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Antifragile Philosophy in R&D Projects: Applying Q Methodology and the Possibility of Open Innovation

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Abstract: Antifragile philosophy can be the key to improving the management of organizations that base their activity on research and development (R&D) projects. These are types of projects with the greatest uncertainty in all aspects, and the application of antifragile philosophy can result in streamlining their management and development. In this article, the Q methodology is used to investigate whether organizations in R&D environments have antifragile characteristics. To this end, 15 innovation experts from research institutes located in Northern Spain were interviewed about their position regarding project management behaviors that are related to antifragile philosophy. As a result, it was verified that the characteristics of an ideal system of a research institute with antifragile philosophy are multidisciplinary and autonomous teams with a capacity for rapid response and adaptation to the environment.

Keywords: antifragility; project management; knowledge management; diversity; open innovation

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1. Introduction

Project management skills are essential to any planned activity targeted to achieve a given goal. The degree of difficulty in project management depends on the size and complexity of the activities and their level of uncertainty. Research and technological development projects fit within the category of projects with the greatest uncertainty in terms of both their scope and the methodology for development [1].

Based on the work from Turner and Cochrane [1], the projects can be classified according to two parameters: how well the objectives are defined and how well the methods to obtain them are defined. The result is a 2 × 2 matrix where four types of projects can be carried out (Figure 1).

According to the Turner and Cochrane classification, research and technology development projects are of Type 4: They involve research and organizational changes (Figure 1). These types of project are common in university departments, in business R&D units and research institutes, which are aimed at obtaining new knowledge and applying it to solve scientific problems or questions. As new knowledge is a source of innovation and wealth, the investigations on the factor that improve the results of R&D project management are matter of interest for the research agents.

Among the different approaches to the study of innovation, the work from Chesbrough [2] described a new model: open innovation. The open innovation paradigm can be interpreted as the antithesis of the traditional model of vertical integration. Chesbrough described open innovation as "the use of internal and external flows of knowledge to accelerate internal innovation and expand markets for the use of such innovation". Interaction with the outside provides knowledge, skills, tools and ideas for project management. In this manner, the research teams from R&D agents are enhanced by incorporating capabilities

from third parties, including management skills, and the open innovation strategy helps to manage the most uncertain projects: research and technology development projects.

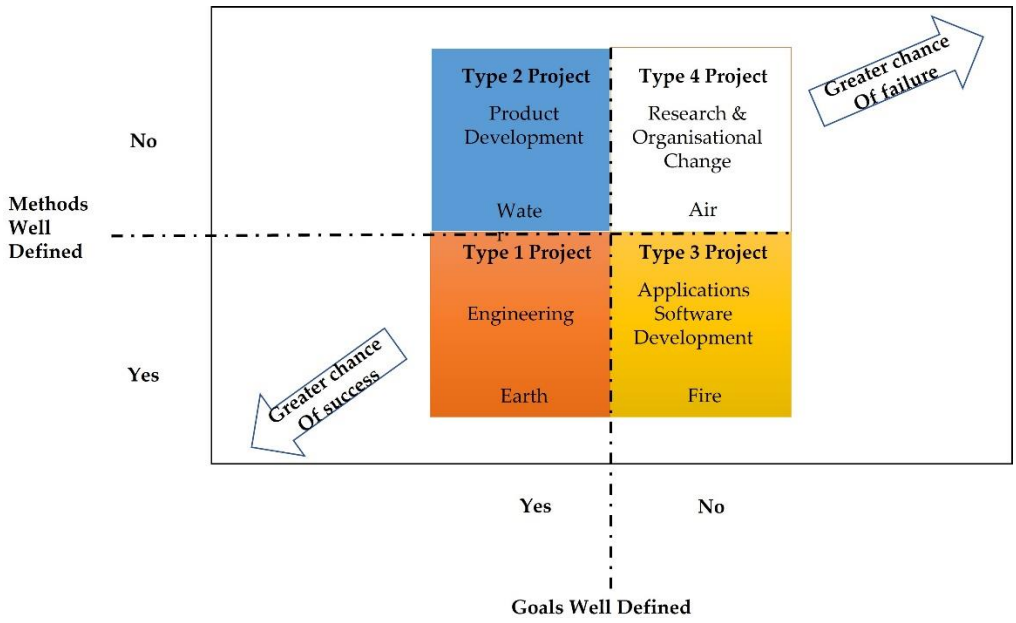

Figure 1. Goals and methods matrix for project classification.

The work from Ayestarán [3] formulates this idea clearly: Provided that the engine of any innovation system is the innovation team, "the key question is how to transform a group of experts into a team of innovation experts". This means that technical and scientific skills are not enough for achieving high performance in the R&D field, and project management and business-related skills are also required. An appealing strategy to develop project teams with this skill integrating profile, which benefits open innovation, is to follow the antifragile philosophy [4] outlined by Taleb.

The concept of antifragile was created by Nicholas Nasim Taleb in 2012 [4]. It is a neologism that Taleb uses to define the opposite to "fragile". Anything under stress will deteriorate and will decompose and/or collapse depending on the intensity of the stressor. Therefore, the opposite is what not only does not deteriorate, break down and/or collapse but also improves, on the contrary.

This definition is not, surprisingly, intuitive. The general tendency is to think that the opposite to fragile is something resistant, tough or perhaps robust. The detail is that robustness is associated with the capability of resisting stressful factors and remaining unaltered; no change is assumed, much less an improvement.

The antifragile philosophy applied to R&D projects should show the following characteristics described by Taleb and several other authors [4–11] (Figure 2):

- Optionality: Successful projects, especially in innovation, require investing in people and ideas and in a timely manner, switching between the different options created on purpose. The introduction of optionality in any project planning is related with risk management contingency actions/corrective measures and renders the surveillance of probable future events unnecessary, eliminating the errors of deterministic cause-effect models. Optionality must not be confused with flexibility. It is not so much a plan and the narrative that goes with it but the network of knowledge and experience that supports it. Among the refences cited above, this concept is presented in [4–6] and more specifically developed in [7] where the history of the complex adaptative systems is reviewed:
- Dispersion (Altera strategy): This is known as "1/N strategy". As a consequence of the uncertainty, the deployment of innovation and research must be approached through multiple experiments or trials. This multiplicity of attempts is related to the

"optionality" mentioned above, but "dispersion" refers to how the resources are shared among the designed options. Antifragile projects should divide the efforts between each option and its complement choice, balancing the higher risk options with the lower ones. This is implemented by distributing potential project investments in the total number of options and their complements N; hence, the name "1/N strategy" is conferred. This concept is grounded in [4,5] and enriched in [6] with non-deterministic methodologies.

- Cliquet (serial opportunities): This is an approach to activity planning by focusing in the short term, with flexibility for correcting the original plan depending on the most recent outcomes of the project. It allows plans taking advantage of the possible new options that are continuously presented during R&D activity. Rigid medium-term to long-term plans invariably present a scenario that, in the event of failure, does not offer opportunities for readjusting the plans in search of new options. In practice, applying "Cliquet" thinking consists of designing adaptable plans, with frequent exits. These plans should be for the short-term but are always aligned with the long-term objectives. This concept is extended in [9] when considering the sequence of learning in an innovative organization.
- Heuristic experimentation: Theories are born from experimentation and not vice versa. Innovation, as well as success in it, has its origin in experimentation. In the history of science and technology, there is more evidence of achievement by random experimentation than by a predetermined deterministic plan (except perhaps in sciences such as physics and mathematics). This property is closely related to the concept of serendipity [11] or unforeseen positives. Antifragile project management must be prone to take advantage of unexpected results even if their probability to happen is small.
- Heuropropiness of simplicity (less is more): Pragmatism is incompatible with complexity. The simplest solutions and technologies are often ignored in R&D despite the view that they can be the most proper choices. This property is related to the "Ockahm's razor" or "principle of parsimony", which is a problem solving principle originally formulated as "pluralitas non est ponenda sine necessitate" which means "complexity should not be assumed if it is not necessary". Learning from failure ("The negative way"): This characteristic is related to failure as a source of learning. Innovation and research based on "trial and error" are a major source of knowledge. Every trial that ends in error teaches, at least, what does not work. Successful failure, by promoting it, fosters collective learning [8] and is a reflection of good research practice. In addition, it allows attention to be paid to the alternative forms that serendipity can show.
- Interaction between all the properties: "bricolage" and spirit "Flâneur". The term "bricolage" refers to the fact that antifragile management must properly combine the characteristics above into a plan that accounts for all the applicable research lines, equilibrating resource distribution among them while allowing strategies to shift between options if necessary, which involves leaving room for randomness, choosing the simplest alternatives available and learning from failure. One property does not exclude the others, nor do they all necessarily exist. The "flâneur spirit" refers to being attentive to the opportunities that arise during project development and is the behavior that allows evaluation of the options that are detected or intuited and to take advantage of them. This interaction is related with learning from chaos [10] and the benefits of being open to the unexpected.

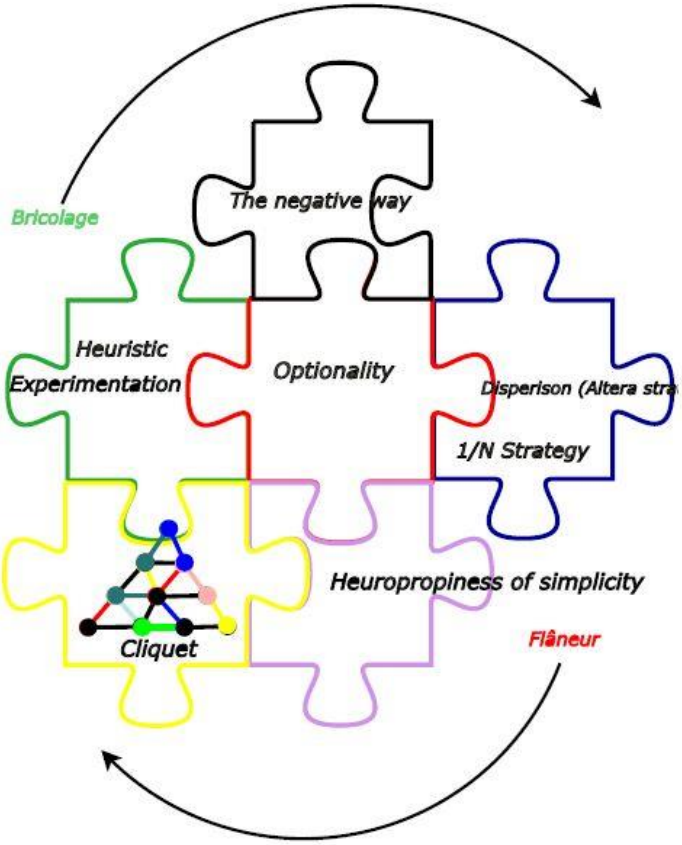

Figure 2. Main antifragile properties.

Based on the seven transversal characteristics of the antifragile philosophy, five representative behaviors have been defined for organizations with an antifragile philosophy:

- Free knowledge (FK): This behavior is mainly characterized by heuristic experimentation and flaneur spirit. Cliquet, failure as a source of learning, simplicity and dispersion are four characteristics also present in organizations that foster free knowledge, but their role is less relevant than the former two.
- Self-managed teams (SMT): This behavior is built on the philosophy characteristics of cliquet, failure as a source of learning, simplicity and the flaneur spirit. Optionality, dispersion and heuristic experimentation are also considered but with less intensity.
- Propensity towards innovation (PI): The main characteristics involved are dispersion, failure as a source of learning and optionality. Those that are second in importance include dispersion, cliquet, heuristics and simplicity.
- Multidisciplinarity (M): The singularities of this behavior are optionality and simplicity. The second level involves dispersion, cliquet, heuristic experimentation, failure as a source of learning and the flaneur spirit.
- Competence in project management (PM): Antifragile philosophy is developed on the basis of multiple projects for which specific management capabilities are required [12]. The main characteristics of this behavior are optionality, dispersion and cliquet. The secondary characteristics are heuristics, simplicity, failure as a source of learning and the flaneur spirit.

Figure 3 helps visualizing how these behaviors consolidate in antifragile organizations in comparison with their manifestation in fragile and robust organizations.

WHAT IS ANTIFRAGILE ?		
FRAGILE	**ROBUST**	**ANTIFRAGILE**
NO KNOWLEGDE MANAGEMENT	KNOWLEGDE MANAGEMENT	Free KNOWLEGDE
THE BOSS THINKS VERTIKAL HERARCHY	PROCESS MANAGEMENT	SELF-MANAGED TEAMS
SHORT TERM PLANNING BUREAUCRATIC OBESE ECONOMY	MEDIUM TERN PLANNING LEAN ECONOMY	PROPENSITY TOWARD INNOVATION
MYSOGYNE TARGETED DEVELOPMENT	NOT THINK/NOT WORRY	MULTIDISCIPLINARITY
TASK MANAGEMENT PASSIVE BEHAVIOUR	REACTS TO CERTAIN INPUTS, TECHNOLOGICAL SURVEILLANCE	COMPETENCES IN PROJECT MANAGEMENT

Figure 3. Comparison of behaviours in different organizations.

Based on the structure of antifragile behaviors presented above, the aim of this research is to find out to what extent Taleb's antifragile philosophy is being used to manage organizations that base their activity on research and technological development projects by taking a specific case study: the Basque Research and Development Ecosystem.

2. Experimental Method

The study has been carried out following an evaluation–planning procedure that can be explained by means of a "V Model" (Figure 4). The five characteristic behaviors related to antifragility described above, PI, M, SMT, FK and PM, have been used to generate a scenario for gathering the opinion of experts in the management of research institutes from the Basque Country. This region is considered a "Strong Innovator" in the 2021 Regional Innovation Scoreboard of the European Commission. Expert opinions, obtained in interviews, have been processed into quantitative results by using the Q methodology explained below.

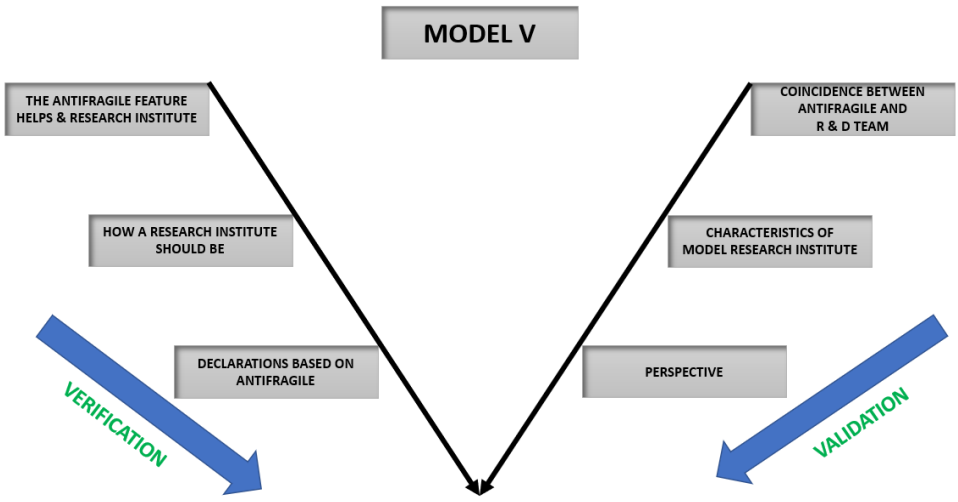

Figure 4. Evaluation and planning model V.

2.1. Q Methodology

Q methodology is an exploratory and semi-quantitative technique and provides a clear and structured method for obtaining the opinions of a certain group of people (called "operating subjectivities" in the Q literature). It is a methodology used to explore human perspectives. This method categorizes individual viewpoints into groups of value positions, belief systems or mental models [13]. Q methodology is used to discover the diversity of independent viewpoints.

Q methodology combines quantitative and qualitative data and analytical techniques. It is a constructionist technique that seeks to identify, from among the subjective opinions of a group of participants, shared visions or perspectives.

Q methodology has four main advantages over other social research methods used for the same purposes. First, it provides numerical results to support perspectives and, therefore, combines the benefits of quantitative and qualitative approaches. Second, it discovers how different but related issues are interconnected, requiring respondents to consider those issues simultaneously (traditional surveys deal with issues separately). Third, in order to synthesize the perspectives into a manageable set, Q focuses on the similarity of individuals (as opposed to similarities between questions and variables). Finally, it can mitigate certain response biases because respondents are required to explicitly engage with opinions they may consider inappropriate or unexpected.

On the other hand, the disadvantages of this methodology include the limitation of not being able to extrapolate results and that it presents less freedom of interpretation than qualitative analysis.

Q methodology can be combined with other methods, such as interviews [14] or surveys [15]. However, it is usually used as a standalone technique. Compared to question-and-answer surveys, Q produces more nuanced and sophisticated results [16].

A Q study is divided into four stages (Figure 5): research design, collection, analysis and interpretation of data [17]. How the stages have been performed in this study is described in the following sections. A more detailed description of the general methodology can be found in [18].

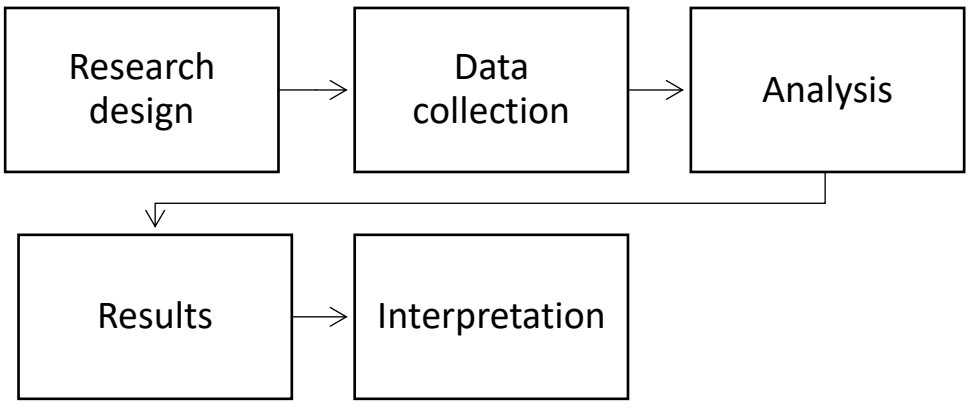

Figure 5. Research process of Q methodology [17].

2.2. Research Design

At this stage, the first step is to identify the scope of the study and thereby define the general question to be asked to respondents.

In this case, the question derived from the introduction is the following: what should an organization that engages in research and technological development be like?

The following is a complete list of topics (in the form of statements) that imply a subjective opinion on the research topic: antifragility as a philosophy in the management of research projects.

Forty-two statements were produced (Table 1), which were classified into the five behaviours identified in the application of the antifragile philosophy: 9 statements on PI,

7 on M, 8 on SMT, 7 on FK and 11 related to PM. The criteria to select the sentences has been based on diversity and homogeneous set size. Relevant literature was analyzed in detail with the goal of building sets with elements in between 9 ± 2 corresponding to each representative behavior. Any new element had to be distinct from the previous ones in each set and had to enrich the scope of opinions. The assessment of the validity of the question set was confirmed by experienced professors.

Table 1. The statements for the Q-sort.

Code	Statements	Source
PI	The best results in innovation come from experimentation and practice.	[4]
PI	In innovation, the concept "the bigger the better" is headed for failure.	[19]
PI	The first step towards innovation is to create ecosystems where all the necessary agents interact.	[20]
PI	Strategy concepts are open to all.	[3]
PI	The best results in innovation come from intuition and team improvisation.	[21]
PI	Randomness and uncertainty are essential components in today's problem solving.	[3]
PI	Less is more: practice is not very friendly relative to complicated solutions.	[22]
PI	The defined strategy is of intelligent specialization (interaction with the environment).	[3]
PI	The concepts of resilience and learning must evolve to adapt to current reality.	[23]
PM	The best results in innovation come from the work of self-managed teams.	[10]
PM	Strategic planning is mainly performed in the short term but with long-term objectives.	[3]
PM	Intuition is a knowledge management tool that allows you to compete in today's world.	[9]
PM	Creativity, communication and learning increase with positive affinity among team members.	[24]
PM	Obsession with the budget and dates kills ideas before they take off.	[4]
PM	There are internal communication plans in place that are agile in any direction.	[3]
PM	There is a unique quality manual, and it is within everyone's reach.	[25]
PM	Solving problems is making imperfect decisions and opting for good enough solutions.	[22]
PM	DIY: the use of the best combination of formal or non-formal tools to solve a problem.	[4]
PM	There is external collaboration (centres, companies, universities . . .) that allows the development of knowledge.	[3]
PM	There is a philosophy of patenting and later plans to exploit these patents.	[26]
M	The presence of women in self-managed teams is normalized.	[27]
M	Senior management teams have women in relevant positions.	[28]
M	Existence of conciliation plans improves team performance.	[29]
M	Paternity/maternity leave has a negative impact on the professional career.	[29]
M	The organization has equality plans.	[30]
M	The hirings carried out have the same conditions regardless of gender.	[31]
M	Best results are achieved by fostering diversity of culture, race and gender.	[3,32]
SMT	The self-managed team is free to create its own tools if necessary.	[3]
SMT	Team members must have the ability to adapt capabilities to the needs of the environment.	[10]
SMT	The self-managed team freely makes its own short-term plans.	[3]
SMT	The organization allows the team to react quickly and freely to opportunities.	[3]
SMT	Improvisation is considered a positive problem-solving skill.	[33]
SMT	Self-managed teams learn from their mistakes and are not penalized for them.	[23]
SMT	The team must be attentive to exploiting positive unexpected events: serendipity.	[11]

Table 1. *Cont.*

Code	Statements	Source
SMT	Redundancy of people = not dying of indigestion, which allows the team to concentrate.	[4]
FK	The challenge of the present is to engage with new things that we do not know exist and that we must learn to perform.	[34]
FK	Redundancy of knowledge is reflected in plans for renewal of skills.	[3]
FK	Creativity is fostering the unreasonable: observing cross-cutting opportunities where they arise.	[3]
FK	Failure is a source of knowledge and learning: successful failure.	[8]
FK	Talent is empowered and managed.	[3]
FK	The integration of knowledge between different disciplines and other actors requires generosity.	[35]
FK	There are formal "organisational" knowledge management tools supported by senior management.	[36]

The scope defines the profile of possible respondents, because it is necessary to choose people related to or with experience in the subject under investigation. In this project, senior personnel with experience in management of research projects in research institutes has been selected.

In contrast to other research methods, rather than a random selection of participants, individuals with various profiles have been selected to ensure that different possible views on the research question are included [37]. The Q methodology aims to reveal some main points of view that are favored by groups of participants. It is quite common in Q methodology to use a very strategic sampling approach in choosing good participants. This process of selection should be based on a coherent rationale and overall strategy. It is necessary to avoid an unduly homogeneous participant group. This means the researchers can legitimately select participants if they are likely to express a particular interesting or pivotal point of view [18].

Therefore, Q studies generally do not need a large sample of participants (unlike other methodologies). Brown (1980) [37] suggests that Q methodology only requires the following: "Enough participants to establish the existence of a factor for purposes of comparing one factor with another." What proportion of the population belongs in one factor rather than another is a wholly different matter and one about with Q technique is not concerned.

In this study, states with no more than 40 participants are needed to represent the point of view of a population.

In this project, 15 people have been selected to conduct in-person interviews following the Q methodology. Table 2 classifies them according to their field of work.

Table 2. The P-set.

Field of Work	Number of Respondents	Respondant #
Engineering	8	1,2,3,7,8,10,11,14
Project Managament	3	4,5,6
Lawyer	2	12,15
Communication Manager	1	9
Education Management	1	13

2.3. Data Collection

Data collection was carried out through individualized face-to-face interviews with the interviewer. Surveys begun with the following question: "What do you think a research organization should be like?" The interviewer explained the question, insisting that the answer should reflect the point of view of the interviewee based on his or her experience in managing R&D projects. The interviewee had to sort the 42 statements from the one

with which he or she most agrees to the one with which he or she most disagrees. For this purpose, a classification board (Figure 6) has been used as an aid.

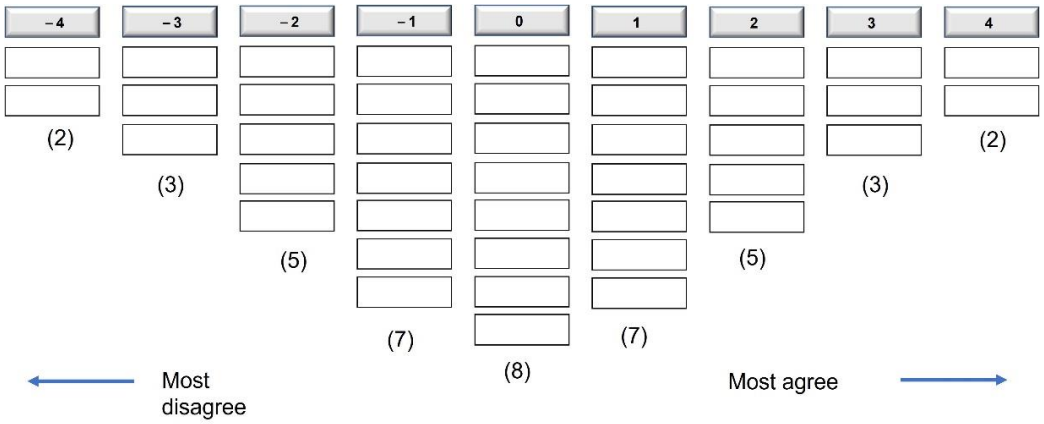

Figure 6. Bell-shaped distribution used for Q sorting.

This is a convenient and simple means of facilitating participant rankings. A square classification board has been defined, which accommodates the 42 statements produced with a fixed quasi-normal distribution (illustrated in Figure 6). The ranking values range from (−4) through (0) to (+4). The numbers in parentheses indicate the number of elements that must be assigned to a particular range so that a forced normal distribution is generated.

Finally, after the complete classification of the statements, two questions were asked in order to help in the final interpretation of the result. The questions asked were, on the one hand, the reasons for placing the two statements on the far left and, on the other hand, the reasons for placing the two statements on the far right. There are tools for conducting online surveys, but conducting face-to-face surveys provides the added value of being able to assist the interviewee in understanding the statements and jointly being able to collect additional information that enriches the quality of the data [37].

All collected Q-sorts were compared and grouped by similarity. Each group was then summarized as a single perspective (the entire analytical process is explained in [37]). These comparisons, grouping and summary are conducted by using multivariate data reduction techniques (such as principal component analysis, abbreviated as PCA). There are a number of dedicated software packages available for analyzing Q data (e.g., PQMethod and Q method for R).

As in the standard PCA, the data are reduced to a few factors (the perspective shared by each group). This reduction is performed in two main steps: extraction and rotation. The main analytical decisions in Q are as follows: the number of groups (i.e., the number of factors), the method for extracting the factors (PCA or centroid FA) and the method for rotating the factors [38].

In this project, the analysis of the surveys has been carried out by using the Q method for R. The analysis has been carried out with different numbers of factors 3, 4 and 5. For the selection of factors, two criteria have been used: on the one hand, the Kaiser–Guttman criterion that EV (eingenvalues) should be 1 or higher and, on the other hand, that an explained variance greater than 40% [18] can be considered a good solution.

Finally, varimax was chosen as the rotation method.

3. Results

The results are obtained from processing via Q methodology, and the answers from all experts are shown in Table 3.

Table 3. Q-method analysis in qmethod for R.

Original data	42 Statements, 15 Q-sorts					
Number of factors	5					
Rotation	Varimax					
Flagging	Automatic					
Correlating coefficient	Pearson					
General factor characteristics						
	av_rel_coef	nload	eigenvals	expl_var	reliability	se_fscores
factor F1	0.8	4	2.67	17.79	0.94	0.24
factor F2	0.8	3	2.67	17.77	0.92	0.28
factor F3	0.8	1	1.67	11.13	0.8	0.45
factor F4	0.8	2	1.63	10.88	0.89	0.33
factor F5	0.8	1	1.47	9.79	0.8	0.45
Total explained variance: 67.37						
Correlation between factor z-scores						
	factor F1	factor F2	factor F3	factor F4	factor F5	
factor F1	1	0.26	0.21	0.32	0.26	
factor F2	0.26	1	−0.21	0.37	0.15	
factor F3	0.21	−0.21	1	−0.04	−0.08	
factor F4	0.32	0.37	−0.04	1	0.09	
factor F5	0.26	0.15	−0.08	0.09	1	

The sentences that are distinctive for each factor have been obtained (see Table 4). The term "distinctive" means that these sentences are uniquely associated in a single factor and are not shared with any other.

Table 4. Distinctive declarations for each factor.

Factor	Numb. Statements	Category	Description
F1	3	M	The presence of the women in self-managed teams.
F2	6	PM	Strategic planning is mainly performed in the short term but with long-term objectives.
	14	SMT	The self-managed team freely makes its own short-term plans.
	20	SMT	Self-managed teams learn from their mistakes and are not penalized for them.
F3	2	PM	The best results in innovation come from the work of self-managed teams.
	11	SMT	Team members must have the ability to adapt capabilities to the needs of the environment.
	25	PM	There are internal communication plans in place that are agile in any direction.
	36	FK	Talent is empowered and managed.
	39	PM	There is external collaboration that allow the development of knowledge.
	42	FK	There are formal organisational knowledge management tools supported by senior management.
F4	19	PI	The best results in innovation come from intuition and team improvisation.
	29	M	Best results are achieved by fostering diversity of culture, race and gender.
F5	5	PI	In innovation, the concept "the bigger the better" is headed for failure.
	9	PM	Intuition is a knowledge and management tool that allows you to compete in today's world.
	16	SMT	The organization allows the team to react quickly and freely to opportunities.

These distinctive statements (see Appendix B) by factor are the ones that will help define the corresponding five perspectives, one corresponding to each factor. In order to perform this, a perspective matrix is built where each interviewee's degree of similarity with each perspective/factor is reflected (see Table 5). It must be kept in mind that the factors turn into perspectives through the interpretation of the quantitative results of the Q method results.

Table 5. Perspective matrix. Highest scores for each respondent have been shadowed in gray.

	Perspective 1	Perspective 2	Perspective 3	Perspective 4	Perspective 5	Field of Work
Respondent 1	−0.074	−0.17	0.524	0.518	0.333	Engineering
Respondent 2	0.208	−0.14	0.797	−0.041	−0.132	Engineering
Respondent 3	0.138	0.61	0.121	0.418	0.176	Engineering
Respondent 4	0.118	0.17	−0.212	0.808	−0.118	Project management
Respondent 5	0.615	−0.47	0.22	−0.032	−0.061	Project management
Respondent 6	0.371	0.19	0.187	0.561	0.161	Project management
Respondent 7	0.098	0.7	−0.203	0.057	−0.173	Engineering
Respondent 8	0.697	0.26	0.229	0.201	0.097	Engineering
Respondent 9	0.549	0.57	0.431	0.02	0.228	Communication Manager
Respondent 10	0.095	0.7	−0.097	0.037	0.08	Engineering
Respondent 11	0.207	0.6	−0.498	0.253	0.215	Engineering
Respondent 12	0.698	0.23	−0.055	−0.026	0.436	Lawyer
Respondent 13	0.48	0.4	0.185	0.106	0.294	Education Management
Respondent 14	0.698	0.11	−0.19	0.312	−0.096	Engineering
Respondent 15	0.131	0.05	−0.092	0.037	0.914	Lawyer

Of the interviewees, 33.33% presented perspective 1, 33.33% presented perspective 2, 13.33% presented perspective 3, 13.33% presented perspective 4 and 6.67% presented perspective 5.

4. Discussion

The analysis of the results reveals the different points of view or perspectives of the group under study. This categorization has been based on the analysis of the distinctive statements (see Appendix B) and of the statements with the highest and lowest scores (see Appendix A) for each of them.

4.1. Perspectives

Perspective 1: Integrator Profiles

This perspective is distinguished from the others by the identification of the following statement: "The presence of women in self-managed teams is normalized". The statements with the highest scores were as follows: "The first step towards innovation is to create ecosystems where all the necessary agents interact" and "The best results are obtained by promoting a diversity of culture, race and gender".

It can be observed that, among the top ten statements, there are statements for each of the antifragile behaviors.

This perspective understands research institutes as multidisciplinary teams. It shows a multidisciplinary profile, giving importance to the integration of different visions and agents.

Perspective 2: Reactive Profiles

This perspective has been distinguished by the following three sentences: "Strategic planning is carried out mainly in the short term but with long-term objectives", "The self-managed team freely carries out its own short-term plans" and "Self-managed teams learn from their mistakes and are not penalized for them". The statements with the highest scores were the following: "The members of the team must have the ability to adapt their capacities to the needs of the environment" and "There is external collaboration (centers, companies, universities . . .) that allows for the development of knowledge". Free knowledge does not appear among the top ten statements.

This perspective is characterized by teams that manage themselves. The approach favors team decisions on the go over scrupulous planning. It implies that research teams

must be empowered to make their own decisions. Furthermore, this form of decision making must be enriched by learning from the environment and collaborating with it. Paradoxically, the teams would not be favorable towards revealing the knowledge developed internally to the outside. The research projects would involve subcontracting tasks to external experts without being inclined to participate in cooperative research projects. This is the second perspective with more representatives within the group of 15 surveyed.

Perspective 3: Experimental Profiles

This perspective has been the one that has presented the highest number of distinctive statements: "There is external collaboration (centers, companies, universities ...) that allows the development of knowledge", "The members of the team must have the ability to adapt capabilities to the needs of the environment", "There are established plans for agile internal communication in any direction", "Talent is empowered and managed" and "There are formal "organizational" knowledge management tools supported by senior management". The following were among the statements with the highest scores: "The challenge of the present is to engage with new things that we do not know exist and that we must learn to perform" and "The best results are obtained by promoting diversity of culture, race and gender". It presents statements of all antifragile behaviors with an emphasis on Innovation Propensity (IP) and Project Management Competencies (PM).

This perspective is materialized in research teams exploring new knowledge and learning to create new products and services by combining members with different abilities, hence, its name as experimental profile. Research institutes with this profile must generate new ideas constantly, in a planned manner, being in contact with the environment and enjoying the tools made available to the team by the management.

Perspective 4: Flaneur Profiles

This perspective has been distinguished by two statements: "The best results in innovation come from intuition and team improvisation" and "The best results are achieved by enhancing diversity of culture, race and gender". The statements with the highest scores are the following: "Creativity is fostering the unreasonable: observing transversal opportunities where they arise" and "The integration of knowledge between different disciplines and other actors requires generosity". Among the highest scoring statements, no Project Management Competence (PM) behaviors are observed.

This perspective is characterized by a flaneur spirit, which is very open to be influenced by the outside. The research institutes of this profile do not focus on planning, but instead allow the teams to improvise. They leave a lot of freedom to them, and they interact with the outside in order to obtain ideas. They are inclined to participate in cooperative projects where they show a profile of followers of innovation.

Perspective 5: Serendipity Profiles

This perspective is distinguished from the others by three statements: "In innovation the concept 'the bigger the better' is headed for failure", "Intuition is a knowledge management tool that allows you to compete in today's times" and "The organization allows the team to react quickly and freely to opportunities". The statements with the highest scores were the following: "Randomness and uncertainty are essential components in problem solving today" and "Creativity is fostering the unreasonable: observing transversal opportunities where they arise". Among the ten declarations with the highest scores, all the characteristic behaviors of antifragility are presented, highlighting the propensity towards innovation.

This perspective is characterized by randomness and uncertainty, being attentive to identifying opportunities (Serendipity). Research institutes with this profile, or the teams that comprise this profile, are small but able to react to opportunities that they identify. As they do not give much importance to the internal existence of resources, they must be able to obtain technological resources abroad in order to take advantage of the opportunities. This is the perspective least represented among the fifteen people interviewed.

4.2. Applicability of Q Research Method to Open Innovation Research

Regarding the applicability of the Q Methodology to research in open innovation, its application in the present manuscript has allowed sorting a rich set of data into a comprehensive subset of related concepts. Despite this outcome not being able to be considered a fully quantitative approach, the method effectively turns subjective positions into an objective snapshot. Thus, it has shown itself to be a capable method for performing a semi-quantitative assessment of open innovation related abstract concepts. As the method can be repeated between regions and at different times, it would be feasible to implement it for interregional comparison and historical evolution monitoring purposes. Thus, the outcome of the Q Methodology can be used as a measure of the opinions of a given population of interest.

This links with the fact that measuring open innovation dynamics and culture is a common interest of the researchers in the field. Several approaches can be found, which can be complementary and show different focuses. Any method proposal must add some new value over the existing alternatives.

Among these approaches, studies employing surveys often using proxies are widespread in the literature [39–42]. For these cases, Q methodology is one further wrench in the toolbox that complements the use of other methods by adding flexibility in sample size and z-score based merit grouping. As for the potential uses, descriptive statistics found, for example, in surveys about open innovation culture [43] could benefit from the methodology, allowing a systematized clustering of answers.

Moreover, difficult to objectivize subjects, such as personality related studies [44], are susceptible to be handled with the generation of sets employing Q Methodology. In fact, the generation of perspectives presented in this investigation is one of the cases where personal views are the raw material for the research.

When big volumes of data are available and methods such as structural equation modelling and partial least squares methods can be used [45], Q Methodology can aid in clustering information and helping to confirm correlations.

When few data are available or the populations of interest are small, the scalability of the method is beneficial. For example, in company environmental strategy-related open innovation competitive advantage measurement, little individual data can be found on the subject [46].

Alternatively, Q-Methodology can also be integrated in the value chain of other methodologies. Some applicable cases would include generating the input set for system dynamics analysis such as the those performed in entrepreneurship assessment [46] or the complementation of strictly indicator-based works [47,48]. For the later type of research, the opinion of policy makers and R&D agents would allow visualizing not only what is strictly bound to indicators but also the feeling of the open innovation community. This is valuable, as indicators are not always capable of measuring all relevant factors.

5. Conclusions

The management of research and technological development projects requires the design and management of teams with high internal and external relation capacities. It is common for technological development functions to be carried out in teams integrated in research institutes. In this manner, research and production functions are separated. The aim of the research institutes is innovation: the successful application of new ideas. Innovation makes improving existing products and services or to create new ones possible. In this framework and for the specific case study of the Basque research institutes, the following can be concluded:

- Within this work, the applicability of antifragile philosophy to the management of research institutes has been analyzed. To this end, the five behaviors that group together the antifragile characteristics defined by Taleb have been defined. Experts in innovation management have been consulted on their vision of the ideal profile of a technology center management system, and ideal profiles were compared with

antifragile behaviors. The results indicate that antifragile philosophy shows similar behaviors to those that can be expected from research institutes in the Basque Country.

- From the analysis of the results, it is concluded that the idealization of research institute management systems must allow the existence of multidisciplinary and autonomous teams with the capacity to observe the opportunities that appear abroad. This possibility of knowing the outside will allow them to react in an agile manner, either in emulating the environment or taking advantage of ideas from other environments. The interviewed people gave less importance to sharing of their knowledge towards the outside and to the planning. It can be concluded that ideal systems share most of the characteristics of antifragile systems.
- This study has the limitation of having interviewed experts in innovation management exclusively from a single profile of an innovation region (strong innovator according to the 2021 European Regional Innovation Scoreboard); in this case, cultural differences between regions of the same category and of different categories cannot be assessed. Furthermore, research institute clientele and stakeholders (contractors, sponsoring companies, public institutions and so on) were not interviewed. It is very possible that these would show profiles more oriented towards the planning of activities.

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Appendix A

Table A1. Top-ranked statements per perspective.

Perspective 1	Perspective 2	Perspective 3	Perspective 4	Perspective 5
(12) The first step towards innovation is to create ecosystems where all the necessary agents interact (PI)	(11) Team members must have the ability to adapt capabilities to the needs of the environment (SMT)	(7) The challenge of the present is to engage with new things that we do not know exist and that we must learn to perform (FK)	(33) Creativity is fostering the unreasonable: observing cross-cutting opportunities where they arise (FK)	(23) Randomness and uncertainty are essential components in today's problem solving (PI)
(29) Best results are achieved by fostering diversity of culture, race and gender (M)	(39) There is external collaboration (centres, companies, universities . . .) that allows the development of knowledge (PM)	(29) Best results are achieved by fostering diversity of culture, race and gender (M)	(41) The integration of knowledge between different disciplines and other actors requires generosity (FK)	(33) Creativity is fostering the unreasonable: observing cross-cutting opportunities where they arise (FK)
(35) Failure is a source of knowledge and learning: successful failure (FK)	(20) Self-managed teams learn from their mistakes and are not penalized for them (SMT)	(2) The best results in innovation come from the work of self-managed teams (PM)	(8) The self-managed team is free to create its own tools if necessary (SMT)	(3) The presence of women in self-managed teams is normalized (M)

Table A1. *Cont.*

Perspective 1	Perspective 2	Perspective 3	Perspective 4	Perspective 5
(31) Solving problems is making imperfect decisions and opting for good enough solutions (PM)	(3) The presence of women in self-managed teams is normalized (M)	(30) The team must be attentive to exploiting positive unexpected events: serendipity (SMT)	(16) The organization allows the team to react quickly and freely to opportunities (SMT)	(5) In innovation, the concept "the bigger the better" is headed for failure (PI)
(39) There is external collaboration (centres, companies, universities . . .) that allows the development of knowledge (PM)	(12) The first step towards innovation is to create ecosystems where all the necessary agents interact (PI)	(35) Failure is a source of knowledge and learning: successful failure (FK)	(12) The first step towards innovation is to create ecosystems where all the necessary agents interact (PI)	(9) Intuition is a knowledge management tool that allows you to compete in today's world (PM)
(30) The team must be attentive to exploiting positive unexpected events: serendipity (SMT)	(27) The hirings carried out have the same conditions regardless of gender (M)	(1) The best results in innovation come from experimentation and practice (PI)	(7) The challenge of the present is to engage with new things that we do not know exist and that we must learn to perform (FK)	(11) Team members must have the ability to adapt capabilities to the needs of the environment (SMT)
(10) Existence of conciliation plans improves team performance (M)	(13) Creativity, communication and learning increase with positive affinity among team members (PM)	(4) Senior management teams have women in relevant positions (M)	(36) Talent is empowered and managed (FK)	(29) Best results are achieved by fostering diversity of culture, race and gender (M)
(11) Team members must have the ability to adapt capabilities to the needs of the environment (SMT)	(15) Strategy concepts are open to all (PM)	(6) Strategic planning is mainly performed in the short term but with long-term objectives (PM)	(11) Team members must have the ability to adapt capabilities to the needs of the environment (SMT)	(31) Solving problems is making imperfect decisions and opting for good enough solutions (PM)
(36) Talent is empowered and managed (FK)	(16) The organization allows the team to react quickly and freely to opportunities (SMT)	(16) The organization allows the team to react quickly and freely to opportunities (PM)	(27) The hirings carried out have the same conditions regardless of gender (M)	(32) The defined strategy is of intelligent specialization (interaction with the environment) (PI)
(7) The challenge of the present is to engage with new things that we do not know exist and that we must learn to perform (FK)	(10) Existence of conciliation plans improves team performance (M)	(22) The organization has equality plans (M)	(4) Senior management teams have women in relevant positions (M)	(36) Talent is empowered and managed (FK)

Table A2. Ten bottom-ranked statements in each perspective.

Perspective 1	Perspective 2	Perspective 3	Perspective 4	Perspective 5
(21) Paternity/maternity leave has a negative impact on the professional career (M)	(6) Strategic planning is mainly performed in the short term but with long-term objectives (PM)	(28) There is a unique quality manual, and it is within everyone's reach (PM)	(19) The best results in innovation come from intuition and team improvisation (PI)	(7) The challenge of the present is to engage with new things that we do not know exist and that we must learn to perform (FK)
(24) Redundancy of knowledge is reflected in plans for renewal of skills (FK)	(21) Paternity/maternity leave has a negative impact on the professional career (M)	(42) There are formal "organisational" knowledge management tools supported by senior management (FK)	(26) Less is more: practice is not very friendly to complicated solutions (PI)	(26) Less is more: practice is not very friendly to complicated solutions (PI)

Table A2. *Cont.*

Perspective 1	Perspective 2	Perspective 3	Perspective 4	Perspective 5
(9) Intuition is a knowledge management tool that allows you to compete in today's world (PM)	(37) Redundancy of people = not dying of indigestion allows the team to concentrate (SMT)	(25) There are internal communication plans in place that are agile in any direction (PM)	(24) Redundancy of knowledge is reflected in plans for renewal of skills (FK)	(15) Strategy concepts are open to all (PI)
(26) Less is more: practice is not very friendly to complicated solutions (PI)	(14) The self-managed team freely makes its own short-term plans (SMT)	(39) There is external collaboration (centres, companies, universities . . .) that allows the development of knowledge (PM)	(29) Best results are achieved by fostering diversity of culture, race and gender (M)	(17) Obsession with the budget and dates kills ideas before they take off (PM)
(15) Strategy concepts are open to all (PI)	(23) Randomness and uncertainty are essential components in today's problem solving (PI)	(41) The integration of knowledge between different disciplines and other actors requires generosity (FK)	(28) There is a unique quality manual, and it is within everyone's reach (PM)	(21) Paternity/maternity leave has a negative impact on the professional career (M)
(28) There is a unique quality manual and it is within everyone's reach (PM)	(5) In innovation, the concept "the bigger the better" is headed for failure (PI)	(11) Team members must have the ability to adapt capabilities to the needs of the environment (SMT)	(31) Solving problems is making imperfect decisions and opting for good enough solutions (PM)	(6) Strategic planning is mainly performed in the short term but with long-term objectives (PM)
(19) The best results in innovation come from intuition and team improvisation (PI)	(18) Improvisation is considered a positive problem-solving skill (SMT)	(17) Obsession with the budget and dates kills ideas before they take off (PM)	(6) Strategic planning is mainly performed in the short term but with long-term objectives (PM)	(16) The organization allows the team to react quickly and freely to opportunities (SMT)
(17) Obsession with the budget and dates kills ideas before they take off (PM)	(31) Solving problems is making imperfect decisions and opting for good enough solutions (PM)	(32) The defined strategy is of intelligent specialization (interaction with the environment) (PI)	(40) There is a philosophy of patenting and later plans to exploit these patents (PM)	(37) Redundancy of people = not dying of indigestion allows the team to concentrate (SMT)
(23) Randomness and uncertainty are essential components in today's problem solving (PI)	(32) The defined strategy is of intelligent specialization (interaction with the environment) (PI)	(33) Creativity is fostering the unreasonable: observing cross-cutting opportunities where they arise (FK)	(32) The defined strategy is of intelligent specialization (interaction with the environment) (PI)	(38) DIY: the use of the best combination of formal or non-formal tools to solve a problem (PM)
(20) Self-managed teams learn from their mistakes and are not penalized for them (SMT)	(40) There is a philosophy of patenting and later plans to exploit these patents (PM)	(36) Talent is empowered and managed (FK)	(38) DIY: the use of the best combination of formal or non-formal tools to solve a problem (PM)	(41) The integration of knowledge between different disciplines and other actors requires generosity (FK)

Appendix B

Table A3. Factor characteristics. Distinguishing and consensus statements.

	Distinguishing and Consensus Statements:					
	Dist.and.cons	f1_f2 sig_f1_f2	f1_f3 sig_f1_f3	f1_f4 sig_f1_f4	f1_f5 sig_f1_f5	f2_f3 sig_f2_f3
1	Consensus	0.2889	0.8432	0.133	0.355	0.554
2	Distinguishes f3 only	0.0018	1.5973 **	0.432	0.133	1.599 **

Table A3. *Cont.*

	Distinguishing and Consensus Statements:					
3	Distinguishes f1	1.9954 **	1.0375 *	1.114 **	2.014 **	0.958
4		0.4982	1.1596*	0.895 *	0.183	0.661
5	Distinguishes f5	0.7605 *	0.1398	0.348	1.813 **	0.621
6	Distinguishes f2	2.9357 **	0.2134	1.893 **	1.739 **	3.149 **
7	Distinguishes f2 Distinguishes f5	1.5322 **	1.0568 *	0.087	2.849 **	2.589 **
8		1.2817 **	0.8147	0.733	1.303 *	0.467
9	Distinguishes f5	1.2572 **	1.1398	0.769	3.093 **	0.117
10		0.4378	1.0965 *	0.385	1.096 *	0.659
11	Distinguishes f3	0.9218*	1.9406 **	0.128	0.012	2.862 **
12		0.5986	1.7465 **	0.493	1.258 *	1.148 *
13		0.5661	0.9352	0.029	0.935	1.501 **
14	Distinguishes f2 only	2.2100 **	0.0617	0.527	0.062	2.148 **
15		2.0524 **	1.1808 *	1.328 **	0.284	0.872
16	Distinguishes f5	0.5329	0.7436	1.315 **	1.289 *	0.211
17		0.4616	0.0299	1.194 **	0.518	0.491
18		0.5478	0.7222	0.478	0.254	1.270 *
19	Distinguishes f4 only	0.5651	0.9648	1.148 **	0.477	0.400
20	Distinguishes f2	2.4753 **	0.2757	1.352 **	0.276	2.200 **
21		0.2794	2.7657 **	2.107 **	0.813	2.486 **
22		0.5043	0.7935	0.059	0.183	1.298 *
23	Distinguishes f2 Distinguishes f5	0.7664 *	1.3199 **	0.561	2.785 **	2.086 **
24		2.0554 **	2.0441 **	0.644	2.044 **	0.011
25	Distinguishes f3 only	0.3805	1.3319 **	0.551	0.133	1.712 **
26		1.4379 **	1.1075 *	0.370	0.357	0.3380
27	Consensus	0.5776	0.0602	0.287	0.060	0.638
28		1.3850 **	0.9557	0.280	0.997 *	2.341 **
29	Distinguishes f4	0.9742 **	0.4891	2.864 **	0.487	1.463 **
30	Consensus	0.6450	0.2339	0.790	0.743	0.879
31		2.3134 **	1.9346 **	2.700 **	0.470	0.379
32		1.2512 **	1.5573 **	1.564 **	0.396	0.306
33		0.3783	0.3785	2.416 **	2.551 **	0.757
34		0.7375 *	0.1729	0.250	0.315	0.910
35		1.3605 **	0.0022	1.168 **	0.974	1.363 **
36	Distinguishes f3 only	0.3058	1.9244 **	0.035	0.029	1.619 **
37		1.2233 **	0.9539	0.489	0.511	2.177 **
38		0.2436	0.2324	0.750	0.744	0.011
39	Distinguishes f3	0.4668	2.8784 **	0.826 *	0.925	3.345 **
40		0.3713	0.2828	0.847 *	0.205	0.654
41	Distinguishes f2 Distinguishes f4	0.8439 *	0.9647	2.318 **	0.476	1.809 **
42	Distinguishes f3 only	0.3793	2.2363 **	0.430	0.772	1.857 **

Note: Sd. standard factor scores, Bt. bootstrap factor scores (shown only if different from the standard result). * $p < 0.01$, ** $p < 0.05$.

Table A4. Factor characteristics. Distinguishing and consensus statements.

	Distinguishing and Consensus Statements:					
	Dist.and.cons	f2_f4 sig_f2_f4	f2_f5 sig_f2_f5	f3_f4 sig_f3_f4	f3_f5 sig_f3_f5	f4_f5 sig_f4_f5
1	Consensus	0.422	0.066	0.9765	4.9×10^{-1}	0.4882
2	Distinguishes f3 only	0.431	0.134	2.0296 **	1.5×10^{0} *	0.5649 *
3	Distinguishes f1	0.881 *	0.019	0.0767	9.8×10^{-1}	0.8998
4		0.397	0.315	0.2645	9.8×10^{-1}	0.7119
5	Distinguishes f5	1.109 *	2.574 **	0.4882	2.0×10^{0} **	1.4647 **
6	Distinguishes f2	1.043 *	1.196 *	2.1062 **	2.0×10^{0} **	0.1533
7	Distinguishes f2 Distinguishes f5	1.619 **	1.317 *	0.9702	3.9×10^{0} **	2.9357 **
8		2.015 **	0.021	1.5476 **	4.9×10^{-1}	2.0359 **
9	Distinguishes f5	0.488	1.836 **	0.3707	2.0×10^{0} **	2.3237 **
10		0.053	0.659	0.7119	0.0×10^{0}	0.7119
11	Distinguishes f3	1.050 *	0.989	1.8122 **	2.0×10^{0} **	0.1408
12		0.106	0.660	1.2536 *	4.9×10^{-1}	0.7653
13		0.595	1.501 **	0.9061	5.6×10^{-17}	0.9061
14	Distinguishes f2 only	1.683 **	2.148 **	0.4650	5.6×10^{-17}	0.4650
15		0.725	2.336 **	0.1470	1.5×10^{0} *	1.6117 **
16	Distinguishes f5	0.782	1.742 **	0.5712	2.0×10^{0} **	2.5241 **
17		0.733	0.980	1.2240 *	4.9×10^{-1}	1.7123 **
18		0.070	0.293	1.2002 *	9.8×10^{-1}	0.2237
19	Distinguishes f4 only	1.713 **	0.089	2.1125 **	4.9×10^{-1}	1.6243 **
20	Distinguishes f2	1.123 **	2.200 **	1.0764	5.6×10^{-17}	1.0764
21		1.828 **	0.533	0.6586	2.0×10^{0} **	1.2944 *
22		0.445	0.321	0.8527	9.8×10^{-1}	0.1238
23	Distinguishes f2 Distinguishes f5	1.327 **	3.551 **	0.7591	1.5×10^{0} *	2.2238 **
24		1.412 **	0.011	1.4006 *	0.0×10^{0}	1.4006 *
25	Distinguishes f3 only	0.170	0.248	1.8826 **	1.5×10^{0} *	0.4179
26		1.808 **	1.795 **	1.4773 **	1.5×10^{0} *	0.0126
27	Consensus	0.290	0.638	0.3475	5.6×10^{-17}	0.3475
28		1.665 **	0.388	0.6761	2.0×10^{0} **	1.2768 *
29	Distinguishes f4	1.890 **	0.487	3.3535 **	9.8×10^{-1}	2.3771**
30	Consensus	0.145	0.098	1.0236	9.8×10^{-1}	0.0471
31		0.387	1.844 **	0.7653	1.5×10^{0} *	2.2300 **
32		0.312	1.647 **	0.0063	2.0×10^{0} **	1.9592 **
33		2.038 **	2.173 **	2.7949 **	2.9×10^{0} **	0.1345
34		0.987 *	0.422	0.0767	4.9×10^{-1}	0.5649
35		0.192	0.386	1.1706 *	9.8×10^{-1}	0.1942
36	Distinguishes f3 only	0.341	0.334	1.9592 **	2.0×10^{0} **	0.0063
37		1.712 **	0.712	0.4650	1.5×10^{0} *	0.9997
38		0.994 *	0.988	0.9827	9.8×10^{-1}	0.0063
39	Distinguishes f3	1.292 **	1.392 **	2.0528 **	2.0×10^{0} **	0.0999

Table A4. *Cont.*

Distinguishing and Consensus Statements:						
40		0.476	0.166	1.1298 *	4.9×10^{-1}	0.6415
41	Distinguishes f2 Distinguishes f4	1.475 **	1.320*	3.2832 **	4.9×10^{-1}	2.7949 **
42	Distinguishes f3 only	0.051 **	0.392	1.8059 **	1.5×10^{0} *	0.3412

Note: Sd. standard factor scores, Bt. bootstrap factor scores (shown only if different from the standard result). * $p < 0.01$, ** $p < 0.05$.

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