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Designing a national science and technology evaluation system based on a new typology of international practices

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ABSTRACT

This paper aims to provide a new classification of national science and technology (S & T) evaluation systems. This evaluation system will consider five analytical dimensions extracted from international practices consisting of the following: evaluation system function, evaluation interactions framework, evaluation organization, evaluation model of funding, and process of result evaluation. The classification proposed in the present paper is intended for application in detecting the current position of and expanding suitable evaluation systems based on the countries' native context as a national analysis tool (especially for late-comer countries). Therefore, in the case of Iran, we reviewed both the existing and optimized modes of national science and technology evaluation systems. The results show that the existing evaluation system in Iran is not optimized, so evolutionary changes are required for obtaining the desired system goals. Policy results of the mentioned classification as well as national science and technology evaluation systems are considered. In general, it appears that such a descriptive analytical typology can be applicable for all countries. However, the classification is specifically applied for designing an optimized S & T evaluation system in Iran.

1. Introduction

The evolving S & T evaluation systems in several countries show that many of these countries have moved to consider all factors involved in the development of S & T in their economies (Vartiainen, 2002; Mrinalini and Nath, 2006; Georghiou and Laredo, 2006). Most of these evaluation systems have been formed gradually and developed through trial and error, and are not necessarily optimal. In Iran, for example, after three decades of dramatic S & T development, policy-makers have begun to evaluate the outcomes of the S & T evaluation system, and have discovered serious shortcomings including:

- The parallel evaluations by different institutions,
- Scattered and case-based evaluations,
- Overly controlling evaluations,
- Lack of the STI evaluation system integration,
- Lack of evaluated institutions' cooperation within the government agency in charge,
- Lack of attention to the interests of all key stakeholders in the evaluation system design,
- Lack of attention to social benefit of STI projects,
- Evaluation only based on output indicators (not impact indicators) (Farazkish, 2017).

It seems that there is no unique solution for dealing with such challenges in different countries, although the comparative studies show that the policy makers face similar key issues in various countries (Coryn et al., 2007). Identification of the main issues, as well as the approaches taken to cope with them in different countries, can be used as a starting point for the conceptual design of an optimal S & T evaluation system, particularly for latecomer countries. To achieve such an explanatory classification by considering extension and dispersion of the S & T evaluation system studies we offer a sound typology below (Marradi, 1990). Because of the different dimensions of the main issues and their solutions, the proposed classification is also multi-dimensional.

The advantage of such a typology is the possibility it gives to partitioning the national S & T evaluation solutions. In fact, this is a new descriptive (not prescriptive) analytical tool that can be used in two situations. At the first situation, a country's S & T evaluation system has been formed during the time. By applying the proposed typology in order to design the desired S & T evaluation system, the existing system

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can be optimized. But at the second situation, a late comer country needs to develop an S & T evaluation system from the beginning. The proposed classification enables the country to choose the specifications of its own S & T evaluation system based on similar experience contexts.

To clarify this advantage, and how to use it, we selected Iran as a case study, and the specifications of its optimized S & T evaluation system have been chosen based on its history and features of the existing system.

Section 2 of this paper describes the typology dimensions. In this regard, the national S & T evaluation systems are classified based on the evaluation system function, evaluation interactions framework, evaluation organization, evaluation model of funding, and process of result evaluation. The historical development of S & T in Iran concerning four different periods from 1980 to 2014 is explored in Section 3. Regarding the descriptive typology given in Section 2, the state of the art S & T evaluation system of Iran is described and also a general picture of the current situation is offered in Section 4. In Section 5, the evaluation system of Iran is dealt with the mentioned typology in order to make a gap analysis between current and desired conditions in Section 6. Finally, a policy conclusion is drawn in the last section. The proposed typology may be applicable in other countries.

2. Typology of national S & T evaluation systems

Comparative studies on S & T evaluation systems have a tendency towards reviewing the differences of evaluation approaches, strengths and weaknesses of each approach, and how they are developed (Coryn et al., 2007). In addition, some studies have analyzed the reasons for the variability in the evaluation systems. Gibbons and Georghiou (1987) suggest that this variety is a reflection of different political and managerial cultures.

But the main questions are: “How can these various experiences be applied by other countries?” and “How can the countries' current S & T evaluation systems be improved by learning from similar situations?” It seems that effective use of the other international cases is dependent on the ability of integrating and framing them as an explanatory typology (Elman, 2005). To achieve such an integrated analytical framework, the systemic and problem-oriented approach has been applied. After identifying the five key dimensions of an evaluation system (Phaal et al., 2004), the species of confronting countries with each dimension's issues also have been extracted. Explanations are provided in the following subsections.

2.1. Evaluation system function

The system level studies survey the effects of the governing structures of S & T on its evaluation system. According to this point of view, Molas-Gallart (2012) has introduced three main functions of national S & T evaluation systems:

- Distributing function, which seeks to distribute resources among the potential actors and stakeholders of a special policy or program;
- Improving function, which seeks to learn from the past experiences in order to find the best practices and replicate them;
- Controlling function, which surveys precisely the way of using public resources, individuals and institutions for the necessary activities in order to reach policy goals.

The differences identified in choosing the S & T evaluation function of countries are appropriate with the structure of their national S & T governance.

2.2. Evaluation interaction framework

As mentioned before, “Governing structure” in this paper specifically refers to the processes in which public policies are defined and implemented, how actors play their roles in these processes, and interactions are formed between them (Jordan, 2008). According to the initial function of a national evaluation system, the framework of actors' interactions should be designed (Cetindamar et al., 2009). Additionally, different applications of such a framework lead to two distinct approaches on S & T evaluation systems: a) a static approach concerned with the structure and position of actors within a S & T evaluation system, and b) a dynamic approach concerned with causality and interaction between the actors of a S & T evaluation system. In such a framework, different stakeholders involved in the evaluation system and their interactions in different levels are considered (Shehabuddeen, 2000).

2.3. Evaluation organization map

An evaluation map supports understanding of the static relationship between actors of a system (Phaal et al., 2004). Therefore, the map analysis shows how to organize the system actors. According to the S & T evaluation system literature, two main approaches have been recognized as funding organizations: the centralized versus decentralized organization (OECD, 2003).

2.4. Evaluation model of funding

The reasoning here is that the mechanisms for evaluating publicly financed S & T must determine the choice of the evaluation model. There are three major types of mechanisms (Coryn, 2007). In the first type, financing practices are based on performance (Georghiou and Laredo, 2006). The second type of S & T-funding models is those that allocate large sums of money granted by the national government to a regional government (or another body) with only general provisions on how to spend the sum (Motohashi, 2003). Indicator-oriented budget models, as the third type, have been developed based on the algorithms derived from student research, institutional programs, or bibliometric indicators.

These three types of models are designed with the aim of a) clarifying the results of public investment in S & T for both government and taxpayers, b) ensuring the agencies and S & T financiers' focus on quality and their communication, and c) avoiding high costs for S & T.

2.5. Process of result evaluation

The fifth dimension is rooted in the understanding of how evaluation processes can be overarched. The literature on process level evaluation (e.g. Campbell, 2003) recommends a systematic and consistent evaluation if it is marked by its thoroughness, regularity, consistency (e.g., of measurement, quality criteria, and performance standards), and being methodical in its procedure. Correspondingly, pluralized evaluation is recommended if the evaluation process is characterized by a high degree of situation-specific variability in terms of their conceptions, methods, and applications.

2.6. Presenting the typology

Therefore, five different dimensions of categorizing related to the choice of evaluation systems are available. Different countries' S & T evaluation systems can be detected by using different analysis dimensions. Combining five dimensions of evaluation ultimately leads to 72 system types, shown in Fig. 1.

Each country based on its national context can be placed in one of the 72 routes in the tree diagram of Fig. 1, and no country is able to have all of them. Comparative studies shows that different types of national S & T evaluation systems based on the context of countries has been created. Some of the experiences are presented in Table 1. For instance, England's S & T evaluation system consists of the improving, dynamic, centralized, performance-based, and systematic categories, so

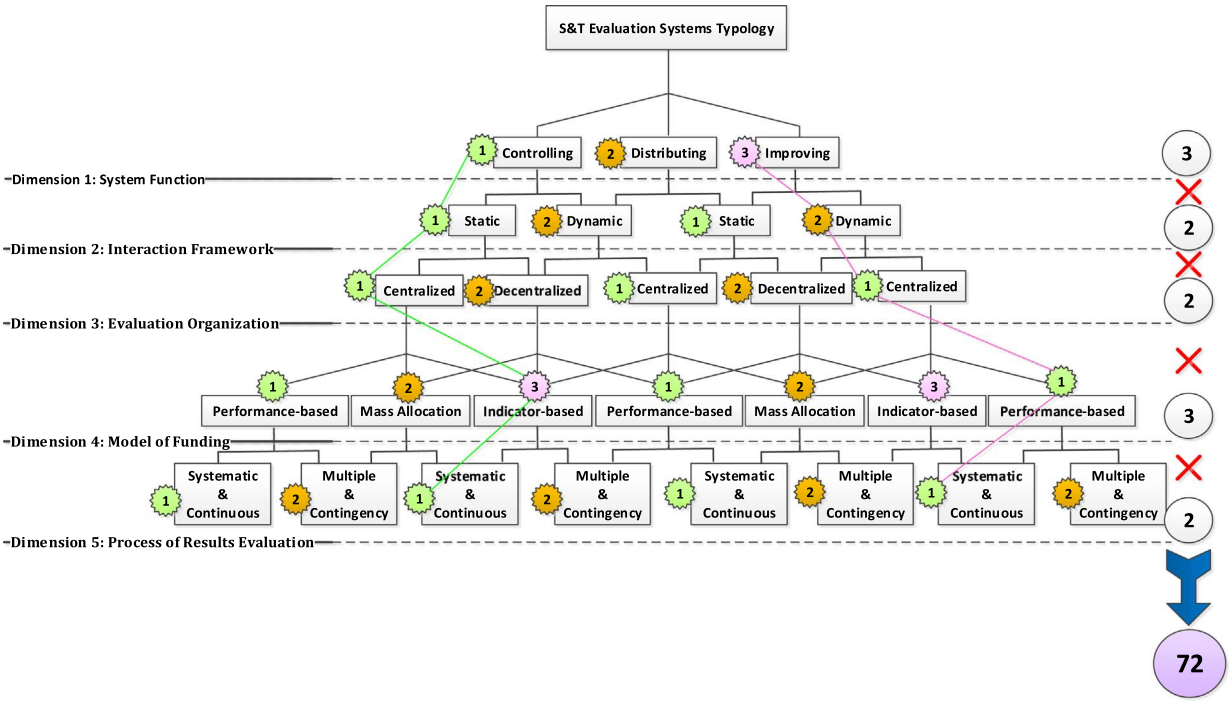

Fig. 1. Proposed typology of national S & T evaluation systems.

it will be presented as Route (3-2-1-1-1) in Fig. 1.

As shown in Table 1, some of the countries, like England, have focused on the important role of improving function (Barker, 2007; Chelimsky, 2006), while the evaluation system of countries, like Spain, have generally focused on controlling function (Cruz-Castro and Sanz-Menéndez, 2007). In addition, Sweden has shaped its national evaluation system based on budget distributing among institutions (Coryn, 2007). Results of comparing twenty case studies indicate that all three system functions (controlling, distributing and improving) are almost identical and have been applied; although the controlling function is still prevailing.

In the second dimension of analysis, England's evaluation framework is dynamic (Barker, 2007). Moreover, in countries such as United States, interactions between evaluation systems' stakeholders play a significant role. In contrast, some countries, including Spain, have just placed actors' identification on the agenda, without considering the dynamics of the evaluation system (Molas-Gallart, 2012).

From the third dimension of analysis, most countries have centralized funding organizations (i.e., S & T funding comes from one government agency or source). Belgium and the United States, however, are decentralized in that multiple agencies or government branches fund a large portion of S & T. The United States, unlike many other nations, has no single research council but rather distributes funding via mission-oriented agencies (such as the National Science Foundation) which distribute funds primarily via peer and expert panel review (Coryn, 2007).

In the fourth dimension, England's Research Assessment Exercise (RAE) is a famous example of performance-based models. The RAEs are periodic evaluations of the S & T undertaken by U.K. universities to inform the allocation of S & T funding. The RAE is designed to give each university research unit a quality rating, and reward excellence. From the start, the RAE was seen as a basis for informing selective allocations of block grants paid to higher education institutions for S & T research (Georghiou and Laredo, 2006). The mass-allocation model of S & T funding is fairly typical in the Japanese S & T system; for example, funding is allocated to the national government's ministries which then distribute these funds as block grants to research performers (e.g., universities, institutes) as they see fit—normally without measures of prior performance (i.e., ex-post evaluation) or assessments of likely future performance (i.e., ex-ante evaluation) (Motohashi, 2003). An example of the indicator-based models was introduced in Australia's Relative Funding Model (RFM) in 1990. The primary basis for the RFM was defining quantitative indicators for distributing the resources of S & T that consider S & T's financial input as a competitive grant receipt. Mixed indicators include S & T inputs from government, public sector, and industry; their outputs include publications and educational degrees with the various weights from one year to another (Coryn et al., 2007).

In the fifth dimension, For instance, the Australian evaluation process is systematic and consistent (in its current form) in that it always applies the same procedures, methods, (e.g., the CI), and measurement of inputs and outputs—making it an indicator-based model—and it allocates S & T funding using an algorithm. Therefore, the distinguishing characteristic of systematic evaluation is that they do not vary to any great degree in terms of method, measurement, criteria, standards, and other relevant features (Coryn et al., 2007). By comparison, pluralized evaluation processes lack these characteristics (i.e., systemization, consistency). In the current German system, for example, most evaluations of research are one-off, situation-specific studies conducted by regional evaluation agencies (Orr and Paetzold, 2006).

Comparative analysis results of 20 national S & T evaluation systems led to 14 different types in terms of five similar dimensions. In this context, the national S & T evaluation systems of the Czech Republic, Finland, France, Hong Kong, and Iran respectively are similar to Japan, Poland, Ireland, Spain and Turkey, and Russia.

After a quick review of the proposed typology, the next step is one detailed case study. In this regard, Iran is selected to be a case in designing a national S & T system based on the suggested typology; hence, in the next section, the current situation of S & T in Iran and its evaluation system are described, and then the mentioned typology-based design is followed.

3. The growing trend of S & T in Iran

In the 4th century BC, the Persian Empire was known as one of the

pioneering civilizations. The acquaintance with new sciences and technologies in modern Iran, however, goes back to the beginning of the 19 century, during the years that the Czarist Russia invaded and occupied the northeast section of the country using its modern weapons and sound army organization. Iranian policy makers thinking about this failure have learned a lesson: develop modern training. By the early twentieth century, the government targeted national development to develop human resources through sending students to Europe or establishing colleges. Importing technological products from the Western countries was the only way for modernizing Iranian society at that time.

Attempts for industrializing the country began around 1920 and ended in the establishment of limited numbers of enterprises and new industries in Iran. These efforts continued after the World War II with the help of American consultants; however, during these years and even up to 1979 (the Islamic Revolution), there is no documented policy to attract, localize, or diffuse technology in Iran.

After 1979, with the expulsion of foreign consultants and companies from Iran, the government was forced to pay special attention to S & T (Ghazinoory et al., 2009). In the following subsections, we consider the development of S & T in Iran during the last four decades.

3.1. The 1980s: The military needs

During the Iraq-Iran war (1980–1988) and failing to procure the military equipment from the traditional suppliers in the Western countries, efforts were made to repair the existing weapons leading to numerous innovations. Civilian industries could not communicate with foreign companies and tried to continue their production with the help of domestic engineers and experts. Therefore, the policy of research and development, especially in the defense sector, was taken seriously in these years.

3.2. The 1990s: Paying attention to research

In this decade, foreign sources supplied many, mostly obsolete, technologies to Iran. However, research was seriously taken into consideration. During this period, the number of governmental research units was doubled, researchers per million people increased 7 fold, and the articles published in foreign academic journals increased over 600% (Ghazinoory et al., 2011). However, the fact is that despite the rapid development in the supply side of S & T there was little demand for it. In the 1990s, most Iranian policymakers believed a causal relationship between the development of sciences, technology, and wealth in the order listed exists. Such belief implies that the policymakers thought that they could overcome the national technological problems by developing scientific research.

3.3. The 2000s: Paying attention to technology

This decade can be considered as a new era in the history of S & T development in Iran. During this period, numerous activities took place for technological development in the country. The institutions that were established for the first time during this decade include: technology parks, incubators, venture capital funds, high-technology development plans, academic entrepreneurship centers, several sponsored organizations supporting R & D, Iran Nanotechnology Initiative Council, academic courses of IT management and S & T policy, and multiple centers of technology development in the defense sector (Soofi and Ghazinoory, 2011).

Because of international sanctions against Iran in the 2000s, there was no foreign involvement in design, administration, and finance of these institutions in practice, which led to the deviation of these institutions from their original missions.

One of the important events with respect to the development of S & T in this decade was the renaming the Ministry of Culture and Higher Education (MCHE) to the Ministry of Science, Research and Technology (MSRT). This change shows that the linear perspective still dominates the views of the Iranian policymakers, and they consider that technology development follows science and research, leading to the negative effects of this attitude which became obvious at the end of the decade.

Moreover, the Iranian policymakers were proud of the rapid rate of increase (20 fold) in the number of articles published by scholars in Iran in the ISI-index journals during1997 to 2008 (11 years), attracting ample attention from around the world (Ghazinoory, 2009).

3.4. The 2010s: Paying attention to commercialization

Early this decade, it was found that a linear approach is not the answer to Iran's technological problems, and the technology needs of the country should still be imported from other countries. Especially after the escalation of international sanctions against Iran, many problems arose in the supply of technological products.

In this period, the government focused on commercializing the output of research, and adopted many policies, like:

- Approval of law in supporting knowledge-based companies;
- Establishment of a big financial fund organization to support innovation;
- Establishment of a vice presidency for S & T to strengthen the relation between the scientific and industrial sectors;
- The launch of national initiatives to develop strategic technologies.

One main neglected issue in these decades was the establishment of a data collecting system for S & T and its evaluation. The government finances almost all investments on R & D of the country. Accordingly, it is only reasonable for it to also take the responsibility of establishing and implementing a national evaluation system. Failure of the government investments in R & D made the policymakers conclude that this situation cannot be allowed to continue, and all occasional evaluative activities should be consolidated into an integrated and consistent evaluation system.

4. S & T evaluation system in Iran: state of the art

The conventional S & T evaluation system in Iran was like a controlling system used to monitor all governmental projects; it means that the budget was allocated merely based on the project's degree of development. A successful research project was defined as the one attracting more funds. It is obvious that such a procedure has no interest in the success of S & T activities.

On the other hand, the wide array of S & T policymaking centers in Iran has tried to design and implement their own evaluation system in recent years. However, in 2009, Iran's parliament took the first step to establishing a national evaluation system for S & T and required all organizations, universities, research centers and public companies to report their R & D activities to the MSRT every three months so that the ministry can publish an annual report for the parliament. After this act and since 2010, the Iran government established a national evaluation system for S & T as follows:

- Designing a national network called the National Information System for Science and Technology (www.SEMAT.ir) where all relevant data are recorded and stored.
- Developing a set of 50 indicators for research inputs, and outcomes. Requiring all governmental agencies to register all the data relevant to these indicators in the National System of Science and Technology Information.

It is worth noting that designers of the aforementioned system claim that these indicators have been designed based on the logic model

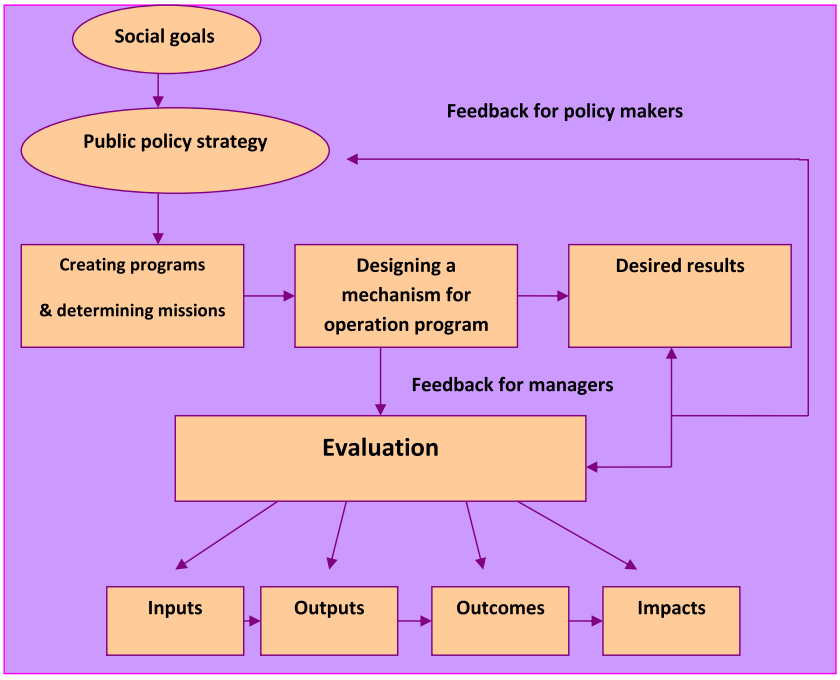

Fig. 2. Logic model of the S & T evaluation system in Iran (Ghazinoory et al., 2012).

(Fig. 2) though there isn't any published analytical report based on this model (Ghazinoory et al., 2012).

The S & T evaluation in Iran has been conducted annually in that it always applies the measurement of inputs, outputs, and outcomes, although it is not clear which outputs were obtained directly from a specific input. Therefore, the main problem of this system is the time lag between measuring the inputs and outputs, and between the outputs and outcomes; thus, any kind of analysis (at least in short-term) lacks sufficient reliability. Moreover, experience has shown that most of the governmental organizations are unable or unwilling to produce, collect, or register their data in the SEMAT system.

Therefore, as stated in the Introduction above, Iran's S & T evaluation system, which has gradually evolved over the last ten years, has faced problems at different levels of the evaluation process. The following subsections are the results of the problem-based analysis of the current system based on dimensions of the typology described in Section 2.

4.1. Main function of Iran's current S & T evaluation system

Since data are collected only as ex-post for delivery to the parliament as a national report, the key governing function of this system is merely control. There are no improving or distributing functions used. Because the evaluation system has no impact on improving the performance of the government in the distribution of the funds, no governmental organizations pay attention to the evaluation system.

4.2. Iran's current S & T evaluation framework

In the current evaluation system, various stakeholders and their roles and interactions have not been considered. The government organizations are the only actors that register their data into the SEMAT passively; therefore, the current system is static (not dynamic).

4.3. Organization of Iran's current S & T evaluation system

The Iran parliament has tried to control the S & T budget by legislation in the recent years. For example, a law was passed requiring all governmental agencies to allocate a certain percentage (e.g. 1 to 3%) of their annual budget to S & T. However, these laws have not been enforced due to bureaucratic problems, and each organization allocates its budget to S & T depending on its manager's preferences (that is usually less than a legal requirement). Accordingly, most of the S & T projects are funded by decentralized organizations in Iran, while it is necessary to control these organizations' funding under the supervision of a centralized organization (MSRT).

4.4. Iran's current S & T evaluation model of funding

As mentioned before in Section 4, Iran's S & T evaluation system in the model level has been designed considering only a number of quantitative indicators and does not pay enough attention to qualitative indicators or expert panels. However, there is no choice in the current situation where the government agencies are even incapable of collecting these quantitative data. It is worth noting that completing the real-time registration system, will make it possible to complete this indicator-based evaluation system.

4.5. Process of Iran's current S & T results evaluation

The current evaluation system includes a set of determined indicators (there are no differences between the indicators of organizations with those of universities and research centers), which have been measured annually. Some government agencies have criticized this system; for example, the Ministry of Health and Medical Education claims that specific indicators for the health care should be considered in this indicator-based system. Moreover, the Ministry of Interior Affairs claims that some important outcomes of R & D projects of the ministry are not included in this system.

Overall, it seems that the current system includes a systematic and continuous method of evaluation, and perhaps it is better that this method continues to maintain the ability of comparison between the different agencies.

As it is described above, Iran's S & T evaluation system consists of controlling, static, centralized, indicator-based and systematic categories, so it will be presented as Route (1-1-1-3-1) in the tree diagram of Fig. 1 (like the current situation of Russia). However, this current S & T evaluation system has not been successful in achieving its goals. It is

beneficial to depart from the current unfavorable situation, describe the desired situation, and predict the optimal transition paths of the current problematic bottlenecks.

5. Designing a new system of S & T evaluation for Iran

According to the previous section, the existing evaluation system is not optimized. The present authors analyzed the contexts of current problems and suggested solutions by relying on the field studies, review of related documents, and interviews with experts as well as managers involved (approximately 29 experts[1]), from both internal and external system aspects by applying the Theory of Constraints (ToC) and Systematic Thinking (ST) approaches. To solve the detected problems, the optimal evaluation system was proposed based on the results of this analysis.

5.1. Main function of Iran's optimum S & T evaluation system

As previously mentioned, one of the most important issues of Iran's current S & T evaluation system is controlling governance. In addition, this approach gives little incentives to the applicant organizations to cooperate with the government agency in-charge. Thus, the control system does not work.

Countries like UK that have completed several consecutive periods of S & T evaluation, have chosen gradually longer-term goals, and have improved their evaluation systems by learning loops. Therefore, it seems the tendency of policymakers to target long-term improvement will likely be chosen as the evaluation approach.

Similarly, the long-term vision of Iranian S & T policymakers is required to adopt the improving approach in designing the S & T evaluation system. In this respect, Iranian experts suggest that the mentioned system be reformed in two steps. The first step is the allocation of organizations' budget based on their performance evaluation (distributing function) to enforce the evaluation task by the responsible agency. In the next step, strengthening the learning loops of the evaluation system (improving function) to lead the organizations towards gradual self-assessment.

As a result, the long-term approach of a system design is improving however, the control and distribution aspects could be realized during the implementation.

5.2. Iran's optimum S & T evaluation framework

Lack of attention to the interests of all key stakeholders is also another factor in the S & T evaluation system, as noted in the Introduction. This is one of the most important consequences of static attitude (focused on the present not the future) within the framework design of the evaluation system.

In the most recent evaluation trends, key stakeholders have been involved in both design and implementation of new systems. In addition, improving the evaluation approach usually, increases the complexity and dynamics of the system. In these circumstances, the use of a static analytical framework for system design will not work. It appears that wherever the improving system is used, the dynamic analytical framework is also considered to the next level (countries such as France, Ireland, Japan, Britain and America).

As it became clear in the expert interviews, one of the results of employing a dynamic evaluation framework for Iran is that the interests of stakeholders such as academics, policymakers, business users, and most importantly the public, will be considered. Based on this fundamental attitude change, the evaluation system must be focused on new indicators such as the sustainable social and economic development in the field of impact assessment, absorption capacity enhancement within outcomes assessment and quality improvement of research outputs.

5.3. Organization of Iran's optimum S & T evaluation system

The STI evaluation system in Iran consists of several institutions, including the Supreme Council of Cultural Revolution, Supreme National Security Council, Parliament (Majlis) Research Center, Expediency Discernment Council of the System, Iranian Supreme Council for Science, Research & Technology (ISCSRT) and vice presidency for Science & Technology.

According to what was mentioned in the statement of problems, the presence of these multiple governmental institutions has followed many parallel activities in Iran's science and technology evaluation system. This problem exists at the organization level of the evaluation system that requires the division of evaluation duties at the national level that is commensurate with the political context of the country.

Since ISCSRT is legally responsible for STI evaluation in Iran, experts believe that the centralized evaluation system must be continued under the stewardship of ISCSRT, and other institutions might do cross-sectional assessments according to other systematic needs. However, these complementary assessments should be anticipated in the macro map of the evaluation system.

5.4. Iran's optimum S & T evaluation model of funding

Several bottlenecks identified in Iran's S & T evaluation system will be meaningful at the dimension of the evaluation model including the lack of integration in the STI evaluation system, imbalance of evaluation indicators, and the impossibility of comparing evaluated organizations as well as projects. Using the results of the interviews with local experts, we concluded that the current indicator-based assessment mechanism is not appropriate for Iran. Instead, it looks like the performance-based assessment model can be used to achieve the following objectives:

a) Transforming the potential outputs of research projects to practical social impacts (due to the relevance, efficiency, effectiveness, utility and sustainability parameters considered integrally in performance-driven approach),
b) Comparing the research and technology performance of organizations with respect to their research budget,
c) Relocating the budget based on the performance and impacts of completed projects.

Furthermore, Iran's desirable S & T evaluation model will be a performance-based model, if the learning aspects of the current controlling system are to be strengthened gradually.

5.5. Process of Iran's optimum S & T results evaluation

Systematic evaluation provides a standard configuration, which resulted in the ignorance of the evaluads' differences. However, this process can be applied for comparing the evaluads' progress to their previous situation or their close competitors.

Based on what was discussed in Section 5.3, an annual pivotal and systematic evaluation can be conducted under the supervision of ISCSRT. Moreover, other periodic evaluations in line with specific situations should be implemented based on cross-sectional supplementary requirements.

According to this section descriptions, Iran's optimum S & T evaluation system includes improving, dynamic, centralized, performance-

[1] Interviews conducted with experts who have at least three characteristics:
1. Their education is related to science and technology policy-making,
2. Experience in managing or policy-making of science and technology more than ten years,
3. Experience in conducting government-funded large Research and Technology projects.
Considering such features, interviews were limited to a few people, but their comments were very valuable.

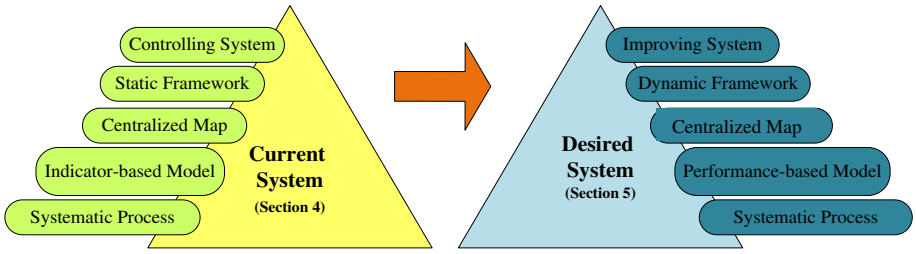

Fig. 3. Gap analysis in different dimensions of Iran's S & T evaluation system.

based, and systematic categories, so it will be presented as Route (3-2-1-1-1) in the tree diagram of Fig. 1 (like the current situation of England).

6. Results

Gap analysis of the current and optimized situations (Ghazinoory et al., 2007) of Iran's S & T evaluation system (Fig. 3) shows that especially in the main system function, interaction framework and model of funding dimensions, significant changes must occur through the implementation of an evolutionary process. The design of such a process can be subjected to further studies in this area.

Applying the presented typology in this paper, and moving towards optimization of Iran's S & T evaluation system will establish the foundations for achieving the following results in line with quintuple dimensions:

1. Main evaluation system function (controlling to improving)
   a. Allocating a certain percentage of the involved organizations' general budget to research and technology development,
   b. Improving the method for allocating the research budget,
   c. Improving the capacity of absorption of S & T in Iran,
   d. Strengthening the learning processes of the evaluation system and gradually forming a self-assessment culture.
2. Evaluation interaction framework (static to dynamic)
   a. Considering the role of different stakeholders in the S & T evaluation system,
   b. Contributing to sustainable social and economic development.
3. Evaluation organization (improvement of the centralized organization)
   a. Assigning appropriate responsibilities among the national institutions involved to avoid parallel work,
   b. Accreditation of the ISCSRT position as an institution responsible

Table 1

Country	Evaluation System Function			Evaluation Interaction Framework		Evaluation Organization Map		Evaluation Model of Funding			Process of Evaluation Results		Route Code
	Controlling	Distributing	Improving	Static	Dynamic	Centralized	Decentralized	Performance-based	Mass-allocation	Indicator-based	Systematic & Continuous	Multiple & Contingency	
Australia		*			*	*				*	*		2-2-1-3-1
Belgium		*			*		*		*			*	2-2-2-2-2
Czech Republic			*	*		*			*			*	3-1-1-2-2
Finland	*			*		*				*		*	1-1-1-3-2
France			*		*	*			*			*	3-2-1-2-2
Germany		*			*	*				*		*	2-2-1-3-2
Hong Kong	*			*		*		*			*		1-1-1-1-1
Hungry		*		*		*			*			*	2-1-1-2-2
Iran	*			*		*				*	*		1-1-1-3-1
Ireland			*		*	*			*			*	3-2-1-2-2
Japan			*	*		*			*			*	3-1-1-2-2
Netherlands	*				*	*		*			*		1-2-1-1-1
New Zealand		*		*		*		*			*		2-1-1-1-1
Poland	*			*		*				*		*	1-1-1-3-2
Russia	*			*		*				*	*		1-1-1-3-1
Spain	*			*		*		*			*		1-1-1-1-1
Sweden		*			*	*			*			*	2-2-1-2-2
Turkey	*			*		*		*			*		1-1-1-1-1
United Kingdom			*		*	*		*			*		3-2-1-1-1
United States			*		*		*	*			*		3-2-2-1-1
Total	8	6	6	11	9	18	2	7	7	6	10	10	14

Identified types of S & T evaluation systems based on the 5 analytical dimensions.

for the allocation of funds for R & D,
   c. The overall planning formation of comprehensive vs case-based S & T assessments.
4. Evaluation model of funding (indicator-based to performance-based)
   a. Consolidation of the S & T evaluation system considering all short-term and long-term performance factors,
   b. Transforming the potential outputs of research projects to have practical impacts,
   c. Comparing the performance of involved organizations in S & T field,
   d. Strengthening S & T by choosing appropriate projects,
   e. Identifying the legal obligation of organizations about the method and the amount of allocated budget.
5. Process of result evaluation (improvement of the systematic process)
   a. Enabling organizations to evaluate their performance compared to the previous year and monitor their progress or failure,
   b. Reallocating the annual budget based on the performance and impacts of completed projects,
   c. Implementing all the comprehensive and case-driven S & T evaluations based on an overall planning assessment map of the country.

7. Conclusions

In this paper, we showed that the systematic approach is the most recent and modern approach to the development of national level S & T evaluations. We have also determined that almost all of the developed countries have moved towards implementing their own national evaluation systems in order to obtain a general picture of the whole structure, process, and relations in their S & T fields. This trend is formed not only by the governments to trace their investments but also by policymaking researchers in order to answer the questions:

- "How is the government accountable to the society regarding the S & T costs?"
- "What is the role of the native context of countries in designing their desired evaluation systems?"
- "What are the bottlenecks of S & T development?"

By reviewing the experiences of different countries, authors present a multi-dimensional typology of national S & T evaluation systems that can be applied in descriptive designing and re-designing of the S & T evaluation systems of countries (especially the latecomer countries).

To evaluate the efficiency of this typology, a case study on Iran was conducted. This country has experienced a fast scientific growth, especially in the number of articles, and has a large investment in many S & T projects; therefore, it requires an efficient and effective national evaluation system. The national S & T evaluation system in Iran has worked since 2010, yet could not reach the desired goals of policymakers. Therefore, it is necessary to change some of its coordinates. Surveying these unattained goals and the existent facilities of the country shows that the present evaluation system dimensions of Iran should change from controlling to improving, static to dynamic, and indicator-based to performance-based categories.

The advantage of such a typology lies in providing a transparent system classification for explanatory analysis of S & T evaluation systems. In addition, classifying experiences of other countries in a structured framework gives the possibility of partitioning the national S & T evaluation solutions. Since similar studies have not been reported in the literature review, this typology is not a final verdict but it presents a reasonable analysis classification and simplifies the complicated details dominating the S & T evaluation systems.

Finally, the most important point is how to move from the current situation towards the optimized situation. There is usually a big gap between the optimum and current options, especially in the developing countries. The strategy of crossing this gap can be the subject of future researches.

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