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THE IMAGE OF SCIENCE: ANALYZING THE INFLUENCE OF KNOWLEDGE, INTEREST AND PERCEPTION IN THE WILLINGNESS TO ENGAGE IN SCIENCE IN EUROPE AND US

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THE IMAGE OF SCIENCE: ANALYZING THE INFLUENCE OF KNOWLEDGE, INTEREST AND PERCEPTION IN THE WILLINGNESS TO ENGAGE IN SCIENCE IN EUROPE AND US

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Subd. Gral. de Relaciones Institucionales y Transferencia del conocimiento

LA IMAGEN DE LA CIENCIA: UN ANÁLISIS DE LA INFLUENCIA DEL CONOCIMIENTO, EL INTERÉS Y LA PERCEPCIÓN EN LA DISPOSICIÓN A ACTUAR EN RELACIÓN CON LA CIENCIA EN EUROPA Y EEUU

Muñoz Van Den Eynde, A.

111 pp, 102 refs.; 12 figs, 4 tbls

Resumen:

Este estudio analiza la influencia del conocimiento, el interés y la percepción (elementos de la imagen de la ciencia) en la disposición a realizar acciones relacionadas con la ciencia utilizando Modelos de Ecuaciones Estructurales. Se analizan tres conjuntos de datos para comparar países e indicadores: la edición 2018 de la Encuesta Social General de EE. UU., El Eurobarómetro 79.2 de 2013, y la edición 2018 de la Encuesta Española de Percepción Social de la Ciencia y la Tecnología. Los resultados muestran que: (1) el conocimiento es el principal determinante; (2) cuando está disponible, la eficacia auto-percibida con respecto a la ciencia es mejor indicador que el conocimiento de “libro de texto” y (3) existen diferencias en el compromiso que parecen estar influidas por la particular cultura científica del país.

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Abstract:

This study is aimed at analyzing the influence of knowledge, interest and perception (elements of the image of science) in the willingness to engage in science using Structural Equation Modelling. Three datasets are analyzed to compare countries and indicators: the 2018 edition of the US General Social Survey, the Eurobarometer 79.2 of 2013, and the 2018 edition of the Spanish Survey of Social Perception of Science and Technology. The results show that: (1) knowledge is the main determinant; (2) when available, self-perceived efficacy regarding science is a better indicator than “textbook” knowledge; and (3) there are differences in engagement that seem to be influenced by the particular scientific culture of the country.

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1 INTRODUCTION

Science is no longer an exclusive topic of scientists but has become an integral part of modern life and contemporaneous culture, with widespread and deep implications for individual and social wellbeing [1]. Many personal and policy decisions are to some extent related to science and technology (S&T) [2, 3] and, therefore, the identification of the most efficacious mechanisms to manage science-society relationship has become a prime line of academic and political interest [4-6]. Both interests are intertwined: most academic activity has been set under the umbrella of public understanding of science (PUS) studies, and research on PUS has been mostly determined by the need to give answers and tools to the governance of S&T [7, 8]. This brings to mind the differences between what has been termed basic and applied research. It can be said that PUS research would have been mainly guided by the objectives of applied science, i.e., be useful for the policy for science, instead of by the purpose of obtaining valid and reliable knowledge about the factors explaining the way science and society interact. Consequently, research in this field has been hampered by circular thinking and the reproduction of outdated models [9]. There are different manifestations of this circularity that are in turn linked to each other.

First, the evolution of the paradigm describing science-society relationship in the PUS field can be described as a process of rectification of deficits [10] in which citizens have been asked for knowledge, interest, positive attitudes, or trust [11]. Despite the evolution of the research paradigm and the efforts to eradicate the idea that the relationship between science and society is determined by a deficit, this concept has shown great resilience and remains fully in force [12, 13].

Second, the origins of the deficit model can be described by what has been called the PUS axiom "the more you know, the more you love it" [10, 11]. The criticisms to the assumptions underlying this axiom, along with the difficulties to find appropriate measures of science knowledge [4] have led to this element being mainly ignored as an explicative variable of science-society relationship, at least in Europe. In fact, it has been criticized that Eurobarometers (public opinion surveys developed by the European Commission) on S&T have been designed under the umbrella of the deficit model only because they included questions about knowledge and attitudes towards S&T [7]. As a result of these criticisms, since 2005 questions aimed at measuring the public knowledge about S&T have disappeared from these surveys.

In our technologically advanced societies it is expected that people achieve all sorts of literacies: visual, numeric, computer, geographic, cultural, political, or moral literacies have all been singled out as being essential [14]. Simultaneously, as a result of the deficit model, as has just been said, it appears that even there is a certain reluctance to speak of scientific literacy, or at least to measure it, in academic settings. But does it make sense to ignore knowledge as a factor influencing science-society relationship? It seems that the answer should be no. Undoubtedly, the relationship between support to science and scientific knowledge is not well accounted for by the deficit model, but ignoring scientific knowledge neither help capturing the full picture [15, 16]. Science is only one of many social institutions that produce knowledge. But its most distinctive feature is knowledge is not an element but its purpose and main product. And this determines its place in society [17]. Therefore, it has been found that citizens exposed to scientific knowledge have more elaborated cognitive maps and, resultantly, a better understanding of science, greater ability to cope with scientific issues, and are more interested in the topic [18]. People with greater levels of scientific understanding also possess a more discriminating view of science [19, 20].

Theory is essential to guide researchers' perception of the problems, determine the design of the methodology and orient the interpretation of the results [21]. But little effort has been made in pursuing the theoretical foundations of research in science-society relationship [22, 23]. This article stems from the assumption that both the absence of a theoretical framework and the "attitude" toward knowledge in the field of PUS research are a consequence of its applied orientation.

The focus of research on science-society relationship has currently shifted towards a more democratic model in which the public is invited to take part in the scientific enterprise and decision making [6]. But, can we assure citizens want to participate in S&T decision making? It seems not very plausible, as there is evidence that citizens demand a role in decision making about questions related to S&T, but they tend to not participate when this possibility is offered [24]. Although the public is the main target of the measures designed by policy to reduce the gap between science and society, it remains largely unknown. [4, 12, 25-29]. And despite it is considered a homogeneous entity, the analyses of surveys of public perception show that there is no a single and shared public perception of science, but many [10].

Finally, the shift to a more participatory perspective about science-society relationship has translated into the emergence of the "science in society" or "public engagement in science" paradigm [11]. It is rooted in science and technology studies (STS) on public participation, but so far has not generated an articulated research program [10, 30]. This inform aims to help fill this gap. However, the theoretical framework in which the data analysis is framed is previously presented.

2 A CONCEPTUAL FRAMEWORK: CULTURE, CONSCIOUSNESS AND THE IMAGE OF SCIENCE

This approach assumes that the relationship of citizens with science depends on and simultaneously determines the image they have of it [31]. Our mind works by manipulating mental images instead of symbolic codes and thus, the scientific concepts are understood and cognitively manipulated as mental models that are transformed, transmitted and received as mental images [17]. The other key elements of our conceptual model are scientific culture and scientific consciousness.

Scientific culture is a dimension of the broader construct "culture" that is key for the adaptive capacity of the human species [32] and has generated new ways of regulation [33]. There are two types of homeostasis, basic and sociocultural. The first focuses on the processes of life regulation, and the second is responsible of social regulation [33]. Culture includes meanings (ideas, images, representations, attitudes, values, prototypes and stereotypes) and instruments (economic interchanges, religious beliefs, social conventions, ethics, laws, arts, science and technology) [33]. Consequently, scientific culture is understood as the dimension of culture that has to do with socially shared meanings and instruments related to science.

Culture stems from the emergence of consciousness in the evolution of mammals and, more specifically, of primates. In this process, the mind would have been gaining progressively more complexity, until the moment that human minds, sustained by higher capacities of memory, reasoning, and language, gave rise to consciousness, that is a mind with subjectivity and, thus, it is responsible of knowledge and of we paying attention to the environment [33]. Consciousness is an emergent property of the mind of individuals, while culture emerges from the consciousness of groups of individuals in interaction [33] and so it is a social attribute. It is considered that scientific consciousness is the specific dimension related to science of the broader construct "consciousness" [31].

As the products of consciousness are images, i.e., neural maps that contribute to direct our actions [33], scientific consciousness generates an image of science that encompass the mental representation of science individuals conform when interact with it in their daily live in a specific social environment. Simultaneously, the social environment influences the image of science of citizens as a result of the way society interacts with it [31]. It is assumed that when individuals make decisions and operate in their daily lives their image of science is operating in the background. This image is very complex and need to be decomposed to be analyzed it. The factors that have received more attention to date are knowledge, perception, interest, and attitudes. As a result of the shift of the PUS paradigm to PES, the study of the image of science needs to incorporate engagement into the analysis of the factors that give shape to this image.

On the other hand, people are extremely susceptible to social influence [34]. From the perspective of Cultural Psychology, this susceptibility is explained by the bidirectional influence between culture and people's minds. Individuals are biological entities, and their behavior has a biological, as well as an evolutionary, foundation. Yet individuals are also ineluctably social and cultural phenomena, to the extent that people and their social worlds are inseparable, they require each other [32]. Therefore, people's actions (and opinions) require, reflect, foster and institutionalize the affordances and influences of their sociocultural environment, i.e., ideas, images, and the embodiment, animation, and realization of this ideas and images in social practices [32]. As a result, it has been found that, for example, there are differences in the social perception of science and its applications among the Europeans [35-37]. It has also been found a strong association between interest in S&T, being informed about it and the innovative capacity of the country of reference. Specifically, evidence shows that the more innovative the country (measured by an indicator that also includes information on the country's scientific capacity), the more interested and informed citizens are [38]. This finding shows that context matters when looking at the relationship between knowledge and perceptions of and support for science [39].

3 KNOWLEDGE, INTEREST AND PERCEPTION AS ELEMENTS OF THE IMAGE OF SCIENCE

3.1 KNOWLEDGE

As it has been pointed above, knowledge has been excluded of the equation that tries to explain the relationship of science and society. But the entirely justified criticisms to these assumptions cannot be accompanied by the suppression of knowledge as a determining factor in the definition of the citizens' image of science. Image that, on the other hand, determines the way citizens relate to science. It is not to be advocating about the significance of knowledge from a position of superiority in which citizens are denied the ability to properly understand the role of science (a criticism of the deficit model) [31]. Instead, it is about considering that knowledge strengthens and enriches people's conceptual maps of science [18] and thus enables them to apply these maps in their daily life actions [40].

There have been important methodological difficulties to measure science knowledge that are related with the impossibility to stablish what kind of knowledge the public needs [41]. The focus on science content is controversial, as each individual is likely to have a different repertoire of science knowledge (the same as each scientist) determined by his or her specific needs, abilities and specific context [42]. The most obvious limitation with the "content" approach is that even scientists who agree with it do not agree with the specific items that should be considered [43]. The attempts to measure science knowledge have also ignored that having a good understanding of science is not to be expert in anything in particular, but to be able to deal effectively with scientific matters as they arise in the course of life [44]. The use people make of formal knowledge depends on the situation: people engage with, select, or construct the scientific elements according to their own interests, involvement or personal and social stories; thus, scientific knowledge is not received impersonally, as the product of disembodied expertise, but comes as part of life, among real people, with real interests, and in a real world [19]. Therefore, there is evidence that people's uptake of scientific knowledge is related to their perception of its relevance for their lives [44].

On the other hand, what people think about themselves has a very significant impact on the way they behave, to the extent that one's self-image can become a self-fulfilling prophecy [45]. A very relevant element of the self-image is the perception of self-efficacy. It has been found that "effective intellectual functioning requires more than simply understanding the factual knowledge and reasoning operations for given activities" [46, p. 117], it also requires "self-beliefs of efficacy to use them well" [46, p. 119]. Thus, perceived self-efficacy is a key determinant of people's choice of activities, the effort they are willing to invest, and their persistence [47].

3.2 INTEREST

Interest has two distinctive features. First, it is a motivational construct and thus, it generates tendencies to engage in the object of interest, or to withdraw from it when it is not present. Second, the decisive criterion that enables interest to be clearly distinguished from other motivational concepts is its content specificity: there is no interest, in general, but an interest about an object, activity, field of knowledge or goal. As a result of both features, people feeling interest about something develop the readiness to acquire knowledge about the object of interest [48]. This seems to have been the rationale behind the widespread and long lasting institutional initiatives aimed at increasing the public interest in science [49,50]. The results of these initiatives have coincided in showing that the public is very interested in science, but this interest does not translate into a great knowledge of S&T [2, 29].

The lack of concordance between the figures of interest and knowledge of S&T might be interpreted as an indication of the complexity of analyzing science-society relationship. On the one hand, what constitutes "interest in science", when asked about it in a survey, is not immediately apparent as it is a vague term [52]. This vagueness poses difficulties to respondents when answering the question, as they have to interpret what the interviewer meant by "interest in science". It also hampers the interpretation of researchers about what respondents have in mind when answering. Furthermore, simply asking people if they are interested in S&T is likely to make the topic to be salient in people's minds and also unleash social desirability. On the other hand, analyses of surveys of public perception of science show a close relationship between being interested in science and feeling informed about it [29]. What remains unclear is the direction of this relationship. Does interest motivate people to know? Or is to be knowledgeable a former condition to be interested? The burden of evidence suggests a strong, essentially linear interest-prior knowledge relationship in which prior knowledge accounts for approximately 20% of the variance in interest [51].

3.3 PERCEPTION

Perception is the cognitive process by which information from the environment is transformed into mental representations, images that reflect in our brain the external information processed according to our knowledge and prior experience [33, 54, 55]. Regarding science, perception implies processing the scientific information of our environment and rebuilding it by means of its assimilation to our mental maps; it includes two products: attitudes and opinions [38].

Perception of science is very complex and difficult to measure, as it can be said that there are different sciences to which the public reacts differently. Simplifying, here we identify three. What we can call academic science was traditionally aimed at the production of reliable public knowledge and functioned through a number of well-established practices that were not formally codified or systematically enforced but may be encompassed by a culture of science [17]. When the focus is on academic science, the feature best describing science-society relationship is acceptation [21]. Industrial science shares the knowledge base with the previous one, but had a parallel culture in which science is used to produce valuable knowledge to address the issues of daily life [17]. The public reaction towards industrial S&T has been marked by ambivalence and instability and be described in terms of people's actual experiences with them, and the relevance or irrelevance for the satisfaction of their particular needs and interests [56]. Nowadays, as science is increasingly being organized on the basis of market principles, has emerged an instrumental version, so captive of material interest and commercial agendas that has become partisan [17]. It is loosening credibility as a neutral arbiter on epistemic matters and thus it is becoming common to hear about the loss of cultural authority of science [57]. Criticisms are not actually grounded on the nature of science, but in the institutional interests that shape and even corrupt the legitimate interest in scientific knowledge [58]. The public perception about this "science" is rather negative.

The complexity of perception has negatively conditioned the analysis of the relationship of this construct with other elements of the citizens' image of science. Nevertheless, there is evidence that knowledge, information and awareness can and do affect the way citizens relate to science and technology [15]. Also, it has been considered that interest and perception are actually the same; that attitude is a superordinate concept and, hence, interest is a type of attitude; and, finally, that both concepts can be clearly distinguished from one another [44]. On the other hand, since the late 1980s, much academic debate has focused on examining and understanding the link between knowledge and perception about science. Although there remains more disagreement than consensus [15], as it has been pointed above, there is evidence that people knowledgeable about science are more discriminating in their judgements, probably because less scientifically informed respondents do not have sufficient knowledge on which to base their opinions and therefore do not have clearly defined attitudes [20]. It has also been found that knowledge is associated with more support for obviously useful science, but with more opposition to morally contentious one [19].

The lack of a clear result about the relationship between perception of science and knowledge can be explained, at least partially, by Ajzen and Fishbein's principle of compatibility [53]. According to it, knowledge and perception should be measured with the same level of specificity to find an association between them. But in surveys of public perception of science, knowledge is measured with a reduced sample of very specific items (e.g. "Electrons are smaller than atoms"), and perception is measured by general statements about science as a whole (e.g. "Science and technology can sort out any problem"). Therefore, there is evidence that the correlation between general "textbook" knowledge and attitudes towards science as a whole is almost twice as high as the overall estimate whereas, for example, the correlation between general knowledge and attitudes to GM food is practically zero; on the other hand, when knowledge relates to biology and genetics, it becomes a considerably stronger predictor of a person's attitudes towards GM food [15]. It has also been found that general attitudes toward science as a whole are poor predictors of specific attitudes on particular science policy issues [19].

Finally, S&T have been evaluated primarily on the basis of potential risks and benefits [21, 59], but it seems that it is necessary to consider other relevant dimensions as values [59,60], trust [61] or the confrontation of uncertainties versus needs [62].

4 WHAT PUBLIC ENGAGEMENT IN SCIENCE?

It can be said that PES has become a *buzzword*, an example of a fashionable stereotyped phrase, ubiquitous and used ad libitum by science policy makers, by industrial companies in their ads, scientists in their research proposals, and journalists in their pieces of information [6]. This makes it necessary to identify how much of the PUS moment's turn to dialogue is genuine and how much is rhetoric that glazes entrenched deficit model positions [63]. In tackling this task, it is necessary to bear in mind that there are two main types of public engagement in science and technology: initiatives that seek to directly influence policy processes, and events aimed at achieving individual learning through social processes under a conception of learning as created, directed, and determined by those participating in it [63,64].

As it has been already pointed, the relation between science and society is considered a challenge to governance and thus, engaging the public in the governance of science has become a kind of gold standard [30]. From this perspective, it is considered that citizens need to be involved in defining the priorities of publicly-funded research [44]. On the other hand, the term participation tends to be presented as an end in itself [65] in what appears to be a new mechanism to continue selling science to the public [66], creating acceptance and restoring trust in experts [24]. In words of the Royal Society: "There is a better chance that society will value and be excited by science if it feels a sense of ownership about its direction [67, p. 4]. Hence, public participation is welcomed as long as it complies with the innovators' demands [68] from an economic perspective [49]. Therefore, it is considered that, despite it is difficult to estimate the costs of failed innovations, the early consideration of ethical aspects and societal needs to avoid social rejection contributes to a more efficient spending of resources for research, development and innovation [69]. Besides, the atmosphere of "show society" has impregnated some of the contemporary actions to bring science closer to the public and thus, the science promoted is not the academic variety, but the kind that can provide attractive and spectacular stories [70]. But public idealizations of science have costs, and the cure would therefore be worse than the disease [71].

For the European Commission, PES is one of the key elements of Responsible Research and Innovation (RRI), its latest initiative to reduce the gap between science and society. This strategy is aimed at achieving the engagement of all the social actors (researchers, industry, politicians and civil society) in the research and innovation process to improve the dialogue between science and the rest of society considering that research and innovation must respond to the needs of society, reflects its values and be responsible [72]. For the American Association for the Advancement of Science (AAAS), PES refers to intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public and it is closely related to science communication [73-75].

The meaning of public engagement is mostly defined top-down [30]. But there are great gulfs between what people sense of themselves and the stereotypes applied to them by researchers, policy makers and media commentators [76]. Consequently, very little is known about the perspective of citizens on public engagement in science [30].

Taking into account everything mentioned so far, the objective of this article is to analyze the influence of knowledge, interest and perception (as elements of the image of science individuals conform in their interaction with it in a specific social context) in the public engagement in science. From previous work it is hypothesized that knowledge directly predicts interest, perception, and engagement in science [31]. It is also hypothesized that engagement is also directly predicted by perception and interest. In tackling this task, there are two additional assumptions to consider. First, it has been found that the nation has a decisive influence on public's perception of science [77] and thus it is assumed that there are countries' differences in the public engagement in science, attributable, at least partly, to the country's level of development in S&T. Second, there is the possibility that the contribution of interest, perception and knowledge depends on the type of engagement we focus on, the one related to informal science learning [78], or the one reflecting willingness to participate in science policy decisions [71].

5 METHOD

5.1 DATA

In order to consider the influence of the social context, three data sets are analyzed: the 2018 edition of the US General Social Survey (GSS); the Eurobarometer 79.2, that includes a set of questions about Responsible Research and Innovation, and was conducted in 2013 (EB); and the 2018 edition of the Spanish Survey of Social Perception of Science and Technology (SPST).

The GSS is a biennial interview survey of U.S households conducted since 1972 by the National Opinion Research Center at the Chicago University. The basic GSS design is a repeated cross-sectional survey of a nationally representative sample of non-institutionalized adults who speak either English or Spanish [79]. Questions about S&T information, knowledge, and perception were added to the GSS by National Science Foundation beginning in 2006 [80]. In the 2018 edition, the sample of respondents presented with the S&T questions is 1,148.

The Eurobarometer are surveys developed since 1973 by the European Commission with the aim of monitoring the evolution of public opinion in the Member States. The Standard Eurobarometer was established in 1974 and each survey consists of approximately 1000 face-to-face interviews per country. Special Eurobarometer are based on in-depth thematic studies carried out for various services of the European Commission or other EU Institutions and integrated in the Standard Eurobarometer's polling waves [81]. The 2013 edition about Responsible Research and Innovation (RRI), Science and Technology is the Special Eurobarometer 401 and was included in the Standard Eurobarometer 79.2. The survey was carried out by TNS Opinion & Social network in the 27 Member States of the European Union and in Croatia between the 26th of April and 14th of May 2013. The sample consists of 27,563 respondents from different social and demographic groups that were interviewed face-to-face at home in their mother tongue on behalf of the Directorate-General for Research & Innovation [82]. Having assumed there are differences among countries in the relationship of the public with science that depend on the level of scientific development of the country [37], it has been used the European innovation scoreboard (EIS) to select the countries to be analyzed. The EIS provides a comparative analysis of innovation performance in EU countries, other European countries, and regional neighbors [83]. According to the edition of 2013 of the EIS, it has been selected Bulgaria and Romania as representatives of modest innovators, Greece and Spain as representatives of moderate innovators, Cyprus, Slovenia and UK as representatives of innovation followers, and Denmark and Germany as representatives of the innovation leaders. There have been selected two countries of each group to stablish if potential differences are due to cultural factors or the level of development in S&T. There have been included three countries in the group of moderate innovators because is more numerous and homogeneous.

The SPST is a biennial survey conducted by the Spanish Foundation for Science and Technology since 2002, aimed at analyzing the perception of Spanish population about science and technology [84]. The design of the questionnaire and the analyses of the results are carried out by a group of experts selected by FECYT, from which the author was part in the 2014, 2016 and 2018 editions. The field work of the 2018 edition took place between 2018 14th May and 2nd July. The sample size is 5,200 [85].

5.2 VARIABLES

Each dataset includes its own questions to measure knowledge, interest, perception and engagement in science. The R code used to obtain the indicators of the four factors analyzed in each data set is included in the Annexes.

5.2.1 GSS 2018

Knowledge is defined from three indicators: science knowledge, knowledge about scientific inquiry process and science courses received at high school. Science knowledge (*sciknow*) is measured using a set of 10 items where correct answers are coded as "1" and all the other responses are coded as "0". Nine of them include a true/false option: (1) "The center of the Earth is very hot" (true, 85.89%), (2) "All radioactivity is man-made" (false, 68.82%), (3) "It is the father gene that decides whether the baby is a boy or a girl" (true, 58.45%), (4) "Lasers work by focusing sound waves" (false, 44.86%), (5) "Electrons are smaller than atoms" (true, 46.86%), (6) "Antibiotics kill viruses as well as bacteria" (false, 51.22%), (7) "The continents on which we live have been moving their locations for millions of years and will continue to move in the future" (true, 46.86%), (8) an item about the universe with three options, one of each being presented to a third part of the sample: (a) "The universe began with a huge explosion", (b) "The universe has been expanding ever since it began", and (c) "According to astronomers, the universe began with a huge explosion" (each of them is true, 57,4%), and (9) an item about evolution with two formulations: (a) "Human beings, as we know them today, developed from earlier species of animals" (true, 25.52%), and (b) "Elephants, as we know them today, descended from earlier species of animals" (true, 35.1%); combined, the percentage of correct answers is 60.63%; the tenth item included a question about the Earth rotation with two options from which respondents have to select the one they think is correct: "Does the Earth go around the Sun (true, 71.78%), or does the Sun go around the Earth?". Science knowledge is the sum of the correct answers to these 10 items (it ranges from 0 to 10) (M = 6.25, SD = 2.3). Cronbach's alfa is 0.65. Although it is low, all the items are equally relevant. Thus, the problem is the lack of other relevant items instead of the presence of bad items. It is an expected finding if we take into account that we are measuring scientific knowledge only with 10 items.

Knowledge about scientific inquiry process (*sciprocess*) includes three elements. The first one is the literal response to the question "In your own words, could you tell me what it means to study something scientifically?", that was included in [2]; the statements were recoded verbatim and coded into eight categories: (1) "Formulation of theories, test hypothesis", (2) "Do experiments, control group", (3) "Rigorous systematic comparison", (4) "Measurement", (5) "Classification", (6) "Redundant, incorrect". According to Durant et al. (1989), these categories are used as a four-point scale, with category (1) scoring 3 points, categories (2) and (3) scoring 2 points, categories (4) and

(5) scoring 1 point, and categories (6), (8) “Don’t know or not codable” and (9) “No answer” scoring 0 points. The second element is measured by two related items: (1) “A doctor tells a couple that their genetic makeup means that they’ve got one in four chances of having a child with an inherited illness. Does this mean that if their first child has the illness, the next three will not have the illness?” (the option “No” is the correct one and scores 1 point), (2) “Does this mean that each of the couple’s children will have the same risk of suffering from the illness?” (the correct option is “Yes”, and scores 1 point). To compute this component, the two items are summed. The third element also includes two components: (1) “Two scientists want to know if a certain drug is effective against high blood pressure. The first scientist wants to give the drug to one thousand people with high blood pressure and see how many of them experience lower blood pressure levels. The second scientist wants to give the drug to five hundred people with high blood pressure, and not give the drug to another five hundred people with high blood pressure, and see how many in both groups experience lower blood pressure levels? Which is the better way to test this drug” (“All 1000 get the drug”, “500 get the drug, 500 don’t (the correct answer)”, “Don’t know”, “Refused”), (2) “Why is better to test the drug this way”. The responses to both items were combined and coded as: 0 – “don’t know or refuse” in the first item, 1 – “Correct, control group”, 2 – “Correct, vague reason”, 3 – “Correct, wrong reason”, 4 – “Correct, don’t know”, 5 – “Wrong, reservations about control group”, 6 - “Wrong, reservations about sample”, 7 – “Wrong, other reason”, 8 – “Wrong, don’t know”, 9 – “No answer”. Option 1 scored 2 points, option 2 scored 1 point and all the other options scored 0 points. Knowledge about science inquiry process is the sum of the points in the three components. It ranges between 0 and 7 (M = 3.29, SD = 1.8). Cronbach’s alpha is 0.56. It is a low index of internal consistency, but the statistic depends on the number of items, and we only have three.

There are four variables to measure science courses received at high school: *colscinm* is computed from the item: (1) “How many college-level science courses have you taken?” (numerical), *hsbio* (having studied biology at school) from the item: “Did you take a high school biology course?” (yes, “1” - no “0”)”, *hschem* (high school courses of chemistry) from: “Did you take a high school chemistry course? (yes, “1” - no “0”)”, and *hsphys* (high school courses of physics) from: “Did you take a high school physics course? (yes, “1” - no “0”)”.

Interest comprises four elements: new scientific discoveries (Median = 1), new inventions and technologies (Median = 1), new medical discoveries (Median = 2), and issues about space exploration (Median = 1). Respondents were asked if they are very interested (coded as “2”), moderately interested (coded as “1”), or not at all interested (coded as “0”).

Perception includes four elements: the opinion of respondents about three statements measured on a four-point scale from “1” (“Strongly disagree”) to “4” (“Strongly agree”). The statements are: “Because of science and technology, there will be more opportunities for the next generation” (*nextgen*) (Median = 3), “Science makes our way of life change too fast” (*toofast*) (Median = 2.5), and “Even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the federal government” (*advfront*) (Median = 3). The other element combines the responses to three additional items: “People have frequently noted that scientific research has produced benefits and harmful results. Would you say that, on balance, the benefits of scientific research have outweighed the harmful results, or have the harmful results of scientific research been greater than its benefits". After that, respondents were asked to quantify their responses to some extent. If respondents answer that benefits are greater, then they were questioned "Would you say that the balance has been strongly in favor of the benefits, or only slightly". If they considered higher the harmful results, then were questioned "Would you say the balance has been strongly in favor of the harmful results, or only slightly". Both items are combined in a variable with five options, from 1 "strongly in favor that the harmful results have been greater" to 5 "strongly in favor that benefits have been greater" (*balance*) (Median = 4).

In the GSS, *Engagement* can only be identified from the self-reported actions related to individual learning and has two components, search for information (*seekinfo*) and *visits*. Search for information in turn is identified from three items. First, there have been considered the two questions about the sources respondents use to get information about S&T: "Where do you get most of your information about science and technology?", and "If you wanted to learn about scientific issues such as global warming or biotechnology, where would you get information?" Both items are recoded giving a "0" to "Don't know" and "refuse"; "1" to TV, radio, family, friends and other; "2" to newspapers, magazines and Internet; "3" to Government agencies"; and "4" to books or other printed materials, or library. The purpose of this codification is computing as far as possible the gradation of the effort put in by respondents to acquire information about S&T. Finally, the same process is applied to the different sources' respondents use to get information about S&T in Internet: "What is the place where you are most likely to go on the internet for science and technology information?" The options are recoded giving "0" to "Don't know" and "Refuse", "1" to "search engine" and "other", "2" to "online news", "online magazines", "Wikipedia" and "social media", "3" to "news site" and "Government site", and "4" to "science site" and "books". The variable search for information is the sum of the three items. It ranges from 0 to 8 (Mean = 3.67, SD = 1.28). Finally, respondents were asked how many times they visited a natural history museum, a zoo or aquarium and a science or technology museum during the previous year. The responses to the three items are coded as "0", "1" and "2 or more". The variable *visits* is obtained summing the three items. It ranges from 0 to 6 (Mean = 1.45, SD = 1.63).

5.2.2 EB 2013

The EB does not include specific questions designed to measure respondents' knowledge about S&T and there is only an item measuring interest. In order to tackle these limitations, it is considered that knowledge may be approached indirectly defining the factor *Background*. It has two components. The first one is grounded on the concept of "science capital". Science capital (*scicapital*) refers to science-related qualifications, understanding, knowledge (about science and 'how it works'), interest and social contacts (e.g. knowing someone who works in a science-related job) and is understood as a resource families provide (Archer – ASPIRES). It is identified from the question: "Does or did any of your family have a job or a university qualification in science or technology? (Yes, your father; Yes, your mother; Yes, another member of your family; No, no one in your family, don’t know)”. In the dataset the question is decomposed in three dichotomic items (yes, “1”/ no, “0”), one for the father, other for the mother and another for other members of the family and so, science capital is the sum of the tree items. It ranges from 0 to 3 with the exception of Cyprus (0-2). The second component (*scistudy*) is measured through the question: “Have you ever studied science or technology (at school, at university or in college, or anywhere else?”. The value “0” is assigned to “Have not studied” and “Don´t answer”, “At school” is assigned the value “1”, "Anywhere else" the value “2”, and "At university", the value “3”. It ranges from 0 to 3 in all the countries.

Second, it is defined the factor *Attentiveness* instead of interest. It has three components: *interest*, *informed* and *getting information about science* (*getinfo*). Getting information about science can also be interpreted as an indicator of engagement. In fact, it is done this way in the other datasets. Nevertheless, the available indicators made impossible to adopt this strategy. The data set only includes an indicator of interest, and at least two are necessary to identify a factor; therefore, following (Miller, 1986) the decision is to define attentiveness as a combination of interest and being informed about S&T, considering also that there is a correlation between interest and the perceived level of information and thus, these two indicators cannot be separated. Once this decision is made, two options were tested: not including getting information about science as an indicator of attentiveness, or including it as an indicator of engagement. In both cases, it has been impossible to find an acceptable model for the all the countries considered. *Interest* is identified from the question: “How interested are you in developments in science and technology?” with a four-points scale from “1” (“Not at all interested”) to “4” (“Very interested”), the value “0” is assigned to the “Don’t know” answers. This option was not mentioned in Cyprus and Slovenia and thus, in these countries interest ranges from 1 to 4. The perceived level of information is measured from the question: “How informed do you feel about developments in science and technology” with a four-point scale from “1” (“Not at all informed”) to “4” (“Very well informed”), the value “0” is assigned to the “Don’t know” answers. It ranges from 0 to 4 in the eight countries analyzed. *Getting information about science (getinfo)* is defined from the question: “Where do you get most of your information about science and technology (newspapers, magazines, the Internet, books or other printed materials, TV, radio, government agencies, family, friends, colleagues, or some other source)?”. Assuming there are grades in the desire to get information related to the sources used, it is assigned 0 to "don't look for information", “1” to TV and radio, “2” to newspapers and magazines, “3” to websites and social media or blogs, and “4” to books. Each source of information is coded independently, so respondents can mention multiple sources. The variable is the sum of all the options. It ranges from 0 to 16 in all the countries.

Perception has eight components: *Social influence of Science* (*Socinfsci)* is measured from the question: “Do you think the overall influence of science and technology on [Nationality] society is positive or negative” with a four-points scale from “1” (“Very negative”) to “4” (“Very positive”), the value “0” is assigned to the “Don’t know” answers. The other seven elements measure the respondents’ level of agreement or disagreement with the following statements: *Opinion1*: “We depend too much on science and not enough on faith”; *Opinion2*: “Science makes our ways of life change too fast"; *Opinion3*: "Thanks to science and technology, there will be more opportunities for future generations"; *Opinion4*: "The applications of science and technology can threaten human rights"; *Opinion5*: "Science and technology could be used by terrorists in the future"; *Opinion6*: "Scientific and technological developments can have unforeseen side-effects that are harmful to human health and the environment"; and *Opinion7*: "If we attach too much importance to risks that are not yet fully understood, we could miss out on technological progress" in a 5-point scale from "1" ("Totally disagree") to "5" ("Totally agree") with the mid-point ("Neither agree nor disagree"), the value "0" is assigned to the "Don't know" answers.

Finally, in the EB *Engagement* is measured with only one item focused on decision making: "What is the level of involvement citizens should have when it comes to decisions made about science and technology?" (*engageDM*). It is assigned "0" to the spontaneous "None" and "DK" answers, "1" to "Citizens do not need to be involved or informed", "2" to "Citizens should only be informed", "3" to "Citizens should be consulted and their opinion should be considered", "4" to "Citizens should participate and have an active role", and "5" to "Citizens' opinions should be binding". In all the countries analyzed it ranges between 0 and 5.

5.2.3 SPST 2018

In this dataset, *Knowledge* is measured by three indicators: *Literacy*, S*elf-perception of knowledge* (*SelfPercep*) and *Dispositions*. *Literacy* is the sum of six items with two response options and respondents have to select the one they consider is correct: (1) "Does the Earth go around the Sun (correct, 88,1%), or does the Sun go around the Earth?", (2) "Antibiotics cure infections caused by viruses and bacteria" or "Antibiotics cure infection caused by bacteria" (correct, 66.17%), (3) "First humans lived at the same time as dinosaurs" or "Humans have never lived with dinosaurs" (correct, 84.96%), (4) "Eating a genetically modified fruit changes the genes of the person who eats it" or "Eating a genetically modified fruit does not change the genes of the person who eats it" (correct, 87.37%), (5) "Current climate change is a consequence of the hole in the ozone layer" or "Current climate change is mainly due to the accumulation of greenhouse gases" (correct, 64.5%), (6) "The number Pi is usually applied, among other things, in the manufacture of tires" (correct, 33.06%) or "The number Pi defines the relationship between the legs and the hypotenuse of a triangle".

Self-perception of knowledge is the sum of four items: The response to the item "The level of science education you have received is…" with the response options: "0" ("Don't know / Don't' answer"), "1" ("Very low"), "2" ("Low"), "3" ("Average"), "4" ("High"), "5" ("Very high") (Median = 3); (2) and three items measuring the respondents' level of agreement or disagreement with the following statements: (a) "I was never good at science" (Median = 3), (b) "Science is too specialized for me to understand it" (Median = 4), and (c) "It is important to know about science in my daily life" (Median = 4) in a 5-point scale from "1" ("Totally disagree") to "5" ("Totally agree") with the mid-point ("Neither agree nor disagree"), the value "0" is assigned to the "Don't know" answers. The scale of the items (a) and (b) is reversed to have all the items scoring in the same direction: lower punctuations showing negative opinion about the issue, and higher punctuations reflecting a positive opinion. Cronbach's alpha is 0.7.

Dispositions is the sum of the responses from “0” (“Not at all”) to “10” (“Perfectly”) to the question: “To what extent does the following statements describe your way of being”: (1) “Often take risks to progress in life, even when you are not sure what will happen” (Mean = 5.29, SD = 2.9), (2) “Are usually open to new ideas and new ways of doing things or thinking” (Mean = 6.71, SD = 2.39), (3) “Tend to plan ahead in advance” (Mean = 5.8, SD = 2.69), (4) “Highly value people who question traditional ways of acting” (Mean = 5.86, SD = 2.63), (5) “Try to learn new things continuously, make learning your lifestyle” (Mean = 6.91, SD = 2.34), and (6) “Rather do important things by yourself, without much help from others” (Mean = 6.85, SD = 2.43). Cronbach’s alpha is 0.77.

Interest is defined from four indicators. (1) Informative interest in S&T (*STinfointerest*) is captured using the item: “Every day we receive information and news on a wide range of topics. Please tell me three topics that you are particularly interested in”. The variable is assigned a “1” whether “science and technology” is selected as the first, second or third option (16.37%). (2) *STInterested* is the response to the question: “I would like to know to what extent you are interested in S&T” and is codified using a 5-point scale from “1” (“Very little”) to “5” (“Very much”), “0” is assigned to the spontaneous “Don’t know” answers (Median = 3 – “Somewhat”). (3) *STInformed* is identified using the same scale to answer the question: “To what extent you consider you are informed about S&T?” (Median = 3 – “Somewhat”). (4) *Getting information about science* (*getinfo*), is defined from two questions: (1) “Through what media you get information about S&T?”, (2) for those that have mentioned internet, “What are the sources you get information about S&T in Internet?”. In the first question, the mention of Internet is assigned “0” as the access to internet is codified in the second question and both are summed up into the variable “getting information about science”, “Don’t know” and “None” are also assigned “0”. On the other hand, TV, radio or the “other” option are assigned “1”, newspapers and magazines are assigned “2”, and science popularization magazines and books are assigned “3”. In the second question, the options are: “1” (podcast, radio, videos, Youtube and “others”), “2” (social networks, online news and Wikipedia), “3” (digital media specialized in S&T) and “4” (blogs, forums) (Mean = 4.7, SD = 4.61). Both variables are summed.

This data set includes multiple and varied items to measure *Perception* that are combined in five indicators. *STBalance* is obtained from the item: “If you had to take stock of S&T taking into account all its positive and negative aspects, which of the following options would best reflect your opinion?”, with “0” for “Don’t have an opinion”, “1” for “The harms of S&T outweigh the benefits”, “2” for “The benefits and harms of S&T are balanced”, and “3” for “The benefits of S&T outweigh the harms” (Median = 3). *SocialBalance* is the sum of the items: “If you had to take similar stock on some aspects of S&T, which of the following options would best reflect your opinion?” The code of the response options is the same than item used to define *STBalance*. The aspects respondents were questioned about are: (a) “The quality of life in society”(Median = 3), (b) “The safety and protection of human life” (Median = 2), (c) “Conservation of the environment and nature” (Median = 2), (d) “Coping with diseases and epidemics” (Median = 3), (e) “Food products and agricultural production” (Median = 2), (f) “The generation of new jobs” (Median = 2), (g) “The increase of individual freedoms” (Median = 2), (h) “Reducing the gap between rich and poor countries” (Median = 2), (i) “The protection of privacy and personal data” (Median = 2). Cronbach’s alfa is 0.86.

The variable *AppRisk (Risks of S&T applications)* is the sum of the respondents' opinion about the risks of the following applications of S&T: (1) "The cultivation of genetically modified plants" (Median = 3), (2) "Nuclear energy" (Median = 4), (3) "Fracking" (Median = 3), (4) "Animal experimentation for medical purposes" (Median = 3), (5) "Windmills" (Median = 1), (6) "Artificial Intelligence" (Median = 3), and (7) "The automation of work" (Median = 3), using a 5-point scale anchored at "1" ("No risk") and "5" ("A lot of risks"). Spontaneous respondents' manifestation they do not have an opinion about the issue is assigned "0". Cronbach's alpha is 0.75. The same procedure is followed to obtain the variable *AppBenefit (Benefits of S&T applications)*; medians are 2 for "Fracking", 3 for "The cultivation of genetically modified plants", "Nuclear energy", "Artificial Intelligence", and "The automation of work", and 4 for "Animal experimentation for medical purposes" and "Windmills". Cronbach's alpha is 0.79.

The variable *Opinion about decision making* (*OpinionDM*) is the sum of the respondents' opinions on a 5-point scale from "1" ("Totally disagree") to "5" ("Totally agree") with the mid-point "3" ("Neither agree nor disagree") about the following statements: (1) "We can't trust scientists to tell the truth if they rely on private funding" (Median = 3), (2) "If the consequences of a new technology are not known, precautionary measures should be adopted and its use controlled to protect health or the environment" (Median = 4), (3) "Scientific knowledge is the best basis for making laws and regulations" (Median = 3), (4) "In making laws and regulations, values are as important as scientific knowledge" (Median = 3). Spontaneous "Don't know" responses are assigned a "0". Cronbach's alpha is 0.62.

Opinion about science (*OpinionST*) includes the agreement or disagreement about the following statements: (1) "S&T are the maximum expression of prosperity in our society" (Median = 4), (2) "S&T serve, above all, to solve problems" (Median = 4), (3) "S&T solve problems, but also generate them" (Median = 4), (4) "S&T are the source of nightmares for our society" (Median = 3) using the same 5-points scale with "0" for "Don't know". The four items are summed. Cronbach's alpha is 0.49. Undoubtedly, it is a low value; this constitutes evidence of the complexity of the construct and the impossibility to measure it with only four items. Nevertheless, item 4 does not match with the others, so we extract it from the indicator. Doing this, Cronbach's alpha improves slightly (alpha = 0.54).

Engagement is defined by three indicators: the number of visits to S&T museums during the previous year (*scimuseum*) (Mean = 0.5, SD = 1.46), the number of times respondents have participated in science popularization activities in the previous year (*scipopular*) (Mean = 0.36, SD = 1.34), and *engagement in decision making* (*engageDM*), defined from the item: "Which of the following statements best describes your opinion about decision-making on scientific issues of social relevance?" with "0" ("Don't know" or "No answer"), "1" ("I am not interested in getting involved in decision-making about scientific issues as long as scientists are dealing with it"), "2" ("I would like citizens to be able to participate in decision-making on scientific issues but I do not want to get personally involved"), "3" ("I would like to have an opinion on scientific decisions"), "4" ("I would like to be actively involved in decision-making on scientific issues"), "5" ("I am already involved in decision-making on scientific issues") (Median = 2).

5.3 ANALYSIS

Data are analyzed with R software. The function *alpha* of the *psych* package is used to calculate the internal consistency (Cronbach's alpha) of the indicators that are the sum of different items [88-psych]. The package *lavaan* [89] is employed for structural equation modeling (SEM). SEM is an extension of linear regression analysis with two characteristic features: they consider several regression equations simultaneously, and an independent (exogenous) variable in one equation can be a dependent (endogenous) variable in another equation [89]. The analyses involved two steps. First, it is defined the measurement model of the four factors analyzed (knowledge, interest, perception and engagement) that specifies the observed indicators of each latent variable (the factors) with the function *cfa*. Second, it is tested the structural model reflecting the hypothesized association among the factors or latent variables with the function *sem*. The syntax of the analyses is included in the annexes. The final structural models are graphically depicted with the function *semPaths* of the package *semPlot* [90]. The *modificationindices* function of *lavaan* is employed to identify whether there are other relevant covariances to include in the model to improve the fit. The criterion was established that only variables with loadings of 0.30 or over are kept in the final structural model [91]. Nevertheless, SEM models require at least two indicators for each factor. Hence, when the factor is explained by only two variables, it has been necessary to keep them in the model even though the loadings were below 0.30.

In assessing the adjustment of the model, the *fitmeasures* function of *lavaan* is employed to obtain the Comparative Fit Index (CFI) and the Root Mean Squared Error of Approximation (RMSEA). It is considered that the fit is good if CFI is over 0.95 [92], although values over 0.90 are also considered acceptable [93]; and if the RMSEA value is under 0.05, although those as high as 0.08 are considered reasonable [94]. The function *mvn* of the package *MVN* [95] was employed to assess multivariate normality. To deal with non-normal data, the *estimator = "MLM"* option is specified to obtain robust standard errors and the Satorra-Bentler scaled test statistic [89]. This way, it is assured that the model test statistic and the standard errors are not too large, avoiding the unjustified rejection of the null hypotheses that the parameters are zero and the model fits the data [96].

Finally, it is employed the function *assocstats* of the package *vcd* [97] to obtain the Cramer's V statistic to analyze the association between the country and the opinion about the engagement in decision making (*engageDM*) in the EB, and the function *mosaicplot* of the package *graphics* [98] to graphically depict the Adjusted Standardized Residuals and identify the specific boxes in which there are significant statistical differences among the countries.

6 RESULTS

6.1 GSS – UNITED STATES

The descriptive results and factor loads obtained from the GSS are included in Table 1.

FACTOR	INDICATORS	STATISTICS[1]	LOADS
Knowledge	Science knowledge (*sciknow*)	6.25(2.31)	0.71
Knowledge	Knowledge about scientific inquiry process (*sciprocess*)	3.29(1.80)	0.73
Knowledge	Num. college-level science courses (*colscinm*)	2.72(6.72)	0.46
Knowledge	High school biology courses (*hsbio*)	1	0.43
Knowledge	High school chemistry courses (*hschem*)	1	0.42
Knowledge	High school physics courses (*hsphys*)	0	0.28
Interest	New scientific discoveries (*intsci*)	1	0.83
Interest	New inventions and technologies (*inttech*)	1	0.69
Interest	New medical discoveries (*intmed*)	2	0.51
Interest	Issues about space exploration (*intspace*)	1	0.68
Interest	R^2	0.19	-
Perception	Because of S&T there will be more opportunities for the next generation (nextgen)	3	0.20
Perception	Science makes our way of life change too fast (*toofast*)	2.5	0.36
Perception	Even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the Federal Government (*advfront*)	3	0.44
Perception	Balance between benefits and harmful effects of scientific research (*balance*)	4	0.52
Perception	R^2	0.67	-
Engagement	Seeking for information (*seekinfo*)	1.45(1.63)	0.32
Engagement	Visits (natural history museum, zoo, aquarium, science or technology museum	3.67(1.28)	0.41
Engagement	R^2	0.82	-

Table 1 Descriptive statistics and factor loads – General Social Survey. 1Mean (Standard Deviation): sciknow, sciprocess, colscinm, visits, seekinfo; Median: intsci, inttech, intmed, intspace, nextgen, toofast, advfront, balance; Mode: hsbio, hschem, hsphys

In the United States, the population seems to be more familiarized with science textbook knowledge (the mean is clearly over the midpoint value- 6.25 over 10) than with the scientific inquiry process (mean slightly under the midpoint - 3.29 over 7). There are three items in which over half the sample provided the wrong answer: the ones asking about the size of electrons, continental drifting and lasers. Although when the two options are combined the percentage of correct answers in the items asking about evolution is 60.63%, it is interesting to highlight that respondents have less difficulties to accept the theory of evolution when is referred to animals (elephants) (35.1% of correct answers) than to humans (25.52% of correct answers). Americans are moderately interested in developments in S&T and show a positive opinion about S&T. Nevertheless, in this sample there are few items measuring opinion about science and the critical perspective is not represented. Finally, results show the low level of engagement; especially regarding the tendency to search for information (the mean value is under the midpoint of the distribution – 3.67 over 8, with no great dispersion – SD is 1.28).

Figure 1a and Figure 1b show the measuring and structural models for the GSS 2018 sample.

All the indicators identified a priori significantly contributed to explain the four factors. The best indicators of *Knowledge* are knowledge about scientific inquiry process (*sciprocess*) and science knowledge (*sciknow*). The factor loads are respectively 0.73 and 0.71. *Interest* is best defined by interest in new scientific discoveries (the coefficient is 0.83) and, to a lesser extent, by interest in new inventions and technologies (0.69) and interest in issues about space exploration (0.68). *Engagement* is not well identified by the two available indicators, being the best the number of visits to science or natural history museums or zoos (0.41). Finally, *Perception* is neither well identified. The best indicator is the opinion on the balance between benefits and risks (*balance*, 0.52), followed by agreement with the statement that scientific research should be publicly supported even if it does not bring immediate benefits (*advfront*, 0.44).

In identifying the measuring model, there have been identified some co-variances. These imply there is some overlapping between interest in new medical discoveries and in new inventions and technologies, between science's courses received at high school, and between agreement with the statement on the need to publicly found science research (*advfront*) and on the opportunities provided by S&T for the next generation (*nextgen*). The adjustment of the measuring model is good (CFI = 0.95, RMSEA = 0.040).

In US, *Knowledge* is the central factor, with a direct and significant influence in the other factors. *Engagement*, than in this sample only includes activities related to informal science education is almost wholly explained by *Knowledge*, accounting for 81.7% of its variance. *Knowledge* has also a strong influence on *Perception*, explaining 68% of its variance. There is a positive and moderate correlation between *Interest* and *Perception* (r = 0.36), while *Knowledge* only explain 18.7% of the variance in *Interest*. The fit of the structural model is good (CFI = 0.963, RMSEA = 0.038).

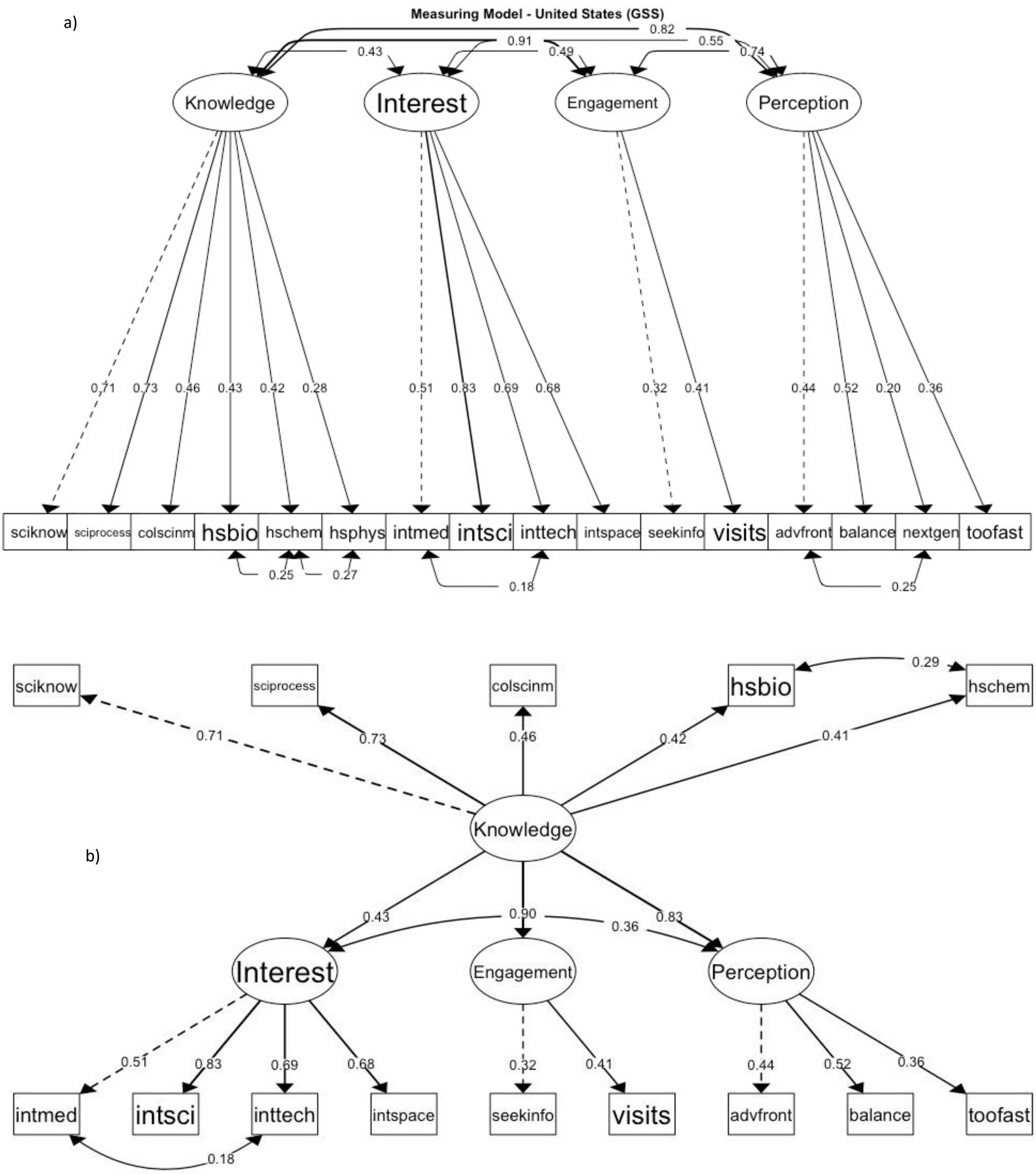


Figure 1 GSS (United States a) Measuring model; b) Structural model

6.2 EUROBAROMETER 79.2

The descriptive statistics and the factor loads for the nine countries analyzed (Bulgaria, Romania, Greece, Spain, Cyprus, Slovenia, UK, Denmark and Germany) are included in Table 2 and Table 3.

FACTOR	INDICATORS	DESCRIPTIVE STATISTICS[1]								
		BG	RO	GR	ES	CY	SI	UK	DK	DE
Background	Science capital (*scicapital*)	0	1	1	0	0	0	1	0	0
Background	Have you ever studied science & technology? (*scistudy*)	0	0	0	0	0	0	0	0	0
Attentiveness	Interested in science & technology (*interested*)	2	2	3	3	3	2	3	3	3
Attentiveness	Informed about science & technology (*informed*)	2	2	2	2	2	2	3	3	2
Attentiveness	Getting information about science & technology (*getinfo*)	2.59 (2.97)	2.88 (3.06)	3.58 (3.43)	2.91 (3.05)	3.32 (2.787)	4.18 (3.42)	3.97 (3.53)	5.92 (4.02)	4.61 (3.70)
Perception	Social influence of science (*socinfsci*)	3	3	3	3	3	3	3	3	3
Perception	We depend too much on science and not enough on faith (*Opinion1*)	2	2	2	2	2	3	2	3	3
Perception	Science makes our ways of life change too fast (*Opinion2*)	2	2	2	2	1	2	2	3	2
Perception	Thanks to S&T, there will be more opportunities for future generations (*Opinion3*)	4	3	4	4	4	4	4	4	4
Perception	The applications of S&T can threaten human rights (*Opinion4*)	2	1	2	2	2	2	2	3	2
Perception	S&T could be used by terrorists in the future (*Opinion5*)	2	1	2	1	1	1	1	1	2
Perception	S&T developments can have unforeseen side-effects that are harmful to human health and the environment (*Opinion6*)	2	1	2	2	1	2	2	2	2
Perception	If we attach too much importance to risks that are not yet fully understood, we could miss out on technological progress (*Opinion7*)	4	3	4	4	4	4	4	4	3
Engagement	What is the level of involvement citizens should have when it comes to decisions made about S&T (*engageDM*)	3	2	3	3	3	2	3	3	3

BG: Bulgaria, RO: Romania, GR Greece, ES: Spain, CY: Cyprus, SI: Slovenia, UK: United Kingdom, DK: Denmark, DE: Germany
[1]Median: scicapital, scistudy, interested, informed, socinfsci, Opinion1– Opinion7, engageDM ; Mean (Standard Deviation): getinfo

Table 2 Descriptive Statistics – Eurobarometer

FACTOR	INDICATORS	FACTOR LOADS								
		BG	RO	GR	ES	CY	SI	UK	DK	DE
Background	Science capital (*scicapital*)	0.50	0.40	0.43	0.49	0.46	0.47	0.35	0.40	0.55
Background	Have you ever studied science & technology? (*scistudy*)	0.76	0.62	0.73	0.73	0.64	0.84	0.63	0.71	0.75
Attentiveness	Interested in science & technology (*interested*)	0.66	0.77	0.69	0.65	0.75	0.89	0.64	0.70	0.73
Attentiveness	Informed about science & technology (*informed*)	0.61	0.71	0.71	0.68	0.87	0.79	0.59	0.69	0.69
Attentiveness	Getting information about science & technology (*getinfo*)	0.73	0.67	0.78	0.73	0.58	0.55	0.69	0.72	0.70
Attentiveness	R^2	0.72	0.68	0.82	0.64	0.46	0.30	0.94	0.54	0.50
Perception	Social influence of science (*socinfsci*)	0.33	0.67	0.50	-	-	0.39	0.32	0.45	0.42
Perception	We depend too much on science and not enough on faith (*Opinion1*)	0.42	0.22	-	0.61	-	0.47	0.51	0.54	0.50
Perception	Science makes our ways of life change too fast (*Opinion2*)	0.19	-	-	0.59	-	0.43	0.58	0.60	0.49
Perception	Thanks to S&T, there will be more opportunities for future generations (*Opinion3*)	0.30	0.49	0.60	0.31	-	-	-	0.41	0.47
Perception	The applications of S&T can threaten human rights (*Opinion4*)	0.73	0.32	-	0.57	-	0.56	0.67	0.59	0.49
Perception	S&T could be used by terrorists in the future (*Opinion5*)	0.60	0.22	-	0.46	-	0.38	0.35	-	0.32
Perception	S&T developments can have unforeseen side-effects that are harmful to human health and the environment (*Opinion6*)	0.67	0.24	-	0.57	-	0.41	0.49	0.41	0.30
Perception	If we attach too much importance to risks that are not yet fully understood, we could miss out on technological progress (*Opinion7*)	0.29	0.50	0.60	0.22	-	-	-	-	-
Perception	R^2	0.11	0.55	0.30	0.15	-	0.08	0.18	0.32	0.21
Engagement	What is the level of involvement citizens should have when it comes to decisions made about S&T (*engageDM*)	0.43	0.44	0.20	0.44	0.20	0.21	0.23	0.34	0.26
Engagement	R^2	0.18	0.19	0.04	0.20	0.04	0.05	0.06	0.12	0.07

BG: Bulgaria, RO: Romania, GR Greece, ES: Spain, CY: Cyprus, SI: Slovenia, UK: United Kingdom, DK: Denmark, DE: Germany

Table 3 Factor Loads – Eurobarometer

6.2.1 EB – BULGARIA

There is 50,2% of Bulgarians that have not studied S&T, 35.66% have studied S&T at school and 13.36% at university. The value of science capital is 0 for 84.5% of respondents, another 14% has a relative with a job or a university qualification in S&T, 1.20% with two, and 0.39% with more than two. There is 22.50% of Bulgarians not at all interested in S&T, 41% not very much interested, 27.9 fairly interested and 5.80% very interested. Besides, 27.80% are not at all informed, 46.40% consider themselves not very well informed, 20.63% say they are fairly well informed and 3.24% very well informed. The mean of the getting information about science indicator is 2.59 with a maximum of 16 and a SD of 3.06. Almost 20% do not manifest an opinion about the social influence of science on Bulgarian society, 5.90% consider it is negative and 75% find it is positive. There are 67% agreeing that we depend too much on science and not enough in faith, 20.83% neither agree nor disagree, and 7.30% disagree. Besides, 82.32% agree that science makes our ways of life change too fast, 10.4% neither agree nor disagree, and 2.95% disagree. There is almost 10% of respondents who not have an opinion about the possibility that the applications of S&T can threaten human rights, 55.10% agree, 23.58% neither agree nor disagree, and 11.40% disagree. On the other hand, 73% agree that S&T could be used by terrorists in the future, 13.85% neither agree nor disagree, and 3% disagree. Similarly, 71.32% agree that developments in S&T can have unforeseen side-effects that are harmful to human health and the environment, 16.31% neither agree nor disagree, and 3.24% disagree. On the contrary, less than 2% of the respondents disagree that thanks to S&T there will be more opportunities for future generations, 10.81% neither agree nor disagree, and 83% agree. Otherwise, 13% say they don't know if we could miss out on technological progress if we attach too much importance to risks that are not yet fully understood, 28.6% disagree, 24.75% neither agree nor disagree, and 57.3% agree. Finally, 16.80% do not answer the question about the level of involvement citizens should have when it comes to decisions made about S&T, 3.63% consider citizens do not need to be involved or informed, for 28.49% citizens should only be informed, for 33.3% citizens should be consulted and their opinion should be considered, 14.64% consider citizens should participate and have an active role, and for 3.14%, citizens' opinions should be binding.

The SEMs for Bulgaria are depicted in Figure 2a and Figure 2b. *Background* is best defined by having studied science, although science capital is also a good indicator. *Attentiveness* is almost equally identified by the three indicators, although the load of getting information about science is slightly higher. *Perception* is best defined by the opinion about the possibility that the applications of S&T threaten human rights (*Opinion4*) and about their unforeseen side-effects for human health and the environment (*Opinion6*).

In this country, *Background* contributes to define "Attentiveness and Perception", explaining 71.8% and 11.2% of their variance respectively. The opinion about the social influence of science (*socinfsci*) is explained by *Attentiveness* instead of by *Perception*. *Engagement* is predicted by *Attentiveness*, explaining 18.4% of its variance. The fit of the model to the data is good (CFI= 0.959, RMSEA = 0.052).

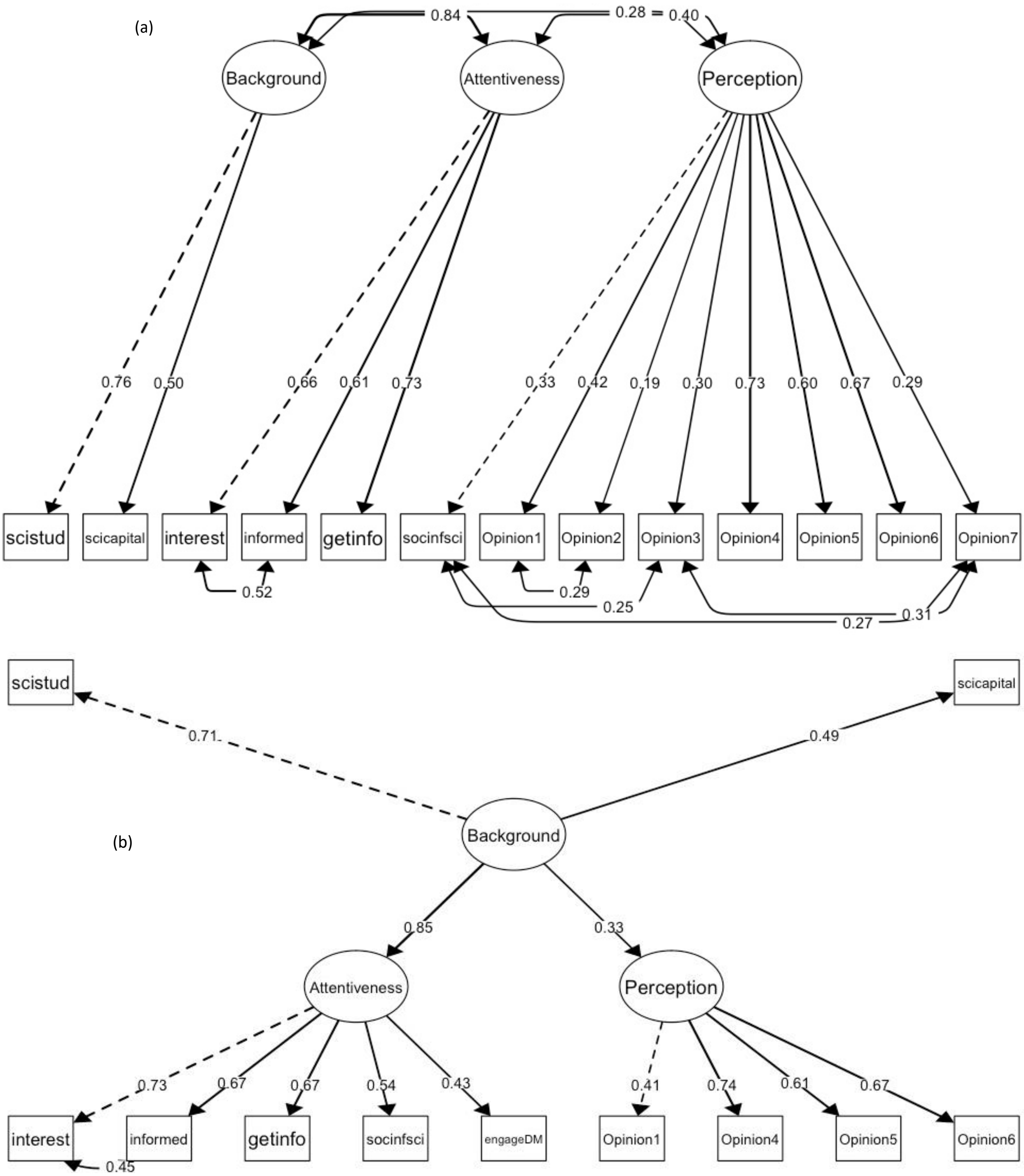
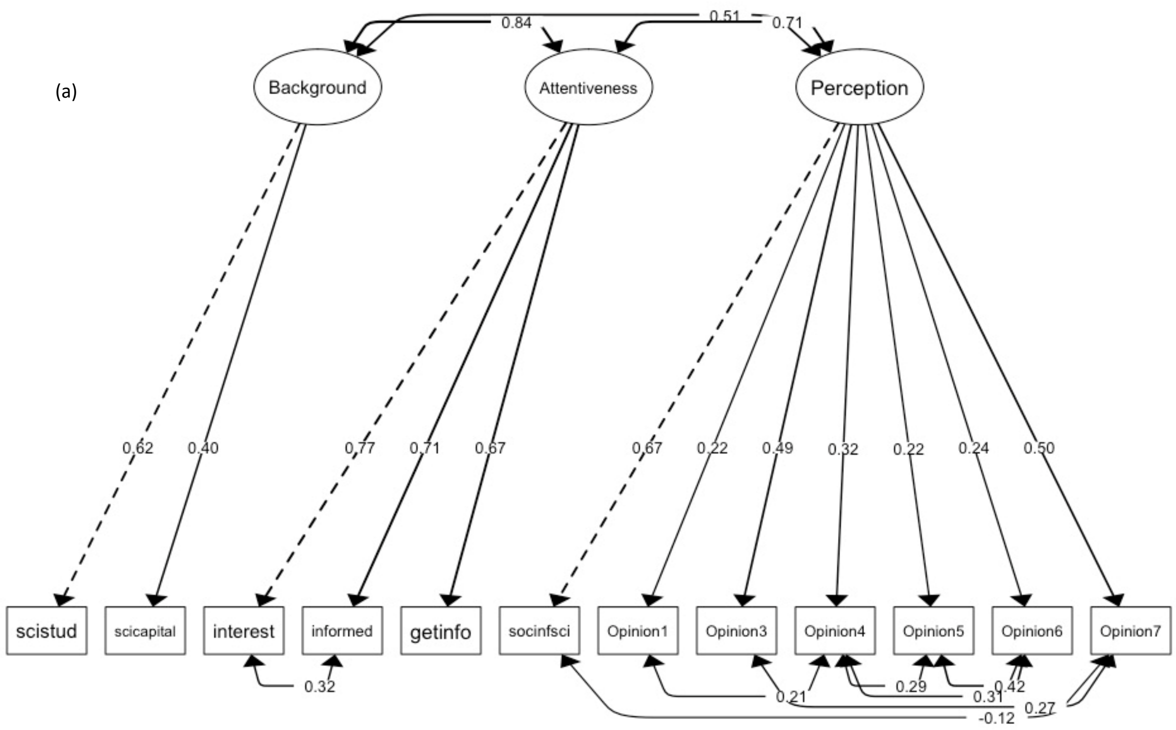


Figure 2 Eurobarometer 79.2 (Bulgaria) a) Measuring model; b) Structural model

6.2.2 EB – ROMANIA

With regards to *Background*, 67.67% of the population have studied science at school, 5.74% at university and 25.9% have not studied science or do not provide an answer (*scistud*); there is a 89.29% of respondents with no one in their family with a job or a university qualification in S&T, and 9.93% has one relative with a job or university qualification in S&T. Almost 25% of the respondents say they are not at all interested in developments in S&T, 37% is somewhat interested, 29.7% is rather interested and 7.21% is very interested. Besides, 33.5% of Romanians are not at all informed, 40.41% not very well informed, 20.45% fairly well informed, and 3.8% very well informed. Additionally, the do not seem to be involved in an active search for information about developments in S&T (the mean of getting information about science is 2.88, SD is 3.06 and the maximum value is 16). There is almost a quarter of the respondents not providing their opinion about the overall influence of S&T on Romanian society, 2.43% consider it is very negative,7.4% fairly negative, 51.22% fairly positive, and 15.29% very positive. Romanians tend to agree that we depend too much on science and not enough on faith (16% disagree or totally disagree, 30.48% opt for the "neither agree nor disagree" option and 48.4% agree or totally agree). They show more agreement with the idea that science makes our ways of life change too fast (only 8.28% disagree, while almost 68% agree, and 19% neither agree nor disagree). They also largely agree with the claim that applications of science and technology can threaten human rights (16.16% disagree, 25% select the undefined middle point and almost 46% agree), could be used by terrorists in the future (almost 7% disagree, and 64% disagree), or have unforeseen side-effects that are harmful to human health and the environment (6.63% disagree, 19.28% select the undefined middle option, and almost 64% agree). On the contrary, they mainly agree that thanks to S&T there will be more opportunities for future generations (66.8% agree, 19.47% have not a defined opinion, and 6.14% disagree) or that if we attach too much importance to risks not yet fully understood, we could miss out technological progress (7% disagree, 28.43% are undefined, and 49.47% agree). Besides, 8.47% consider that citizens do not need to be involved or informed, 31.74% consider they should only be informed, 28.82% opines that citizens should be consulted and their opinion should be considered, 11% agree that citizens should participate and have an active role, and 2.82% think that citizens' opinions should be binding.

The models for Romania are included in Figure 3a and Figure 3b. Having studied S&T is a better predictor of *Background* than science capital (the loads are, respectively, 0.63 and 0.40). *Attentiveness* is mainly explained by interest and being informed, although getting information about science also makes an important contribution to this factor. Positive opinions are more relevant to explain *Perception* than those representing a more critical perspective, being the most relevant the opinion about the overall influence of S&T for the country (*socinfsci*). *Background* only has a direct influence on *Attentiveness*, explaining a 67.9% of its variance. *Perception* is directly explained by *Attentiveness*, and indirectly by *Background* through the former, being the percentage of explained variance of 55.3%. The opinion about citizens' engagement in decision making regarding science is defined by *Perception*, that explains 19.2% of its variance. The fit of the model is good (CFI = 0.989, RMSEA = 0.027).



b) Structural model

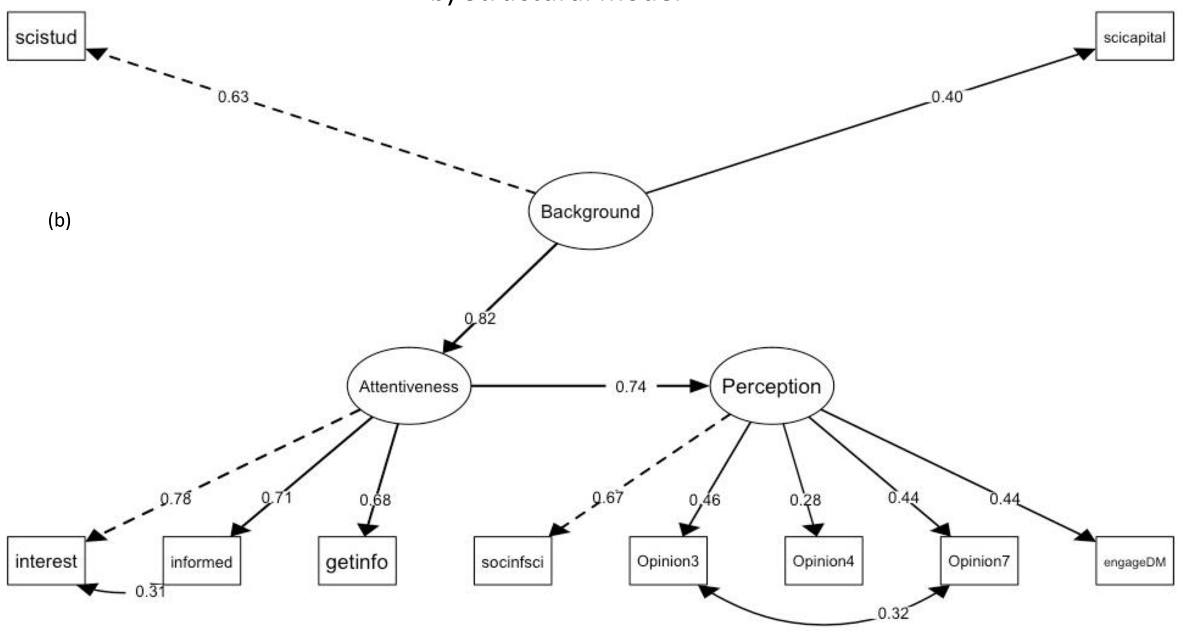


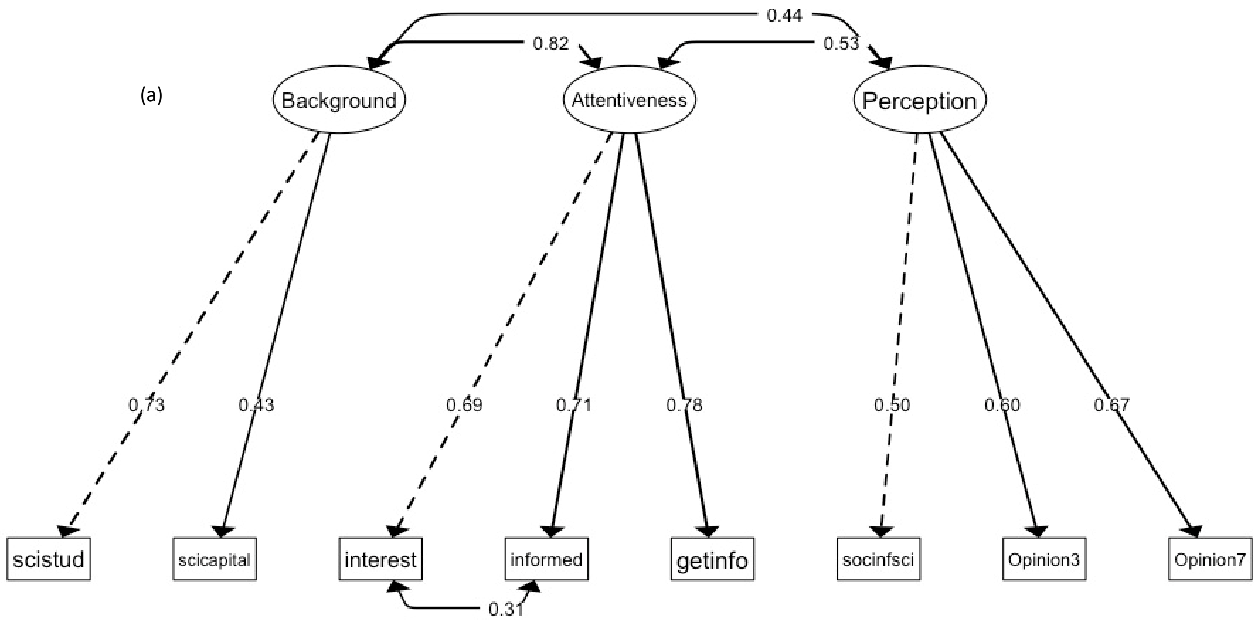
Figure 3 Eurobarometer 79.2 (Romania) a) Measuring model; b) Structural model

6.2.3 EB - GREECE

In this country, 49.7% of the respondents have not studied S&T at all, 33.7% at school, and 15.3% at university. There is a 74.8% that have no one in the family with a job or university qualification in S&T, while 23% has one member of the family meeting this condition. There is a medium level of interest in S&T (9.2% is not at all interested, 31.1% is not very interested, 47% is fairly interested and 12.5% is very interested). Respondents tend to feel not very well informed (22.3% perceive themselves not at all informed, 47% not very well informed, 25.8% fairly well informed and 4.8% very well informed). The mean for getting information about S&T is 3.58, the standard deviation is 3.25 and the maximum is 16. There is broad agreement around the idea that the global influence of S&T is positive for Greek society (89%). Greek's respondents tend to agree that we depend too much on science (62% agree, 14.4% disagree and 21.1% is undetermined). There are 89% who agree that science makes our ways of life change to fast, 7.9% neither agree nor disagree, and 1.4% disagree. There are 68.3% who agree that the applications of S&T can threaten human rights (9.1% disagree, and 19.3% neither agree nor disagree), while about 75% agree that S&T could be used by terrorists in the future (5.5% disagree and 15.3% is not sure). A majority agree about the possibility that developments in S&T have harmful side effects to human health and the environment (29.8% totally agree, 44.7% tend to agree, 16.8% neither agree nor disagree, 5.5% tend to disagree and 0.8% totally disagree). But also a majority agree about the good prospects S&T offer for future generations (75.2% agree, 5.9% disagree, 16.5% select the undetermined response), while 15.5% disagree with the worry that paying excessive weight to risks not yet fully understood might undermine technological progress, 53.9% agree and 25.2% neither agree nor disagree.

The results of SEM are shown in Figure 4a and Figure 4b. *Background* is better defined by science study (0.73) than by science capital (0.43). *Attentiveness* is better explained by getting information about science, being interest the worst indicator. Only the positive statements about S&T contribute to explain *Perception*: agreement that the overall influence of S&T for society is positive (*socinfsci*), agreement that S&T will provide more opportunities for future generations (*Opinion3*), and agreement that attaching excessive importance to risks not yet fully understood might hamper technological progress (*Opinion7*).

Background has a direct influence on *Attentiveness* (the load is 0.91 and thus explains 82.2% of its variance) and perception (0.55 and 30.7% of explained variance). Furthermore, engagement in decision making is explained by *Attentiveness*, and the association is weak (the coefficient is 0.20 and the percentage of variance explained is 3.8%). The model fits well the data (CFI = 0.976, RMSEA = 0.044).



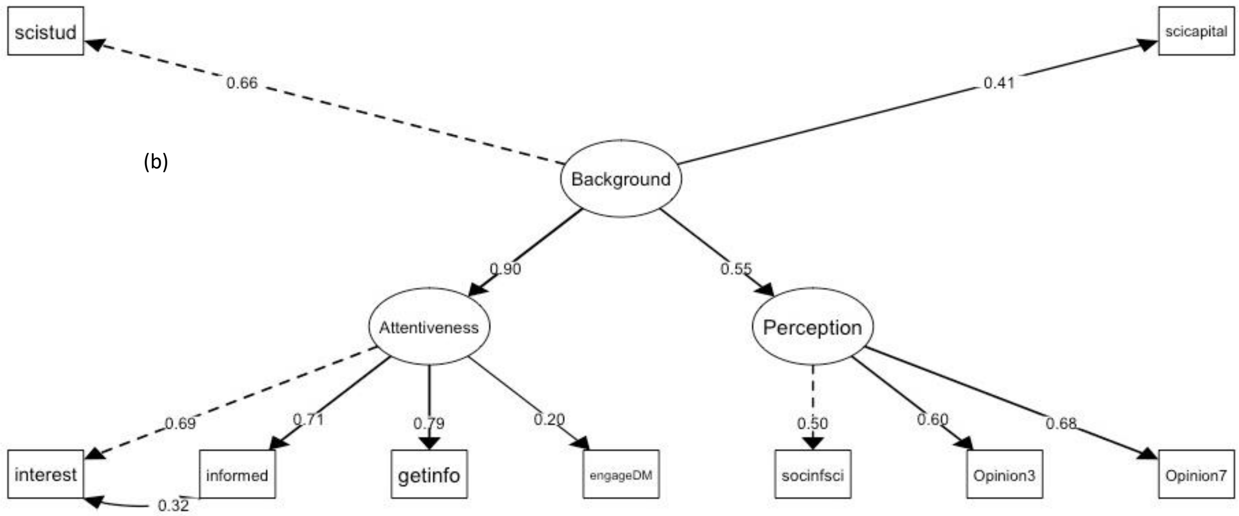


Figure 4 Eurobarometer 79.2 (Greece) a) Measuring model; b) Structural model

6.2.4 EB – SPAIN

Almost 60% of the respondents have not ever studied S&T, 30.7% have studied them at school and 8.57% at university. Regarding science capital, 75.57% have not a relative with a job or a university qualification in S&T, 23.43% has at least one, and only 1% has two or three relatives. There is 15.85% not at all interested in S&T, 33.5% not very interested, 38.29% fairly interested, and 11.86% very interested. On the other hand, 23.53% are not at all informed, 45.16% are not very well informed, 26.72% fairly well informed, and 4% very well informed. Consequently, Spanish citizens do not seem to invest great effort on getting information about S&T (Mean = 2.91, SD = 3.05). About 12% do not manifest an opinion about the overall influence of S&T on Spanish society, less than 10% consider it is very or fairly negative, and for 78.37% it is fairly or very positive. Almost half the respondents agree that we depend too much on science and not enough on faith, about 29% disagree, and 17.65% neither agree nor disagree. In the same vein, 78.37% agree that science makes our ways of life change too fast, 8.67% is undefined, and 11.16% disagree. There is also wide agreement about the possibility that S&T can threaten human rights (62.22% agree, 15.65% neither agree nor disagree, and 13% disagree), could be used by terrorists in the future (76% agree, 11,67% neither agree nor disagree, and 5,58% disagree), and even more that developments in S&T can have unforeseen side-effects harmful to human health and the environment (75.57 agree, 12.68% neither agree nor disagree and almost 6% disagree). Simultaneously, 72% agree that S&T will provide more opportunities for future generations (10.27% is undefined and 12.36% disagree). Opinion on the possibility that placing too much emphasis on risks that are not yet fully understood could be detrimental to technological progress is somewhat more evenly distributed: 56.63% agree, 16.555 neither agree nor disagree, 14% disagree, and 12.76% do not answer. Regarding public engagement in S&T decision making, 10.27% do not answer, 7.48% consider citizens do not need to be involved or informed, for 31.7% citizens consider they should only be informed, for 30.91% citizens should be consulted and their opinion should be considered, 12.46% agree that citizens should participate and have an active role, and 7.18% think that citizens' opinions should be binding.

The models obtained for Spain are shown in Figure 5a and Figure 5b. *Background* is better represented by having studied S&T (0.69) than by science capital (0.48). Getting information about science is a stronger indicator of *Attentiveness* (0.73) than interest (0.67) and being informed (0.68). The best determinants of *Perception* are the statements offering a critical perspective: we depend too much on science (*Opinion1*, 0.60), it makes our ways of life change too fast (*Opinion2*, 0.60), the applications of S&T can threaten human rights (*Opinion4*, 0.57), developments in S&T can have unforeseen side-effects that are harmful to human health and environment (*Opinion6*, 0.57), and S&T could be used by terrorists in the future (*Opinion5*, 0.46).

There is a direct effect of *Background* on *Attentiveness* and an indirect on *Perception* through Attentiveness. It explains 63.5% of the variance in *Attentiveness*, and *Attentiveness* explains 14.5% of the variance in *Perception*. Engagement in science decision making is a component of attentiveness and is not related to perception of science (the load is 0.44 and the percentage of variance explained is 19.6%). The fit of the model is acceptable (CFI = 0.933, RMSEA = 0.059).

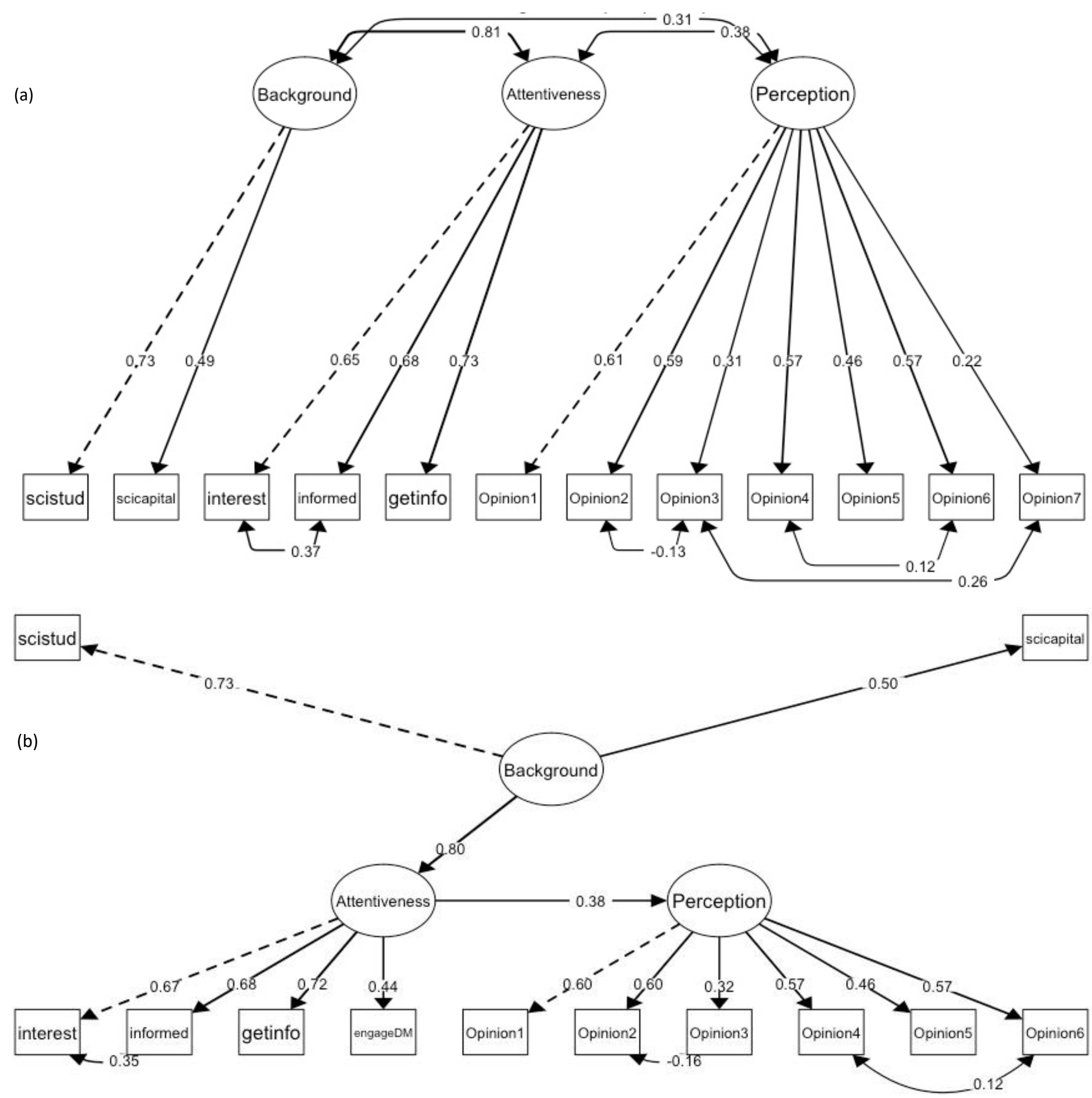


Figure 5 Eurobarometer 79.2 (Spain) a) Measuring model; b) Structural model

6.2.5 EB – CYPRUS

In this country, 74.46% of the population have not studied S&T or did not answer to the question, 14.65% have studied them at school, and 9.7% at university. There are 68.71% of respondents without any relative having a job or a university qualification on S&T, 30.1% with one relative, and 1.19% with two. There are 11.68% not at all interested in S&T, 24.36% not very interested, 45.74% fairly interested, and 18.22% very interested, while 15.25% are not at all informed, 47.13% not very well informed, 31.29% fairly well informed and 6.14% very well informed. The mean value of getting information about science is 3.32, and the standard deviation is 2.78 (the maximum is 16). In Cyprus, 30.10% of respondents consider overall influence of S&T on society is very positive, 57.23% fairly positive, 6.93% fairly negative, and less than 1% very negative. Additionally, 65.75% of respondents agree that we depend too much on science and not enough on faith, 21.98 neither agree nor disagree, and 12% disagree. And there is almost unanimity in believing that science makes our ways of life change too fast (93.47% totally agree or tend to agree, 5.54% neither agree nor disagree, and 0.79 tend to disagree). It is also widely accepted that the applications of S&T can threaten human rights (77.63% agree, 11.49% neither agree nor disagree, and 8.12% disagree), S&T could be used by terrorist in the future (84.35% agree, 7.72 neither agree nor disagree, and 4% disagree), or developments in S&T can have unforeseen side-effects that are harmful to human health and the environment (89.70% agree, 6.14% neither agree nor disagree, and 2% disagree). Simultaneously, 77.63% disagree that thanks to S&T there will be more opportunities for future generations (11.49% neither agree nor disagree, and 8.12% agree), but 65% agree that if we attach too much importance to risks that are not yet fully understood, we could miss out on technological progress (24.55% neither agree nor disagree, and 4.56% disagree). Finally, 5.74% did not give an opinion about the engagement of citizens in S&T decision making, 1.56% consider citizens do not need to be involved or informed, 34.85% consider citizens should only be informed, 26.93% consider citizens should be consulted and their opinion considered, 26.34% consider citizens should participate and have an active role, and 4.55% consider citizens' opinions should be binding.

The measuring and structural models for Cyprus are shown in Figure 6a and Figure 6b. In this country, *Perception* does not contribute to define the analyzed sector of the image of science. *Background* is better defined by having studied S&T (0.64) than by science capital (0.46). *Attentiveness* is mainly defined by being informed (0.87), followed by interest (0.75) and to a lesser extent, getting information about S&T (0.58). The load of *Background* on *Attentiveness* is moderate (0.67) and explains 45.5% of its variance, a percentage notably lower in comparison with the other countries. Engagement in S&T decision making is explained by *Attentiveness*, but the association is week (the coefficient is 0.2 and the percentage of variance explained is 4%). The fit of the model to the data is good (CFI = 0.971, RMSEA = 0.066).

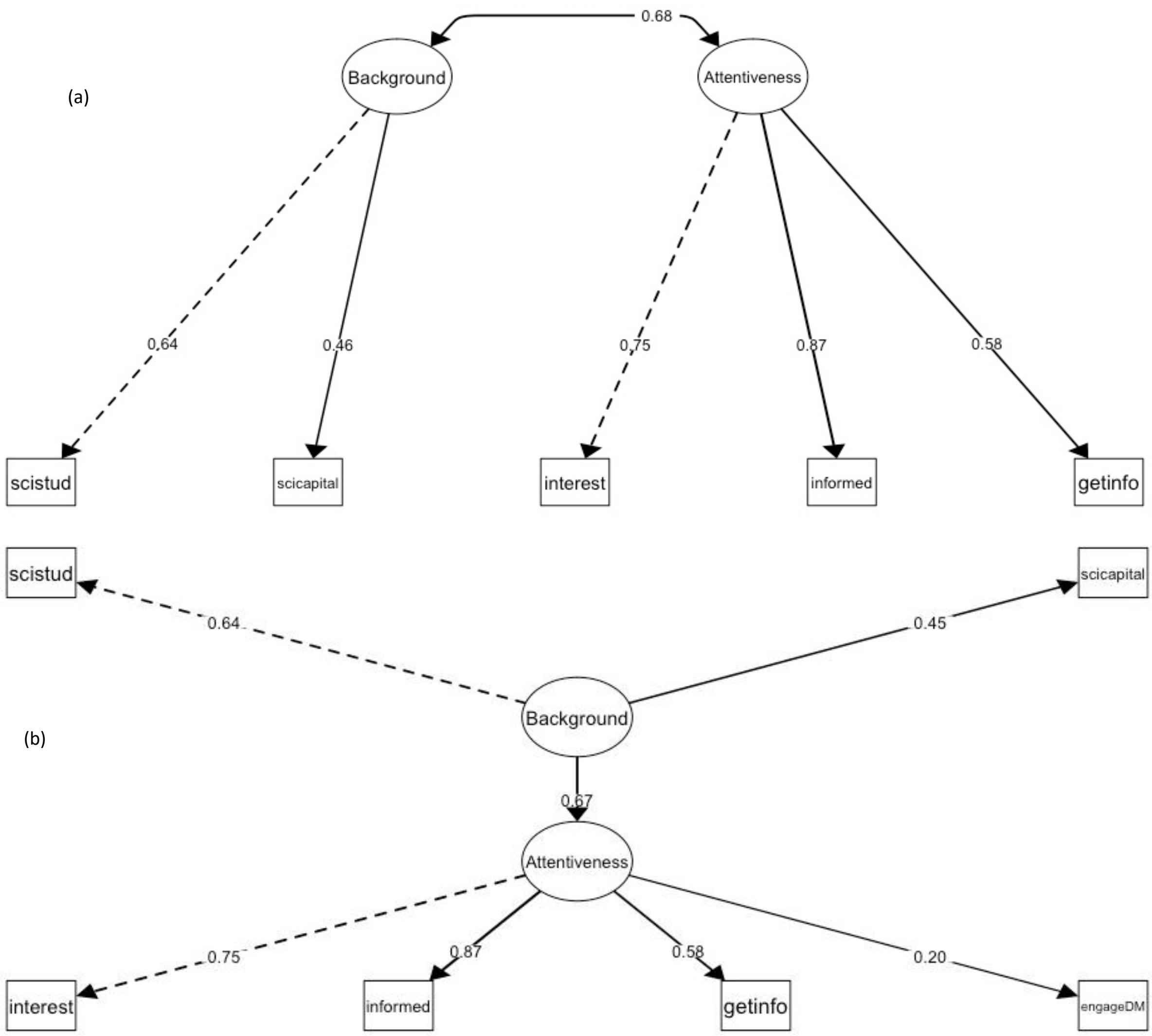


Figure 6 Eurobarometer 79.2 (Cyprus) a) Measuring model; b) Structural model

6.2.6 EB – SLOVENIA

There are 78.37% of the respondents that have never studied S&T, 9.83% at school and 10.23% at university. Regarding science capital, 84.17% of respondents do not have any relative with a job or a university qualification in S&T, 14.55% have one, and 1.28% more than one. There are 14.95% not at all interested in S&T, 35.10% not very interested, 39.33% fairly interested, and 10.62% very interested. On the other hand, 18% are not at all informed about S&T, 44.94% are not very well informed, 32.06% are fairly well informed, and 4.92% are very well informed. The mean value for getting information about S&T is 4.18 (SD is 3.42). There are 13.86% of respondents not answering the question about the overall influence of S&T for Slovenian society, for 1.08% it is very negative, for 11.50% is fairly negative, for 60.18% is fairly positive, and for 13.37% is very positive. There are 27.63% who agree that we depend too much on science and not enough in faith, 24.68% neither agree nor disagree, and 40% disagree. On the contrary, 80% agree that science makes our ways of life change too fast (12% neither agree nor disagree, and 7.47% disagree); 70.5% agree that the applications of S&T can threaten human rights (15.63% neither agree nor disagree, and 10% disagree); 84% agree that S&T could be used by terrorists in the future (6.88% neither agree nor disagree, and 5% disagree); and 87% agree that developments in S&T can have unforeseen side-effects that are harmful to human health and the environment (9% neither agree nor disagree, 3% disagree). At the same time, 63% agree that thanks to S&T there will be more opportunities for future generations (22.12% neither agree nor disagree, and 12.5% disagree), and 60.27% agree that giving too much importance to risks that are not yet fully understood could lead to miss technological progress opportunities (21.93% neither agree nor disagree, 11.3% disagree). Finally, 5.8% do not have an opinion about the level of involvement citizens should have regarding S&T decision making, 10.42% think citizens do not need to be involved or informed, 43.85% consider citizens should only be informed, for 24.29% citizens should be consulted and their opinion considered, for 13% citizens should participate and have an active role, and for 2.56% citizens' opinions should be binding.

The measuring and structural models for Slovenia are shown in Figure 7a and Figure 7b. The contribution of having studied S&T almost twofold the contribution of science capital (the regression coefficients are 0.84 and 0.47 respectively). *Attentiveness* is mainly explained by interest (0.89) and being informed (0.79). There are multiple covariations among the components of *Perception*, an indication that some overlap exists between them. The most significant indicator is the opinion about the possibility that the applications of S&T were able to threaten human rights (*Opinion4*, 0.56), followed by the opinion that we depend too much on science and not enough on faith (*Opinion1*, 0.48), science makes our ways of life change too fast (*Opinion2*, 0.43), developments in S&T can have unforeseen side-effects that are harmful to human health and the environment (*Opinion6*, 0.41) and the opinion about the overall influence of S&T on the country's society (*socinfsci*, 0.40). On the other hand, *Background* influences *Attentiveness* (0.42) and *Perception* (0.28). *Attentiveness* is also explained by *Perception* (0.26). Both factors explained 30% of its variance. *Background* explains 7.7% of the variance in *Perception*. Engagement in S&T decision making is determined by *Attentiveness*, but it only explains 4.5% of its variance. Despite all the parameters are significant, the fit of the model to the data is only minimally acceptable (CFI = 0.909, RMSEA = 0.062). This means that other relevant indicators are missing.

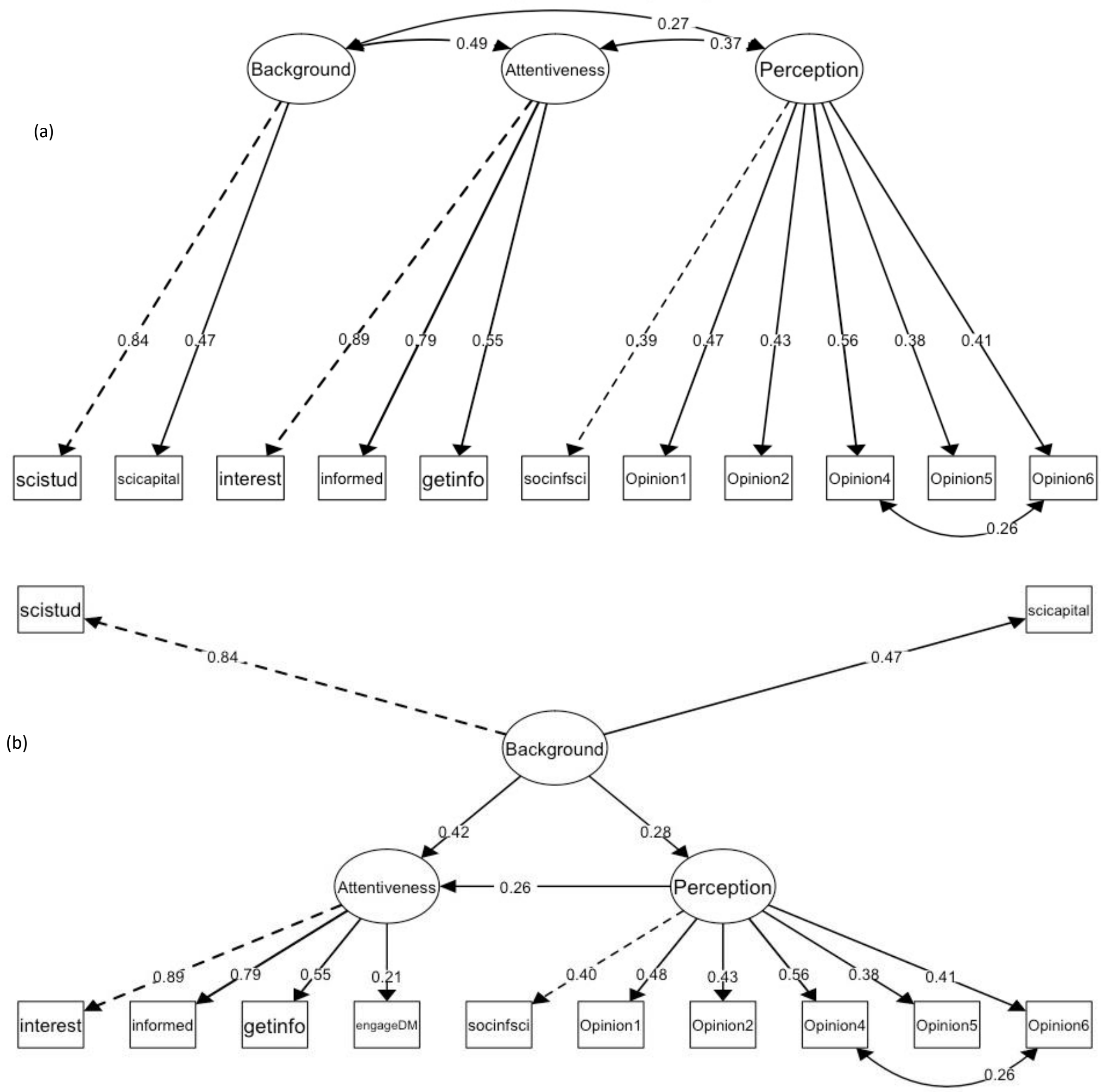


Figure 7 Eurobarometer (Slovenia) a) Measuring model; b) Structural model

6.2.7 EB – UNITED KINGDOM

There are 32.31% respondents who have not ever studied science, 50.20% have studied science at school, and 15.90% at university. Regarding science capital, 71.17% have no one in their family with a job or a university qualification in S&T, 27.14% have one relative meeting this condition, and 1.69% more than one. On the other hand, 14.12% are not at all interested in S&T, 22.96% are not very interested, 41.75% are fairly interested, and 20.87% are very interested, while 11.83% manifest to be not at all informed about S&T, 32.31% not very well informed, 43.84% fairly well informed and 10.93% very well informed. The mean value for getting information about S&T is 3.97 (SD is 3.53). There are 12.13% of respondents that did not offer an opinion about the overall influence of S&T on British society, 2.49% consider it very negative, 9.24% fairly negative, 53.08% fairly positive, and 23.06 very positive. The sample is practically divided into two equal halves among those who agree with the statement that we depend too much of science and not enough in faith (36.28%) and those who disagree (32.5%), while 28% neither agree nor disagree. There is somewhat more agreement that science makes our ways of life change too fast (42.38% versus 25.85%, while 19.58% neither agree nor disagree), and the applications of S&T can threaten human rights (52% agree, 26.34% neither agree nor disagree, and 16.30% disagree). On the other hand, it is widely accepted that S&T technology could be used by terrorists in the future (85.89% agree, 8.95% neither agree nor disagree, and 2.38 disagree) and that developments in S&T can have unforeseen side-effects harmful to human health and the environment (74.55% agree, 16.9% neither agree nor disagree, and 4.67% disagree). Simultaneously, 78.23% agree that thanks to S&T there will be more opportunities for future generations (13.62% neither agree nor disagree, and about 6% disagree), while 63.32% agree that if we attach too much importance to risks that are not yet fully understood, we could miss out on technological progress (22.27% neither agree nor disagree, and 9.64% disagree). Regarding the opinion about the involvement of citizens in decision making about S&T, 7.65% did not answer, 6.46% consider citizens do not need to be involved or informed, 23% agree citizens should only be informed, 49.60% agree they should be consulted and their opinion should be considered, 10.74% agree citizens should participate and have an active role, and 2.58% agree citizens' opinions should be binding.

The measuring and structural models for UK are shown in Figure 8a and Figure 8b. As it has been found in the other countries, *Background* is better defined by having studied science (0.63) than by science capital (0.35). The best predictor of *Attentiveness* is getting information about science (0.69) and for *Perception* is the opinion about the possibility that S&T applications can threaten human rights (*Opinion4*, 0.66), followed by the level of agreement with the statements: "science makes our ways of life change too fast" (*Opinion2*, 0.59), "we depend too much on science and not enough on faith" (*Opinion1*, 0.52), and "scientific and technological developments can have unforeseen side-effects that are harmful to human health and the environment (*Opinion6*, 0.48). The indicators reflecting a positive perspective about S&T are the less relevant. *Attentiveness* is almost wholly explained by *Background* (93.5%). *Background* also has a direct influence on *Perception*, although it explains only a 18.3% of its variance. The available indicators only explain 5.5% of the variance in the opinion about the citizens' engagement in S&T decision making, an indicator explained by

Perception in this country, although there is a strong covariance with *Attentiveness* (0.71). The fit of the model is acceptable (CFI = 0.918, RMSEA = 0.06).

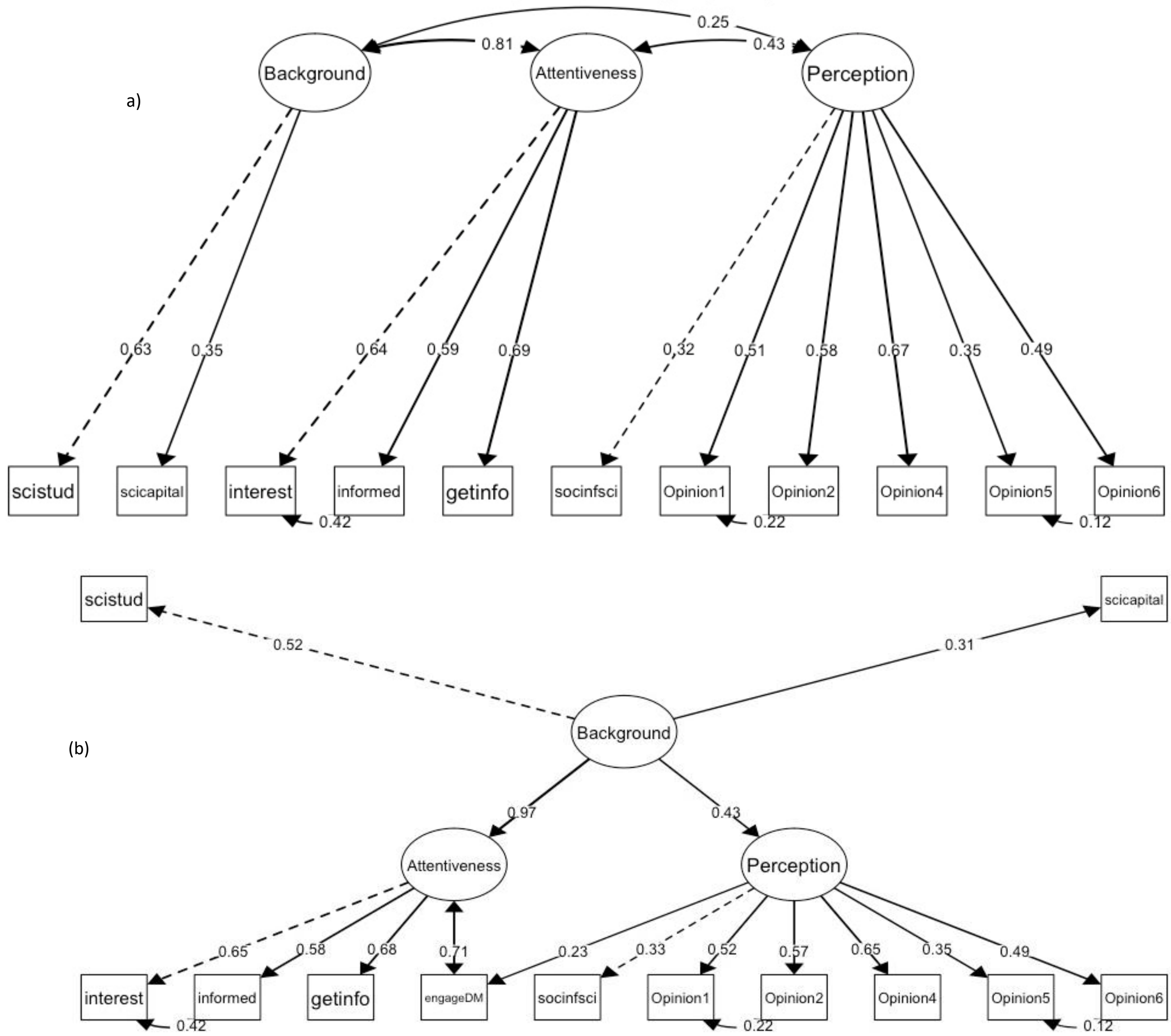


Figure 8 Eurobarometer 79.2 (United Kingdom) a) Measuring model; b) Structural model

6.2.8 EB - DENMARK

In Denmark, 61.55% of respondents have not ever studied S&T, 11.45% have studied S&T at school, 8% anywhere else, and 19% at university. The value of science capital is "0" for 66.53% (no one in the family have a job or a university qualification in S&T), 30.38% have one member of the family meeting this condition, 2.49% have two relatives and 0.6% have three. There are 4.98% not at all interested in S&T, 26.89% not very interested, 47% fairly interested and 20.82% very interested. Besides, 5.58% are not at all informed, 30.88% not very well informed, 47.71% fairly well informed, and 15.14% very well informed. The mean value for getting information about S&T is 5.92 (SD is 4.02). There are 10.56% of the respondents not answering the question about the overall influence of S&T on Danish society, 4.48% consider is very o fairly negative, 60.86% consider is fairly positive, and for 24.1% is very positive. There are 24.7% who agree that we depend too much on science and not enough on faith, 25.1% neither agree nor disagree, and 47.41% disagree. On the contrary, 46.11% agree that science makes our ways of life change too fast, 28.1% disagree, and 24.1% neither agree nor disagree. Also 46.41% agree that the applications of S&T can threaten human rights, 24.3% mention the neutral option and 26.2% disagree. There is almost consensus with the idea that S&T could be used by terrorist in the future (almost 90% agree, 6.67% neither agree nor disagree, and 2.4% disagree), and broad agreement that development in S&Ts can have unforeseen side-effects that are harmful to human health and the environment (80.48% agree, 12% neither agree nor disagree, and 4% disagree). Simultaneously, 84% agree that thanks to S&T there will be more opportunities for future generations (10.66% neither agree nor disagree and 3.59% disagree), and 68% agree that if we attach too much importance to risks that there are not yet fully understood, we could miss out on technological progress (20.42% neither agree nor disagree, and 8.66% disagree). Finally, 4.28% do not have an opinion about the involvement of citizens regarding S&T decisions, 4% consider citizens do not need to be involved or informed, for 19.12% citizens should only be informed, for 51.2% citizens should be consulted and their opinion should be considered, 18.13% agree that citizens should participate and have an active role, and 3.29% consider citizens' opinions should be binding.

The measuring and structural models for Denmark are shown in Figure 9a and Figure 9b. Again, *Background* is better defined by having studied science (0.71) than by science capital (0.40). *Attentiveness* is equally identified by getting information about S&T (0.72), interest (0.70) and being informed (0.69). *Perception* is best defined by the opinion about the effects of S&T applications on human rights (*Opinion4*, 0.59), the speed of change in our ways of life due to science (*Opinion2*, 0.59) and our excessive reliance on science in detriment of faith (*Opinion1*, 0.53), although it is also well defined by the opinion about the overall influence of S&T on Danish society (*socinfsci*, 0.47) and the good perspectives for future generations (*Opinion3*, 0.43).

Background contributes to explain *Attentiveness, Attentiveness* explains *Perception*, and engagement in decision making is directly explained by *Attentiveness* and indirectly by *Background*. This factor explains 54% of the variance in *Attentiveness*, and *Attentiveness* explains 31.7% of the variance in *Perception*. The model explains 12% of the variance in engagement in decision making. The fit of the model is minimally acceptable (CFI = 0.905, RMSEA = 0.071).

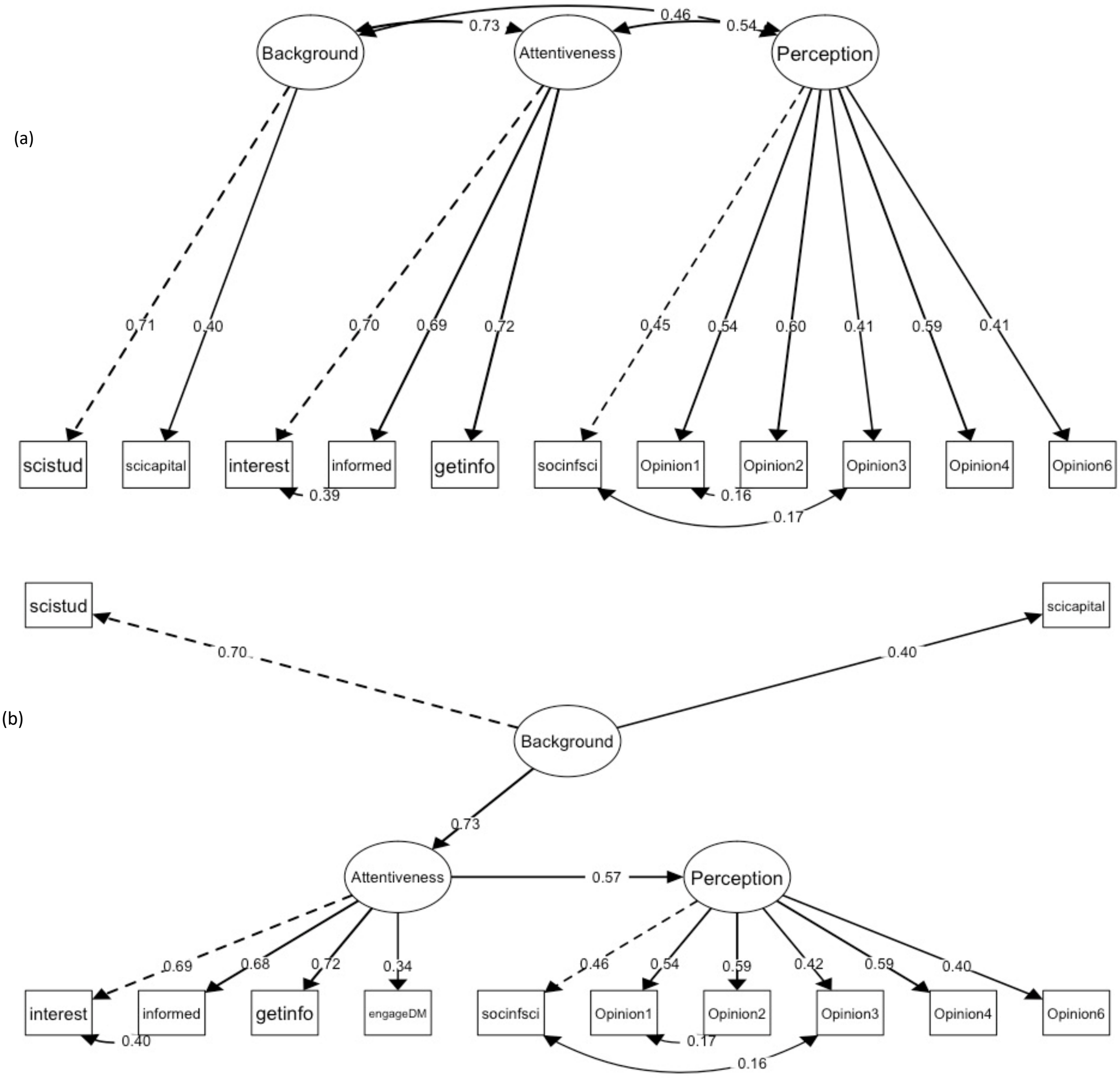


Figure 9 Eurobarometer 79.2 (Denmark) a) Measuring model; b) Structural model

6.2.9 EB - GERMANY

There are 68% of respondents that have not studied S&T, 17.48% at school, 13.4% at university, and 1.33% anywhere else. Almost three quarters of respondents do not have any relative with a job or a university degree in S&T (74.18%), 23% has one, 2.13% has two and 0.67% has three. There are 11% not at all interested in S&T, 33.76% not very interested, 39.69% fairly interested, and 14.74% very interested. There are 12.61% not at all informed about S&T, 41.69% not very well informed, 37.22% fairly well informed, and 6.4% very well informed. The mean value for getting information about S&T is 4.6 (SD = 3.7). There are 15.54% of respondents that do not value the overall influence of S&T for German society, 0.87% consider it is very negative, 6.74% fairly negative, 61.11% fairly positive, and 15.74% very positive. Another 34% agree that we depend too much on science and not enough in faith, 24.35% neither agree nor disagree, and 36.83% disagree. The agreement with the statement that science makes our ways of life change too fast is higher (52%), while 21.81% opt for the neutral/undefined option, and 23.6% disagree. On the other hand, 48.9% agree that the applications of S&T can threaten human rights, 22.35% neither agree nor disagree, and 23.62% disagree. Besides, 78.25% agree that S&T could be used by terrorists in the future, 11.47% neither agree nor disagree, and 5.67% disagree. Also, 80.26% agree that development in S&Ts can have unforeseen side-effects that are harmful for human health and the environment. Finally, 80.72% agree that thanks to S&T there will be more opportunities for future generations (12% select the middle option, and 4.27% disagree), while 49% agree that if we attach too much importance to risks that are not yet fully understood, we could miss out on technological progress (20.68% neither agree nor disagree, and 23.48% disagree). For 3.47%, citizens do not need to be involved or informed when it comes to decisions made about S&T, 24.48% consider citizens should only be informed, for 48.37% citizens should be consulted and their opinion should be considered, for 14.48% citizens should participate and have an active role, and 3.6% opine that citizens' opinions should be binding.

Figure 10a and Figure 10b depict the measuring and structural models for Germany. Again, science capital is a worse indicator of *Background* than having studied science, while the three indicators of *Attentiveness* contribute equally to identify this factor. Regarding *Perception*, there are two groups of indicators considering the loads' size. The most relevant indicators include the opinion about the influence of S&T in society (*socinfsci*), agreement with the statements that we depend too much on science (*Opinion1*), science makes our ways of life change too fast (*Opinion2*), the applications of S&T can threaten human rights (*Opinion4*), and thanks to S&T there will be more opportunities for future generations (*Opinion3*). On the other hand, *Background* influences directly *Attentiveness* that in turn influences *Perception*. Engagement in S&T decision making is directly influenced by *attentiveness* that, with the indirect contribution of *Knowledge*, explains 6.6% of its variance. *Background* explains 50% of the variance in *Attentiveness*, and *Attentiveness* 21% of the variance in *Perception*. The model fits the data properly (CFI = 0.918 and RMSEA = 0.06).

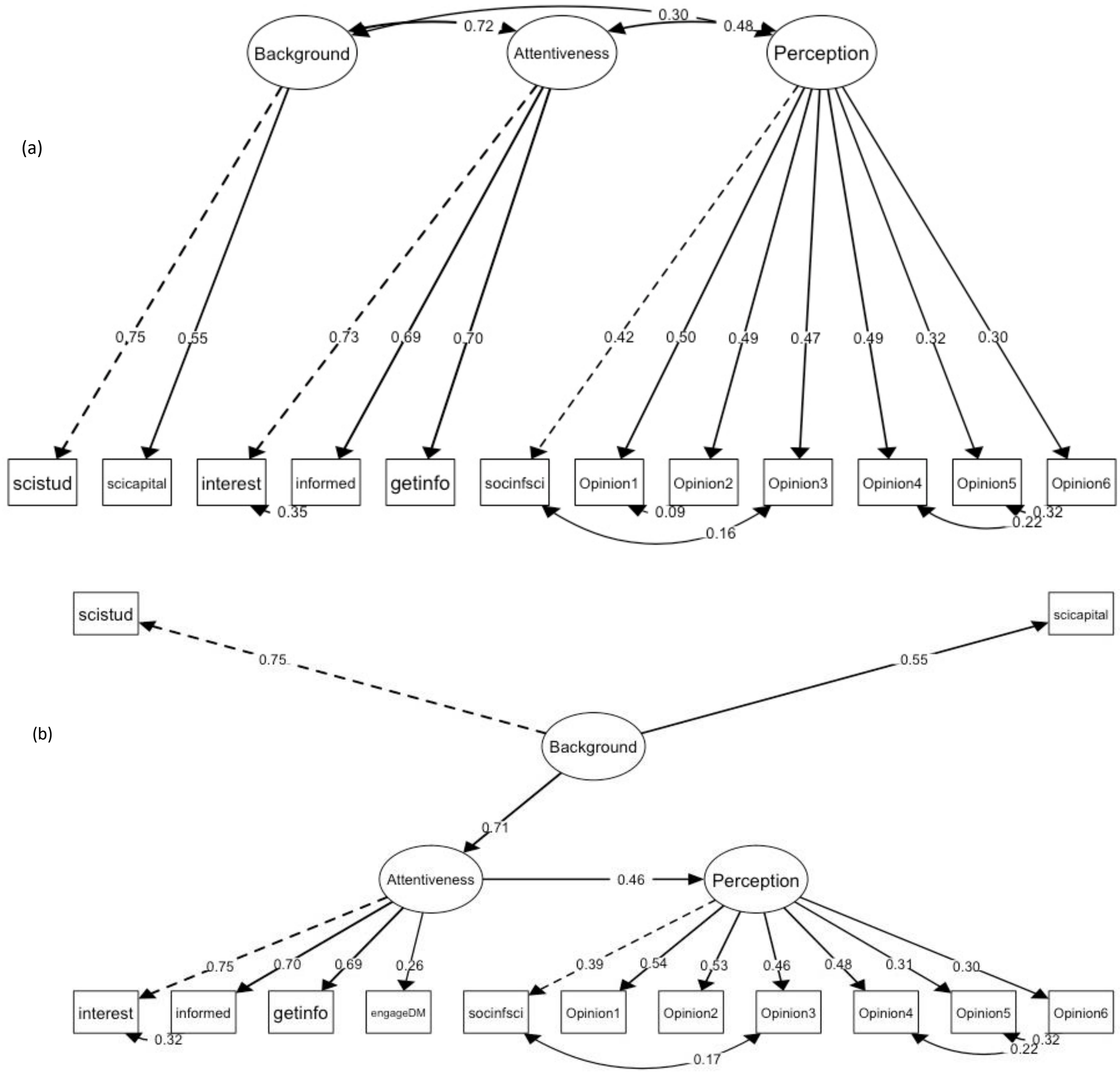


Figure 10 Eurobarometer 79.2 (Germany) a) Measuring model; b) Structural model

6.3 SPST - SPAIN

Table 4 shows the descriptive statistics and factor loads of the Spanish Survey of Social Perception of Science and Technology.

FACTOR	INDICATORS		STATISTICS[1]	LOADS
Knowledge	Literacy		4.24(1.22)	0.37
Knowledge	Self-perception of knowledge (*SelfPercep*)		11.65(3.30)	0.78
Knowledge	Dispositions		37.40(10.42)	0.42
Interest	Informative interest in S&T (*STInfointerest*)		0	0.41
Interest	"To what extent you are interested in S&T" (*STinterested*)		3	0.73
Interest	"To what extent you consider you are informed about S&T?" (*STInformed)*		3	0.77
Interest	Getting information about science (*getinfo)*		5.45(4.44)	0.55
Interest		R^2	0.66	-
Perception	"If you had to take stock of S&T taking into account all its positive and negative aspects, which of the following options would best reflect your opinion" (*STBalance*)		3	0.50
Perception	"If you had to take similar stock on some aspects of S&T, which of the following options would best reflect your opinion?" (*SocialBalance*)		18.65(6.31)	0.54
Perception	Risks of S&T applications (*AppRisk*)		20.4(6.98)	-
Perception	Benefits of S&T applications (*AppBenefit*)		20.79(6.76)	0.49
Perception	Opinion about decision making (*OpinionDM*)		13.77(3.43)	0.46
Perception	Opinion about science (*OpinionST*)		10.72(2.37)	0.48
Perception		R^2	0.39	-
Engagement	Visits to S&T museums during the previous year (*scimuseum*)		0	0.34
Engagement	Number of participations in science popularization activities in the previous year (*scipopula* R)		0	0.43
Engagement	Engagement in decision making (*engageDM*)		2	0.58
Engagement		R^2	0.57	-

Table 4 Descriptive statistics and factor loads – Spanish Survey of Social Perception of Science and Technology

[1]*Mean (Standard Deviation): Literacy, SelfPercep, Dispositions, getinfo, SocialBalance, AppRisk, AppBenefit, OpinionDM, OpinionST; Median: STinterested, STinformed, STBalance, scimuseum, scipopular, engageDM; Mode: STinforinterest*

Literacy ranges between 0 and 6, the mean is 4.24 and the standard deviation is 1.22. *Self-perception of knowledge* ranges between 0 and 29, the mean is 11.65 and the standard deviation is 3.30. The values of *Dispositions* are between 0 and 60, the mean value is 37.4 and the standard deviation is 10.43. There is 16.37% of respondents interested in news about S&T, the median of interest and be informed about S&T is 3 (somewhat interested and somewhat informed). Getting information about science ranges between 0 and 19, the mean value is 5.45 and the standard deviation is 4.44. The median of the balance between the positive and negative aspects of S&T is 3, that is also the maximum ("The benefits of S&T outweigh the harms"). In regards to the opinion about the negative and positive social consequences of S&T (*SocialBalance*), the range is between 0 and 27, the mean is 18.65, and the standard deviation is 6.31. Risks of S&T applications (*AppRisk*) measure the opinion about the risks of seven S&T applications. It ranges from 0 to 35, the mean is 20.4 and the standard deviation is 6.98. *AppBenefit* measures the opinion about the benefits of the same seven applications and it also ranges from 0 to 35, with a mean of 20.79 and a standard deviation of 6.76. The minimum value of opinion about decision making (*OpinionDM*) is 0, the maximum is 20, the mean is 13.77 and the standard deviation is 3.43. Opinion about S&T (*OpinionST*) measures respondents' agreement with three statements about S&T. It ranges from 0 to 15, the mean is 10.72 and the standard deviation is 2.37. The mean value of the number of visits to S&T museums (*scimuseum*) during the previous year is 0.5, although the maximum is 12, the standard deviation is 1.46. Regarding the participation in science popularization activities (*scipopular*), the minimum is 0, the maximum 13, the mean is 0.36 and the standard deviation is 1.34. Finally, the median of the opinion about decision-making on scientific issues of social relevance is 2 ("I would like citizens to be able to participate in decision-making on scientific issues but I do not want to get personally involved").

Figure 11a and Figure 11b include the measuring and structural models for the 2018 edition of the SPST survey. In this dataset, *Knowledge* is mainly explained by self-perception, i.e., the sense that one is good at science (the load is 0.78). On the contrary, *Dispositions* (0.42) and specially *Literacy* (0.37) have almost half the explicative power. *Interest* is mainly explained by being interested (0.73) and informed about S&T (0.77). Finally, the opinion about decision-making on scientific issues of social relevance (*engageDM*) is the best predictor of *Engagement* (0.58), followed by participation in science popularization activities (0.43). *Knowledge* has a direct influence on the other three factors, explaining 66.2% of the variance in *Interest* and 39% of the variance in *Perception*; therefore, *Knowledge* is a better predictor of *Interest* than of *Perception*. *Engagement* is predicted by *Knowledge* and, to a lesser extent, by *Interest*. It seems to be independent of *Perception*. Both *Knowledge* and *Interest* explain 57% of the variance in *Engagement*. The fit of the model to the data is good (CFI = 0.954; RMSEA = 0.040).

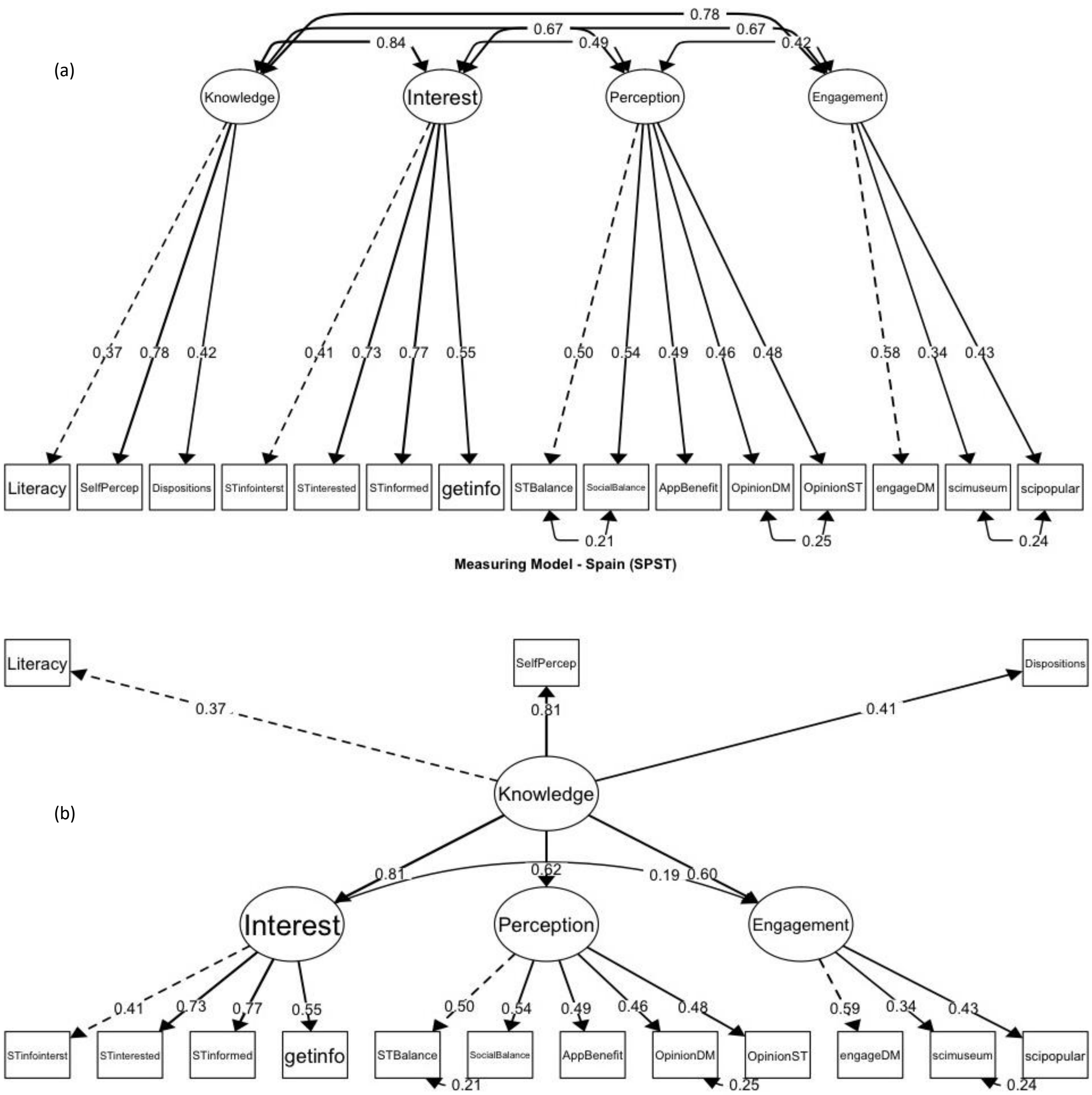


Figure 11 Social Perception of Science and Technology survey (Spain) a) Measuring model; b) Structural model

None of the data sets meet the assumption of multivariate normality. However, when tested the models obtaining robust standard errors and the Satorra-Bentler scaled test statistic [79], we found no differences between the results provided by the two procedures. This is not surprising as the violation of the assumption of normality may contribute to the rejection of accurate models, not to the confirmation of inaccurate ones [95]. Additionally, it is also established that to avoid problems when data violate the assumptions of multivariate normality, sample size need to adjust to a ratio of 15 respondents for each parameter [90], and the three data sets meet this criterion.

In performing the analyses three datasets were employed to compare different countries and different datasets: one (EB) includes indirect indicators of knowledge and interest, a very small sample of indicators of perception, and it also measures the opinion about engagement in science policy decisions, but does not include any indicator (direct or indirect) of engagement in informal science education; the other two (GSS and SPST) include direct indicators of the four factors considered (knowledge, interest, perception and engagement), although the GSS only measures engagement in informal science education, while the SPST dataset measures both types of engagement. When direct indicators of the factors are available, the structure of the association among them is tree shaped, being knowledge the trunk, and interest, perception and engagement the branches. When using indirect indicators, two structures are obtained, tree shaped and sequential, depending on the country. In the sequential structure, knowledge influences interest (attentiveness) that in turn influences perception. The sequential structure is present in Romania (low level of scientific development), Spain (medium level of scientific development), and Denmark and Germany (high level of scientific development).

On the other hand, using indirect indicators, and regardless the shape of the structure and level of development in S&T of the countries, the opinion about citizens' engagement in science policy decisions is directly influenced by interest (attentiveness) and indirectly by knowledge in most of the countries; while is independent of perception (opinions and attitudes). There are two exceptions: Romania, where engagement depends on perception, and United Kingdom, where engagement is influenced by perception at the same time that there is a strong covariation between engagement and attentiveness.

The analysis of the differences in opinion about the engagement in S&T decision making by country (Figure 12) shows two interesting findings.

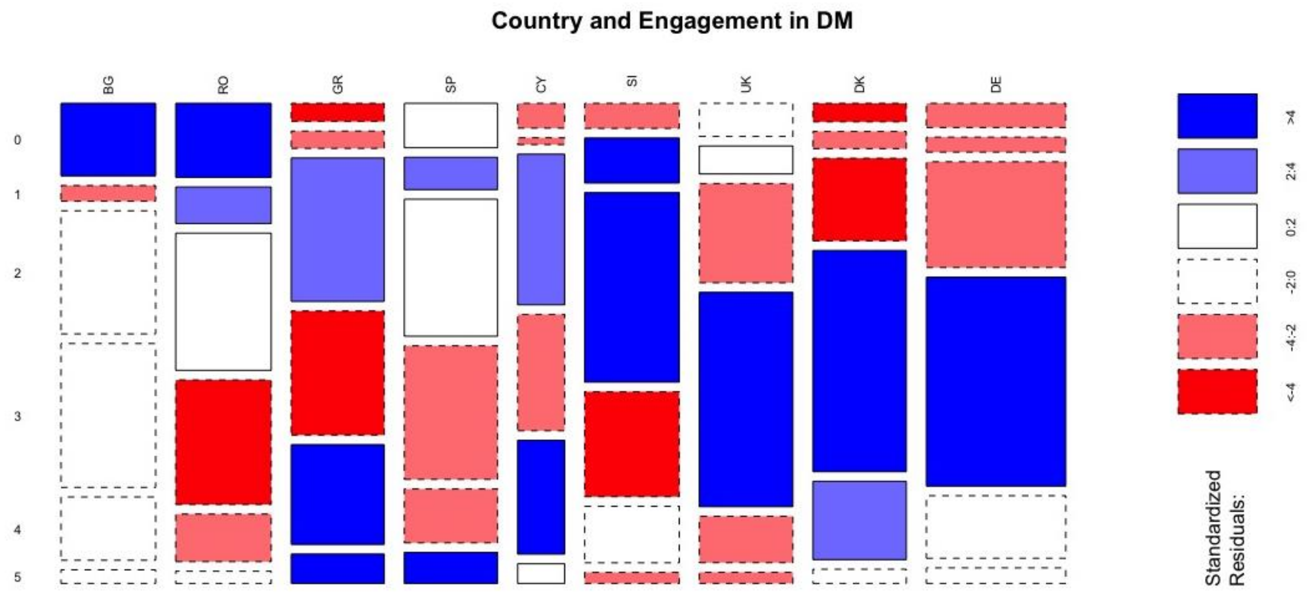


Figure 12 Adjusted Standardized Residuals of the Crosstab of Country and opinion about citizens' engagement in S&T decision making (engageDM)

On the one hand, there appears to be a pattern related to the level of scientific development of the country and thus there can be identified three groups. The group of the less developed countries (Bulgaria and Romania) stands out in the percentage of citizens who do not answer the question. The countries with an intermediate level of development in S&T (Greece, Spain and Cyprus) stand out because they significantly show higher figures of agreement in the extreme positions: (1) citizens do not have to be informed nor involved; and (2) citizens need to participate and have an active role, and even that their opinions should be binding. The citizens of United Kingdom, Denmark and Germany show the highest figures of agreement with the opinion that citizens should be consulted and their opinion considered. Finally, Slovenia does not match with any group. Ii is in the same group than United Kingdom regarding the level of development in S&T, but shows a pattern quite similar to the one of Romania.

On the other hand, each country shows its own peculiarities in the citizens' responses to the question about public engagement in S&T policy decisions. Greece is the country with a pattern of responses clearly most distinctive in comparison with the others.

Regarding interest (attentiveness), there are no big differences among the countries except in the percentages of the variance explained by knowledge. It ranges from 30% in Slovenia and 46% in Cyprus, two countries that show on the whole quite distinctive results when compared with the others, to 82% in Greece and 94% in UK.

Most part of the differences among the countries takes place in perception. For example, in USA, Romania and Greece, one of the most significant factors is the statement about the precautionary principle that, in turn, is not a predictor in Slovenia, UK, Denmark and Germany. In Romania and Greece, the weights of the positive statements are higher; in the other countries is the reverse. In Greece, in fact, science perception is only explained by the positive statements about S&T, while in Cyprus perception of science is not even an element of the image of science.

7 DISCUSSION

This work presents evidence that there is a segment of the image of science, shared by people from different countries, that is defined from the association among engagement, knowledge, interest and perception. Despite the shared structure, there are differences in the structure of the association among these factors that seem to depend on the way they are measured and the country. When the factors are measured directly, the structure is tree shaped, being knowledge the factor that influences the others. With indirect indicators, two structures are obtained, tree shaped or sequential, depending on the country. In the sequential structure, knowledge influences interest (attentiveness) that in turn influences perception. The sequential structure is present in Romania (low level of scientific development), Spain (medium level of scientific development), and Denmark and Germany (high level of scientific development). When there are available datasets with direct and indirect indicators of the factors for the same country (Spain), the relationship between them depends on the indicators, but it is tree shaped when there are direct indicators. This finding suggests that the structure of the association between the four factors depends more on the indicators than the country. This evidence is reinforced by the result of the analysis of the Special Eurobarometer 224 (2005), the last one that included direct indicators of knowledge, interest, perception and actions related to science. In this study, it was obtained a tree shaped structure when all the countries were analyzed simultaneously [99].

In line with what was hypothesized, knowledge is a key element in shaping the segment of the image of science defined by the four factors analyzed. Nevertheless, as it has already been mentioned, the relationship depends on the indicators and, to a lesser extent, on the country. We also found that knowledge is better defined by the sense of being good at science, and also by what can be described as features of a scientific attitude (the desire to know) that by a reduced sample of items measuring “textbook” knowledge about science. This finding highly resembles the concept of self-efficacy of Bandura [46, 47].

The evidence about the relationship of interest and perception with engagement does not go exactly in line with the initial hypothesis. It also depends on the indicators and the country. Focusing on the results obtained with the direct indicators, engagement is independent of interest and perception. When there are used indirect indicators, the opinion about citizens’ engagement in science policy decisions is directly influenced by interest (attentiveness), indirectly by knowledge, and it is independent of perception, although it is not this way in all the countries. Anyway, the countries’ differences do not seem to be explained by the level of development in S&T.

There have been identified two modalities of engagement, one that can be described as informal science education (ISE) and other focused on public participation in the governance of science. Engaging in ISE is easier, as citizens are recipients of the efforts and contents developed by the promoters of this type of engagement. It has been pointed that engaging in informal science education experiences is associated with science interest and attitudes [42], but our results do not support this assertion. When direct indicators of engagement in ISE are available (GSS), we found that engagement is not dependent on perception or interest, but on knowledge.

On the other hand, engaging in science policy decisions implies a deeper involvement, citizens are not the receptors of the actions designed by others, but need to develop an active role. When indirect indicators are available, the opinion about the engagement in decision making depends mainly on attentiveness. Attentiveness is closely associated with motivation and thus, it seems that engagement in S&T decision making is influenced by motivation in the majority of the countries when indirect indicators are available. When both types of engagement are considered (SPST), willingness to engage in S&T decision-making is a slightly better indicator of engagement than participation in informal science education activities, although the differences are small. But we must bear in mind that in the EB the question on engagement refers to the general opinion of the respondents about the role of citizens, while in the SPST is asked the willingness to personally be involved in S&T decision-making. These results are a clear indicator of one of the limitations of this study, i.e., the results strongly depend on the dataset.

When direct indicators are available (GSS and SPST), knowledge explains a high percentage of the variance of engagement. When there are employed indirect indicators (EB), the percentage of variance explained in engagement is significantly lower, although it is higher when it is obtained a tree shaped structure and, thus, knowledge is the direct predictor of engagement. Anyway, we should not ignore that even in countries with a consolidated tradition in public participation and involvement in S&T issues as Denmark [7], the majority of the population agrees that the participation of citizens in S&T decision-making should be limited to being consulted and their opinion considered, and does not agree that citizens should have an active role or their opinion should be binding. Therefore, it seems there are differences in the positions of promoters and receivers of the initiatives to engage the public in S&T decision making that does not seem to be an issue about to engage or not engage but about the level of engagement. To address the complexity of scientific knowledge, societies have developed a cognitive division of labor [100]. It seems that citizens, especially those most familiar with science and technology, have internalized this division and, therefore, are able to dissociate themselves from it while agreeing that it is important for society [100]. Our results point in this direction.

There is a pattern in the countries regarding the opinion of citizens about their participation in S&T decision-making that seems to depend on their level of development in S&T. The less developed stand out because of the lack of opinion of their citizens. The more developed stand out because the agreement predominates with the statement that citizens should be consulted and their opinion should be considered. Finally, the countries in the middle show a somewhat eclectic opinion: they stand out both because they consider that citizens should not participate in these decisions, and because they consider that citizens should participate and have an active role, and even their opinions should be binding. On the other hand, despite this pattern, the opinion of citizens about engagement in S&T decision-making has its own specificities in each country that seem to stem from "the 'integration' or 'embedding' of science in each national culture" [77, p.35]. For example, our results show that Great Britain is the only country of the more developed ones in which the opinion about citizens' engagement in S&T decision making is dependent on the perception of science. It is possible that this finding is the result of the long tradition of contesting the role played by science in policy in this country, the cradle of two reports that have defined two critical moments in public understanding of science activity [29]. In Denmark, a country with a long tradition in public engagement in S&T, the figures of people who believe that citizens should play an active role in S&T decision-making are particularly high. In this matter Denmark is similar to Greece and Cyprus. But it is also the country with the lowest percentage of people who believe that citizens do not need to be informed nor considered. It is possible that these results show the stages of the development of a consciousness about public engagement in science with respect to scientific policy that depends on the scientific culture of the country. Nevertheless, to properly identify the similarities and differences among countries and the influence of scientific culture, harmonized global datasets are needed that also include indicators of countries' scientific culture of the countries.

Despite the evidence that there is a strong, essentially linear relationship between interest and prior knowledge in which the latter is a strong determinant of the former [51], and that people with less knowledge about S&T are less interested [20], efforts to promote public understanding of science and participation have been primarily aimed at increasing interest [2]. However, in line with other studies [20, 51], we found that interest is largely explained by knowledge. This finding is independent of the indicators and the country. On the other hand, it has been mentioned that knowledge explains 20% of the variance in interest [51]. We found this result in the GSS using a sample of indicators of "textbook" knowledge of science and having studied science at school. In the EB, the percentage of variance explained ranges from 30% in Slovenia to 94% in UK using indirect indicators (science capital and having study science at school). In Spain, the percentage of variance in interest explained by knowledge is almost the same regardless there are used direct or indirect indicators (67% and 64% respectively). Therefore, it seems that the weight of knowledge in explaining interest depends more on the country than in the indicator. Although this result is very tentative and needs to be explored further.

On the other hand, although the results are dependent on the available indicators and the country, we found that perception of science depends directly on knowledge when the relationship between knowledge, interest and perception is tree shaped (with direct indicators and with indirect indicators in some countries). And it depends on interest and, indirectly through interest, on knowledge, when a sequential shape is obtained (with indirect indicators and only in some countries). On the other hand, there is evidence that people's perceptions of science in the abstract (the kind of perceptions that have guided public opinion surveys about science) are not as relevant as people's actual experiences and the way they sense the relevance or irrelevance of science for the satisfaction of particular needs and interests [58]. This result may explain the lack of association between interest and perception when the model includes indicators of perception about science in general. It is possible that the relationship of perception with knowledge and interest depends on how the factors are measured. However, our results show that, when there are available multiple indicators , the predominant relationship reflect a tree-shaped structure in which interest and perception are dependent on knowledge and are independent one form the other.

Finally, the perception of science is the factor that presents the greatest variability in terms of both the indicators and the country. Undoubtedly, the available indicators represent a very small portion of the elements that influence people's perception of science. Its relationship with knowledge and interest is positive and this means that knowledge and interest are associated with agreeing on positive statements about science and disagreeing with negative ones. Nevertheless, negative statements tend not to be significant predictors of perception when there are fewer negative statements than positive ones, and vice versa. Therefore, it seems that the positive and the negative dimensions of the perception of science should be analyzed separately. This is something to be explored. We must also begin to consider other relevant dimensions such as values [59, 60], trust [61], the confrontation between uncertainties and needs [62], and the public perception of the different "sciences" (e.g. academic, industrial and instrumental).

8 CONCLUSIONS

Citizens' opinion and their willingness to engage in science vary depending on characteristics of the country that do not seem to be fully explained by the level of scientific and technological development. In words of Martin W. Bauer [101, p.49]: "the way people think of, imagine, value, admire and contest scientists and scientific knowledge in their everyday life continues to vary across the world's persistent diversity". From the perspective of the conceptual model presented, it is considered that the scientific consciousness of individuals is influenced by the particular scientific culture of their country.

For the science-society relationship to be more fluid, it is necessary to listen to citizens and take into account that there is a majority aware that there is a social distribution of powers and functions. Therefore, although they certainly want to be heard, citizens also seem to consider that their attributions do not include getting involved in decision-making on S&T.

Public engagement in science is highly dependent on knowledge. At the same tame, the way in which people perceived themselves with respect to science knowledge has more influence on individual's image of science than the availability of specific "textbook" knowledge. Therefore, it would be convenient for institutional campaigns designed to address dysfunctionalities in the science-society relationship and promote public engagement in science to be aimed at: (1) improving the self-perceived efficacy of citizens about S&T; (2) fostering the development of a scientific attitude; and (3) encouraging citizens to search for, identify, and evaluate the most useful information to address the complexities of developments in S&T.

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ANNEX

ANNEX 1. R CODE - US GENERAL SOCIAL SURVEY 2018

```
#Perception
advfront <- GSS2018_SCI$ADVFRONT #adfront recoded from disagree to agree: even if not bring immediate benefits, scientific research that advances the frontiers of Knowledge is necessary and should be supported by the federal government.
table(advfront)
reorder1 <- function(x) {
ifelse(x == 1, 4, ifelse(x == 2, 3, ifelse(x == 3, 2, 1)))
}advfront <- reorder1(advfront)
table(advfront)
scibnfts <- GSS2018_SCI$SCIBNFTS # Would you say that, on balance, the benefits of scientific research have outweighted the harmful results, or have harmful results of scientific research been greater than its benefits
balneg <- GSS2018_SCI$BALNEG # strongly or slightly in favor of the marmful results
balpos <- GSS2018_SCI$BALPOS # strongly or slightly in favor of the benefits
table(scibnfts)
table(balneg)
table(balpos)
scibnfts <- ifelse(scibnfts > 3, 0, scibnfts) # 1, benefits greater; 2, about equal; 3, harmfult results greater; 0, DK
balneg <- ifelse(balneg > 2, 0, balneg) # 1, strongly in favor; 2, slightly in favor; 0, DK
balpos <- ifelse(balpos > 2, 0, balpos) # 1, strongly in favor; 2, slightly in favor; 0, DK
balance <- ifelse((scibnfts == 3 & balneg == 1), 1, ifelse((scibnfts == 3 & balneg == 2), 2, ifelse(scibnfts == 2, 3, ifelse((scibnfts == 1 & balpos == 2), 4, ifelse((scibnfts == 1 & balpos == 1), 5, 0)))))

nextgen <- GSS2018_SCI$NEXTGEN # because of science and technology, there will be more opportunities for the next generation
table(nextgen)
reorder2 <- function(x) {
  ifelse(x == 1, 4, ifelse(x == 2, 3, ifelse(x == 3, 2, ifelse(x == 4, 1, 0))))
}
nextgen <- reorder2(nextgen)
toofast <- GSS2018_SCI$TOOFAST # science makes our way of life change too fast; it's a negative statement so we do not reorder it.
toofast <- ifelse(toofast > 4, 0, toofast)
table(toofast)
A <- data.frame(advfront, balance, nextgen, toofast)
library(psych)
alpha(A) # Bad internal consistency. Is not appropriate to sum the 4 variables

# Creation of the science Knowledge indicator:
bigbang1 <- (GSS2018_SCI$BIGBANG)
bigbang2 <- GSS2018_SCI$BIGBANG1
bigbang3 <- GSS2018_SCI$BIGBANG2
bigbang <- ifelse((bigbang1 == 1 | bigbang2 == 1 | bigbang3 == 1), 1, 0)
condrift <- GSS2018_SCI$CONDRIFT
condrift <- ifelse(condrift == 1, 1, 0)
```

```
boyorgirl <- GSS2018_SCI$BOYORGRL
boyorgirl <- ifelse(boyorgirl == 1, 1, 0)
earthsun <- GSS2018_SCI$EARTHSUN
earthsun <- ifelse(earthsun == 1, 1, 0)
electron <- GSS2018_SCI$ELECTRON
electron <- ifelse(electron ==1, 1, 0)
evolved1 <- GSS2018_SCI$EVOLVED
evolved2 <- GSS2018_SCI$EVOLVED2
evolved <- ifelse((evolved1 ==1 | evolved2 == 1), 1, 0)
evolved_humans <- ifelse(evolved1 ==1, 1, 0)
evolved_elefants <- ifelse(evolved2 ==1, 1, 0)
round(prop.table(table(evolved_humans))*100, 2)
round(prop.table(table(evolved_elefants))*100, 2)
hotcore <- GSS2018_SCI$HOTCORE
hotcore <- ifelse(hotcore == 1, 1, 0)
lasers <- GSS2018_SCI$LASERS
lasers <- ifelse(lasers == 2, 1, 0)
radioact <- GSS2018_SCI$RADIOACT
radioact <- ifelse(radioact == 2, 1, 0)
viruses <- GSS2018_SCI$VIRUSES
viruses <- ifelse(viruses == 2, 1, 0)
sciknowdf <- data.frame(bigbang, boyorgirl, condrift, earthsun, electron, evolved,
hotcore, lasers, radioact, viruses)
sciknow <- rowSums(sciknowdf[, 1:10]) # Scientific Knowledge variable
library(psych)
alpha(sciknowdf)
#Internal consistency is low, but all the items are equally relevant. Thus, the
problem is the lack of other relevant items instead of the presence of bad items.
# Creation of the indicator of Knowledge about scientific inquiry process:
scitext <- GSS2018_SCI$SCITEXT
table(scitext)
# 0 means respondents consider they have little understanding of what it means to
study something scientifically. It scores 0
# 1 means they consider it means the formulation of theories and test hypothesis.
According to Durant et al. (1989) this option scores 3 points
# 2 and 3 refer to the notion of experimentation. Following Durant et al. (1989)
these options scores 2 points.
# 4 and 5 make vague references to measurement or classification and scores 1
point,
# 6, 8 and 9 socre 0 points.
scitext <- ifelse(scitext == 1, 3, ifelse((scitext == 2 | scitext ==3), 2,
ifelse((scitext == 4 | scitext == 5), 1, 0))) # First component of the Knowledge
of science process variable
odds1 <- GSS2018_SCI$ODDS1
odds2 <- GSS2018_SCI$ODDS2
odds1 <- ifelse(odds1 == 2, 1, 0)
odds2 <- ifelse(odds2 == 1, 1, 0)
oddsdf <- data.frame(odds1, odds2)
odds <- rowSums(oddsdf) # Second component of the Knowledge of science process
variable
exptext <- GSS2018_SCI$EXPTEXT
```

```
table(exptext)
# 0 means 'Don't know' (answer provided to the previous question)
# 1 means correct answer to explain response to the previous question, it scores 2 points.
# 2 means correct answer but vague reason, it scores 1
# The remaining options include correct and incorrect answers, but wrong reasons; they score 0 points.
exptext <- ifelse(exptext == 1, 2, ifelse(exptext == 2, 1, 0)) #Third component of the Knowledge of science process variable
# Sciprocess variable: Knowledge of the process of scientific inquiry
sciprocessdf <- data.frame(scitext, odds, exptext)
sciprocess <- rowSums(sciprocessdf)
alpha(sciprocessdf)

# Science courses at high school:
colscinm <- GSS2018_SCI$COLSCINM
colscinm <- ifelse((colscinm == 0 | colscinm == 98 | colscinm == 99), 0, colscinm)
hsbio <- GSS2018_SCI$HSBIO
hsbio <- ifelse(hsbio == 1, 1, 0) # Took a high scool biology course (no/yes)
hschem <- GSS2018_SCI$HSCHEM    # Took a high scholl chemistry course (no/yes)
hschem <- ifelse(hschem == 1, 1, 0)
hsphys <- GSS2018_SCI$HSPHYS    # Took a high school physics course (no/yes)
hsphys <- ifelse(hsphys == 1, 1, 0)

# Interest:
intmed <- GSS2018_SCI$INTMED
reorder <- function(x) {
  ifelse((x == 3 | x == 8), 0, ifelse(x == 2, 1, 2 ))
}
intmed <- reorder(intmed)
intsci <- GSS2018_SCI$INTSCI
intsci <- reorder(intsci)
inttech <- GSS2018_SCI$INTTECH
inttech <- reorder(inttech)
intspace <- GSS2018_SCI$INTSPACE
intspace <- reorder(intspace)

#Engagement:
##Creation of the seekinfo indicator
## Scifrom:
## Don't know and refuse (98, 99): 0
## Internet (3): 0 because it is codified appart and then both variables are summed
## TV (5), radio (6), family (8), friends (9), other (10): 1
## Newspapers (1), magazines (2): 2
## Government agencies (7), Ted Talks (11): 3
## Books (4): 4
scifrom <- GSS2018_SCI$SCIFROM
scifrom <- ifelse((scifrom == 98 | scifrom == 99 | scifrom == 3), 0, ifelse((scifrom == 5 | scifrom ==6 | scifrom == 8 | scifrom == 9 | scifrom == 10),
```

```
1, ifelse((scifrom ==1 | scifrom == 2), 2, ifelse((scifrom == 7 | scifrom == 11),
3, 4))))
## Scinews3:
## Don't know and refuse (98, 99): 0
## Other(10), search engine (11): 1
## Online news (1), online magazines (2), Wikipedia (6), social media (8): 2
## News site (4), Government site (7): 3
## Science site (3), books (5): 4
scinews <- GSS2018_SCI$SCINEWS3
scinews <- ifelse((scinews == 0 | scinews == 98 | scinews == 99), 0,
ifelse((scinews == 10 | scinews == 11), 1, ifelse((scinews == 1 | scinews == 2 |
scinews == 6 | scinews == 8), 2, ifelse((scinews == 4 | scinews == 7), 3, 4))))

## Seeksci:
## Don't know and refuse (98, 99): 0
## TV (5), radio (6), family (8), friends (9), other (11): 1
## Newspapers (1), magazines (2), Internet (3): 2
## Government (7): 3
## Books (4), library (10): 4
seeksci <- GSS2018_SCI$SEEKSCI
seeksci <- ifelse((seeksci == 98 | seeksci == 99), 0, ifelse((seeksci == 5 |
seeksci ==6 | seeksci == 8 | seeksci == 9 | seeksci == 11), 1, ifelse((seeksci ==
1 | seeksci == 2 | seeksci == 3), 2, ifelse(seeksci == 7, 3, 4))))
seekinfodf <- data.frame(scifrom, scinews, seeksci)
seekinfo <- rowSums(seekinfodf[, 1:3])
# Visits
visnhist <- GSS2018_SCI$VISNHIST
visnhist <- ifelse(visnhist == 0, 0, ifelse(visnhist == 1, 1, 2)) # 0, 1, 2 or
more
wvissci <- GSS2018_SCI$VISSCI
vissci <- ifelse(vissci == 0, 0, ifelse(vissci == 1, 1, 2)) # 0, 1, 2 or more
viszoo <- GSS2018_SCI$VISZOO
viszoo <- ifelse(viszoo == 0, 0, ifelse(viszoo == 1, 1, 2)) # 0, 1, 2 or more
V <- data.frame(visnhist, vissci, viszoo)
visits <- rowSums(V[, 1:3])

# Data frame:
gsskeai <- data.frame(advfront, balance, nextgen, toofast, bigbang, condrift,
boyorgirl, earthsun, electron, evolved, hotcore, lasers, radioact, viruses,
sciknow, sciprocess, colscinm, hsbio, hschem, hsphys, intmed, intsci, intspace,
inttech, seekinfo, visits)
save(gsskeai, file = "gsskeai.RData")
# DESCRIPTIVE ANALYSIS:
# Individual items and ordinal variables:
bigbangf <- factor(gsskeai$bigbang, labels = c("Wrong", "Correct"))
condriftf <- factor(gsskeai$condrift, labels = c("Wrong", "Correct"))
boyorgirlf <- factor(gsskeai$boyorgirl, labels = c("Wrong", "Correct"))
earthsunf <- factor(gsskeai$earthsun, labels = c("Wrong", "Correct"))
electronf <- factor(gsskeai$electron, labels = c("Wrong", "Correct"))
evolvedf <- factor(gsskeai$evolved, labels = c("Wrong", "Correct"))
hotcoref <- factor(gsskeai$hotcore, labels = c("Wrong", "Correct"))
```

```
lasersf <- factor(gsskeai$lasers, labels = c("Wrong", "Correct"))
radioactf <-factor(gsskeai$radioact, labels = c("Wrong", "Correct"))
virusesf <- factor(gsskeai$viruses, labels = c("Wrong", "Correct"))
round(prop.table(table(bigbangf)) * 100, 2)
round(prop.table(table(condriftf)) * 100, 2)
round(prop.table(table(boyorgirlf)) * 100, 2)
round(prop.table(table(earthsunf)) * 100, 2)
round(prop.table(table(electronf)) * 100, 2)
round(prop.table(table(evolvedf)) * 100, 2)
round(prop.table(table(hotcoref)) * 100, 2)
round(prop.table(table(lasersf)) * 100, 2)
round(prop.table(table(radioactf)) * 100, 2)
round(prop.table(table(virusesf)) * 100, 2)
summary(gsskeai$intmed)
summary(gsskeai$intsci)
summary(gsskeai$inttech)
summary(gsskeai$intspace)
summary(gsskeai$advfront)
summary(gsskeai$balance)
summary(gsskeai$nextgen)
summary(gsskeai$toofast)
library(modeest)
mfv(gsskeai$hsbio)
mfv(gsskeai$hschem)
mfv(gsskeai$hsphys)
# Summary and sd of numeric and aggregated variables:
summary(gsskeai$sciknow); sd(gsskeai$sciknow)
summary(gsskeai$sciprocess); sd(gsskeai$sciprocess)
summary(gsskeai$colscinm); sd(gsskeai$colscinm)
summary(gsskeai$visits); sd(gsskeai$visits)
summary(gsskeai$seekinfo); sd(gsskeai$seekinfo)
#Histograms of the numeric and aggregated variables:
library(ggplot2)
h1 <- ggplot(gsskeai, aes(x = sciknow)) +
  geom_histogram(bins = 7, color = "black", fill = "white") +
  ggtitle("Science text Knowledge")
h2 <- ggplot(gsskeai, aes(x = sciprocess)) +
  geom_histogram(bins = 7, color = "black", fill = "white") +
  ggtitle("Knowledge of science process")
h3 <- ggplot(gsskeai, aes(x = colscinm)) +
  geom_histogram(bins = 4, color = "black", fill = "white") +
  ggtitle("No. science courses")
h4 <- ggplot(gsskeai, aes(x = seekinfo)) +
  geom_histogram(bins = 8, color = "black", fill = "white") +
  ggtitle("Search of science info")
h5 <- ggplot(gsskeai, aes(x = visits)) +
  geom_histogram(bins = 4, color = "black", fill = "white") +
  ggtitle("No. visits related to science")
library(cowplot)
```

```
plot_grid(h1, h2, h3, h4, h5, nrow = 3)

# IDENTIFYING THE MEASUREMENT MODEL:
library(lavaan)
keai_mm1 <- '
Knowledge =~ sciknow + sciprocess + colscinm + hsbio + hschem + hsphys
Interest =~ intmed + intsci + inttech + intspace
Engagement =~ seekinfo + visits
Perception =~ advfront + balance + nextgen + toofast
'
fkeai_mm1 <- cfa(keai_mm1, gsskeai_comp)
summary(fkeai_mm1)
fitmeasures(fkeai_mm1, c("cfi", "rmsea", "srmr"))
# The fit is not good. We obtain the modification indices:
modificationindices(fkeai_mm1, minimum.value = 20) # and observe the need to include the covariances among the mentioned elements.
keai_mm2 <- '
Knowledge =~ sciknow + sciprocess + colscinm + hsbio + hschem + hsphys
Interest =~ intmed + intsci + inttech + intspace
Engagement =~ seekinfo + visits
Perception =~ advfront + balance + nextgen + toofast
# Covariances
hschem ~~ hsbio
hschem ~~ hsphys
advfront ~~ nextgen
'
fkeai_mm2 <- cfa(keai_mm2, gsskeai)
summary(fkeai_mm2)
fitmeasures(fkeai_mm2, c("cfi", "rmsea", "srmr"))
# The fit is acceptable, but we explore if there are other relevant covariances to include:
modificationindices(fkeai_mm2, minimum.value = 10) # It seems that there is also covariance between Interest in medicine and Interest in technology:
keai_mm3 <- '
Knowledge =~ sciknow + sciprocess + colscinm + hsbio + hschem + hsphys
Interest =~ intmed + intsci + inttech + intspace
Engagement =~ seekinfo + visits
Perception =~ advfront + balance + nextgen + toofast
# Covariances
hschem ~~ hsbio
hschem ~~ hsphys
intmed ~~ inttech
advfront ~~ nextgen
'
fkeai_mm3 <- cfa(keai_mm3, gsskeai)
summary(fkeai_mm3, standardized = TRUE)
fitmeasures(fkeai_mm3, c("cfi", "rmsea", "srmr"))# The fit now is good enough
library(semPlot)
```

```
semPaths(fkeai_mm3, what = "std", residuals = FALSE, rotation = 1, nCharNodes = 13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67, edge.label.cex = 0.75, label.prop = 1.5, curvePivot = TRUE)
title(main = list("Measuring Model - United States (GSS)", cex = 0.80, font = 2), line = 3)
library(MVN)
mvn(gsskeai, mvnTest = "mardia") # Analysis of multivariate normality. We reject the null hypothesis
fkeai_mm3 <- cfa(keai_mm3, gsskeai, estimator = "MLM") # We use de MLM estimator
summary(fkeai_mm3)
fitmeasures(fkeai_mm3, c("cfi", "rmsea", "srmr"))
# we can see that there are not differences between the standard and robust statistics. The correction factor is 1, indicating that there are no problems due to lack of normality, as is expected considering that we have 1148 observations.

# THE STRUCTURAL MODEL:
# According to Muñoz et al. (2017), we stem from the hypotesis that Knowledge is the predictor of Interest, Perception and Engagement. Engagement is also predicted by Perception and Interest.
gss_sem1 <- '
# Measurement model
Knowledge =~ sciknow + sciprocess + colscinm + hsbio + hschem + hsphys
Interest =~ intmed + intsci + inttech + intspace
Engagement =~ seekinfo + visits
Perception =~ advfront + balance + nextgen + toofast

#Covariances
hschem ~~ hsbio
hschem ~~ hsphys
hsbio ~~ hsphys
intmed ~~ inttech
advfront ~~ nextgen
# Regressions:
Perception ~ Knowledge
Interest ~ Knowledge
Engagement ~ Interest + Perception + Knowledge
'
fgss_sem1 <- sem(gss_sem1, gsskeai)
summary(fgss_sem1, standardized = TRUE, rsquare = TRUE)
fitmeasures(fgss_sem1, c("cfi", "rmsea", "srmr"))
# The result shows that Engagement is only predicted by Knowledge
gss_sem_2 <- '
# Measurement model
Knowledge =~ sciknow + sciprocess + colscinm + hsbio + hschem + hsphys
Interest =~ intmed + intsci + inttech + intspace
Engagement =~ seekinfo + visits
Perception =~ advfront + balance + nextgen + toofast
#Covariances
hschem ~~ hsbio
hschem ~~ hsphys
hsbio ~~ hsphys
```

```
intmed ~~ inttech
advfront ~~ nextgen
Interest ~~ 0*Engagement # The covariance between both is cero
# Regressions:
Perception ~ Knowledge
Interest ~ Knowledge
Engagement ~ Knowledge
'
fgss_sem_2 <- sem(gss_sem_2, gsskeai)
summary(fgss_sem_2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fgss_sem_2, c("cfi", "rmsea", "srmr"))
# The fit is good.
# Final model - excluding loads under 0.30:
gss_sem_fin <- '
# Measurement model
Knowledge =~ sciknow + sciprocess + colscinm + hsbio + hschem
Interest =~ intmed + intsci + inttech + intspace
Engagement =~ seekinfo + visits
Perception =~ advfront + balance + toofast
#Covariances
hschem ~~ hsbio
intmed ~~ inttech
Interest ~~ 0*Engagement
Perception ~~ 0*Engagement # The covariance between both is cero

# Regressions:
Perception ~ Knowledge
Interest ~ Knowledge
Engagement ~ Knowledge
'
fitgss_sem_fin <- sem(gss_sem_fin, gsskeai)
summary(fitgss_sem_fin, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitgss_sem_fin, c("cfi", "rmsea"))
library(semPlot)
semPaths(fitgss_sem_fin, what = "std", residuals = FALSE, rotation = 1, nCharNodes
= 13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.5)
title(main = list("Structural Model - United States (GSS)", cex = 0.80, font =
2), line = 2)
fgss_sem_rob <- sem(gss_sem_fin, gsskeai, estimator = "MLM")
summary(fgss_sem_rob, standardized = TRUE, rsquare = TRUE)
# We can see that non-normality does neither influence the structural model
modificationindices(fitgss_sem_fin, minimum.value = 10)
# There is no indication that the hypothesized regressions are not correct.
```

ANNEX 2. EUROBAROMETER 79.2 2013

```
Country <- factor(Eb79_2_2013_IKE$country, labels = c("FR", "BE", "NL", "DE-W", "IT", "LU", "DK", "IE", "GB", "GB-NIR", "GR", "ES", "PT", "DE-E", "FI", "SE", "AT", "CY", "CZ", "EE", "HU", "LV", "LT", "MT", "PL", "SK", "SI", "BG", "RO", "HR"))
informed <- Eb79_2_2013_IKE$qd1
reorder5 <- function(x) {
  ifelse(x == 1, 4, ifelse(x == 2, 3, ifelse(x == 3, 2, ifelse(x == 4, 1, 0))))
}
informed <- reorder5(informed)
table(informed)
interest <- Eb79_2_2013_IKE$qd2
interest <- reorder5(interest)
qd3a1 <- Eb79_2_2013_IKE$qd3a.1 # Father: job or university qualification in science or technology
sqfather <- as.numeric(qd3a1)
qd3a2 <- Eb79_2_2013_IKE$qd3a.2 # Mother: job or university qualification in science or technology
sqmother <- as.numeric(qd3a2)
qd3a3 <- Eb79_2_2013_IKE$qd3a.3 # Another member of family: job or university qualification in science or technology
sqfamiliar <- as.numeric(qd3a3)
SC <- data.frame(sqfather, sqmother, sqfamiliar)
scicapital <- rowSums(SC)
table(scicapital)
qd3b <- Eb79_2_2013_IKE$qd3b # The original variable includes 5 categories: yes, at school; yes, at university or in college; yes, anywere else; no; DK. No and DK are assigned a zero value. In an analysis of mean differences between these groups in age education, interest and informedness we can see that DK is associated with high education but low interest and informedness, then, they are assigned the value zero. On the other hand, the category "yes, anyware else" is possitioned, in the three variables, between "yes, at school" and "yes, at university or in college". Thus, "at school is assigned the value 1, "anywhere else" the value 2, and "at university", the value 3.
scistud <- ifelse((qd3b == 4 | qd3b == 5), 0, ifelse(qd3b == 1, 1, ifelse(qd3b == 3, 2, 3))) # Have ever studied science
# qd4: get information about developments in science and technology. Considering that there are grades in the desire to get information related to the sources used, we assigned 1 to TV and radio, 2 to newspapers and magazines, 3 to website and social media or blogs, 4 to books, and 0 to "don't look for information.
qd41 <- as.numeric(Eb79_2_2013_IKE$qd4.1)
qd42 <- as.numeric(Eb79_2_2013_IKE$qd4.2)
qd42 <- 2*qd42
qd43 <- as.numeric(Eb79_2_2013_IKE$qd4.3)
qd43 <- 2*qd43
qd44 <- as.numeric(Eb79_2_2013_IKE$qd4.4)
qd44 <- 4*qd44
qd45 <- as.numeric(Eb79_2_2013_IKE$qd4.5)
qd46 <- as.numeric(Eb79_2_2013_IKE$qd4.6)
qd46 <- 3*qd46
qd47 <- as.numeric(Eb79_2_2013_IKE$qd4.7)
```

```
qd47 <- 3*qd47
qd49 <- as.numeric(Eb79_2_2013_IKE$qd4.9)
qd49 <- ifelse(qd49 == 1, 0, 0)
GI <- data.frame(qd41, qd42, qd43, qd44, qd45, qd46, qd47, qd49)
getinfo <- rowSums(GI) # Getting information about science
qd5 <- Eb79_2_2013_IKE$qd5
socinfsci <- reorder5(qd5) #Social influence of science

qd6 <- Eb79_2_2013_IKE$qd6
engageDM <- ifelse((qd6 == 6 | qd6 ==7), 0, qd6) #Level of involvement of citizens in S&T decision making
qd93 <- Eb79_2_2013_IKE$qd9_3
Opinion1 <- ifelse(qd93 == 6, 0, qd93) # Depend too much on science and not enough on faith
qd94 <- Eb79_2_2013_IKE$qd9_4
Opinion2 <- ifelse(qd94 == 6, 0, qd94) # science makes our ways of life change too fast
qd95 <- Eb79_2_2013_IKE$qd9_5 # thanks to S&T, there will be more opportunities for future generations
reorder6 <- function(x) {
  ifelse(x == 1, 5, ifelse(x == 2, 4, ifelse(x == 3, 3, ifelse(x == 4, 2, ifelse(x == 5, 1, 0)))))
}
Opinion3 <- reorder6(qd95)
qd96 <- Eb79_2_2013_IKE$qd9_6
Opinion4 <- ifelse(qd96 == 6, 0, qd96) # The applications of S&T can threaten human rights
qd97 <- Eb79_2_2013_IKE$qd9_7
Opinion5 <- ifelse(qd97 == 6, 0, qd97) # S&T could be used by terrorists in the future
qd98 <- Eb79_2_2013_IKE$qd9_8
Opinion6 <- ifelse(qd98 == 6, 0, qd98) # S&T developments can have unforseen side-effects harmful to human health and the environment
qd99 <- Eb79_2_2013_IKE$qd9_9
Opinion7 <- reorder6(qd99) # If we attach too much importance to risks not fully understood, we could miss out on technological progress
A <- data.frame(Opinion1, Opinion2, Opinion3, Opinion4, Opinion5, Opinion6, Opinion7)
library(psych)
alpha(A) # We make this to guarantee that the direction of the statements is the same.
# Reasonable internal consistency of Perceptions although there are only 7 variables. The most discriminant Perceptions are Perception 3, Perception 4 and Perception 1 respectively. Perception 5 does not discriminate anything at all according to r.drop (the correlation of the item with the scale composed of the remaining items). This is an indication that the majority of respondents agree with this statement.
eb792_keai <- data.frame(Country, scistud, scicapital, interest, informed, getinfo, engageDM, socinfsci, Opinion1, Opinion2, Opinion3, Opinion4, Opinion5, Opinion6, Opinion7)
save(eb792_keai, file = "eb792_keai.RData")

# DESCRIPTIVE ANALYSIS:
```

```
library(plyr)
ddply(eb792_keai, "Country", summarise,
      median = median(scicapital),
      min = min(scicapital),
      max = max(scicapital))
ddply(eb792_keai, "Country", summarise,
      median = median(scistud),
      min = min(scistud),
      max = max(scistud))
ddply(eb792_keai, "Country", summarise,
      median = median(interest),
      min = min(interest),
      max = max(interest))
ddply(eb792_keai, "Country", summarise,
      median = median(informed),
      min = min(informed),
      max = max(informed))
ddply(eb792_keai, "Country", summarise,
      mean = mean(getinfo),
      sd = sd(getinfo))
ddply(eb792_keai, "Country", summarise,
      median = median(ethiccitizexp),
      min = min(ethiccitizexp),
      max = max(ethiccitizexp))
ddply(eb792_keai, "Country", summarise,
      median = median(socinfsci),
      min = min(socinfsci),
      max = max(socinfsci))
ddply(eb792_keai, "Country", summarise,
      median = median(Opinion1),
      min = min(Opinion1),
      max = max(Opinion1))
ddply(eb792_keai, "Country", summarise,
      median = median(Opinion2),
      min = min(Opinion2),
      max = max(Opinion2))
ddply(eb792_keai, "Country", summarise,
      median = median(Opinion2),
      min = min(Opinion2),
      max = max(Opinion2))
ddply(eb792_keai, "Country", summarise,
      median = median(Opinion3),
      min = min(Opinion3),
      max = max(Opinion3))
ddply(eb792_keai, "Country", summarise,
      median = median(Opinion4),
      min = min(Opinion4),
      max = max(Opinion4))
ddply(eb792_keai, "Country", summarise,
```

```
      median = median(Opinion5),
      min = min(Opinion5),
      max = max(Opinion5))
ddply(eb792_keai, "Country", summarise,
      median = median(Opinion6),
      min = min(Opinion6),
      max = max(Opinion6))
ddply(eb792_keai, "Country", summarise,
      median = median(Opinion7),
      min = min(Opinion7),
      max = max(Opinion7))
ddply(eb792_keai, "Country", summarise,
      median = median(engageDM),
      min = min(engageDM),
      max = max(engageDM))
# According to IUS-2013, we select Romania as the representative of modest innovators, Greece and Spain as the representatives of moderate innovators, Cyprus, Slovenia and UK (with very different "behaviors") as representatives of innovation followers, and Denmark and Germany (also very different behavior despite belonging to the same group - "Between Understanding...") as representatives of the innovation leaders.
# BULGARIA
# Data frame:
BGeb792_keai <- eb792_keai[eb792_keai$Country == "BG",]
# Descriptive statistics:
round(prop.table(table(BGeb792_keai$scistud))*100, 2)
round(prop.table(table(BGeb792_keai$scicapital))*100, 2)
round(prop.table(table(BGeb792_keai$interest))*100, 2)
round(prop.table(table(BGeb792_keai$informed))*100, 2)
round(prop.table(table(BGeb792_keai$socinfsci))*100, 2)
round(prop.table(table(BGeb792_keai$Opinion1))*100, 2)
round(prop.table(table(BGeb792_keai$Opinion2))*100, 2)
round(prop.table(table(BGeb792_keai$Opinion3))*100, 2)
round(prop.table(table(BGeb792_keai$Opinion4))*100, 2)
round(prop.table(table(BGeb792_keai$Opinion5))*100, 2)
round(prop.table(table(BGeb792_keai$Opinion6))*100, 2)
round(prop.table(table(BGeb792_keai$Opinion7))*100, 2)
round(prop.table(table(BGeb792_keai$engageDM))*100, 2)
summary(BGeb792_keai)
summary(BGeb792_keai$getinfo); sd(BGeb792_keai$getinfo)

## Measuring model:
library(lavaan)
BG_mm1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 + Opinion6 + Opinion7
'
fitBGmm1 <- cfa(BG_mm1, BGeb792_keai)
```

```
summary(fitBGmm1)
fitmeasures(fitBGmm1, c("cfi", "rmsea"))
# The fit is not good despite all the indicators significantly contribute to the model. Therefore, there is a lack of relevant covariations among them
modificationindices(fitBGmm1, minimum.value = 40)
BG_mm2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 + Opinion6 + Opinion7
# Covariances:
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
'
fitBGmm2 <- cfa(BG_mm2, BGeb792_keai)
summary(fitBGmm2)
fitmeasures(fitBGmm2, c("cfi", "rmsea"))
# The fit is acceptable. This is the measuring model
# Multivariate normality

library(MVN)
mvn(BGeb792_keai[2:15], mvnTest = "mardia") # Analysis of multivariate normality. We reject the null hypothesis
fitBGmm2_rob <- cfa(BG_mm2, BGeb792_keai, estimator = "MLM")
summary(fitBGmm2_rob)
library(semPlot)
semPaths(fitBGmm2, what = "std", residuals = FALSE, rotation = 1, nCharNodes = 13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67, edge.label.cex = 0.75, label.prop = 1.3, curvePivot = TRUE)
title(main = list("Measuring Model - Bulgaria (Eb 79.2)", cex = 0.80, font = 2), line = 2.5)

# THE STRUCTURAL MODEL:
BG_sem1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 + Opinion6 + Opinion7
# Covariances:
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
# Regressions:
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Background + Attentiveness + Perception
'
```

```
fitBGsem1 <- sem(BG_sem1, BGeb792_keai)
summary(fitBGsem1, standardized = TRUE, rsquare = TRUE)
# engageDM is not identified by Background
BG_sem2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# Covariances:
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
# Regressions:
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Attentiveness + Perception
'
fitBGsem2 <- sem(BG_sem2, BGeb792_keai)
summary(fitBGsem2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitBGsem2, c("cfi", "rmsea"))
# The fit is not good.
modificationindices(fitBGsem2, minimum.value = 40) # We need to include a direct
link from Attentiveness to socinfsci.
BG_sem3 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo + socinfsci
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# Covariances:
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
# Regressions:
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Attentiveness + Perception
'
fitBGsem3 <- sem(BG_sem3, BGeb792_keai)
summary(fitBGsem3, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitBGsem3, c("cfi", "rmsea"))
# The fit is good, but engageDM is not defined by Perception
BG_sem4 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo + socinfsci
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# Covariances:
interest ~~ informed
```

```
socinfsci ~~ Opinion3 + Opinion7
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
Perception ~~ 0*engageDM
# Regressions:
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Attentiveness
'
fitBGsem4 <- sem(BG_sem4, BGeb792_keai)
summary(fitBGsem4, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitBGsem4, c("cfi", "rmsea"))
# This is the final model, but we need to exclude the loads under 0.30:
BG_fin <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo + socinfsci
Perception =~ Opinion1 + Opinion4 + Opinion5 + Opinion6
# Covariances:
interest ~~ informed
Perception ~~ 0*engageDM
# Regressions:
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Attentiveness
'
fitBGfin <- sem(BG_fin, BGeb792_keai)
summary(fitBGfin, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitBGfin, c("cfi", "rmsea"))
modificationindices(fitBGfin, minimum.value = 10)
BG_sem5 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo + socinfsci
Perception =~ Opinion1 + Opinion4 + Opinion5 + Opinion6
# Covariances:
interest ~~ informed
Perception ~~ 0*engageDM
# Regressions:
Attentiveness ~ Background + Perception
Perception ~ Background
engageDM ~ Attentiveness
'
fitBGsem5 <- sem(BG_sem5, BGeb792_keai)
summary(fitBGsem5, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitBGsem5, c("cfi", "rmsea"))
# If we include the regression from perception to attentiveness, the fit of the
model improves.But the loads are under 0.30. Thus, it is not a good option
semPaths(fitBGfin, what = "std", residuals = FALSE, rotation = 1, nCharNodes =
13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3)
```

```
title(main = list("Structural Model - Bulgaria (Eb 79.2)", cex = 0.80, font = 2),
line = 1)

# ROMANIA
## Data frame:
ROeb792_keai <- eb792_keai[eb792_keai$Country == "RO",]
# Descriptive statistics:
round(prop.table(table(ROeb792_keai$scistud))*100, 2)
round(prop.table(table(ROeb792_keai$scicapital))*100, 2)
round(prop.table(table(ROeb792_keai$interest))*100, 2)
round(prop.table(table(ROeb792_keai$informed))*100, 2)
round(prop.table(table(ROeb792_keai$socinfsci))*100, 2)
round(prop.table(table(ROeb792_keai$Opinion1))*100, 2)
round(prop.table(table(ROeb792_keai$Opinion2))*100, 2)
round(prop.table(table(ROeb792_keai$Opinion3))*100, 2)
round(prop.table(table(ROeb792_keai$Opinion4))*100, 2)
round(prop.table(table(ROeb792_keai$Opinion5))*100, 2)
round(prop.table(table(ROeb792_keai$Opinion6))*100, 2)
round(prop.table(table(ROeb792_keai$Opinion7))*100, 2)
round(prop.table(table(ROeb792_keai$engageDM))*100, 2)
summary(ROeb792_keai)
summary(ROeb792_keai$getinfo); sd(ROeb792_keai$getinfo)

## Measuring model:
library(lavaan)
RO_mm1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
'
fitROmm1 <- cfa(RO_mm1, ROeb792_keai)
summary(fitROmm1)
fitmeasures(fitROmm1, c("cfi", "rmsea", "srmr"))
# There is a bad adjustment of the model to the data, although all the exogenous
variables significantly contribute to define the implicit factors. Therefore, it
seems that relevant associations among the indicators are missing.
modificationindices(fitROmm1, minimum.value = 20)
# We include the different covariations between the indicators of Perception with
a possitive epc (the paramenter increases, not decreases).
RO_mm2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# Residual covariances
socinfsci ~~ Opinion3
Opinion1 ~~ Opinion2
Opinion2 ~~ Opinion6
Opinion3 ~~ Opinion7
```

```
Opinion5 ~~ Opinion6
'
fitROmm2 <- cfa(RO_mm2, ROeb792_keai)
summary(fitROmm2)
fitmeasures(fitROmm2, c("cfi", "rmesea", "srmr"))
# The fit improves, but is not good enough
modificationindices(fitROmm2, minimum.value = 20)

RO_mm3 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# Residual covariances
socinfsci ~~ Opinion7
Opinion1 ~~ Opinion2 + Opinion4
Opinion2 ~~ Opinion4 + Perception 5 + Opinion6
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion5 + Opinion6
Opinion5 ~~ Opinion6
interest ~~ informed
'
fitROmm3 <- cfa(RO_mm3, ROeb792_keai)
summary(fitROmm3)
fitmeasures(fitROmm3, c("cfi", "rmsea", "srmr"))
# The fit is good, although Perception 2 is no longer significant
RO_mm4 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion3 + Opinion4 + Opinion5 + Opinion6 +
Opinion7
# Residual covariances
socinfsci ~~ Opinion7
Opinion1 ~~ Opinion4
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion5 + Opinion6
Opinion5 ~~ Opinion6
interest ~~ informed
'
fitROmm4 <- cfa(RO_mm4, ROeb792_keai)
summary(fitROmm4)
fitmeasures(fitROmm4, c("cfi", "rmsea", "srmr"))
# The fit is good and thus, this is the final model
library(semPlot)
semPaths(fitROmm4, what = "std", residuals = FALSE, rotation = 1, nCharNodes =
13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3, curvePivot = TRUE)
title(main = list("Measuring Model - Romania (Eb 79.2)", cex = 0.80, font = 2),
line = 3.4)
# Multivariate normality
```

```
library(MVN)
mvn(ROeb792_keai[2:15], mvnTest = "mardia") # Analysis of multivariate normality. We reject the null hypothesis
fitROmm3_rob <- cfa(RO_mm3, ROeb792_keai, estimator = "MLM")
summary(fitROmm3_rob)
# There are not big differences between ML and MLM estimations

# THE STRUCTURAL MODEL:
RO_sem1 <- '
# measuring model
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion3 + Opinion4 + Opinion5 + Opinion6 + Opinion7
# Residual covariances
socinfsci ~~ Opinion7
Opinion1 ~~ Opinion4
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion5 + Opinion6
Opinion5 ~~ Opinion6
interest ~~ informed
#Regressions
  Attentiveness ~ Background
  Perception ~ Background
  engageDM ~ Background + Attentiveness + Perception
'
fitROsem1 <- sem(RO_sem1, ROeb792_keai)
summary(fitROsem1, standardized = TRUE)
fitmeasures(fitROsem1, c("cfi", "rmsea"))
# The fit is good but engageDM is only predicted by Perception and there is a warning because the variance of Perception is negative. This might be an indication that Perception is not predicted by Background but by Attentiveness.
RO_sem_2 <- '
# measuring model
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion3 + Opinion4 + Opinion5 + Opinion6 + Opinion7
# Residual covariances
socinfsci ~~ Opinion7
Opinion1 ~~ Opinion4
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion5 + Opinion6
Opinion5 ~~ Opinion6
interest ~~ informed
#Regressions
Attentiveness ~ Background
Perception ~ Attentiveness
engageDM ~ Perception
'
```

```
fitROsem_2 <- sem(RO_sem_2, ROeb792_keai)
summary(fitROsem_2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitROsem_2, c("cfi", "rmsea"))
# The fit is good and there is no negative variance. All the parameters are significant. This is the final model, but we exclude loads under 0.30
RO_fin <- '
# measuring model
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion3 + Opinion4 + Opinion7
# Residual covariances
Opinion3 ~~ Opinion7
interest ~~ informed

#Regressions
Attentiveness ~ Background
Perception ~ Attentiveness
engageDM ~ Perception
'
fitROfin <- sem(RO_fin, ROeb792_keai)
summary(fitROfin, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitROfin, c("cfi", "rmsea"))
library(semPlot)
semPaths(fitROfin, what = "std", rotation = 1, nCharNodes = 13, edge.color = "black", fade = FALSE, esize = 2, residuals = FALSE, edge.label.position = 0.67, edge.label.cex = 0.75, label.prop = 1.3)
title(main = list("Structural Model - Romania (Eb 79.2)", cex = 0.80, font = 2), line = 1)
fitROsem_rob <- sem(RO_sem_2, ROeb792_keai, estimator = "MLM")
summary(fitROsem_rob, standardized = TRUE)
# We can see that non-normality does neither influence the structural model
modificationindices(fitROfin, minimum.value = 10)
# There is no suggestion that the regressions are different from the hypothesized.

# GREECE:
## Data frame:
GReb792_keai <- eb792_keai[eb792_keai$Country == "GR",]
# Descriptive statistics:
round(prop.table(table(GReb792_keai$scistud))*100, 2)
round(prop.table(table(GReb792_keai$scicapital))*100, 2)
round(prop.table(table(GReb792_keai$interest))*100, 2)
round(prop.table(table(GReb792_keai$informed))*100, 2)
round(prop.table(table(GReb792_keai$socinfsci))*100, 2)
round(prop.table(table(GReb792_keai$Opinion1))*100, 2)
round(prop.table(table(GReb792_keai$Opinion2))*100, 2)
round(prop.table(table(GReb792_keai$Opinion3))*100, 2)
round(prop.table(table(GReb792_keai$Opinion4))*100, 2)
round(prop.table(table(GReb792_keai$Opinion5))*100, 2)
round(prop.table(table(GReb792_keai$Opinion6))*100, 2)
round(prop.table(table(GReb792_keai$Opinion7))*100, 2)
```

```
round(prop.table(table(GReb792_keai$engageDM))*100, 2)
summary(GReb792_keai)
summary(GReb792_keai$getinfo); sd(GReb792_keai$getinfo)

## Measuring model:
GRmm1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~  socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 + Opinion6 + Opinion7
'
fitGRmm1 <- cfa(GRmm1, GReb792_keai)
summary(fitGRmm1)
# Opinion5 and Opinion6 are notpredictors of Perception
GRmm2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~  socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion7
'
fitGRmm2 <- cfa(GRmm2, GReb792_keai)
summary(fitGRmm2)
fitmeasures(fitGRmm2, c("cfi", "rmsea"))
# Fit is not good
modificationindices(fitGRmm2, minimum.value = 20)
GRmm3 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion7
# residual covariances
interest ~~ informed
Opinion1 ~~ Opinion2
Opinion2 ~~ Opinion4
'
fitGRmm3 <- cfa(GRmm3, GReb792_keai)
summary(fitGRmm3)
fitmeasures(fitGRmm3, c("cfi", "rmsea"))
# The fit is good. All the parameters are significant. This is the measuring model. But we exclude the loads under 0.30
GRmm3b <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion3 + Opinion7

# residual covariances
interest ~~ informed
'
fitGRmm3b <- cfa(GRmm3b, GReb792_keai)
summary(fitGRmm3b)
fitmeasures(fitGRmm3b, c("cfi", "rmsea"))
```

```
semPaths(fitGRmm3b, what = "std", residuals = FALSE, rotation = 1, nCharNodes = 13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67, edge.label.cex = 0.75, label.prop = 1.3, curvePivot = TRUE)
title(main = list("Measuring Model - Greece (Eb 79.2)", cex = 0.80, font = 2), line = 3.5)
mvn(GReb792_keai[2:19], mvnTest = "mardia") # Analysis of multivariate normality. We reject the null hypothesis
fitGRmm_rob <- cfa(GRmm3, GReb792_keai, estimator = "MLM")
summary(fitGRmm_rob)

# THE STRUCTURAL MODEL
GRsem1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion7
# residual covariances
interest ~~ informed
Opinion1 ~~ Opinion2
Opinion2 ~~ Opinion4
# regressions
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Background + Perception + Attentiveness
'
fitGRsem1 <- sem(GRsem1, GReb792_keai)
summary(fitGRsem1, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitGRsem1, c("cfi", "rmsea"))
# engageDM is only predicted by Attentiveness.
GRsem2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion7
# residual covariances
interest ~~ informed
Opinion1 ~~ Opinion2
Opinion2 ~~ Opinion4
Perception ~~ 0*engageDM
 # regressions
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Attentiveness
'
fitGRsem2 <- sem(GRsem2, GReb792_keai)
summary(fitGRsem2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitGRsem2, c("cfi", "rmsea"))

# The fit is good. All the parameters are significant. This is the final model. But we exclude the loads under 0.30
GRfin <- '
Background =~ scistud + scicapital
```

```
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion3 + Opinion7
# residual covariances
interest ~~ informed
Perception ~~ 0*engageDM
# regressions
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Attentiveness
'
fitGRfin <- sem(GRfin, GReb792_keai)
summary(fitGRfin, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitGRfin, c("cfi", "rmsea"))
semPaths(fitGRfin, what = "std", rotation = 1, nCharNodes = 13, edge.color =
"black", fade = FALSE, esize = 2, residuals = FALSE, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3)
title(main = list("Structural Model - Greece (Eb 79.2)", cex = 0.80, font = 2),
line = 2)
fitGRsem_rob <- sem(GRsem2, GReb792_keai, estimator = "MLM")
summary(fitGRsem_rob, standardized = TRUE)
# There are slightly more differences between the robust and non-robust models,
but still are small. Anyway, the model is well defined, and the robust estimator
is aimed at avoiding the rejection of good models.

modificationindices(fitGRfin, minimum.value = 10)
# There is no suggestion that the regressions are different from the hypothesized.

# SPAIN
## Data frame:
SPeb792_keai <- eb792_keai[eb792_keai$Country == "ES",]
# Descritive analysis:
round(prop.table(table(SPeb792_keai$scistud))*100, 2)
round(prop.table(table(SPeb792_keai$scicapital))*100, 2)
round(prop.table(table(SPeb792_keai$interest))*100, 2)
round(prop.table(table(SPeb792_keai$informed))*100, 2)
round(prop.table(table(SPeb792_keai$socinfsci))*100, 2)
round(prop.table(table(SPeb792_keai$Opinion1))*100, 2)
round(prop.table(table(SPeb792_keai$Opinion2))*100, 2)
round(prop.table(table(SPeb792_keai$Opinion3))*100, 2)
round(prop.table(table(SPeb792_keai$Opinion4))*100, 2)
round(prop.table(table(SPeb792_keai$Opinion5))*100, 2)
round(prop.table(table(SPeb792_keai$Opinion6))*100, 2)
round(prop.table(table(SPeb792_keai$Opinion7))*100, 2)
round(prop.table(table(SPeb792_keai$engageDM))*100, 2)
summary(SPeb792_keai)
summary(SPeb792_keai$getinfo); sd(SPeb792_keai$getinfo)



## Measuring model:
```

```
library(lavaan)
SP_mm1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
'
fitSPmm1 <- cfa(SP_mm1, SPeb792_keai)
summary(fitSPmm1)
fitmeasures(fitSPmm1, c("cfi", "rmsea"))
# All the predictors are significant, but the fit is bad:
modificationindices(fitSPmm1, minimum.value = 20)
SP_mm2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances:
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion2 ~~ Opinion3
'
fitSPmm2 <- cfa(SP_mm2, SPeb792_keai)
summary(fitSPmm2)
fitmeasures(fitSPmm2, c("cfi", "rmsea"))
# The fit has improved but its not good enough
modificationindices(fitSPmm2, minimum.value = 10)
SP_mm3 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances:
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion2 ~~ Opinion3
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion6
'
fitSPmm3 <- cfa(SP_mm3, SPeb792_keai)
summary(fitSPmm3)
fitmeasures(fitSPmm3, c("cfi", "rmsea"))
# The fit is acceptable, this is the final model. Although we extract the
indicators with loads under 0.30
SP_mm3b <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 + Opinion6 +
Opinion7
# residual covariances:
```

```
interest ~~ informed
Opinion2 ~~ Opinion3
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion6
'
fitSPmm3b <- cfa(SP_mm3b, SPeb792_keai)
summary(fitSPmm3b)
fitmeasures(fitSPmm3b, c("cfi", "rmsea"))
semPaths(fitSPmm3b, what = "std", residuals = FALSE, rotation = 1, nCharNodes =
13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3, curvePivot = TRUE)
title(main = list("Measuring Model - Spain (Eb 79.2)", cex = 0.80, font = 2), line
= 3.4)
mvn(SPeb792_keai[2:19], mvnTest = "mardia") # Analysis of multivariate normality.
We reject the null hypothesis
fitSPmm_rob <- cfa(SP_mm3, SPeb792_keai, estimator = "MLM")
summary(fitSPmm_rob)

# THE STRUCTURAL MODEL
SP_sem1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances:
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion2 ~~ Opinion3
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion6
# regressions:
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Background + Attentiveness + Perception
'
fitSPsem1 <- sem(SP_sem1, SPeb792_keai)
summary(fitSPsem1, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitSPsem1, c("cfi", "rmsea"))
# engageDM is not predicted by Background and only marginally by Perception
SP_sem2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances:
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion2 ~~ Opinion3
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion6
```

```
Perception ~~ 0*engageDM
# regressions:
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Attentiveness
'
fitSPsem2 <- sem(SP_sem2, SPeb792_keai)
summary(fitSPsem2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitSPsem2, c("cfi", "rmsea"))
# The fit is acceptable and all the parameters are significant. This is the final model, but we exclude the loads under 0.30
SP_fin <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~  Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 + Opinion6
# residual covariances:
interest ~~ informed
Opinion2 ~~ Opinion3
Opinion4 ~~ Opinion6
Perception ~~ 0*engageDM
# regressions:
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Attentiveness
'
fitSPfin <- sem(SP_fin, SPeb792_keai)
summary(fitSPfin, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitSPfin, c("cfi", "rmsea"))
fitSPsemrob<- sem(SP_sem2, SPeb792_keai, estimator = "MLM")
summary(fitSPsemrob, standardized = TRUE, rsquare = TRUE)

# No differences between robust and non-robust models
modificationindices(fitSPfin, minimum.value = 10)
SP_fin2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~  Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 + Opinion6
# residual covariances:
interest ~~ informed
Opinion2 ~~ Opinion3
Opinion4 ~~ Opinion6
Perception ~~ 0*engageDM
# regressions:
Attentiveness ~ Background
Perception ~ Background + Attentiveness
engageDM ~ Attentiveness
'
fitSPfin2 <- sem(SP_fin2, SPeb792_keai)
summary(fitSPfin2, standardized = TRUE, rsquare = TRUE)
```

```
fitmeasures(fitSPfin2, c("cfi", "rmsea"))
# If Perception is defined by Attentiveness, Background is no significant
SP_fin3 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~  Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 + Opinion6

# residual covariances:
interest ~~ informed
Opinion2 ~~ Opinion3
Opinion4 ~~ Opinion6
Perception ~~ 0*engageDM
# regressions:
Attentiveness ~ Background
Perception ~ Attentiveness
engageDM ~ Attentiveness
'
fitSPfin3 <- sem(SP_fin3, SPeb792_keai)
summary(fitSPfin3, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitSPfin3, c("cfi", "rmsea"))
# The fit of the model improves. This is the final model
semPaths(fitSPfin3, what = "std", residuals = FALSE, rotation = 1, nCharNodes =
13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3)
title(main = list("Structural Model - Spain (Eb 79.2)", cex = 0.80, font = 2),
line = 2)

# CYPRUS
## Data frame:
CYeb792_keai <- eb792_keai[eb792_keai$Country == "CY",]
# Descritive analysis:
round(prop.table(table(CYeb792_keai$scistud))*100, 2)
round(prop.table(table(CYeb792_keai$scicapital))*100, 2)
round(prop.table(table(CYeb792_keai$interest))*100, 2)
round(prop.table(table(CYeb792_keai$informed))*100, 2)
round(prop.table(table(CYeb792_keai$socinfsci))*100, 2)
round(prop.table(table(CYeb792_keai$Opinion1))*100, 2)
round(prop.table(table(CYeb792_keai$Opinion2))*100, 2)
round(prop.table(table(CYeb792_keai$Opinion3))*100, 2)
round(prop.table(table(CYeb792_keai$Opinion4))*100, 2)
round(prop.table(table(CYeb792_keai$Opinion5))*100, 2)
round(prop.table(table(CYeb792_keai$Opinion6))*100, 2)
round(prop.table(table(CYeb792_keai$Opinion7))*100, 2)
round(prop.table(table(CYeb792_keai$engageDM))*100, 2)
summary(CYeb792_keai)
summary(CYeb792_keai$getinfo); sd(CYeb792_keai$getinfo)

## Measuring model:
library(lavaan)
CYmm1 <- '
```

```
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
'
fitCYmm1 <- cfa(CYmm1, CYeb792_keai)
summary(fitCYmm1)
fitmeasures(fitCYmm1, c("cfi", "rmsea"))
# Bad fit:

modificationindices(fitCYmm1, minimum.value = 20)
CYmm2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Perception 1 + Opinion2 + Opinion3 + Opinion4 + Opinion5
+ Opinion6 + Opinion7
# residual covariances
socinfsci~~ Opinion3
Opinion3 ~~ Opinion7
 '
fitCYmm2 <- cfa(CYmm2, CYeb792_keai)
summary(fitCYmm2)
fitmeasures(fitCYmm2, c("cfi", "rmsea"))
# The only significant, and marginally, atittudes are Opinion4, Opinion5 and
Opinion6
CYmm3 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion4 + Opinion5 + Opinion6
'
fitCYmm3 <- cfa(CYmm3, CYeb792_keai)
summary(fitCYmm3)
fitmeasures(fitCYmm3, c("cfi", "rmsea", "srmr"))
# The factor Perception is not well defined for Cyprus
CYmm4 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
'
fitCYmm4 <- cfa(CYmm4, CYeb792_keai)
summary(fitCYmm4)
fitmeasures(fitCYmm4, c("cfi", "rmsea"))
# Not including Perception, the fit is acceptable
semPaths(fitCYmm4, what = "std", residuals = FALSE, rotation = 1, nCharNodes =
13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3, curvePivot = TRUE)
title(main = list("Measuring Model - Cyprus (Eb 79.2)", cex = 0.80, font = 2),
line = 3.2)
mvn(CYeb792_keai[2:19], mvnTest = "mardia") # Analysis of multivariate normality.
We reject the null hypothesis
fitCYmm4_rob <- cfa(CYmm4, CYeb792_keai, estimator = "MLM")
```

```
summary(fitCYmm4_rob)

# THE STRUCTURAL MODEL:

CYsem1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
# regressions
Attentiveness ~ Background
engageDM ~ Background + Attentiveness
'
fitCYsem1 <- sem(CYsem1, CYeb792_keai)
summary(fitCYsem1, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitCYsem1, c("cfi", "rmsea"))
# The fit is good but Background is only marginally significant as a predictor of engageDM
CYsem2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
# regressions
Attentiveness ~ Background
engageDM ~ Attentiveness
'
fitCYsem2 <- sem(CYsem2, CYeb792_keai)
summary(fitCYsem2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitCYsem2, c("cfi", "rmsea"))
# The fit is good.
semPaths(fitCYsem2, what = "std", rotation = 1, nCharNodes = 13, edge.color = "black", fade = FALSE, esize = 2, residuals = FALSE, edge.label.position = 0.67, edge.label.cex = 0.75, label.prop = 1.3)
title(main = list("Structural Model - Cyprus (Eb 79.2)", cex = 0.80, font = 2), line = 2)
fitCYsemrob <- sem(CYsem2, CYeb792_keai, estimator = "MLM")
summary(fitCYsemrob, standardized = TRUE, rsquare = TRUE)
# We can see that the model in Cyprus is very different. There are no differences between the robust and non-robust models.
modificationindices(fitCYsem2, minimum.value = 10)
# There is no suggestion that the regressions are different from the hypothesized.

# SLOVENIA
## Data frame:
SIeb792_keai <- eb792_keai[eb792_keai$Country == "SI",]
# Descritive analysis:
round(prop.table(table(SIeb792_keai$scistud))*100, 2)
round(prop.table(table(SIeb792_keai$scicapital))*100, 2)
round(prop.table(table(SIeb792_keai$interest))*100, 2)
round(prop.table(table(SIeb792_keai$informed))*100, 2)
round(prop.table(table(SIeb792_keai$socinfsci))*100, 2)
round(prop.table(table(SIeb792_keai$Opinion1))*100, 2)
round(prop.table(table(SIeb792_keai$Opinion2))*100, 2)
```

```
round(prop.table(table(SIeb792_keai$Opinion3))*100, 2)
round(prop.table(table(SIeb792_keai$Opinion4))*100, 2)
round(prop.table(table(SIeb792_keai$Opinion5))*100, 2)
round(prop.table(table(SIeb792_keai$Opinion6))*100, 2)
round(prop.table(table(SIeb792_keai$Opinion7))*100, 2)
round(prop.table(table(SIeb792_keai$engageDM))*100, 2)
summary(SIeb792_keai)
summary(SIeb792_keai$getinfo); sd(SIeb792_keai$getinfo)

## Measuring model:
library(lavaan)
SI_mm1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
'
fitSImm1 <- cfa(SI_mm1, SIeb792_keai)
summary(fitSImm1)
fitmeasures(fitSImm1, c("cfi", "rmsea", "srmr"))
# Poor fit
modificationindices(fitSImm1, minimum.value = 20)
SI_mm2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances:
socinfsci ~~ Opinion3 + Opinion7
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion6
'
fitSImm2 <- cfa(SI_mm2, SIeb792_keai)
summary(fitSImm2)
fitmeasures(fitSImm2, c("cfi", "rmsea", "srmr"))
# The model fits the data reasonably. This is the final model, although we delete
the loads under 0.30:
SI_mm2b <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion4 + Opinion5 + Opinion6
# residual covariances:
Opinion4 ~~ Opinion6
'
fitSImm2b <- cfa(SI_mm2b, SIeb792_keai)
summary(fitSImm2b)
fitmeasures(fitSImm2b, c("cfi", "rmsea"))
semPaths(fitSImm2b, what = "std", residuals = FALSE, rotation = 1, nCharNodes =
13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3)
```

```
title(main = list("Measuring Model - Slovenia (Eb 79.2)", cex = 0.80, font = 2),
line = 3)
mvn(SIeb792_keai[2:19], mvnTest = "mardia") # Analysis of multivariate normality.
We reject the null hypothesis
fitSImmfin2 <- cfa(SImmfin, SIeb792_keai, estimator = "MLM")
summary(fitSImmfin2)

# THE STRUCTURAL MODEL:
SIsem1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances:
socinfsci ~~ Opinion3 + Opinion7
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion6
# regressions
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Background + Perception + Attentiveness
'
fitSIsem1 <- sem(SIsem1, SIeb792_keai)
summary(fitSIsem1, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitSIsem1, c("cfi", "rmsea", "srmr"))
# Engagement is not explained by Background
SIsem2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances:
socinfsci ~~ Opinion3 + Opinion7
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion6
# regressions
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Perception + Attentiveness
'
fitSIsem2 <- sem(SIsem2, SIeb792_keai)
summary(fitSIsem2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitSIsem2, c("cfi", "rmsea"))
# The fit is not good enough although all the coefficients are significant. We
see if there are other relationships that need to be included.
modificationindices(fitSIsem2, minimum.value = 20)
# The modification indices suggest that Attentiveness is influenced by Perception

SIsem3 <- '
Background =~ scistud + scicapital
```

```
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances:
socinfsci ~~ Opinion3 + Opinion7
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion6
# regressions
Attentiveness ~ Background + Perception
Perception ~ Background
engageDM ~ Perception + Attentiveness
'
fitSIsem3 <- sem(SIsem3, SIeb792_keai)
summary(fitSIsem3, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitSIsem3, c("cfi", "rmsea", "srmr"))
# With this modification the fit is acceptable, but the regression of Perception
on engagement is only marginally significant, as there is an indirect link between
both through attentivenes. We try a new model with engageDM being only predicted
by Attentiveness
SIsem4 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances:
socinfsci ~~ Opinion3 + Opinion7
Opinion3 ~~ Opinion7
Opinion4 ~~ Opinion6
# regressions
Attentiveness ~ Background + Perception
Perception ~ Background
engageDM ~ Attentiveness
'
fitSIsem4 <- sem(SIsem4, SIeb792_keai)
summary(fitSIsem4, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitSIsem4, c("cfi", "rmsea"))
# The fit does not change and the model is more parsimonious. Thus, this is the
final model. But we exclude the loads under 0.30
fitSIsemrob <- sem(SIsem4, SIeb792_keai, estimator = "MLM")
summary(fitSIsemrob, standardized = TRUE, rsquare = TRUE)
# There are no differences between the robust and non-robust models.
SIfin <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion4 + Opinion5 + Opinion6
# residual covariances:
Opinion4 ~~ Opinion6
# regressions
Attentiveness ~ Background + Perception
Perception ~ Background
```

```
engageDM ~ Attentiveness
'
fitSIfin <- sem(SIfin, SIeb792_keai)
summary(fitSIfin, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitSIfin, c("cfi", "rmsea"))
modificationindices(fitSIfin, minimum.value = 10)
# The modification indices suggest a regression of Perception on engageDM
SIfin2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion4 + Opinion5 + Opinion6
# residual covariances:
Opinion4 ~~ Opinion6
# regressions
Attentiveness ~ Background + Perception
Perception ~ Background
engageDM ~ Attentiveness + Perception
'
fitSIfin2 <- sem(SIfin2, SIeb792_keai)
summary(fitSIfin2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitSIfin2, c("cfi", "rmsea"))
# The model fit improves, but only slightly, and the load of perception on engageDM
is very small. THe final model is SIfin
library(semPlot)
semPaths(fitSIfin, what = "std", rotation = 1, nCharNodes = 13, edge.color =
"black", fade = FALSE, esize = 2, residuals = FALSE, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3)
title(main = list("Structural Model - Slovenia (Eb 79.2)", cex = 0.80, font = 2),
line = 2)
# UNITED KINGDOM
## Data frame:
UKeb792_keai <- eb792_keai[eb792_keai$Country == "GB",]
# Descriptive analysis:
round(prop.table(table(UKeb792_keai$scistud))*100, 2)
round(prop.table(table(UKeb792_keai$scicapital))*100, 2)
round(prop.table(table(UKeb792_keai$interest))*100, 2)
round(prop.table(table(UKeb792_keai$informed))*100, 2)
round(prop.table(table(UKeb792_keai$socinfsci))*100, 2)
round(prop.table(table(UKeb792_keai$Opinion1))*100, 2)
round(prop.table(table(UKeb792_keai$Opinion2))*100, 2)
round(prop.table(table(UKeb792_keai$Opinion3))*100, 2)
round(prop.table(table(UKeb792_keai$Opinion4))*100, 2)
round(prop.table(table(UKeb792_keai$Opinion5))*100, 2)
round(prop.table(table(UKeb792_keai$Opinion6))*100, 2)
round(prop.table(table(UKeb792_keai$Opinion7))*100, 2)
round(prop.table(table(UKeb792_keai$engageDM))*100, 2)
summary(UKeb792_keai)
summary(UKeb792_keai$getinfo); sd(UKeb792_keai$getinfo)

## Measuring model:
```

```
library(lavaan)
UK_mm1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
'
fitUKmm1 <- cfa(UK_mm1, UKeb792_keai)
summary(fitUKmm1)
fitmeasures(fitUKmm1, c("cfi", "rmsea", "srmr"))
# The fit is bad:
modificationindices(fitUKmm1, minimum.value = 20)
UK_mm2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances:
interest ~~ informed
socinfsci ~~ Opinion3
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
Opinion5 ~~ Opinion6
'
fitUKmm2 <- cfa(UK_mm2, UKeb792_keai)
summary(fitUKmm2, standardized = TRUE)
fitmeasures(fitUKmm2, c("cfi", "rmsea"))
# The fit is acceptable. This is the measuring model. But we exclude the loads
under 0.30:
UK_mm2b <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion4 + Opinion5 + Opinion6
# residual covariances:
interest ~~ informed
Opinion1 ~~ Opinion2
Opinion5 ~~ Opinion6
'
fitUKmm2b <- cfa(UK_mm2b, UKeb792_keai)
summary(fitUKmm2b, standardized = TRUE)
fitmeasures(fitUKmm2b, c("cfi", "rmsea"))
semPaths(fitUKmm2b, what = "std", residuals = FALSE, rotation = 1, nCharNodes =
13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3)
title(main = list("Measuring Model - United Kingdom (Eb 79.2)", cex = 0.80, font
= 2), line = 3)
mvn(UKeb792_keai[2:19], mvnTest = "mardia") # Analysis of multivariate normality.
We reject the null hypothesis
fitUKmm_rob <- cfa(UK_mm2, UKeb792_keai, estimator = "MLM")
summary(fitUKmm_rob)
```

```
# THE STRUCTURAL MODEL:
UKsem1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7

# residual covariances:
interest ~~ informed
socinfsci ~~ Opinion3
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
Opinion5 ~~ Opinion6
# regressions
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Background + Perception + Attentiveness
'
fitUKsem1 <- sem(UKsem1, UKeb792_keai)
summary(fitUKsem1, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitUKsem1, c("cfi", "rmsea"))
# Engagement is only explained by Perception
UKsem2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances:
interest ~~ informed
socinfsci ~~ Opinion3
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
Opinion5 ~~ Opinion6
# regressions
Perception ~ Background
Attentiveness ~ Background
engageDM ~ Perception
'
fitUKsem2 <- sem(UKsem2, UKeb792_keai)
summary(fitUKsem2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitUKsem2, c("cfi", "rmsea"))
# The fit is acceptable and all the parameters are significant. This is the final
model. The variance of Attentiveness is not significant because is almost wholly
explained by Background. We exclude the loads under 0.30
UKfin <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion4 + Opinion5 + Opinion6
# residual covariances:
```

```
interest ~~ informed
Opinion1 ~~ Opinion2
Opinion5 ~~ Opinion6
# regressions
Perception ~ Background
Attentiveness ~ Background
engageDM ~ Perception
'
fitUKfin <- sem(UKfin, UKeb792_keai)
summary(fitUKfin, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitUKfin, c("cfi", "rmsea"))
fitUKsemrob <- sem(UKsem2, UKeb792_keai, estimator = "MLM")
summary(fitUKsemrob, standardized = TRUE, rsquare = TRUE)
modificationindices(fitUKfin, minimum.value = 10)
UKfin2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion4 + Opinion5 + Opinion6
# residual covariances:
interest ~~ informed
Opinion1 ~~ Opinion2
Opinion5 ~~ Opinion6
# regressions
Perception ~ Background
Attentiveness ~ Background + Perception
engageDM ~ Perception
'
fitUKfin2 <- sem(UKfin2, UKeb792_keai)
summary(fitUKfin2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitUKfin2, c("cfi", "rmsea"))
# The modification indices suggest that Attentiveness is also predicted by Perception. But if we test this model, the fit increases only slightly and the percentage of variance explained in Perception decreases almost a 50%. Therefore, we select UKfin as the final model
semPaths(fitUKfin, what = "std", rotation = 1, nCharNodes = 13, edge.color = "black", fade = FALSE, esize = 2, residuals = FALSE, edge.label.position = 0.67, edge.label.cex = 0.75, label.prop = 1.3)
title(main = list("Structural Model - United Kingdom (Eb 79.2)", cex = 0.80, font = 2), line = 2)

# DENMARK:
## Data frame:
DKeb792_keai <- eb792_keai[eb792_keai$Country == "DK",]
# Descriptive analysis:
round(prop.table(table(DKeb792_keai$scistud))*100, 2)
round(prop.table(table(DKeb792_keai$scicapital))*100, 2)
round(prop.table(table(DKeb792_keai$interest))*100, 2)
round(prop.table(table(DKeb792_keai$informed))*100, 2)
round(prop.table(table(DKeb792_keai$socinfsci))*100, 2)
round(prop.table(table(DKeb792_keai$Opinion1))*100, 2)
```

```
round(prop.table(table(DKeb792_keai$Opinion2))*100, 2)
round(prop.table(table(DKeb792_keai$Opinion3))*100, 2)
round(prop.table(table(DKeb792_keai$Opinion4))*100, 2)
round(prop.table(table(DKeb792_keai$Opinion5))*100, 2)
round(prop.table(table(DKeb792_keai$Opinion6))*100, 2)
round(prop.table(table(DKeb792_keai$Opinion7))*100, 2)
round(prop.table(table(DKeb792_keai$engageDM))*100, 2)
summary(DKeb792_keai)
summary(DKeb792_keai$getinfo); sd(DKeb792_keai$getinfo)

# measuring model:
DKmm1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
'
fitDKmm1 <- cfa(DKmm1, DKeb792_keai)
summary(fitDKmm1)
fitmeasures(fitDKmm1, c("cfi", "rmsea"))
# the fit is bad
modificationindices(fitDKmm1, minimum.value = 20)
DKmm2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances
interest ~~  informed
socinfsci ~~ Opinion3
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
Opinion5 ~~ Opinion6
'
fitDKmm2 <- cfa(DKmm2, DKeb792_keai)
summary(fitDKmm2)
fitmeasures(fitDKmm2, c("cfi", "rmsea"))
# The fit is reasonable. This is the measuring model. But we exclude the loads
under 0.30.

DKmm2b <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion6
# residual covariances
interest ~~  informed
socinfsci ~~ Opinion3
Opinion1 ~~ Opinion2
'
fitDKmm2b <- cfa(DKmm2b, DKeb792_keai)
```

```
summary(fitDKmm2b)
fitmeasures(fitDKmm2b, c("cfi", "rmsea"))
semPaths(fitDKmm2b, what = "std", residuals = FALSE, rotation = 1, nCharNodes =
13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3)
title(main = list("Measuring Model - Denmark (Eb 79.2)", cex = 0.80, font = 2),
line = 3)
mvn(DKeb792_keai[2:19], mvnTest = "mardia") # Analysis of multivariate normality.
We reject the null hypothesis
fitDKmmfin2 <- cfa(DKmmfin, DKeb792_keai, estimator = "MLM")
summary(fitDKmmfin2)

# THE STRUCTURAL MODEL
DKsem1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances
interest ~~  informed
socinfsci ~~ Opinion3
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
Opinion5 ~~ Opinion6
# regressions:
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Background + Perception + Attentiveness
'
fitDKsem1 <- sem(DKsem1, DKeb792_keai)
summary(fitDKsem1, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitDKsem1, c("cfi", "rmsea", "srmr"))
# engageDM is not predicted by background.
DKsem2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances
interest ~~  informed
socinfsci ~~ Opinion3
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
Opinion5 ~~ Opinion6
# regressions:
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Perception + Attentiveness
'
fitDKsem2 <- sem(DKsem2, DKeb792_keai)
```

```
summary(fitDKsem2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitDKsem2, c("cfi", "rmsea"))
# The fit is acceptable and all the parameters are significant. This is the final model. We exclude the loads under 0.30
DKfin <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion6
# residual covariances
interest ~~  informed
socinfsci ~~ Opinion3
Opinion1 ~~ Opinion2
# regressions:
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Perception + Attentiveness
'
fitDKfin <- sem(DKfin, DKeb792_keai)
summary(fitDKfin, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitDKfin, c("cfi", "rmsea"))
modificationindices(fitDKfin, minimum.value = 10)
DKfin2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion6
# residual covariances
interest ~~  informed
socinfsci ~~ Opinion3
Opinion1 ~~ Opinion2
# regressions:
Attentiveness ~ Background
Perception ~ Background + Attentiveness
engageDM ~ Perception + Attentiveness
'
fitDKfin2 <- sem(DKfin2, DKeb792_keai)
summary(fitDKfin2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitDKfin2, c("cfi", "rmsea"))
# If Perception is a function of attentiveness, there is no direct influence of BAckgroun on Perception
DKfin3 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion6
# residual covariances
interest ~~  informed
socinfsci ~~ Opinion3
Opinion1 ~~ Opinion2
engageDM ~~ 0*Perception
# regressions:
```

```
Attentiveness ~ Background
Perception ~ Attentiveness
engageDM ~ Attentiveness
'
fitDKfin3 <- sem(DKfin3, DKeb792_keai)
summary(fitDKfin3, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitDKfin3, c("cfi", "rmsea"))
#The fit of the model improves signifcantly, thus this is the final model.
semPaths(fitDKfin3, what = "std", rotation = 1, nCharNodes = 13, edge.color =
"black", fade = FALSE, esize = 2, residuals = FALSE, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3)
title(main = list("Structural Model - Denmark (Eb 79.2)", cex = 0.80, font = 2),
line = 2)

# GERMANY:
## Data frame:
DEeb792_keai <- eb792_keai[(eb792_keai$Country == "DE-E" | eb792_keai$Country ==
"DE-W"),]
# Descritive analysis:
round(prop.table(table(DEeb792_keai$scistud))*100, 2)
round(prop.table(table(DEeb792_keai$scicapital))*100, 2)
round(prop.table(table(DEeb792_keai$interest))*100, 2)
round(prop.table(table(DEeb792_keai$informed))*100, 2)
round(prop.table(table(DEeb792_keai$socinfsci))*100, 2)
round(prop.table(table(DEeb792_keai$Opinion1))*100, 2)
round(prop.table(table(DEeb792_keai$Opinion2))*100, 2)
round(prop.table(table(DEeb792_keai$Opinion3))*100, 2)
round(prop.table(table(DEeb792_keai$Opinion4))*100, 2)
round(prop.table(table(DEeb792_keai$Opinion5))*100, 2)
round(prop.table(table(DEeb792_keai$Opinion6))*100, 2)
round(prop.table(table(DEeb792_keai$Opinion7))*100, 2)
round(prop.table(table(DEeb792_keai$engageDM))*100, 2)
summary(DEeb792_keai)
summary(DEeb792_keai$getinfo); sd(DEeb792_keai$getinfo)

## measuring model:
DEmm1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
'
fitDEmm1 <- cfa(DEmm1, DEeb792_keai)
summary(fitDEmm1)
fitmeasures(fitDEmm1, c("cfi", "rmsea", "srmr"))
# the fit is bad:
modificationindices(fitDEmm1, minimum.value = 20)
DEmm2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
```

```
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
Opinion6 ~~ Opinion4 + Opinion6
'
fitDEmm2 <- cfa(DEmm2, DEeb792_keai)
summary(fitDEmm2)
fitmeasures(fitDEmm2, c("cfi", "rmsea", "srmr"))
modificationindices(fitDEmm2, minimum.value = 10)
DEmm3 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
Opinion6 ~~ Opinion4 + Opinion6
Opinion5 ~~ Opinion6
'
fitDEmm3 <- cfa(DEmm3, DEeb792_keai)
summary(fitDEmm3)
fitmeasures(fitDEmm3, c("cfi", "rmsea"))
# The fit is acceptable. This is the measuring model. But we exclude the loads
under 0.30
DEmm3b <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6
# residual covariances
interest ~~ informed
socinfsci ~~ Opinion3
Opinion1 ~~ Opinion2
Opinion6 ~~ Opinion4 + Opinion6
Opinion5 ~~ Opinion6
'
fitDEmm3b <- cfa(DEmm3b, DEeb792_keai)
summary(fitDEmm3b)
fitmeasures(fitDEmm3b, c("cfi", "rmsea"))
semPaths(fitDEmm3b, what = "std", residuals = FALSE, rotation = 1, nCharNodes =
13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3)
```

```
title(main = list("Measuring Model - Germany (Eb 79.2)", cex = 0.80, font = 2),
line = 3.4)
mvn(DEeb792_keai[2:19], mvnTest = "mardia") # Analysis of multivariate normality.
We reject the null hypothesis
fitDEmmfin2 <- cfa(DEmmfin, DEeb792_keai, estimator = "MLM")
summary(fitDEmmfin2)
# THE STRUCTURAL MODEL:
DEsem1 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion1 ~~ Opinion2
Opinion3 ~~ Opinion7
Opinion6 ~~ Opinion4 + Opinion6
Opinion5 ~~ Opinion6
# regressions
Attentiveness ~ Background
Perception ~ Background
engageDM ~ Background + Perception + Attentiveness
'
fitDEsem1 <- sem(DEsem1, DEeb792_keai)
summary(fitDEsem1, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitDEsem1, c("cfi", "rmsea", "srmr"))
# The fit is acceptable. All the parameters are significant, except the covariance
between attitude1 and Opinion2. But as the fit is only acceptable, we analyze
the possibility that other associations need to be included.
modificationindices(fitDEsem1, minimum.value = 20)
# They point to the influence of Attentiveness on Perception
 DEsem2 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion3 ~~ Opinion7
Opinion6 ~~ Opinion4 + Opinion6
Opinion5 ~~ Opinion6
# regressions
Attentiveness ~ Background
Perception ~ Background + Attentiveness
engageDM ~ Background + Perception + Attentiveness
'
fitDEsem2 <- sem(DEsem2, DEeb792_keai)
summary(fitDEsem2, standardized = TRUE, rsquare = TRUE)
```

```
fitmeasures(fitDEsem2, c("cfi", "rmsea", "srmr"))
# engageDM is no longer predicted by Perception, while Perception is not predicted
by bakground.
DEsem3 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion3 ~~ Opinion7
Opinion6 ~~ Opinion4 + Opinion6
Opinion5 ~~ Opinion6
# regressions
Attentiveness ~ Background
Perception ~ Attentiveness
engageDM ~  Perception + Attentiveness
'
fitDEsem3 <- sem(DEsem3, DEeb792_keai)
summary(fitDEsem3, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitDEsem3, c("cfi", "rmsea", "srmr"))
# The fit is acceptable but Attentiveness is not a good predictor of engageDM.
DEsem4 <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6 + Opinion7
# residual covariances
interest ~~ informed
socinfsci ~~ Opinion3 + Opinion7
Opinion3 ~~ Opinion7
Opinion6 ~~ Opinion4 + Opinion6
Opinion5 ~~ Opinion6
Perception ~~ 0*engageDM
# regressions
Attentiveness ~ Background
Perception ~ Attentiveness
engageDM ~  Attentiveness
'
fitDEsem4 <- sem(DEsem4, DEeb792_keai)
summary(fitDEsem4, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitDEsem4, c("cfi", "rmsea"))
# The fit is acceptable and all the parameters are significant. This is the final
model. We exclude the loads under 0.30
DEfin <- '
Background =~ scistud + scicapital
Attentiveness =~ interest + informed + getinfo
Perception =~ socinfsci + Opinion1 + Opinion2 + Opinion3 + Opinion4 + Opinion5 +
Opinion6
```

```
# residual covariances
interest ~~ informed
socinfsci ~~ Opinion3
Opinion6 ~~ Opinion4 + Opinion6
Opinion5 ~~ Opinion6
Perception ~~ 0*engageDM
# regressions
Attentiveness ~ Background
Perception ~ Attentiveness
engageDM ~  Attentiveness
'
fitDEfin <- sem(DEfin, DEeb792_keai)
summary(fitDEfin, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitDEfin, c("cfi", "rmsea"))
semPaths(fitDEfin, what = "std", rotation = 1, nCharNodes = 13, edge.color = "black", fade = FALSE, esize = 2, residuals = FALSE, edge.label.position = 0.67, edge.label.cex = 0.75, label.prop = 1.3)
title(main = list("Structural Model - Germany (Eb 79.2)", cex = 0.80, font = 2), line = 2)
fitDEsemrob <- sem(DEsem3, DEeb792_keai, estimator = "MLM")
summary(fitDEsemrob, standardized = TRUE, rsquare = TRUE)
modificationindices(fitDEfin, minimum.value = 10)
# There is no suggestion that the regressions are different from the hypothesized.
# CROSSTAB Country - engageDM
EB9 <- rbind(BGeb792_keai, ROeb792_keai, GReb792_keai, SPeb792_keai, CYeb792_keai, SIeb792_keai, UKeb792_keai, DKeb792_keai, DEeb792_keai)
EB9$Country <- factor(c(rep(1, 1018), rep(2, 1027), rep(3, 1000), rep(4, 1003), rep(5, 505), rep(6, 1017), rep(7, 1006), rep(8, 1004), rep(9, 1499)), labels = c("BG", "RO", "GR", "SP", "CY", "SI", "UK", "DK", "DE"))
library(descr)
CrossTable(EB9$Country, EB9$engageDM, asresid = TRUE)
library(vcd)
assocstats(table(EB9$Country, EB9$engageDM))
library(graphics)
mosaicplot(table(EB9$Country, EB9$engageDM), shade = TRUE, las = 2, main = "Country and Engagement in DM")
```

ANNEX 3. SPAIN – SURVEY OF SOCIAL PERCEPTION OF SCIENCE AND TECHNOLOGY 2018

```
# DATA DEPURATION:
# Knowledge:
# Literacy:
p24.1 <- FECYT_18_KEAI$P24_1
p24.2 <- FECYT_18_KEAI$P24_2
p24.3 <- FECYT_18_KEAI$P24_3
p24.4 <- FECYT_18_KEAI$P24_4
p24.5 <- FECYT_18_KEAI$P24_5
p24.6 <- FECYT_18_KEAI$P24_6
p24.1_literacy <- ifelse(p24.1 == 2, 1, 0) # 1 = correct, 0 = incorrect
p24.2_literacy <- ifelse(p24.2 == 2, 1, 0)
p24.3_literacy <- ifelse(p24.3 == 2, 1, 0)
p24.4_literacy <- ifelse(p24.4 == 2, 1, 0)
p24.5_literacy <- ifelse(p24.5 == 2, 1, 0)
p24.6_literacy <- ifelse(p24.6 == 1, 1, 0)
p24 <- data.frame(p24.1_literacy, p24.2_literacy, p24.3_literacy, p24.4_literacy,
p24.5_literacy, p24.6_literacy)
Literacy <- rowSums(p24)
# Self perception of knowledge:
p22.1 <- FECYT_18_KEAI$P22P22_1
p22.2 <- FECYT_18_KEAI$P22P22_2
p22.3 <- FECYT_18_KEAI$P22P22_3
p22.1_SciSelf <- ifelse((p22.1 == 98 | p22.1 == 99), 0, p22.1) # Opinion about
science from the respondent perspective.
p22.2_SciSelf <- ifelse((p22.2 == 98 | p22.2 == 99), 0, p22.2)
p22.3_SciSelf <- ifelse((p22.3 == 98 | p22.3 == 99), 0, p22.3)
reorder6 <- function(x) {
  ifelse(x == 1, 5, ifelse(x == 2, 4, ifelse(x == 3, 3, ifelse(x == 4, 2, ifelse(x
== 5, 1, 0)))))
}
selfpercep1 <- reorder6(p22.1_SciSelf)
selfpercep2 <- reorder6(p22.2_SciSelf)
selfpercep3 <- p22.3_SciSelf
p25 <- FECYT_18_KEAI$P25 # perceived level of science education recieved
scieduclev <- reorder6(p25)
p22 <- data.frame(selfpercep1, selfpercep2, selfpercep3, scieduclev)
library(psych)
alpha(p22)
SelfPercep <- rowSums(p22)
# Dispositions:
p29.1 <- FECYT_18_KEAI$P29P29_1
p29.2 <- FECYT_18_KEAI$P29P29_2
p29.3 <- FECYT_18_KEAI$P29P29_3
p29.4 <- FECYT_18_KEAI$P29P29_4
p29.5 <- FECYT_18_KEAI$P29P29_5
```

```
p29.6 <- FECYT_18_KEAI$P29P29_6
p29.1_value <- ifelse(p29.1 == 98, 0, p29.1)
p29.2_value <- ifelse(p29.2 == 98, 0, p29.2)
p29.3_value <- ifelse(p29.3 == 98, 0, p29.3)
p29.4_value <- ifelse(p29.4 == 98, 0, p29.4)
p29.5_value <- ifelse(p29.5 == 98, 0, p29.5)
p29.6_value <- ifelse(p29.6 == 98, 0, p29.6)
p29 <- data.frame(p29.1_value, p29.2_value, p29.3_value, p29.4_value,
p29.5_value, p29.6_value)
alpha(p29)
Dispositions <- rowSums(p29)
# Interest
p1.1 <- FECYT_18_KEAI$P1_1
p1.2 <- FECYT_18_KEAI$P1_2
p1.3 <- FECYT_18_KEAI$P1_3
STinfointerest <- ifelse((p1.1 == 3 | p1.2 == 3 | p1.3 ==3), 1, 0)
p2.2 <- FECYT_18_KEAI$P2P2_2
STinterested <- ifelse((p2.2 == 98 | p2.2 == 99), 0, p2.2)
p9.2 <- FECYT_18_KEAI$P9P9_2
STinformed <- ifelse((p9.2 == 98 | p9.2 == 99), 0, p9.2)
##Getting information
# P10 and p11: media from which respondents get information about S&T
## Don't know and refuse (98, 99): 0
## Internet (2): 0 because it is codified appart and then both variables are
summed
## TV (8), radio (5), other (9, 10, 11, 12, 13, 97): 1
## Newspapers (4), magazines (7): 2
## Science popularization magazines (6) = 3
## Books (3): 3
p10 <- FECYT_18_KEAI$P10A
getinfo1 <- ifelse((p10 == 98 | p10 == 99 | p10 == 2), 0, ifelse((p10 == 5 | p10
> 7), 1, ifelse((p10 == 4 | p10 == 7), 2, 3)))
p11.1 <- FECYT_18_KEAI$P11P11_1
p11.2 <- FECYT_18_KEAI$P11P11_2
p11.3 <- FECYT_18_KEAI$P11P11_3
p11.4 <- FECYT_18_KEAI$P11P11_4
p11.5 <- FECYT_18_KEAI$P11P11_5
p11.6 <- FECYT_18_KEAI$P11P11_6
p11.7 <- FECYT_18_KEAI$P11P11_7
p11.8 <- FECYT_18_KEAI$P11P11_8
zero.na = function(x){
  ifelse(is.na(x),0,x)}
p11.1 <- zero.na(p11.1)
p11.2 <- zero.na(p11.2)
p11.3 <- zero.na(p11.3)
p11.4 <- zero.na(p11.4)
p11.5 <- zero.na(p11.5)
p11.6 <- zero.na(p11.6)
p11.7 <- zero.na(p11.7)
p11.8 <- zero.na(p11.8)
```

```
p11.1 <- ifelse(p11.1 == 1, 4, 0) # blogs, forums -> 4
p11.2 <- ifelse(p11.2 == 1, 2, 0) # social networks -> 2
p11.3 <- ifelse(p11.3 == 1, 2, 0) # Online news -> 2
p11.4 <- ifelse(p11.4 == 1, 3, 0) # digital media specialized in S&T -> 3
p11.5 <- ifelse(p11.5 == 1, 1, 0) # Podcast, radio -> 1
p11.6 <- ifelse(p11.6 == 1, 1, 0) # videos and youtube -> 1
p11.7 <- ifelse(p11.7 == 1, 2, 0) # Wikipedia -> 2
p11.8 <- ifelse(p11.8 == 1, 1, 0) # Others -> 1
gi <- data.frame(p11.1, p11.2, p11.3, p11.4, p11.5, p11.6, p11.7, p11.8)
getinfo2 <- rowSums(gi)
getinfo = getinfo1 + getinfo2
# Engagement
# Decision making:
p20 <- FECYT_18_KEAI$P20
engageDM <- reorder6(p20)
#Informal Science Education
##Partipation in science popularization activities
p27a <- FECYT_18_KEAI$P27aP27a_1
p27b <- FECYT_18_KEAI$P27aP27a_2
p27a <- ifelse(p27a == 1, 1, 0)
p27b <- ifelse(p27b == 1, 1, 0)
p27a_2 <- FECYT_18_KEAI$P27B_1_A
zero.na = function(x){
  ifelse(is.na(x),0,x)}
p27a_2 <- zero.na(p27a_2)
p27a_2 <- ifelse(p27a_2 == 99, 0, p27a_2)
scimuseum <- p27a * p27a_2                #science museums visits
p27b_2 <- FECYT_18_KEAI$P27B_2_A
table(p27b_2)
p27b_2 <- zero.na(p27b_2)
p27b_2 <- ifelse(p27b_2 == 99, 0, p27b_2)
scipopular <- p27b * p27b_2               #Science popularization activities
# Perception:
p13 <- FECYT_18_KEAI$P13
reorder <- function(x) {
  ifelse(x == 1, 3, ifelse(x == 2, 2, ifelse(x == 3, 1, 0)))
}
STBalance <- reorder(p13)
p14.1 <- FECYT_18_KEAI$P14P14_1
p14.2 <- FECYT_18_KEAI$P14P14_2
p14.3 <- FECYT_18_KEAI$P14P14_3
p14.4 <- FECYT_18_KEAI$P14P14_4
p14.5 <- FECYT_18_KEAI$P14P14_5
p14.6 <- FECYT_18_KEAI$P14P14_6
p14.7 <- FECYT_18_KEAI$P14P14_7
p14.8 <- FECYT_18_KEAI$P14P14_8
p14.9 <- FECYT_18_KEAI$P14P14_9
p14.1_SocBal <- reorder(p14.1)
p14.2_SocBal <- reorder(p14.2)
```

```
p14.3_SocBal <- reorder(p14.3)
p14.4_SocBal <- reorder(p14.4)
p14.5_SocBal <- reorder(p14.5)
p14.6_SocBal <- reorder(p14.6)
p14.7_SocBal <- reorder(p14.7)
p14.8_SocBal <- reorder(p14.8)
p14.9_SocBal <- reorder(p14.9)

p14 <- data.frame(p14.1_SocBal, p14.2_SocBal, p14.3_SocBal, p14.4_SocBal, p14.5_SocBal, p14.6_SocBal, p14.7_SocBal, p14.8_SocBal, p14.9_SocBal)
alpha(p14)
# The internal consistency is good and hence we can obtain a single indicator by summing the 9 items.
SocialBalance <- rowSums(p14)
p15r.1 <- FECYT_18_KEAI$P15_1P15_1_1
p15r.2 <- FECYT_18_KEAI$P15_1P15_1_2
p15r.3 <- FECYT_18_KEAI$P15_1P15_1_3
p15r.4 <- FECYT_18_KEAI$P15_1P15_1_4
p15r.5 <- FECYT_18_KEAI$P15_1P15_1_5
p15r.6 <- FECYT_18_KEAI$P15_1P15_1_6
p15r.7 <- FECYT_18_KEAI$P15_1P15_1_7
p15.1_apprisk <- ifelse(p15r.1 >5, 0, p15r.1)
p15.2_apprisk <- ifelse(p15r.2 >5, 0, p15r.2)
p15.3_apprisk <- ifelse(p15r.3 >5, 0, p15r.3)
p15.4_apprisk <- ifelse(p15r.4 >5, 0, p15r.4)
p15.5_apprisk <- ifelse(p15r.5 >5, 0, p15r.5)
p15.6_apprisk <- ifelse(p15r.6 >5, 0, p15r.6)
p15.7_apprisk <- ifelse(p15r.7 >5, 0, p15r.7)
p15_apprisk <- data.frame(p15.1_apprisk, p15.2_apprisk, p15.3_apprisk, p15.4_apprisk, p15.5_apprisk, p15.6_apprisk, p15.7_apprisk)
alpha(p15_apprisk)
# The internal consistency is reasonable and hence we can obtain a single indicator:
AppRisk <- rowSums(p15_apprisk)

p15b.1 <- FECYT_18_KEAI$P15_2P15_2_1; p15b.1 <- zero.na(p15b.1)
p15b.2 <- FECYT_18_KEAI$P15_2P15_2_2; p15b.2 <- zero.na(p15b.2)
p15b.3 <- FECYT_18_KEAI$P15_2P15_2_3; p15b.3 <- zero.na(p15b.3)
p15b.4 <- FECYT_18_KEAI$P15_2P15_2_4; p15b.4 <- zero.na(p15b.4)
p15b.5 <- FECYT_18_KEAI$P15_2P15_2_5; p15b.5 <- zero.na(p15b.5)
p15b.6 <- FECYT_18_KEAI$P15_2P15_2_6; p15b.6 <- zero.na(p15b.6)
p15b.7 <- FECYT_18_KEAI$P15_2P15_2_7; p15b.7 <- zero.na(p15b.7)
p15.1_appbenef <- ifelse(p15b.1 >5, 0, p15b.1)
p15.2_appbenef <- ifelse(p15b.2 >5, 0, p15b.2)
p15.3_appbenef <- ifelse(p15b.3 >5, 0, p15b.3)
p15.4_appbenef <- ifelse(p15b.4 >5, 0, p15b.4)
p15.5_appbenef <- ifelse(p15b.5 >5, 0, p15b.5)
p15.6_appbenef <- ifelse(p15b.6 >5, 0, p15b.6)
p15.7_appbenef <- ifelse(p15b.7 >5, 0, p15b.7)
```

```
p15_appbenef <- data.frame(p15.1_appbenef, p15.2_appbenef, p15.3_appbenef, p15.4_appbenef, p15.5_appbenef, p15.6_appbenef, p15.7_appbenef)
alpha(p15_appbenef)
# The internal consistency is reasonable and hence we can obtain a single indicator:
AppBenefit <- rowSums(p15_appbenef)
p18.1 <- FECYT_18_KEAI$P18P18_1
p18.2 <- FECYT_18_KEAI$P18P18_2
p18.3 <- FECYT_18_KEAI$P18P18_3
p18.4 <- FECYT_18_KEAI$P18P18_4
AtDM1 <- ifelse((p18.1 == 98 | p18.1 == 99), 0, p18.1) # Perception to decision making
AtDM2 <- ifelse((p18.2 == 98 | p18.2 == 99), 0, p18.2)
AtDM3 <- ifelse((p18.3 == 98 | p18.3 == 99), 0, p18.3)
AtDM4 <- ifelse((p18.4 == 98 | p18.4 == 99), 0, p18.4)
p18 <- data.frame(AtDM1, AtDM2, AtDM3, AtDM4)
alpha(p18)
OpinionDM <- rowSums(p18)
p21.1 <- FECYT_18_KEAI$P21P21_1
p21.2 <- FECYT_18_KEAI$P21P21_2
p21.3 <- FECYT_18_KEAI$P21P21_3
p21.4 <- FECYT_18_KEAI$P21P21_4
OpST1 <- ifelse((p21.1 == 98 | p21.1 == 99), 0, p21.1) # Opinion about science
OpST2 <- ifelse((p21.2 == 98 | p21.2 == 99), 0, p21.2)
OpST3 <- ifelse((p21.3 == 98 | p21.3 == 99), 0, p21.3)
OpST4 <- ifelse((p21.4 == 98 | p21.4 == 99), 0, p21.4)
p21 <- data.frame(OpST1, OpST2, OpST3, OpST4)
alpha(p21)
p21 <- data.frame(OpST1, OpST2, OpST3)
alpha(p21)
OpinionST <- rowSums(p21)
# DATA FRAME:
fecyt_keai <- data.frame(Literacy, SelfPercep, Dispositions, STinfointerest, STinterested, STinformed, getinfo, engageDM, scimuseum, scipopular, STBalance, SocialBalance, AppRisk, AppBenefit, OpinionDM, OpinionST)
save(fecyt_keai, file = "fecyt_keai.RData")
# DESCRIPTIVE ANALYSIS:
literacy1 <- factor(p24.1_literacy, labels = c("Incorrect", "Correct"))
round(prop.table(table(literacy1)) * 100, 2)
literacy2 <- factor(p24.2_literacy, labels = c("Incorrect", "Correct"))
round(prop.table(table(literacy2)) * 100, 2)
literacy3 <- factor(p24.3_literacy, labels = c("Incorrect", "Correct"))
round(prop.table(table(literacy3)) * 100, 2)
literacy4 <- factor(p24.4_literacy, labels = c("Incorrect", "Correct"))
round(prop.table(table(literacy4)) * 100, 2)
literacy5 <- factor(p24.5_literacy, labels = c("Incorrect", "Correct"))
round(prop.table(table(literacy5)) * 100, 2)
literacy6 <- factor(p24.6_literacy, labels = c("Incorrect", "Correct"))
round(prop.table(table(literacy6)) * 100, 2)
summary(scieduclev)
```

```
summary(p22.1_SciSelf)
summary(p22.2_SciSelf)
summary(p22.1_SciSelf)
summary(p22.3_SciSelf)
summary(p29.1_value); sd(p29.1_value)
summary(p29.2_value); sd(p29.2_value)
summary(p29.3_value); sd(p29.3_value)
summary(p29.4_value); sd(p29.4_value)
summary(p29.5_value); sd(p29.5_value)
summary(p29.6_value); sd(p29.6_value)
round(prop.table(table(STinfointerest))*100, 2)
summary(p2.SciTech)
summary(p9.SciTech)
summary(getinfo); sd(getinfo)

summary(p14.1_SocBal)
summary(p14.2_SocBal)
summary(p14.3_SocBal)
summary(p14.4_SocBal)
summary(p14.5_SocBal)
summary(p14.6_SocBal)
summary(p14.7_SocBal)
summary(p14.8_SocBal)
summary(p14.9_SocBal)
summary(p15.1_apprisk)
summary(p15.2_apprisk)
summary(p15.3_apprisk)
summary(p15.4_apprisk)
summary(p15.5_apprisk)
summary(p15.6_apprisk)
summary(p15.7_apprisk)
summary(p15.1_appbenef)
summary(p15.2_appbenef)
summary(p15.3_appbenef)
summary(p15.4_appbenef)
summary(p15.5_appbenef)
summary(p15.6_appbenef)
summary(p15.7_appbenef)
summary(AtDM1)
summary(AtDM2)
summary(AtDM3)
summary(AtDM4)
summary(OpST1)
summary(OpST2)
summary(OpST3)
summary(scimuseum); sd(scimuseum)
summary(scipopular); sd(scipopular)
summary(engageDM)
# Descriptive analysis of the indicators:
```

```
summary(fecyt_keai$Literacy); sd(fecyt_keai$Literacy)
summary(fecyt_keai$SelfPercep); sd(fecyt_keai$SelfPercep)
summary(fecyt_keai$Dispositions); sd(fecyt_keai$Dispositions)
round(prop.table(table(fecyt_keai$STinfointerest))*100, 2)
library(modeest)
mfv(fecyt_keai$STinfointerest)
summary(fecyt_keai$STinterested)
summary(fecyt_keai$STinformed)
summary(fecyt_keai$getinfo); sd(fecyt_keai$getinfo)
summary(fecyt_keai$STBalance)
summary(fecyt_keai$SocialBalance); sd(fecyt_keai$SocialBalance)
summary(fecyt_keai$AppRisk); sd(fecyt_keai$AppRisk)
summary(fecyt_keai$AppBenefit); sd(fecyt_keai$AppBenefit)
summary(fecyt_keai$OpinionDM); sd(fecyt_keai$OpinionDM)
summary(fecyt_keai$OpinionST); sd(fecyt_keai$OpinionST)
summary(fecyt_keai$scimuseum); sd(fecyt_keai$scimuseum)
summary(fecyt_keai$scipopular); sd(fecyt_keai$scipopular)
summary(fecyt_keai$engageDM)
#IDENTIFYING THE MEASURING MODEL:
library(lavaan)
SPSTmm1 <- '
Knowledge =~ Literacy + SelfPercep + Dispositions
Interest =~ STinfointerest + STinterested + STinformed + getinfo
Perception =~  STBalance + SocialBalance + AppRisk + AppBenefit + OpinionDM +
OpinionST
Engagement =~  engageDM + scimuseum + scipopular
'
fitSPSTmm1 <- cfa(SPSTmm1, fecyt_keai)
summary(fitSPSTmm1, standardized = TRUE)
fitmeasures(fitSPSTmm1, c("cfi", "rmsea"))
modificationindices(fitSPSTmm1, minimum.value = 30)
# The fit is reasonable, but we see if we can improve it
SPSTmm2 <- '
Knowledge =~ Literacy + SelfPercep + Dispositions
Interest =~ STinfointerest + STinterested + STinformed + getinfo
Perception =~  STBalance + SocialBalance + AppRisk + AppBenefit + OpinionDM +
OpinionST
Engagement =~  engageDM + scimuseum + scipopular
# Residual covariances
STBalance ~~  SocialBalance
OpinionDM ~~ OpinionST
scimuseum ~~  scipopular
'
fitSPSTmm2 <- cfa(SPSTmm2, fecyt_keai)
summary(fitSPSTmm2, standardized = TRUE)
fitmeasures(fitSPSTmm2, c("cfi", "rmsea"))
# The fit is good. This is the final model. We extract the loads under 0.30:
SPSTmm2b <- '
Knowledge =~ Literacy + SelfPercep + Dispositions
```

```
Interest =~ STinfointerest + STinterested + STinformed + getinfo
Perception =~  STBalance + SocialBalance + AppBenefit + OpinionDM + OpinionST
Engagement =~  engageDM + scimuseum + scipopular
# Residual covariances
STBalance ~~  SocialBalance
OpinionDM ~~ OpinionST
scimuseum ~~  scipopular
'
fitSPSTmm2b <- cfa(SPSTmm2b, fecyt_keai)
summary(fitSPSTmm2b, standardized = TRUE)
fitmeasures(fitSPSTmm2b, c("cfi", "rmsea"))
library(semPlot)
semPaths(fitSPSTmm2b, what = "std", residuals = FALSE, rotation = 1, nCharNodes =
13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3, sizeLat = 6, curvePivot = TRUE)
title(main = list("Measuring Model - Spain (SPST)", cex = 0.80, font = 2), line =
-22)
# Multivariate normality
# The mardia test of multivariate normality applies to samples up to 5000. The
SPST sample is higher. An indication that the assumption of mutlivariate normality
is not a problem with big samples. Anyway, we test the robust model:
fitSPSTmm3_rob <- cfa(SPSTmm3, fecyt_keai, estimator = "MLM")
summary(fitSPSTmm3_rob)
# There are not big differences between ML and MLM estimations
# THE STRUCTURAL MODEL:
SPSTsem1 <- '
Knowledge =~ Literacy + SelfPercep + Dispositions
Interest =~ STinfointerest + STinterested + STinformed + getinfo
Perception =~  STBalance + SocialBalance + AppRisk + AppBenefit + OpinionDM +
OpinionST
Engagement =~  engageDM + scimuseum + scipopular
# Residual covariances
STBalance ~~  SocialBalance
OpinionDM ~~ OpinionST
scimuseum ~~  scipopular
# Regressions:
Interest ~ Knowledge
Perception ~ Knowledge
Engagement ~ Knowledge + Interest + Perception
'
fitSPSTsem1 <- cfa(SPSTsem1, fecyt_keai)
summary(fitSPSTsem1, standardized = TRUE)
# Engagement is not predicted by Perception:
SPSTsem2 <- '
Knowledge =~ Literacy + SelfPercep + Dispositions
Interest =~ STinfointerest + STinterested + STinformed + getinfo
Perception =~  STBalance + SocialBalance + AppRisk + AppBenefit + OpinionDM +
OpinionST
Engagement =~  engageDM + scimuseum + scipopular
# Residual covariances
```

```
STBalance ~~  SocialBalance
OpinionDM ~~ OpinionST
scimuseum ~~  scipopular
Perception ~~ 0*Engagement
# Regressions:
Interest ~ Knowledge
Perception ~ Knowledge
Engagement ~ Knowledge + Interest
'
fitSPSTsem2 <- cfa(SPSTsem2, fecyt_keai)
summary(fitSPSTsem2, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitSPSTsem2, c("cfi", "rmsea"))
# This is the final model, but we need to exclude the loads under 0.30
SPSTfin <- '
Knowledge =~ Literacy + SelfPercep + Dispositions
Interest =~ STinfointerest + STinterested + STinformed + getinfo
Perception =~  STBalance + SocialBalance + AppBenefit + OpinionDM + OpinionST
Engagement =~  engageDM + scimuseum + scipopular
# Residual covariances
STBalance ~~  SocialBalance
OpinionDM ~~ OpinionST
scimuseum ~~  scipopular
Perception ~~ 0*Engagement
# Regressions:
Interest ~ Knowledge
Perception ~ Knowledge
Engagement ~ Knowledge + Interest
'
fitSPSTfin <- cfa(SPSTfin, fecyt_keai)
summary(fitSPSTfin, standardized = TRUE, rsquare = TRUE)
fitmeasures(fitSPSTfin, c("cfi", "rmsea"))
modificationindices(fitSPSTfin, minimum.value = 10)
# There is no indication of the need to change the regressions.
semPaths(fitSPSTfin, what = "std", residuals = FALSE, rotation = 1, nCharNodes =
13, edge.color = "black", fade = FALSE, esize = 2, edge.label.position = 0.67,
edge.label.cex = 0.75, label.prop = 1.3)
title(main = list("Structural Equation Model - Spain (SPST)", cex = 0.80, font =
2), line = 3)
```

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