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Factors Affecting the Effectiveness of Scientific Elites in Society: A Systems Thinking Approach

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ABSTRACT

Elites, a distinct group by a privileged status, must positively impact their society. In developed countries, they can be found to contribute to improvements at national and global levels and cause more value added in different areas. However, in countries with a low elite quality rating, they cannot influence society as much and usually tend to immigrate from the country. This paper uses a systems thinking approach to model the influences and effectiveness of elites in society and the main parameters that can improve them. The whole system in this paper consists of the family system, education system (school and university), and society. The study shows how elites can influence society through causal maps and causal loop diagrams. In the following, the MICMAC technique is used to find the most important and influencing variables and categorize them into three main groups: The determinant variables are mostly influencing than dependence, for example, invention and innovation. Dependency on factors, including elites' drive for work, is more dependent than influencing. The autonomous variables have low influence and low dependence. The whole model's variables diagram shows the system as a stable, meaning its results can be predicted accurately with a degree of assurance.

Keywords

Elite, Effectiveness, Influence, Systems thinking, System dynamics, MICMAC.

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1. Introduction

"Elite" was first used in the seventeenth to describe a particular excellence in a social group (Bottomore, 1964). Later, the argument of "elite influence" was introduced, which means elites are defined by their performance rather than other positions such as family or wealth. Also, influencing elites is defined by four characteristics:

(1) Flexibility: They do not have a fixed attachment to a particular position and easily shift their roles.
(2) Informality: They easily replace the formal structures whenever they are not beneficial.
(3) Mobilizing entities: They mobilize consultancies, think tanks, and NGOs.
(4) Connector: They have a connector role in different ecosystems and networks (Wedel, 2017).

As a special group, scientific elites, comprising researchers, academics, and thought leaders, have become increasingly significant in shaping public discourse, helping technological advancements, collaborating in innovative research, and influencing policy decisions. These elites mainly come from universities and academic places and can be masters, PhDs, postdoc students, graduates, or faculty members. They can bridge the gap between scientific concepts and society needs. Understanding the mechanisms through which these elites exert their influence is critical for society to maximize effectiveness.

In the Elite Quality Report for 2023, Iran is ranked 140 of 151 studied countries. In this report, Iran's place in the power and value creation matrix in the fourth quadrant is described as striving elites that show a bad situation and need to be considered. Since improving the place of elites in their power needs much attention from the political structure and is more complicated, value creation is considered the main subject. The place of Iran in the elite quality matrix shows that elites cannot create value on the whole, which may be one of the reasons for the miserable trend of brain drain. Therefore, the problem is defined as understanding the systems and mechanisms that can help the scientific elites in Iran to be more effective for their society. The entire system and its subsystems must be considered, along with the primary variables and their interactions, to identify the systems and mechanisms. In this study, the scientific elites were considered, the ones who originate from universities and academic centers, for example, postgraduate and PhD students, the graduated ones, and faculty members in all fields (except medical sciences).

This paper represents a novel approach to studying the effects of scientific elites on society through a systems-thinking perspective. To the best of the researcher's knowledge, no prior

work has utilized this approach to explore the dynamics and complexities of the scientific elites' influence on society. This research aims to uncover the interconnections and feedback loops that shape the interactions between different parameters of elites' effectiveness. This innovative perspective allows for a more comprehensive understanding of how scientific elites disseminate knowledge and engage with various societal factors, ultimately affecting public discourse and decision-making. The effects of these elites on the society and the processes are derived from elites and experts who work with elites in INEF[1] (Yazd branch) using causal maps. Then, the causal maps were turned into system dynamics models by a systems thinking approach, and finally, by a MICMAC[2] algorithm, the most influencing factors were identified.

The rest of the paper is organized as follows: The next section is about the problem statement and main assumptions, followed by a review of related research. Section 3 states the research methodology, and its process. Section 4 describes the steps of methodology including causal maps and loops, model validation, MICMAC algorithm and variable categories, and the results of each step. In the final section, the main results of the research are described, and some recommendations for future researchers are made.

2. Literature review

The term "elite" is rooted in Pareto's work on distributing wealth; however, today, it goes beyond its roots in classes and describes different actors in a society. As a definition, elites are "a distinct group within a society that enjoys a privileged position and exercises decisive control over the organization of society". It does not require that elites are wealthy or members of the ruling class, but it shows that they have a measurable impact on development outcomes (Casas and Cozzi, 2023). While national wealth is a determinant of growth, it can result from elites' actions; they can initiate and motivate institutional changes that drive development (Mistree, 2013). Therefore, an important question here is how elites use their influence for society's improvement.

Prior research has examined the role of elites in economic development. Amsden et al. (2012) used case studies from South Africa to China to analyze elites' engagement in economic development, employing economic modeling, theoretical analysis, social research, and program evaluation (Amsden et al., 2012).

[1] Iran National Elite Foundation
2 Matrice d'Impacts Croisés Multiplication Appliquée à un Classement

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In the field of sociology, studies have explored the origins, education, and formation of elites (Vergara, 2013), such as Korolczuk's (2023) examination of the influence of elites in shaping civil society organizations in Poland (Vergara, 2013). A study in China has investigated the social origins of scientific elites, defining members of the Chinese Academy of Sciences as the country's scientific elite (Korolczuk, 2023).

This paper focuses on a specific group of elites – the academic and scientific ones from universities and research centers, excluding medical scientists. As UNESCO defines, science is a significant collective endeavor that improves people's lives (Cao, 1999). Therefore, scientific elites can serve societies in various ways to enhance their quality of life.

One key impact of scientific elites on society is through educating students and young elites, which can occur in research teams and through research projects. Feldman et al. (2009) found that apprenticeship is an effective tool for research education based on their study of an interdisciplinary research project (Feldman et al., 2009). Another area of elites' influence is their participation in government decision-making, such as serving on advisory boards, committees, and panels (Feldman et al., 2009). However, a 2019 survey identified tensions between policy-makers and scientists, with the policy-making system primarily shaped by a techno-scientific perspective rather than a socio-technical one (Gianos, 1974). Boberg-Fazlig et al. (2023) explore the role of agricultural elites in transitioning Denmark from a post-Malthusian era to a modern economic growth regime. They played a significant role in introducing new agricultural methods, including centralized dairy production, eventually leading to the establishment of cooperative creameries throughout Denmark (Boberg-Fazlic et al., 2024).

At the time of this paper, INEF is responsible for recognizing, organizing, and supporting elites through various means, such as funding research and providing grants to researchers. However, this foundation's administrative and highly bureaucratic structure has led to inefficiencies in many of these processes (Smallman, 2020; Boberg-Fazlic et al., 2024). Another study conducted within INEF, which utilized soft systems and cognitive mapping approaches, developed a model for the factors affecting the life cycle of elites. This research identified three groups of factors influencing the life cycle of elites within INEF: (1) structural factors, including both facilitating and leading elements; (2) behavioral factors, encompassing personal characteristics and human values; and (3) contextual factors, consisting of cultural, ethical, and social elements (Yari et al., 2023).

In summary, it can be concluded that scientific elites impact their societies through different mechanisms, from teaching and growing students to making wealth through their own

companies, helping others to develop their businesses, or solving their problems. While the literature provides some insights into the impact of scientific elites, there is a lack of research examining the underlying mechanisms of these influences, especially from a systems-thinking perspective. This study aims to address this gap by using a system dynamics approach to model the factors affecting the effectiveness of scientific elites in society. In systems thinking and related tools, many previous works have been done on other subjects; for example, Ruhani et al. (2015), a System of Systems (SoS) approach designed some green public policies, Rostami et al. (2020) used interpretive structural modeling (ISM) and MICMAC analysis to study the induced demand of health service and its effects (Golshahi et al., 2022).

3. Research methodology

Elites and their influences and effectiveness in society are complex systems of different social sub-systems (Figure 2), with many variables that seem too complex to quantify. Therefore, this paper utilized a systems thinking approach to model this complex phenomenon. The research began with a literature review and semi-structured interviews with experts working with elites at the INEF, Yazd branch, during 2023. These interviews helped to extract the main indicators and variables influencing the effectiveness of elites (Table 1).

Using the Decision Explorer tool, the causal mapping technique was used to illustrate the links between these factors. The experts collaborated to visually represent the causal linkages between the identified variables as a causal map (Figure 3).

Next, the researchers used Causal Loop Diagrams (CLDs) to model the various subsystems and identify the main feedback loops within the system. It allowed them to understand the dynamic interactions between the elements and pinpoint the external variables that can impact these loops.

Finally, the study utilized the MICMAC technique and the associated software application to categorize the main variables affecting the system. This analysis helped to determine the most influential variables and assess the system's overall stability.

The step-by-step process of this research approach is summarized in Figure 1.

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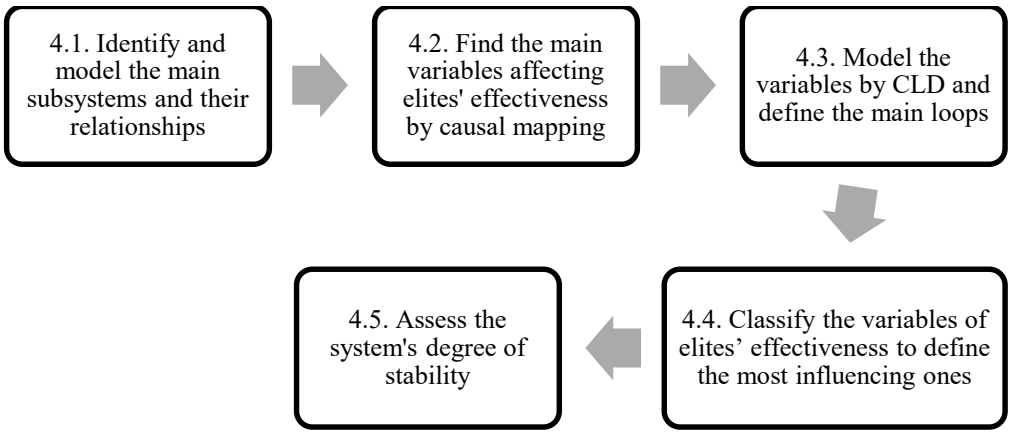

Figure 1. The research process

4. Results

In this part, the research methodology is explained step by step, and the results of each part are described.

4.1. Identify and model the main subsystems and their relationships

The goal of designing a system model for elites' effectiveness is to recognize the dynamic relations between different actors and variables contributing to the system to find the leverage points to maximize their effectiveness. Understanding the subsystems and their relationships is necessary before attempting this goal. These main subsystems and their relations are illustrated in Figure 2. In this model, the family system is the creator of the culture and personal behaviors of students in schools and higher education systems. The output of the school system is students for the higher education system and graduates for society. The higher education system also provides research services for society, besides the graduates that serve society.

Conversely, society also provides opportunities for students and faculty members in the higher education system to work and gain experience. Of course, the society itself includes the education and higher education system, but these two parts are separated for analysis. The higher education system provides teachers for the education system and schools. Some higher education graduates and faculty members can serve the scientific centers abroad. This relationship is two-way; it means that these centers provide graduates or faculty members with access to the internal higher education system. Research, including articles, books, and research reports, are sent from the higher education system to science centers, and credit and ratings from these centers are given to the higher education system.

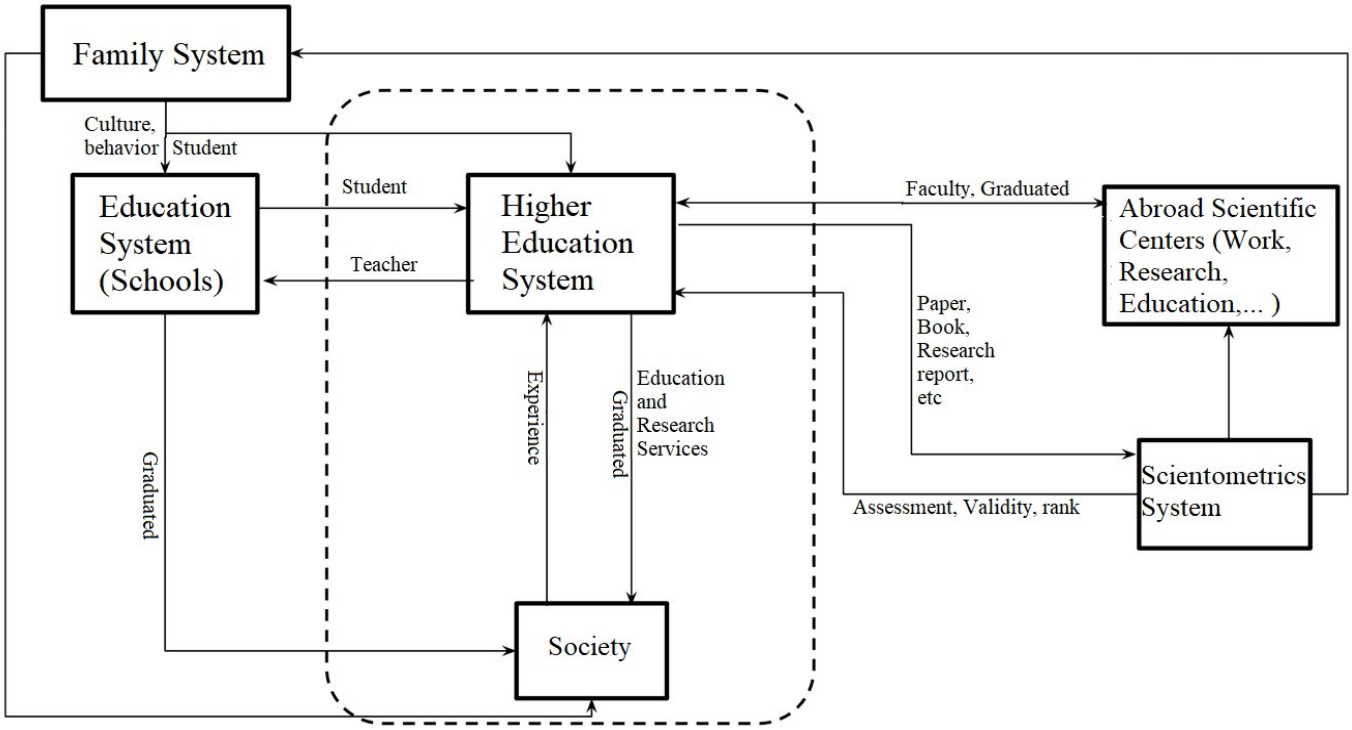

Figure 2. The relationship between the main sub-systems of the elite effectiveness system

4.2. Find the main variables affecting elites' effectiveness by causal mapping

A causal map is a network of links (arcs) between variables, for example, A and B that means someone believes A has an influence on B. Ackermann and Alexander (2016) exploring causal mapping, show its strengths, weaknesses, and opportunities to be used in systems thinking approaches and in complex projects (Teymourifar and Trindade, 2023). This paper extracted the mind maps during semi-structured interviews with elites and experts who worked with INEF in the Yazd branch during 2023. The variables were initially extracted from the literature review and the strategic plans of INEF and reformed into causal maps during interviews. The final achieved causal map is depicted in Figure 3, and the main variables are defined in Table 1.

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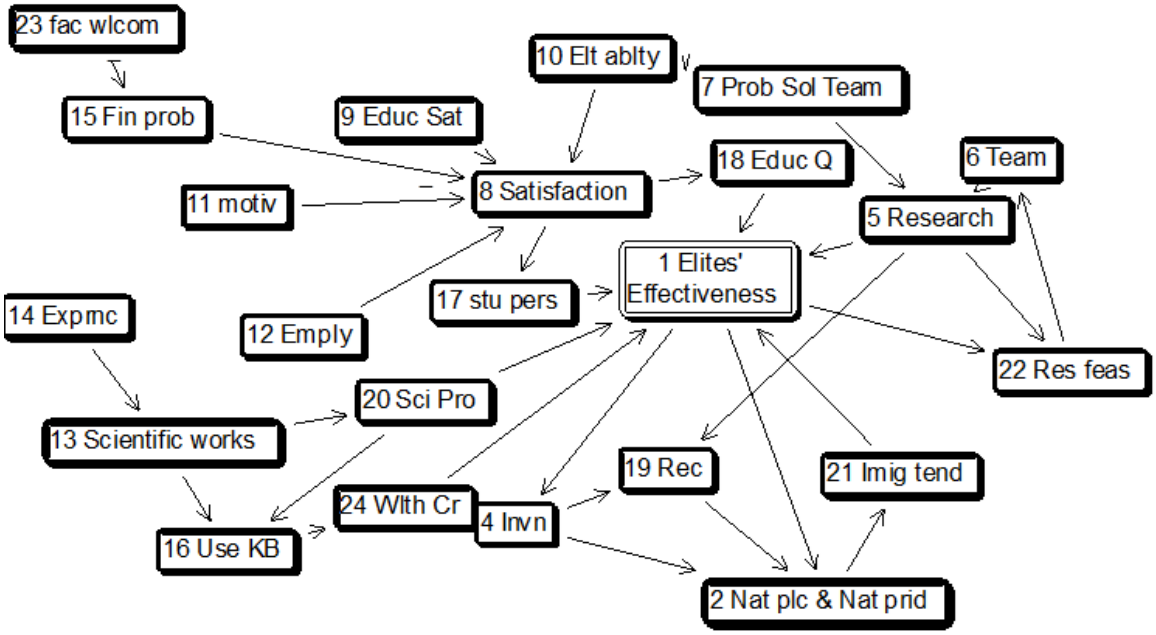

Figure 3. Final causal map for variables affecting elites' effectiveness

Table 1. Variables definition and their symbol in model

Variable description	**Symbol**
Accessing powerful teams for research	Team
Cooperation in problem solving teams of enterprises and government	Prob.Sol Team
Elite's satisfaction by the education system provided for him/her	Educ Sat
Elites' abilities for scientific works	Elt ablty
Elites' motivation to work	motiv
Employment of elites	Emply
Experience in scientific works	Exprnc
Financial problems that occur for elite	Fin prob
Inventions and innovations by elite	Invn
Knowledge that used in knowledge enterprises	Use KB
National pride (to be pride of their country and origin)	Nat prid
Persuade students and young elites for scientific work	stu pers
Quality of educations provided by elites for students	Educ Q
Recognition and knowing elite by elites' society	Rec
Researches (for government/ companies to solve their problems)	Rsch
Science production (books, research reports, papers, etc.)	Sci Pro
Tend to immigrate from the country	Imig tend
The feasibility of elite (time and facilities) to do researches	Res feas
The place of country in international rankings	Nat plc
Using INEF facilities (like subsidy)	fac wlcom
Wealth creation	Wlth Cr

4.3. Model the variables by causal loop diagrams

A causal loop diagram (CLD) is developed to show the interaction between components of subsystems and the main feedback loops of system behavior. In these diagrams, the relationship between variables A and B can be positive (+) or negative (-), which means a similar or inverse change in variables. The main variables of CLD are derived from the causal map in Figure 3. In order to be clearer, the subsystem loops are described separately in the following sections. These loops are developed during interviews with elites and experts in INEF to understand the direction and relationships between variables.

4.3.1. Research system and loops

Researching and finding responses to different questions are among the main responsibilities of an elite. Here, the main variables that affect research and their consequences are developed in a CLD (Figure 4). A group of reinforcing loops in the CLD links research to other variables and reinforces research behavior for elites. These loops, as shown in Figure 4, are named as:

Loop 1- Research quality: By doing more research, an elite gets more experience and, therefore, can do better research in the future.

Loop 2- Research team: With more research, more innovations and inventions will occur, which makes the elite more recognized. Therefore, he/she can access better teams, which will result in more research.

Loop 3- Innovation and invention: With more inventions and innovations, the percentage of them used in knowledge organizations will increase, creating more wealth. It will decrease the elite's financial problems, and therefore, she/he can do better research again to increase innovations and inventions.

Loop 4- Science creation: Research results in more science creation used in knowledge organizations, creating more wealth that will decrease financial problems again. Like the previous loop, it will increase research again.

Some of the external parameters impacting these loops are:

- Governmental support is needed to launch knowledge enterprises to use the science and knowledge produced by scientists in these companies.

- Improving the intellectual property laws that persuade innovations and inventions and strengthening the relationship between them and launching knowledge enterprises.

- The research rules in universities that affect the feasibility of doing research by elites who work there.

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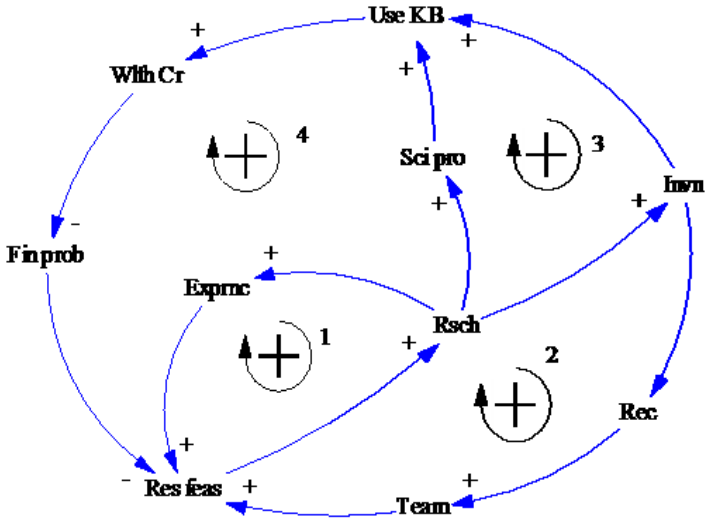

Figure 4. CLD for research

4.3.2. Education loops

Another way for elites to influence society is by educating young students and potential elites, the main circles shown in Figure 5. This graph shows that by educating young elites, they will be persuaded to do better scientific work that can finally improve the country's place in international rankings and national pride. With more national pride, the potential elites' motivation and encouragement for work increases again, and their desire to immigrate from the country decreases; therefore, they use more facilities provided by the INEF. Using more facilities decreases elites' financial problems and improves the quality of their education services, which will encourage young elites again. More elites' persuasion for scientific work will improve their abilities, which will help them find better employment and motivation for work. In this diagram, six reinforcement loops can be seen, and three of them are described here. In order to summarize, the authors used "+" to show the increase, "–" to show the decrease, and "→" to show the result.

Loop 1- Education provided by elites and the consequences for young elites: Education quality → +Students persuasion → +Elites' abilities → +Employment → + Elites' motivation for work → + Using National Elite Foundation facilities → -Financial problems → - Education quality.

Loop 2- Students persuading that empowers itself: Students persuasion → +Elites' abilities → +Students persuasion.

Loop 3- National Elite Foundations' facilities: Using National Elite Foundation facilities → -Financial problems → +Immigration tendency → - Using National Elite Foundation facilities.

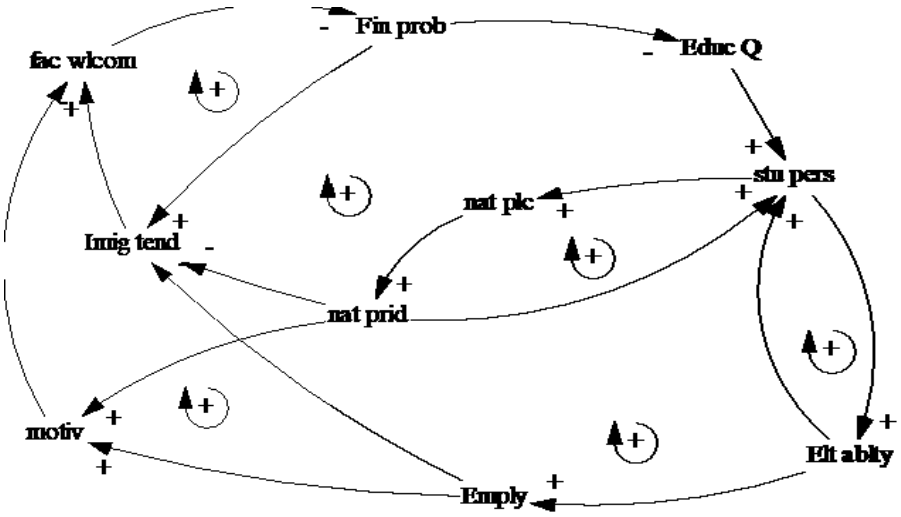

Figure 5. CLD for education provided by elites

Some of the external parameters impacting these loops are:

- Education, training, and empowerment of elites that improve their abilities, their motivation for work, and the quality of training they provide for students.

- Financial support for elites to reduce their financial problems and work with more peace of mind.

- Social satisfaction that affects all the factors, especially increases the elite's motivation to work and the quality of education they provide.

4.3.3. Problem solving loops

Involving elites in solving the problems of institutes (government or private), increases their effectiveness for society. Since the government has more power and influence on other parts of society, these institutes are more important here. The loops of problem-solving are depicted in Figure 6. As shown there, with more motivation from the elites for work, their participation in problem-solving teams will increase, which means more elites' employment, work experience, and better research activities. More research means more science production that can be used in knowledge enterprises, increasingtheir employment and motivation for work. Some of the main reinforcement loops of this model are:

Loop 1- Problem solving teams and employment: Cooperation in problem solving teams of enterprises → +Experience → +The feasibility to do researches → +Doing researches → +Inventions and innovations → +Use in knowledge enterprises → +Employment of elites → +Elites' motivation to work → +Cooperation in problem solving teams of enterprises.

Loop 2- Problem solving teams and motivation: Cooperation in problem solving teams of enterprises → +Employment of elites → +Elites' motivation to work → +Cooperation in problem solving teams of enterprises

Loop 3- Research and recognition: The feasibility to do researches → +Doing researches → +Inventions and innovations → +Recognition → +Access to powerful team for research → +The feasibility to do researches.

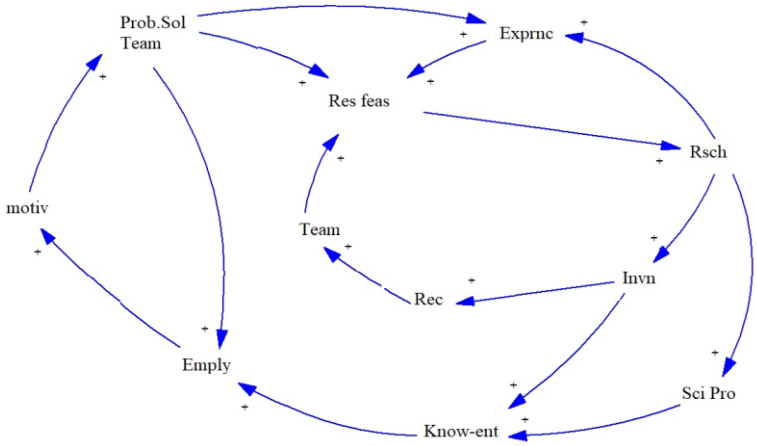

Figure 6. CLD for participating in problem solving teams

Some of the external parameters that impact these loops are:

- Special attention from governmental institutions to use elites in their problem-solving teams.

- Governmental support is needed to launch knowledge enterprises to use the science and knowledge produced by scientists in these companies.

- Elites' social satisfaction affects all the factors, especially the motivation of elites to work and their participation in problem-solving teams and projects.

4.3.4. Combining the loops and model validation

After defining the loops for different parts of elites' effectiveness, all these loops are combined, and the final model is formed. The current model was validated during a discussion with the INEF experts in the Yazd branch. Validating CLD is an iterative process in the project lifecycle (Teymourifar and Trindade, 2023). In this project, the model was also changed according to the feedback provided by the foundation until they approved it. In this process, some new potential relations have been drawn to perform the MICMAC analysis. The final model is shown in Figure 7.

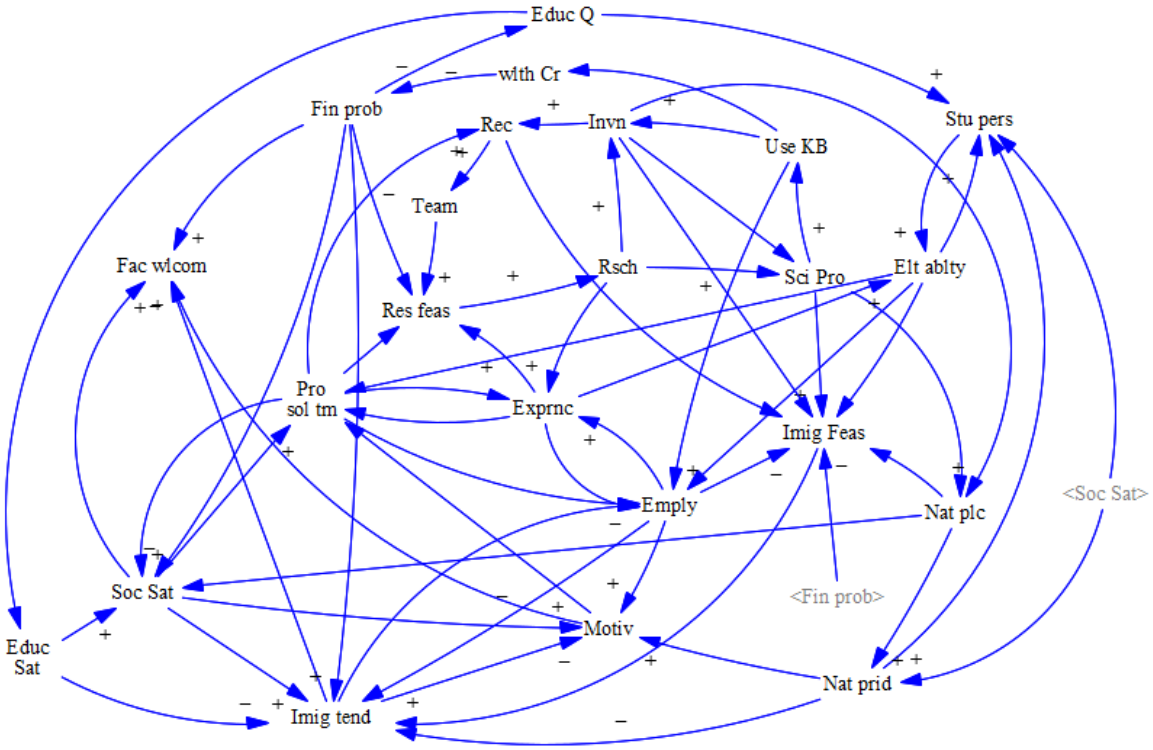

Figure 7. The CLD for elites' effectiveness

4.4. Assess the system's degree of stability and classifying the variables

In previous sections, several factors have been identified that can influence the scientific elites' effectiveness in society. In order to identify the most important and most influential factors, the MICMAC analysis is used (Rostami et al., 2020). Therefore, the model developed in the previous part is used as the input for analysis. The steps of this process are as follows:

4.4.1. Developing a direct relationship matrix

According to the system dynamics model, a direct relationship matrix was developed to collect the experts' opinions about the degree of influence between variables. Data was collected from a group of INEF specialists who had previously participated in identifying the variables to populate the matrix. This statement formed the question: "Can variable A influence directly on variable B?" In this scoring, 0 means no relationship, 1 means a low influence, 2 means a medium influence, 3 means a high influence, and P is a potential influence. Based on the answers gathered here, some of the relations in the causal model have been edited, and the final model has been formed, as shown in Figure 7.

4.4.2. Calculating the influence and dependency of each variable.

At this step, the influence and dependency of each variable are calculated by summing up the

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numbers in the rows and columns. In this research, the data were entered into a MICMAC application (designed and published by http://www.3ie.org/lipsor), and the influence and dependency were calculated and shown in Table 2. This table is sorted by total influence and shows social satisfaction, financial problems, the elite's abilities, invention, and innovation as the most influential ones. Also, the dependency column shows immigration feasibility, the tendency to immigrate from the country, the employment of elites, the elites' motivation to work, and the persuasion of young elites for scientific work as the most dependent variables.

Table 2. The variables' total influence and dependency

Variable	Total influence	Total dependency
Social satisfaction	14	7
Financial problems	13	4
Elites' abilities	10	5
Invention and innovation	10	3
National place in international rankings	8	4
National pride	8	6
Research	8	3
Knowledge used in knowledge enterprises	7	4
Experience	6	6
Quality of education provided by elites	6	2
Science production	6	4
Cooperation in problem solving teams	5	6
Employment of elites	5	11
Tend to immigrate from the country	5	12
Education system satisfaction	4	3
Elites' motivation to work	3	10
Persuade students and young elites for scientific work	3	10
Recognition by academies and Society	3	2
Research feasibility	3	5
Wealth creation	3	3
Immigration feasibility	2	18
Team accessibility	1	0
Using elite's facilities	1	6

4.4.3. Identification of key variables

A direct influence-dependency matrix was formed after calculating the influence and dependency, as shown in Figure 8. This matrix categorizes the factors studied into three main groups, as shown in Table 3, described in the conclusion.

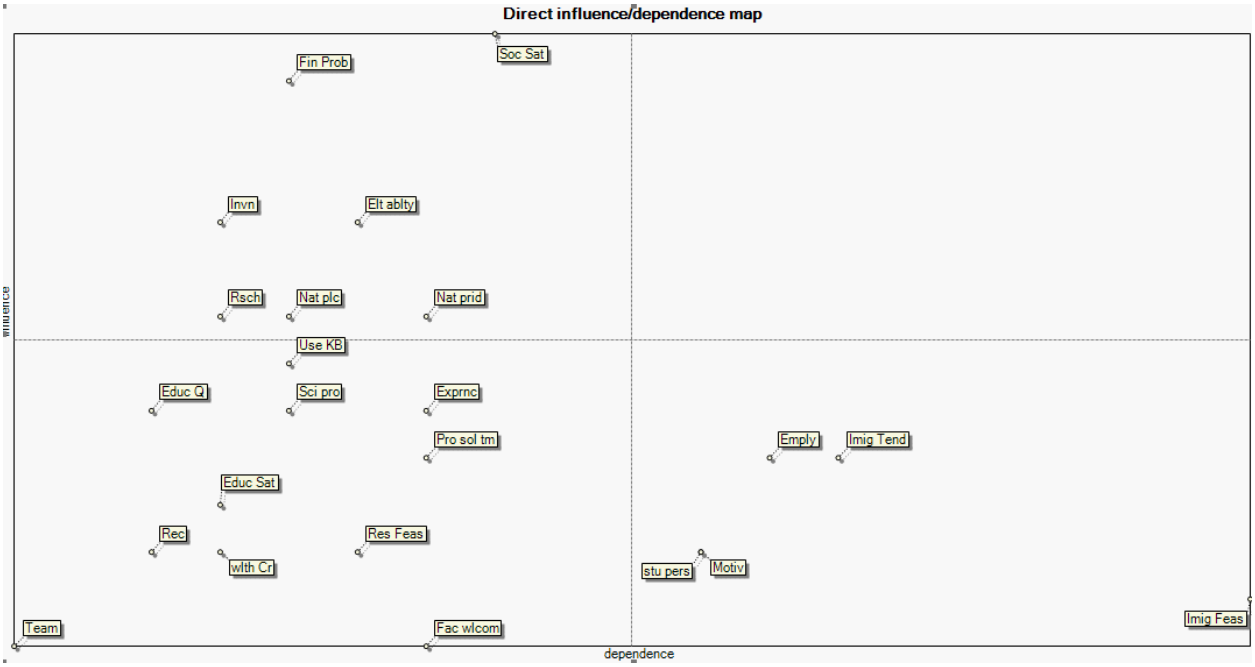

Figure 8. The influence – dependence matrix

Table 3. The three categories of studied variables by their influence and importance

Category name	Description	Variables
1- Determinant/ Influent	High influence and low dependence. The system depends on these crucial variables.	Social satisfaction, elites' financial problems, elites' abilities, invention and innovation, doing researches, national pride, and the place of country in international rankings
2- Depending / result	Low influence and high dependence. Especially sensitive to other variables.	Employment of elites, elites' motivation to work, persuade students and young elites for scientific work, tend to immigrate, and immigration feasibility
3- Autonomous / excluded: 3-1- Disconnected	Low influence and low dependence: near the axis's origin, whose evolution seems to be rather excluded from the system	Access to powerful team for research, wealth creation, research feasibility, using INEF facilities, cooperation in problem-solving teams of enterprises
3-2- Secondary acting	more influential than dependent. located quite above the diagonal.	Experience, quality of education provided by elites, education system satisfaction

4.5. Assessing the system's degree of determination

In order to assess the level of stability of the elites' system, the Figure 9 model was used. According to the matrix obtained in Figure 8 and the model of stability, since elites' system points spread along the axes and the matrix is L-shaped, it is determined (stable). It implies that the system's reaction to a pulse in variables can be predicted with a degree of assurance.

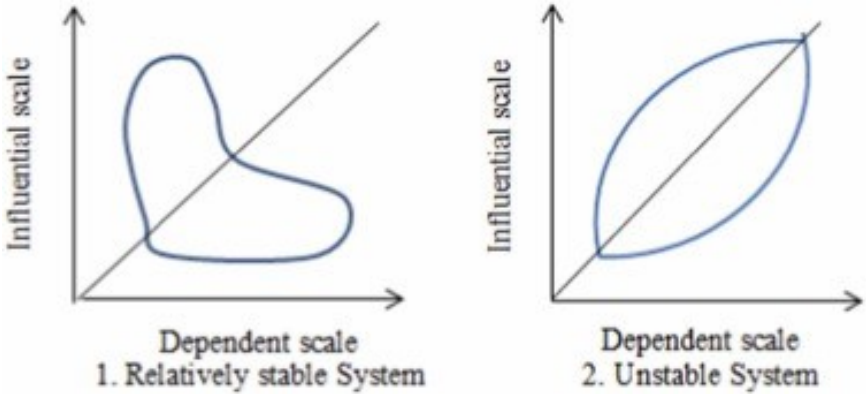

Figure 9. Shape of the system and its stability (Rostami et al., 2020).

5. Discussion and conclusion

The main problem of this paper was to find the variables that can influence the effectiveness of scientific elites in society. First, the main subsystems and the system boundary were defined to define the systems that affect this group of elites. In order to realize the dynamics of elites' subsystems, a systems thinking approach and system dynamics tool were used. Firstly, the causal map was used to determine the influencing variables and their effect. Then, system dynamics and Vensim software defined the main loops of elites' effectiveness in society and developed the model of variables. In the next step, the main influencing and dependent variables were defined by a MICMAC analysis and then categorized into three main groups. The total system is stable, as the matrix of variables finally shows. Since the system of elites' effectiveness is stable, its performance can be predicted with some certainty. Here the research shows "social satisfaction", "elites' financial problems", "elites' abilities", "invention and innovation", "doing research", "national pride", and "the place of the country in international rankings" as the crucial variables. It implies that an improvement in these variables can influence the scientific elites' effectiveness. These crucial variables, such as social satisfaction, national pride, and the place of country in international rankings, are more complicated and need much attention from social, economic, scientific, and political systems. The crucial variables INEF and universities can influence are elites' financial problems, abilities, and research. Universities can improve students' abilities for work and research and persuade them to do research. Also, financial programs like scholarships, grants, loans, work-study programs, food and meal plans, housing, and textbook assistance can be offered by universities and INEF to help elites with their financial problems.

The model categorizes "employment of elites", "their motivation for work", "their persuading of students and young elites", "tendency to immigrate", and "immigration feasibility", which

are mostly sensitive and not influential. It means that directly addressing or attempting to manipulate these variables may not yield the desired results, as they are likely the consequence of other variables and the whole system. By understanding and targeting the root causes, the model implies that the desired changes in these sensitive variables may be more effectively achieved.

Another group in the model is disconnected variables; the ones with low influence and low dependence located near the axis's origin and their evolution seem to be rather excluded from the system. These variables are “access to the powerful team for research”, “wealth creation”, “research feasibility”, “using INEF facilities”, and “cooperation in problem-solving teams of enterprises”. These variables appear to be largely excluded from the core dynamics of the system. Their evolution and behavior seem relatively isolated from the primary factors driving the model's outcomes. It suggests that these disconnected variables may not be actively shaping or being shaped by the overarching system dynamics. Consequently, any efforts to directly target or manipulate these disconnected variables may limit the overall system performance.

The final group of variables are named secondary acting ones, located quite above the diagonal, which means they are more influential than dependent. These variables are: “experience”, “quality of education provided by elites”, and “education system satisfaction”. These variables occupy a position of relative importance within the system, while they may not be as directly dependent on the other variables. These secondary acting variables could be key leverage points for driving change or desired outcomes within the system. By targeting and manipulating these variables, it may be possible to indirectly affect the behavior and evolution of the system's more sensitive or disconnected elements.

Based on the findings of this paper, there are some suggestions for policymakers who work with elites, especially INEF and universities, to improve the elites’ influence on society (their effectiveness):

- Focus on enhancing the “elites' abilities” by designing better course syllabus at universities for students (potential elites), providing rigorous training programs, mentorship opportunities, and access to cutting-edge research tools and facilities.
- Implement financial support programs for elites, such as scholarships, grants, loans, work-study opportunities, and assistance with housing and other living expenses, to address their “financial problems”.
- Encourage and facilitate “doing research” by elites through dedicated research funding, infrastructure, and collaborative initiatives with industry and international partners. Also, incentives such as academic recognition, professional growth, grant opportunities, rewards for best researchers, and tax reliefs can be considered for researchers.

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- Cultivate a strong sense of “national pride” among elites by highlighting their contributions to the country's scientific and technological advancements and fostering a patriotism and civic engagement culture.
- Actively work to improve the “place of the country in international rankings” by investing in research and development, promoting scientific excellence, and building global partnerships and collaborations.
- Monitor and address “education system satisfaction” by gathering feedback from students, faculty, and industry stakeholders and implementing data-driven improvements to the educational ecosystem.
- Leverage the “experience” of seasoned elites by creating mentorship programs, knowledge-sharing platforms, and opportunities for cross-generational collaboration with younger scholars and researchers.

The paper has been undertaken to structure the system influencing elites’ effectiveness in society. However, this work has answered some important questions and categorized the affecting variables; it highlighted several topics for further research:

One of the main findings of this paper is the high impact of social parameters on scientific elites’ effectiveness, which shows the importance of social studies in this subject. The most influential variable is social satisfaction; about 43% of the crucial variables are considered in this group. From the high influence variables in the subject, some suggestions for future research in social sciences are about designing different interventions to improve social satisfaction and national pride. Conducting in-depth studies on the underlying factors and drivers of social satisfaction and national pride among scientific elites could provide valuable insights for developing effective strategies. Also, studying the immigration tendency among scientific elites can help find solutions to decrease the brain drain and different social, economic, and cultural impacts of the problem. Examining the factors that influence the decision-making process of scientific elites when considering migration could inform policy interventions aimed at retaining top talent. Another research potential is developing scenarios for future interventions and simulating them to find the best strategy to improve elites’ effectiveness in society. Since the elites in medical sciences are not considered in the current paper, a more detailed study about this relatively large group of elites is suggested to future researchers. Expanding the scope of the analysis to include medical professionals could provide a more comprehensive understanding of the factors influencing the effectiveness of scientific elites across various disciplines. Since some variables in the model are categorized as disconnected, it may suggest that other unidentified variables or relationships are not being captured, which could be essential for a more comprehensive understanding of the system. Addressing these gaps could lead to a more robust and accurate representation of the complex

dynamics. Further research to identify and integrate these missing elements could enhance the model's explanatory power and lead to more impactful interventions.

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