistics software, SPSS
o Forming a rectangular coordinate
o Each two factor scores from high to low in order from left to right in the coordinate system arrangement, depicting the points into smooth curves, where, F_1 is the highest score, F_m is the lowest score
o For vertical to the abscissa to each point, the formation of M 1 closed graph, like a trapezoid, the top and bottom are respectively two adjacent points, as high as 1 (Fig. 5)
o Calculate the area of the closed graph area, which is the factor score:

$$Zt = \sum_{i=1}^{m} YFi + FjY \quad and \quad j = i + 1, t = 1, 2, \cdots, (9 + 12)$$

o Similarly calculated area score domain of each factor, then calculating the area of domain scores of all factors:

$$Z = \sum_{t}^{21} YZtY$$

o For each two factor score area domain of the primary factor score area domain and the ratio of Wt, this proportion is the weights of the factors:

$$Wt = \frac{Zt}{Z} = \frac{\sum_{j=1}^{m} \frac{Fj + Fi}{2}}{\sum_{t=1}^{21} \sum_{j=1}^{m} \frac{Fj + Fi}{2}} \quad (i = j + 1)$$

- **Case study:** In this part, the R&D procedure of some a new product will be analyzed as a case. The project is firstly evaluated within the model mentioned above, by stage and stage gate selection and the final items are chosen. Then the specific indexes and weighting of each factor, respectively are listed in the table below, which are from relevant departments and the calculation of the experts.

The calculated weight multiplied by 0.01, which indicates the factors in the whole evaluation system of proportion, then multiplied by each factor evaluation level, namely the factor score, all factors scores together is the project evaluation score. Therefore, the

evaluation system of the full score is 5 points. As can be seen from Table 2, the sample project complexity weight and 57, the experts believe that the importance of project complexity to occupy the whole evaluation system 57%, the importance of innovation 43%. The total score is 3.43, the equivalent of 68.4%, explain this project feasible, but not excellent, which belongs to the lower middle type.

CONCLUSION

To sum up, the present enterprises' failure to the R&D activities implementation causes effective budgeting, the value chain and the stage gate management idea into the R&D budgeting, to build a R&D budgeting model based on value chain with stage-gate approach. The model takes into account the effect of transverse, longitudinal and enterprise value chain of internal R&D project value and the allocation of resources, the important sign of development in the process of events as development approach, the R&D budget implementation stage management. The model of a R&D project budget is decomposed into multiple budget each access point, shorten the budget range, ease the problem of budget information basis, is conducive to the realization of the effective budget of R&D funds control, put the limited resources reasonably assigned according to the largest potential value.

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