The nexus between research impact and sustainability assessment: From stakeholders' perspective

Abstract

A multi-criteria decision-making (MCDM) system based on stakeholder evaluation is performed to investigate the nexus between research impact and sustainability performance in the agro-food sector, in Spain. This study attempts to go a step further beyond the scientific assessment of research by examining its societal contribution. The empirical application is built upon ELECTRE III methodology. Combining Evaluation theory and Stakeholder theory, the analysis facilitates the assessment of research impact with the inclusion of stakeholders' knowledge. Four research programs are selected from different agro-food industries, representing the case studies addressed in this study. Each stakeholder performs an evaluation of the research programs based on indicators and sub-indicators of sustainability performance. The findings reveal ranking matrices of research impact and demonstrate its implicit contribution to the Sustainable Development Goals. This study provides insights to policy-makers and practitioners and sheds light on how research evaluation accentuates the transition to sustainable agro-food sector.

Keywords: *sustainability assessment; research impact; multi-criteria decision-making; research evaluation*

I. Introduction

Sustainability assessment is a complex paradigm, comprising a spectrum of analysis, factors, and uncertainties (Cinelli et *al.*, 2014). It consists of multi-dimensional impacts, involving network of stakeholders and set of criteria. During the last decades, an emergent concern is widely identified in the literature about measurement and evaluation of societal or sustainable impact of research (Dewaele et *al.*, 2021). The scientific community has proposed both conceptual and methodological frameworks to describe and comprehend sustainability principles (Cinelli et *al.*, 2014; Fiandrino et *al.*, 2022). We propose an evaluation tool consisting of comprehensive set of pillars and parameters to evaluate and monitor sustainability practices.

Previous studies have commonly applied expert-system analysis (Turner et *al*., 2022) in diverse ecological issues related to pollution, waste management, environmental damages, natural resources, and water quality (Gamboa, 2006; Pedras and Pereira, 2009; Saarikoski et *al.*, 2019). While the bulk of literature examines one or two dimensions of sustainability, i.e. economic, ecological, or social (Sala et *al.*, 2013), a gap remains in examining the performance of research development and innovation (R&I) in different industries. To the best of our knowledge, no prior study has yet been undertaking stakeholders´ perceptions of R&I impact on the Sustainable Development Goals (SDG) of the United Nation General Assembly 2015, in the Spanish agro-food sector. The main challenge facing researchers and policy-makers is to involve and encompass opinions of different stakeholders engaged in a specific research program (Braunschweig et *al*., 2001). Therefore, this study compares different case studies in this corresponding sector.

The purpose of this research is to provide policy-makers and researchers with a methodological tool to value the contribution of science to the economy and the society. As we are examining the nexus between impact and sustainability performances, we develop the scope of our analysis based on Evaluation theory (Scriven, 1980) and Stakeholder theory (Freeman, 1984). Bridging these two theoretical paradigms, this study investigates the role of research and its evaluation process toward the enhancement of sustainability performance. The empirical implementation relies on four case studies of R&I programmes (Table 1): *sustainable practices in rice cultivation* (Case 1); *innovative recirculation system for* *aquaculture* (Case 2); *genetic cross breeding methods in the almond industry* (Case 3); and *innovative technology in meat production* (Case 4).

Following MCDM techniques, the ranking model includes evaluation of global impacts (GI) i.e., indicators, and segregated impacts (SI) i.e., sub-indicators. We implement elimination and choice translating reality (ELECTRE) method (Appendix A). This procedure evaluates and highlights empirically the outcomes of each programme in relation to the SDG. The contribution of this work is to reveal how stakeholders perceive the relation between R&I and sustainability. Scientific impact can be complemented and communicated by other measures to reflect accountability, quality, and relevance (Glanzel and Chi, 2020). We aim to provide evidence on the "value" of science to the society and the ecosystem. Lastly, we consider that the novelty of our research is the inclusion of comprehensive and broader set of GI and SI. Furthermore, the inference of this study allows policy-makers and researchers to prioritizing, monitoring, and matching research funds, project planning and ranking of research outputs, to facilitate the impact evaluation.

MCDM is considered as an efficient evaluative tool "to identify priorities of SDG and to rank the desirability of adaptation options" (Qin et *al.*, 2008: 2165). This methodology enables a comparative evaluation between R&I outcomes at different levels. It is perceived as an appropriate approach due to its flexibility and ability to combine both qualitative and quantitative assessments (Chan et *al.*, 2012). Hajkowicz (2008) advocates that MCDM is a "process" rather than an "answer". It provides transparency, objectivity, and consistency among criteria choices. Due to the sensitivity of R&I impact, sustainability assessment entails an evaluative approach built upon stakeholders' backgrounds and skills (Marttunen and Hämäläinen, 1995). It facilitates the ranking and comparison of parameters and benchmarks of R&I. To mitigate the effect of biasness and avoid subjective judgement (Ramanathan, 2001), we triangulate the assessment from different experts' points of view.

The remainder of the article is structured as follow. Section 2 elaborates on the theoretical paradigm applied in this study. The methodology and research design are explained in Section 3. A brief background of the case studies and their impacts is presented in Section 4. Section 5 reveals the results of ELECTRE III analysis and robustness checks. Conclusions are drawn in Section 6.

II. Theoretical framework

Since 1980, there is a pivotal dialogue of theories about research-based and practice-based evaluations. As quoted by Glass and Ellett (1980, p. 211): "Evaluation-more than any science-is what people say it is". Scriven (1980) defines the process of evaluation as fundamental act of valuing. Glass and Ellet take into account "people" evaluation i.e., stakeholders' perspective. Scriven's process integrates four stages of evaluation: select criteria of importance, allocate standard or reference benchmark to compare the selected criteria, data collection to run the analysis of criteria performance vis-à-vis the standard benchmark, and finally, communicate the final judgement of criteria ranking.

We aim to contribute to the theoretical debate on evaluation of research and practice. As highlighted by Shadish (1998), he postulates that Evaluation theory is mainly driven by empirical analysis and by practice. Prior scholars accentuate the need to further investigate underexamined themes in the research evaluation doctrine, such as: valuing of knowledge, knowledge use, knowledge production, and nature of the evaluand (Shadish, 1998; Campbell, 1971). While, Patton (1988) concentrated on the instrumental use of evaluation, Weiss (1988) supported the conceptual use of knowledge. Shadish (1998, p. 14) declares that "*Without evaluation practice, there would be no evaluation theory. Evaluation practice, without evaluation theory, can never be recognized as an established field*". Accordingly, we integrate a methodological approach to shed light on the interaction between research-based evaluation (research impact) and practice-based evaluation (sustainability performance).

To emphasize on the sustainability aspect of this research, Meyer and Rowan (1977) argue that institutions are considered as "rationalized" bodies with acquired roles and responsibilities to achieve a specific set of goals. Based on the Stakeholder framework, institutions are perceived as being authoritative entities responsible for addressing both interests of shareholders and stakeholders (Freeman, 1984). Mio et *al.*, (2020, p.1) describe firms "as sustainable development agents".

The theoretical contribution remains on providing evidence on the interconnection between Evaluation theory and Stakeholder theory. Therefore, in this study, the theoretical framework relies on proposing an empirical approach; first to analyse the interlink between science and practice, and second by highlighting the synergy between the scientific value and the societal impact of research and innovation. From the Stakeholder paradigm, the analysis accommodates for multiple stakeholders' perceptions (i.e., various actors engaged in the research development processes), engendering the evaluation and ranking of the importance of both global and segregated sustainability impacts. The outcome of this study articulates the relevance and accountability of R&I. and tackles a dual benefit of both shareholders' and stakeholders' needs and interests (Freeman, 1984). In contrast to the Sociological theory of power suggested by Williams (2020), we instead follow a constructivist approach under the premises of the Evaluation theory (Shadish, 1998). On one hand, the theoretical contribution implicitly sheds light on the quantitative societal value of R&I, and on the other hand, it unfolds the hindered dialogue between scientific actors (researchers and project managers) and societal actors (policy-makers, corporate partners, and end-users) (Smit and Hessels, 2021).

III. Methodology and research design

MCDM approach comprises mainly three fundamental theories: utility function, outranking technique, and decision rule (Greco et *al.*, 2004; Slowinski et *al.*, 2012). Introduced by Keeney and Raiffa (1976), the utility theory is described as a "performance aggregation" tool to synthesize specific parameters for information. As for the outranking framework, also known as "preference aggregation" instrument, it is used to conduct comparative analysis between a range of alternatives (Roy, 1991). The last theoretical paradigm of MCDM is the decision rule, which originates a preference approach to decision classification and comparison (Greco et *al.*, 2001). MCDM methods have been implemented in several projects' evaluation and integrated in policy formulation, case studies, and adaptation programs. It takes into account a broad spectrum of evaluation from scholars, stakeholders, and regulators (Hajkowicz, 2008; Failing et *al.*, 2007) and inter- and intra-assessment of actors involved in decision-making or research development (Gasparatos et *al.*, 2012)

ELECTRE III: Ranking of research program

This research relies on ELECTRE III framework. Govindan and Jepsen (2016) demonstrate that ELECTRE III method is commonly used in disciplines, such as energy management, water management, waste management, natural resources, and environmental management. Carrico et *al.* (2012) reach to a conclusion that ELECTRE III is considered as a more convenient tool to decision makers, for both results and parameters interpretation. The weights in ELECTRE method are considered as "coefficients of importance" rather than "criteria of substitution rates" as in compensatory aggregation procedures, like in Analytical Hierarchy Process (AHP) technique (Wang and Triantaphyllou, 2014). Thus, low values for a given criterion cannot be offset by higher values of other criteria. It accommodates for heterogeneity of parameters and variances vis-à-vis different preferences (Qin et *al.*, 2008). One advantage of ELECTRE method is that trade-offs among multiple attributes are partially or non-compensatory (Garmendia et *al.*, 2010b). Based on the aforementioned evidences, we select ELECTRE III approach to assess and rank GI and SI of the case studies. The logic behind this technique is to evaluate whether criteria "*a* outranks criteria *b*" (Figueira et *al.*, 2005; Roy, 1996). Known as credibility matrix, two indices are generated: concordance and discordance measures. The outcome of these indices are used to display the ranking scale of the selected criteria (Cinelli et *al.*, 2014).

Research Design

In this analysis, alternatives are the four case studies (Case1 = a1; Case2 = a2; Case3 = a3; Case4 = a4) and criteria are the six impacts used as proxy of sustainability pillars (economic, socio-territorial, environmental, health, capacity building, and political). We refer to each sustainability pillar as GI "global impact". Each GI is measured by a set of segregated impacts SI. Two decision models are generated from stakeholders' evaluation: ranking of SI and ranking of GI. The outcome of ELECTRE III is the decision matrix, mapping the performance of each alternative i.e. case study, based on the set of identified criteria i.e., indicators and sub-indicators. The outputs can be classified in four contexts:

- Criteria a is *strictly preferred* to criteria b
- Criteria b is *strictly preferred* to criteria a
- Criteria a is *indifferent* to criteria b
- Criteria a is *incomparable* to criteria b

The main objectives of thresholds´ choice are, first to account for preference and indifference while comparing alternatives, and second to address the effect of degree of compensation between the set of criteria (Buchholz et *al.*, 2009).

- *i*: indicates the label of criteria.
- *gi(a)*: represents the individual importance evaluation of alternative *a* according to criteria *i*.
- *wi:* is the weight assigned by each evaluator to the criterion.
- *pi*: is the preference threshold, representing strong preference i.e., evaluator strongly and strictly evaluates alternative *a* as more important than *b*, if $gi(a)>gi(b)+p(gi(b))$.
- *qi*: is the indifference threshold, representing weak preference i.e., evaluator is indifferent between the two alternatives. Alternative *a* is weakly preferred than *b*, if $gi(a)>gi(b)+q(gi(b))$.
- *vi:* is the veto threshold where the outranking relation is blocked i.e., alternative *b* cannot outrank *a*, if *a* exceeds that of *b* by a value greater than veto, if $gi(b) \geq gi(a) + vi(gi(a))$.

The output of ELECTRE III reveals concordance matrix (index for the strength to support that alternative *a* is at least as important as *b*); discordance matrix (index for the strength to support against the latter hypothesis); credibility matrix (index of the strength of the hypothesis); and dominance matrix.

We rely on the method proposed by Liu and Zhang (2011) to derive three thresholds for decision modelling. Kokaraki et *al.* (2019) describe *q* as the largest deviation and *p* as the smallest deviation (i.e., sufficient evidence to conclude a complete preference). For the general analysis of the evaluation of GI and SI, we use the following thresholds figures:

q = 5% (maximum importance (10) – minimum importance (1)) = 0.5
$p = 3\,q$ = 15% (maximum importance – minimum importance) = 1.5
v = 3 (maximum importance – minimum importance) = 3

For the sensitivity analysis, two methods have been applied, assigning different values of thresholds *q*, *p*, and *v* (Buchanan and Vanderpooten, 2007; Khalili and Duecker, 2013). The first sensitivity check relies on the method suggested by Balali et *al.* (2014). Weight *w* assigned by stakeholders remain same as in the general analysis; whereas *q*, *p*, and *v* are derived as follow. In this scenario, *q* is defined as the difference between most desired preference (i.e. end of scale, 10) and acceptable preference (7.5). As for the preference threshold *p*, it is calculated as the difference between most desired preference (10) and strictly not beyond level (3). Finally, veto threshold *v* is the difference between most desired preference (10) and critical condition (1). To run the second robustness check, we follow Rogers and Bruen's recommendation (1998) and determine the benchmark of thresholds based on input and consultation of decision-makers and experts in the field. The three thresholds fulfil the rule of Rogers and Bruen (1998): vi (0.7) $\geq$ pi (0.5) $\geq$ qi (0.3).

Data Collection

The standardized index was distributed to the stakeholder network (Reale et *al.*, 2018; Reed et *al.*, 2018), which includes 120 participants. Each evaluator rates the performance of each case study. The importance score varies between 0 (not important) and 10 (very important). Besides evaluating GI and SI, participants had to assign an importance weight (relative weight, *w*) for each GI. Weights assigned by the stakeholder group might not capture explicitly their objective opinions. The proxy reflecting evaluation and importance represented quantitatively might engender some biasness. However, similar to Keeney and Raiffa (1976), this research identifies numerical criteria to case studies and their generated impacts. The following section provides a brief background of the selected case studies (Table 1).

IV. Case Studies Background

Case 1: Sustainable practices in the rice cultivation

Through "sustainable practices" research program, Case 1 is mainly focused on sustainable strategies in rice cultivation. The eco-friendly techniques consist of land and water management, controlled pesticides usage, and efficient application of fertilizers. The research output is development of an educational tool (i.e., theoretical and practical trainings and workshops) for knowledge production/transfer and promotion of awareness toward sustainability management. The practices acquired by the program's participants are described as: improve cost-effectiveness and optimization of resource allocation, increase profitability, minimize harmful impacts on the ecosystem, implement adequate irrigation systems, and control of chemicals´ dosages.

Case 2: Innovative recirculation system for aquaculture

As response to SDGs of the 2030 Agenda and in specific to SDG 14 (conservation and sustainable use of oceans, seas, and marine resources), Case 2 focuses on the aquaculture industry and concentrates on innovative mechanisms to build sustainable sector. It tackles different practices, such as: extensive monitoring of the marine ecosystem and aquatic production, food safety and water quality, valuation of seafood products, and microbiological parameters. The outcome of this R&I is digitalizing the aquaculture industry, through an automated recirculation systems. Following ethical production and environmental-friendly mechanisms, it minimizes the negative impact on the maritime biodiversity, maintains biological and safety milieu, and facilitates CO2 removal.

Case 3: Genetic cross breeding methods in the almond industry

Through the genetic breeding program, Case 3 identifies controlled crossing methods of almond’s cultivars. The objective of this R&I is to maximize productivity, maintain standard quality up to EU benchmarks, and sustain an economic growth within the industry. The main output of this project is related to the economic factor of sustainability. The products indicate an improvement of agricultural characteristics in comparison to other almond categories, such as: absence of double-kernel nuts, minimized worm and bird damage, and low aflatoxin contamination.

Case 4: Innovative technology in the meat production

Case 4 elaborates on an integrated drying system of meat and sausage products. It shows an example of how the meat industry has been shifting from traditional to sustainable production mechanisms. These strategies consist of an improvement of chemical substances (i.e., antioxidant, probiotics, and omega 3 fatty acids), hygiene and food safety regulations, and nutrients compositions. The outcome of Case 4 has an impact on time efficiency, energy conservation, and contamination control.

V. Results: analysis by impacts and by case studies

The response rate is 44.2% with the following sample distribution: 14 responses from program personnel (project director, partners, and consultants); 14 responses from end users; 13 responses from researchers; and 12 responses from intermediary actors and policy makers.

For the importance weights, Table 2 and Figure 1 reveal the different point of views of the stakeholder group. From these findings, we may conclude that despite the growing concern about environmental and social performances, economic and knowledge pillars remain as priority impacts from stakeholder perspective.

To perform the evaluation of R&I, we conduct firstly partial least squares discriminant analysis (PLS-DA) (Appendix B) (Brereton and Lloyd, 2014; Hair et *al.*, 1995). Four sub-indicators, with the highest coefficients, were selected to measure each GI. All the coefficients are higher than 0.7, except for "job creation" of the economic impact, which is 0.5.

Results of the general analysis: GI and SI impacts

Like any decision modelling and project ranking, the dual challenge is defined as "no single criterion" and "no single decision-maker" (Buchanan and Vanderpooten, 2007). In other words, to capture the impact generated, this may require a set of multiple criteria and consensus among the group of stakeholders. With the support of MCDM tool, our results reveal the perception of multiple stakeholder network, evaluating the importance of R&I on sustainability performance.

Segregated impacts SI: by sustainability performance

Table 3 displays summary of the credibility matrix of each GI based on the evaluation of SI. Alternatives which have a higher number of coefficients closer to zero, are ranked first. They indicate the strength of assertation to conclude that "*a* is at least as good as *b*" (Figueira et *al.*, 2012; Figueira et *al*., 2022). Figure 2 presents the average pre-order of the SI. We cluster the outcome of this analysis in three importance levels based on stakeholders' evaluation of SI of each case study: high, medium, and low.

Economic impact: has higher level of importance according to stakeholders of Case 3 and lower level of importance for stakeholders of Case 4. This evaluation might be contradictive to the figures displayed in Table 2. Actually, stakeholders assigned the second highest weighted importance score of economic pillar to Case 4.

S*ocio-territorial impact*: has high level of importance according to stakeholders of Case 1, medium level for stakeholders of Cases 3 and 2 (within this category, SI is higher in Case 3 in comparison to Case 2), and low level of importance for stakeholders of Case 4. In contrast to this results, Table 2 indicates that the highest weighted importance score of socio-territorial pillar is assigned by stakeholders of Case 3 and the lowest by stakeholders of Cases 1 and 4.

Environmental impact: has high level of importance according to stakeholders of Case 1, medium level for stakeholders of Cases 2 and 3 (within this category, SI is higher in Case 2, than in Case 3), and low level for stakeholders of Case 4. This raking is consistent with the weighted importance scores presented in Table 2.

Health impact: has high level of importance according to stakeholders of Case 1, medium level for stakeholders of Cases 2 and 4, and low level of importance for stakeholders of Case 3. Comparing these results with Table 2, we conclude slight difference, with the highest weighted importance score assigned to Case 2 and lowest to Case 3.

Capacity building: has higher level of importance according to stakeholders of Cases 1 and 2 and lower level for stakeholders of Cases 3 and 4. Within the high category, Case 1 outperforms Case 2, in terms of the SI of capacity building (Table 3). Whereas, Case 4 and Case 3 are equally ranked. Opposite to these results, Table 2 shows that stakeholders assigned the highest weighted importance score to Case 4.

Political impact: has high level of importance according to stakeholders of Case 1, medium level of Case 4, and low level of importance of Cases 2 and 3 (within the low category, SI is higher in Case 2 than in Case 3). Comparing these results with Table 2, the highest weighted importance score was assigned to Case 4.

Global impacts GI: by case studies

Applying the thresholds proposed by Liu and Zhang (2011), the second analysis consists of ranking case studies based on GI (Table 4). Figure 3 illustrates the ascending distillation (smallest qualification is retained initially), descending distillation (largest qualification is retained initially), and average (combined pre-order). Results reveal that Case 1 is ranked as the best alternative for the six GI. Case 2 reveals high sustainability performance for four GI i.e., economic, environmental, health, and capacity building. Case 3 indicates high ranking for two GI i.e., economic and socio-territorial. Lastly, Case 4 scores high for two GI i.e., political and health.

These finding reveal how R&I can have an implicit contribution to the implementation of SDGs. Each case reflects an input to different clusters of SDGs. For instance, Case 1 indicates an implicit support to SDGs: 1 (no poverty), 5 (gender equality), 8 (economic growth), 12 (responsible consumption and production), and 15 (life on land). Whereas Case 2, its indirect contribution might be translated as an integration of SDGs: 2 (no hunger), 8 (economic growth), 9 (industry and innovation), and 14 (life below water). Case 3 reveals an implication to SDGs: 8 (economic growth) and 15 (life on land). Case 4 tends to enhance the implementation of SDGs: 9 (industry and innovation) and 12 (sustainable consumption and production).

Sensitivity Analysis

The inclusion of 24 sub-indicators denotes some challenge, as requesting from stakeholders to provide several sets of thresholds. Therefore, further sensitivity tests have been conducted to validate the GI results. The purpose of this robustness check is to draw on the consistency of the evaluation and to mitigate thresholds' selection bias. ELECTRE III method overcomes explicitly the uncertainty criteria, by iterating thresholds' values in the decision-making modelling (Cinelli et *al.*, 2014; Figueira et *al.*, 2005). We follow the methods suggested by Balali et *al.* (2014), and Rogers and Brue (1998). Weight's values *w* remain the same as in the original analysis; whereas *q*, *p*, and *v* are modified. Table 5 and Figure 4 display the results of the first sensitivity test. Table 6 and Figure 5 reveal the findings of the second sensitivity analysis. To elaborate on the findings of the sensitivity analysis, Case 2 and Case 3 are incomparable, according to the set of criteria included in the ranking model. Incomparability is not interpreted as indifference in the decision-making, rather as lack of sufficient evidences or of stakeholders' participation, to support the findings (Roy, 1993). Therefore, we consider that ELECTRE III technique might not be the recommended tool for Case 2 and Case 3 to conduct the evaluation of sustainability performance.

VI. Conclusions

Practitioners, policy makers, and experts are becoming more concerned about the societal value of research and innovation. This article has attempted to bring together knowledge about the nexus between R&I and sustainability performance. Stakeholders evaluated sets of criteria and provided importance weights for sustainability pillars. We conclude that in the agro-food sector, there is a slight convergence, within the stakeholder groups, towards sustainability priorities. Although, there might be a divergence on the evaluation of "importance" of impact, we might shed light on the intertwining association between economic and capacity building impacts.

From the methodological aspect, the criteria weighting in general are subjective and could be a source of uncertainty in the decision-making process. It is worth noting that stakeholders are not familiar with the concepts of evaluation of societal research impacts against a set of criteria. Nevertheless, a detailed presentation of the evaluation method and objectives have been defined. Under the premises of the Evaluation theory, we cluster our theoretical contribution in two aspects: 1) heterogeneity of the evaluation criteria (Budtz et *al*., 2020) and 2) constructivist approach of research and evaluation mechanisms (Smit and Hessels, 2021). Our findings encompass the reliability and heterogeneity factors, first through the inclusion of a standardized set of indicators and sub-indicators for the evaluation of societal value, and second through the extension of the network of evaluators to curtailing the "boundaries" between research producers (internal actors) and research users (external actors). As for the constructivist approach, our analysis relies on impact-laden evaluation bridging research and practice, and drawing conclusions on the bidirectional relationship between science and society. While the linear model of evaluation frames research in isolation from society, our inference sheds light on the co-production integration of participatory mechanisms, in which both academic and non-academic assessments are taken into consideration.

It is important to recall that ELECTRE method, which outperforms other multi-criteria decision making techniques, relies on concordance-discordance principle and allows to tackling potential biases due to subjectivity issues. To overcome this methodological constraint, alternative criteria weighing methods could be used to account for uncertainty issues, through stochastic techniques or interval weight approach (Vahdani et *al.*, 2010;

Balali et *al.*, 2014). As noted by Cinelli et *al.* (2014), MCDM could be an adequate tool for sustainability assessment, taking into consideration multiple criteria in a flexible manner, by means of a structured framework. Inclusion of a comprehensive list of SI measuring six GI improves the ranking criteria and classification of case studies. Although the selection of thresholds and weights might indicate some degree of subjectivity or biasness, robustness checks and sensitivity analyses were performed. Ranking schemes remain consistent with different threshold values. Extending the present research to such framework could offer other direction for future research as means to improve data availability, ranking of alternatives, and distinguishing between preference and importance evaluation.

Building on Evaluation theory and Stakeholder theory, this study provides evidence on the interaction between two mechanisms: research-based evaluation (research impact) and practice-based evaluation (sustainability performance). For the theoretical implication, we summarize three inferences to issues raised by Evaluation theorists: 1) Campbell's (1971) vision on comparative theory of evaluation which, helped us in revealing opportunities and threats of research evaluation and in highlighting trade-offs of research goals; 2) Shadish's (1991) perspective on how the evaluation process has been improving to show the capacity of R&I in tackling societal needs; and 3) Shadish's (1998) recommendation on the empowerment of stakeholders to express their judgement and evaluation of R&I impact.

We acknowledge the fact that our research might reveal some limitations. For instance, the nature of the analysis is mostly empirical and qualitative. This might infer a weakness of validity criteria i.e., internal validity to demonstrate a cause-effect association. However, as argued by Shadish (1998), the empirical design tends to focus more on the applicability of validity criteria i.e., "the meaningfulness of observations". Another limitation could be related to the ELECTRE III method, which is the rank reversal. Therefore, to overcome this challenge, future work might consider the integration of "dynamic evaluation", which is mainly performed by expert choice of AHP. We would also encourage research to tackle R&I evaluation based on their nature, distinguishing between sustainability-oriented, innovation-oriented, and technology-oriented impacts.

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References

Balali, V., Zahraie, B., Roozbahani, A., 2014. Integration of ELECTRE III and PROMETHEE II decision-making methods with an interval approach: Application in selection of appropriate structural systems. J. Comput. Civ. Eng. 28, 297–314. https://doi.org/10.1061/(asce)cp.1943-5487.0000254

Braunschweig, T., Janssen, W., Rieder, P., 2001. Identifying criteria for public agricultural research decisions. Res. Policy 30, 725–734. https://doi:.org/10.1016/s0048-7333(00)00122-0

Brereton, R. G., Lloyd, G. R., 2014. Partial least squares discriminant analysis: taking the magic away. J. Chemom. 28, 213–225.

Buchanan, J., Vanderpooten, D., 2007. Ranking projects for an electricity utility using ELECTRE III. Int. Trans. Oper. Res. 14, 309–323. https://doi.org/10.1111/j.1475-3995.2007.00589.x

Buchholz, T., Rametsteiner, E., Volk, T.A., Luzadis, V.A., 2009. Multi criteria analysis for bioenergy systems assessments. Energy Policy 37, 484–495. https://doi.org/10.1016/j.enpol.2008.09.054

Budtz Pedersen, D., Grønvad, J. F., and Hvidtfeldt, R., 2020. Methods for Mapping the Impact of Social Sciences and Humanities—A Literature Review. Research Evaluation, 29, 4–21. https://doi.org/10.1093/reseval/rvz033

Campbell, D. T., 1971. Methods for the experimenting society. Paper presented to the Eastern Psychological Association, New York City, and to the American Psychological Association, Washington, DC.

Carrico N., Covas D.I.C., Almeida M.C., Leitao J.P., Alegre H., 2012. Prioritization of rehabilitation interventions for urban water assets using multiple criteria decision-aid methods. Water Science and Technology, 66, 1007-1014

Chams, N., Guesmi, B., & Gil, J. M. (2020). Beyond scientific contribution: Assessment of the societal impact of research and innovation to build a sustainable agri-food sector. Journal of environmental management, 264, 110455.

Chan, K., Satterfield, T., Goldstein, J., 2012. Rethinking ecosystem services to better address and navigate cultural values. Ecol. Econ. 74, 8–18. https://doi.org/10.1016/j.ecolecon.2011.11.011

Cinelli, M., Coles, S. R., Kirwan, K., 2014. Analysis of the potentials of multi criteria decision analysis methods to conduct sustainability assessment. Ecol. Indic. 46, 138–148. https://doi.org/10.1016/j.ecolind.2014.06.011

Dewaele, A., Vandael, K., Meysman, S., Buysse, A., 2021. Understanding collaborative interactions in relation to research impact in social sciences and humanities: A meta-ethnography. Research Evaluation, 30, 179–190. https://doi.org/10.1093/reseval/rvaa033

European Commission EC, 2004. The SAFENUT AGRI GEN RES action. Retrieved from https://ec.europa.eu/agriculture/sites/agriculture/files/genetic-resources/actions/f-068/final-fact-sheet_en.pdf.

Failing, L., Gregory, R., Harstone, M., 2007. Integrating science and local knowledge in environmental risk management: a decision-focused approach. Ecol. Econ. 64, 47–60. https://doi.org/10.1016/j.ecolecon.2007.03.010

Fiandrino, S., Scarpa, F. Torelli, R., 2022. Fostering Social Impact Through Corporate Implementation of the SDGs: Transformative Mechanisms Towards Interconnectedness and Inclusiveness. J. Bus. Ethics, 1–37. https://doi.org/10.1007/s10551-022-05189-9

Figueira, J. R., Greco, S., Roy, B., 2022. Electre-Score: A first outranking based method for scoring actions. European Journal of Operational Research, 297, 986-1005. https://doi.org/10.1016/j.ejor.2021.05.017

Figueira, J., Greco, S., Roy, B., Słowiński, R., 2012. An overview of ELECTRE methods and their recent extensions. J. Multi-Criteria Decis. Anal. 20, 61–85. https://doi.org/10.1002/mcda.1482

Figueira, J., Salvatore, G., Ehrgott, M. (Eds.) 2005. Multiple Criteria Decision Analysis: State of the art surveys. Springer, New York. pp. 1–1045.

Freeman, R., 1984. Strategic Management: A Stakeholder's approach. Pitman. Boston, MA

Gamboa, G., 2006. Social multi-criteria evaluation of the different development scenarios of the Aysén region, Chile. Ecol. Econ. 59, 157–170. https://doi.org/10.1016/j.ecolecon.2005.10.014

Garmendia, E., Prellezo, R., Murillas, A., Escapa, M., Gallastegui, M., 2010b. Weak and strong sustainability assessment in fisheries. Ecol. Econ. 70, 96–106. https://doi.org/10.1016/j.ecolecon.2010.08.001

Gasparatos, A., Scolobig, A., 2012. Choosing the most appropriate sustainability assessment tool. Ecol. Econ., 80, 1–7. https://doi.org/10.1016/j.ecolecon.2012.05.005

Glanzel, W., Chi, P., 2020. The Big Challenge of Scientometrics 2.0: Exploring the Broader Impact of Scientific Research in Public Health. Scientometrics, 125, 1011–31.

Glass, G. V., Ellett, F. S., 1980. Evaluation research. Annual Review of Psychology, 31, 21 l-228.

Greco, S., Matarazzo, B., Słowinski, R., 2004. Axiomatic characterization of a general utility function and its particular cases in terms of conjoint measurement and rough-set decision rules. European Journal of Operational Research, 158, 271-292. https://doi.org/10.1016/j.ejor.2003.06.004

Greco, S., Matarazzo, B., & Slowinski, R., 2001. Rough sets theory for multicriteria decision analysis. European journal of operational research, 129(1), 1-47. https://doi.org/10.1016/S0377-2217(00)00167-3

Govindan, K., Jepsen, M. B., 2016. ELECTRE: A comprehensive literature review on methodologies and applications. European Journal of Operational Research, 250, 1-29. https://doi.org/10.1016/j.ejor.2015.07.019

Hair, J. F., Anderson, R. E., Tatham, R. L., Black, W. C., 1995. Multivariate Data Analysis with Readings Fourth Edition. New Jersey: Prentice Hall.

Hajkowicz, S. A., 2008. Supporting multi-stakeholder environmental decisions. J. Envir. Manage. 88, 607–614. https://doi.org/10.1016/j.jenvman.2007.03.020

Keeney, R.L., and Raiffa, H., 1976, Decisions with Multiple Objectives: Preferences and Value Tradeoffs, Wiley, New York.

Khalili, N. R., Duecker, S., 2013. Application of multi-criteria decision analysis in design of sustainable environmental management system framework. J. Clean. Prod. 47, 188–198. https://doi.org/10.1016/j.jclepro.2012.10.044

Kokaraki, N., Hopfe, C. J., Robinson, E., Nikolaidou, E., 2019. Testing the reliability of deterministic multi-criteria decision-making methods using building performance simulation. Renewable Sustainable Energy Rev. 112, 991–1007. https://doi.org/10.1016/j.rser.2019.06.018

Liu, P., Zhang, X., 2011. Research on the supplier selection of a supply chain based on entropy weight and improved ELECTRE-III method. Int. J. Prod. Res. 49, 637–46. https://doi.org/10.1080/00207540903490171.

Markard, J., Raven, R., Truffer, B., 2012. Sustainability transitions: an emerging field of research and its prospects. Res. Policy, 41, 955–967. https://doi.org/10.1016/j.respol.2012.02.013

Marttunen, M., Hämäläinen, R. P., 1995. Decision analysis interviews in environmental impact assessment. Eur. J. Oper. Res. 87, 551–563. https://doi.org/10.1016/0377-2217(95)00229-4

Meyer, J., Rowan, B., 1977. Institutionalized organizations: Formal structure as myth and ceremony. Am. J. Soc. 83, 340–63.

Mio, C., Panfilo, S., Blundo, B., 2020. Sustainable development goals and the strategic role of business: A systematic literature review. Business Strategy and the Environment, 29, 3220–3245. https://doi.org/10.1002/bse.2568

Munda, G., 2005. Multi criteria decision analysis and sustainable development, pp. 953-986 in J. Fiigueir, S. Greco, and M. Ehrgott, editors. Multiple Criteria Decision Analysis: State of the Art

Surveys. Springer, New York. http://publications.jrc.ec.europa.eu/repository/handle/111111111/13077
Patton, M. Q. 1988. The evaluator's responsibility for utilization. Evaluation Practice, 9,5-24.
Pedras C.M.G., Pereira L.S., 2009. Multicriteria analysis for design of microirrigation systems. Application and sensitivity analysis. Agric. Water Manag. 96, 702–710
Qin, X., Huang, G., Chakma, A., Nie, X., Lin, Q., 2008. A MCDM-based expert system for climate-change impact assessment and adaptation planning – A case study for the Georgia Basin. Canada. Expert Syst. Appl. 34, 2164–2179. https://doi.org/10.1016/j.eswa.2007.02.024
Ramanathan, R., 2001. A note on the use of the analytic hierarchy process for environmental impact assessment. J. Environ. Manage. 63, 27–35. https://doi.org/10.1006/jema.2001.0455
Reale, E., Avramov, D., Canhial, K., Donovan, C., Flecha, R., Holm, P., ... & Van Horik, R., 2018. A Review of Literature on Evaluating the Scientific, Social and Political Impact of Social Sciences and Humanities Research. Research Evaluation. 27, 298–308. https://doi.org/10.1093/reseval/rvx025
Reed, M., Bryce, R., and Machen, R., 2018. Pathways to Policy Impact: A New Approach for Planning and Evidencing Research Impact. Evidence & Policy. 14 (3), 431–58. https://doi.org/10.1332/174426418X15326967547242
Rogers, M., Bruen, M., 1998. Choosing realistic values of indifference. preference and veto thresholds for use with environmental criteria within ELECTRE. Eur. J. Oper. Res. 107, 542–551. https://doi.org/10.1016/S0377-2217(97)00175-6
Roy, B., 1996. Multicriteria methodology for decision aiding (Vol. 12). Springer Science & Business Media
Roy, B., 1993. Decision science or decision-aid science? Eur. J. Oper. Res. 66, 184–203. https://doi.org/10.1016/0377-2217(93)90312-B
Roy, B., 1991. The outranking approach and the foundations of ELECTRE methods. Theor. Decis. 49–73. https://doi.org/10.1007/BF00134132
Saarikoski, H., Mustajoki, J., Hjerppe, T., Aapala, K., 2019. Participatory multi-criteria decision analysis in valuing peatland ecosystem services—Trade-offs related to peat extraction vs. pristine peatlands in Southern Finland. Ecol. Econ. 162, 17–28. https://doi.org/10.1016/j.ecolecon.2019.04.010
Sala, S., Farioli, F., Zamagni, A., 2013. Life cycle sustainability assessment in the context of sustainability science progress (part 2). Int. J. Life Cycle Assess. 18, 1686–1697. https://doi.org/10.1007/s11367-012-0509-5
Sanchez-Escobar, F., Coq-Huelva, D., Sanz-Cañada, J., 2018. Measurement of sustainable intensification by the integrated analysis of energy and economic flows: Case study of the olive-oil agricultural system of Estepa. Spain. J. Clean. Prod. 201, 463–470. https://doi.org/10.1016/j.jclepro.2018.07.294
Scriven, M., 1980. The logic of evaluation. Inverness, California: Edgepress.
Shadish, W. R. 1998. Evaluation theory is who we are. American Journal of Evaluation, 19(1), 1–19. https://doi.org/10.1177/109821409801900102
Shadish, W. R., Cook, T. D., Leviton, L. C., 1991. Foundations of program evaluation: Theories of practice. Thousand Oaks, California: Sage Publications.
Smit, J.P., Hessels, L.K., 2021. The production of scientific and societal value in research evaluation: a review of societal impact assessment methods. Research Evaluation, 30, 323-335. https://doi.org/10.1093/reseval/rvab002
The United Nations 2030 Agenda for Sustainable Development (2015, October 04). Retrieved from https://www.un.org/sustainabledevelopment/sustainable-development-goals/
Thornton, P.K., Toulmin, C., Vermeulen, S.J., Godfray, H.C.J., 2013. Sustainable intensification in agriculture: premises and policies. Sci. 341, 33–34. https://doi.org/10.1126/science.1234485
Turner, J. A., Guesmi, B., Gil, J. M., Heanue, K., Sierra, M., Percy, H., ... & Milne, C. (2022). Evaluation capacity building in response to the agricultural research impact agenda: Emerging

insights from Ireland, Catalonia (Spain), New Zealand, and Uruguay. Evaluation and Program Planning, 102127.

Vahdani, B., Jabbari, A. H. K., Roshanaei, V., & Zandieh, M. (2010). Extension of the ELECTRE method for decision-making problems with interval weights and data. The International Journal of Advanced Manufacturing Technology, 50(5), 793-800. https://doi.org/10.1007/s00170-010-2537-2

Wang, X. and Triantaphyllou, E., 2014. Ranking irregularities when evaluating alternatives by using some multi-criteria decision analysis methods. Industrial and systems engineering, 819.

Weiss, C. H. 1988. If program decisions hinged only on information: A response to Patton. Evaluation Practice, 9, 15-28

Table 1. Summary of the four case study and their impacts

This table represents a qualitative analysis of the R&I and its impact, providing a summary of the input, output, and outcome of each research program.

Impacts	Case 1	Case 2	Case 3	Case 4
Economic	• Improved productivity: 15% yield increase • Reduce costs through optimization of fertilizers and pesticides application • Continuity of family business • Sustain an economic growth	• Multi-species and multi-stage cultivation: 5% annual increase of aquaculture production • Optimization of resource consumption and energy saving • Improve the Spanish Aquaculture industry	• Increase in production capacity (2004-2009: from 200 to > 2000 kg/ha) • Improve the Spanish market in sales and exports of almond • Maintain economic growth and nuts quality abiding to the EU standards	• Increase yield 400kg/h: reduced production time, space, and costs • Reduce waste and food residuals: prolonged shelf-life and product preservation • Maintain economic growth and build sustainable value chain
Socio-territorial	• Improvement of farmers' conditions • Job creation for women and young farmers • Geographical Indication labelling • Regional expansion: Ebro Delta, Valencia, and Seville	• Improve SES through employment opportunities • Expansion in: Spain, EU, and International markets • Conservation of maritime territory and aquatic biodiversity	• Improvement of farmers' conditions • Sustain Spanish almond cultivation as second largest producer • Market expansion at EU and international level	• Initiative toward a platform for sustainable value chain • National and International expansion in Spain and some EU countries as a result of the patents exploitation and participation in global trade exhibitions
Political	• Addressing public interests within the crops and grains cultivation field • Providing new insights and scientific support to farmers: for Spanish and EU regulations (RD43/2002; EC1312/2008)	• Contribute to the public interest and policy-making by advancing the maritime sector and aquaculture industry • Use in public debate, policy negotiation, and societal importance of the policy domain (EC1421/2004)	• Addressing public interests within the tree nuts cultivation • Providing new insights to farmers and academicians • Improve Spanish production and trade balance • Contribution to the debate and policy making (EC870/2004 and EC73/2009)	• Regulatory implication to Spanish and EU laws (i.e., EC853-4/2004; EC2073/2005; RD1376/2003) • Contribution to public debate, policy negotiation, and societal importance domain in the meat production sector

Health	• Improvement of the quality of the grains and the nutritional status of the soil • Promote well-being of the consumers • Minimize farm workers' exposure to pesticides and chemical hazards	• Animal welfare: rich nutritious cultivation environment • Contribute to the health and well-being of the population by providing a rich source of protein and omega-3 food	• Contribute to good nutritional status and well-being of the population • Reduce aflatoxin contamination fulfilling the EU regulation • Provide rich source of protein (24%), fibers (10%), and healthy oil (52%)	• Provide food products rich in protein and minerals • Control of pathogens and microbial levels: assuring food safety and quality • Customization of chemical composition by producing sliced meat with low salt and low-fat levels
Environmental	• Controlling time, frequency and use of fertilizers • Reduces losses and contamination • Water and waste management strategies • Land use efficiency: 27% of land apply “sustainable practices”	• Reduce energy consumption: 90% water and 70% electricity • Overcome sporadic problems related to the quality of water • Monitoring of the physical and chemical parameters • Sustainable aquaculture (SDG14)	• Provide diversity and variety of genetic almond cultivars • Enhancement of ecosystem biodiversity • Increase disease tolerance, self-compatibility, and improvement of nuts’ traits	• Efficient energy utilization and promotion of sustainable allocation of natural resources • 30% reduction in energy consumption compared to the conventional drying process • Waste management and minimize food losses
Capacity building	• Educational training, theoretical and practical knowledge, and scientific publications • Providing new insights of the sustainable cultivation • Formation: potential replication in other industries	• Scientific publications and conference presentations • Replication methods in others species • Training formation: scientific guidance; continuous instructions and follow-up	• New insights and scientific publications: providing promising lines for future research • Innovative investigation techniques: as model for replication	• International course: theoretical and practical knowledge production • Scientific publications: new insights for the agri-food innovation • Improvement and realization of new lines of product development

* EU: Europe; European Commission policy (EC): Royal Decree (RD); SDG: Sustainable development goals; kilogram (kg); hectares (ha); hour (h)

Table 2. Weighted importance scores of GI

This table displays the weights (*w*) assigned by the stakeholders to each of the sustainability pillars.

	Case 1	**Case 2**	**Case 3**	**Case 4**	Total
Sustainability pillars	*w*	*w*	*w*	*w*	*w*
Economic	0.21	0.23	0.41	0.30	1.15
Socio-territorial	0.14	0.16	0.23	0.14	0.67
Environmental	0.21	0.20	0.09	0.08	0.58
Health	0.10	0.15	0.07	0.09	0.41
Capacity building	0.31	0.24	0.16	0.33	1.04
Political	0.02	0.02	0.03	0.06	0.13

Table 3. ELECTRE III output of SI

This table elaborates on the coefficients of the ranking matrix of SI.

Credibility Matrix									
Economic	a1	a2	a3	a4	**Health**	a1	a2	a3	a4
a1	0.0	0.75	0.74	1.0	a1	0.0	1.0	1.0	1.0
a2	0.85	0.0	0.68	1.0	a2	0.0	0.0	0.98	0.75
a3	0.90	0.82	0.0	1.0	a3	0.0	0.0	0.0	0.46
a4	0.0	0.0	0.0	0.0	a4	0.0	0.75	1.0	0.0
Socio-Territorial	a1	a2	a3	a4	**Capacity**	a1	a2	a3	a4
a1	0.0	1.0	1.0	1.0	a1	0.0	1.0	1.0	1.0
a2	0.0	0.0	0.0	1.0	a2	1.0	0.0	1.0	1.0
a3	0.82	1.0	0.0	1.0	a3	0.0	0.02	0.0	1.0
a4	0.0	0.69	0.0	0.0	a4	0.03	0.04	1.0	0.0
Environmental	a1	a2	a3	a4	**Political**	a1	a2	a3	a4
a1	0.0	1.0	1.0	1.0	a1	0.0	1.0	1.0	0.98
a2	0.0	0.0	0.88	1.0	a2	0.51	0.0	0.96	0.51
a3	0.0	0.0	0.0	0.95	a3	0.33	0.95	0.0	0.66
a4	0.0	0.0	0.78	0.0	a4	0.80	1.0	1.0	0.0

Table 4. ELECTRE III output of the GI

This table elaborates on the coefficients of the ranking matrix of GI.

Concordance Matrix:	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Case 1	0.000	0.964	1.000	1.000
Case 2	0.570	0.000	0.842	0.993
Case 3	0.445	0.476	0.000	0.978
Case 4	0.207	0.3055	0.685	0.000
Dominance Matrix:	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Case 1	0	P+	P+	P+
Case 2	P-	0	P+	P+
Case 3	P-	P-	0	P+
Case 4	P-	P-	P-	0

*P: Preference

Table 5. ELECTRE III output of sensitivity test 1

The following table displays the results of the sensitivity analysis following the method of Balali et al. (2014).

Concordance Matrix:	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Case 1	0.000	0.777	0.971	1.000
Case 2	0.537	0.000	0.842	0.970
Case 3	0.428	0.394	0.000	0.875
Case 4	0.030	0.227	0.584	0.000
Dominance Matrix:	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Case 1	0	P+	P+	P+
Case 2	P-	0	P+	P+
Case 3	P-	P-	0	P+
Case 4	P-	P-	P-	0

*P: Preference

Table 6. ELECTRE III output of sensitivity test 2

The following table displays the results of the sensitivity analysis following the method of Rogers and Bruen (1998).

Concordance Matrix:	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Case 1	0.000	0.743	1.000	1.000
Case 2	0.535	0.000	0.842	0.970
Case 3	0.416	0.394	0.000	0.861
Case 4	0.030	0.188	0.584	0.000
Dominance Matrix:	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Case 1	0	P+	P+	P+
Case 2	P-	0	R	P+
Case 3	P-	R	0	P+
Case 4	P-	P-	P-	0

*P: Preference; R: Indifference

Appendix A

Algorithms of each matrix are represented below based on (Figueira et al., 2005):

- Ci(a,b) concordance index for each criterion and overall
  $Ci(a,b) = 0, \text{ if } gi(b) \geq gi(a) + Pi(gi(a))$
  $Ci(a,b) = 1, \text{ if } gi(b) \leq gi(a) + Qi(gi(a))$
  $Ci(a,b) = (gi(a) + Pi(gi\ (a)) - gi\ (b))/(Pi(gi(a)) - Qi(gi(a))$
  Overall $C(a,b) = \sum Wi\ Ci(a,b) / \sum Wi$

- Di(a,b) discordance index for each criterion
  $Di(a,b) = 0, \text{ if } gi(b) \leq gi(a) + Pi(gi(a))$
  $Di(a,b) = 1, \text{ if } gi(b) \geq gi(a) + Vi(gi(a))$
  $Di(a,b) = (gi(b) - gi\ (a) - Pi(gi\ (a)))/(Vi(gi(a)) - Pi(gi(a))$

- S(a,b) credibility index
  $S(a,b) = C(a,b), \quad \text{if } Di(a,b) \leq C(a,b)\ i\ \forall$
  $S(a,b) = C(a,b) \quad \prod Di(a,b) > C(a,b) \quad (1 - Di(a,b))/(1 - C(a,b))$

Appendix B

Selection of sub-indicators using PLS-DA for SI analysis (Hair et *al.*, 1995).

Economic	***c***	***Socio-territorial***	***c***	***Environment***	***c***
Productivity	**0.915**	Job for female	**0.904**	Contamination	**0.844**
Cost reduction	**0.855**	landscape	**0.904**	Pesticide dose	**0.835**
Econ. Growth	**0.770**	Sustained resource	**0.893**	Gas Emission	**0.858**
Job creation	**0.556**	Rural development	**0.892**	Water protection	**0.860**
Health	***c***	***Capacity Building***	***c***	***Political***	***c***
Well-being	**0.823**	Collaboration	**0.869**	Quality & strength of research	**0.883**
Food safety	**0.822**	Knowledge Production	**0.908**	Intensity of media coverage	**0.826**
Food quality	**0.853**	Improvement	**0.915**	Quality &Intensity Debate	**0.795**
Chemical exposure	**0.866**	Post evaluation	**0.839**	Social concern	**0.799**