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Percepciones sobre ciencia y tecnología en Chile: análisis factorial exploratorio y confirmatorio para la primera versión de la Encuesta Nacional de Cultura Científica y Tecnológica

Perceptions about Science and Technology in Chile: Exploratory and Confirmatory Factorial Analysis for the first version of the National Survey of Scientific and Technological Culture

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RESUMEN

La preocupación social y política en materia de ciencia y tecnología (CyT) ha adquirido relevancia, tanto por sus contribuciones al campo laboral y médico como por sus externalidades negativas vinculadas a un desarrollo desregulado. En este panorama de política pública, los Estados definen CyT como línea de desarrollo e implementan variadas intervenciones para educar y concientizar a su población. Con el objeto de indagar en las creencias y valoraciones que tiene la ciudadanía chilena, este artículo pretende validar mediante análisis factorial, en sus modalidades exploratoria y confirmatoria, un conjunto de reactivos actitudinales recogidos por la primera versión de la Encuesta de Percepción Social sobre Ciencia y Tecnología (EPSCT), aplicada el año 2015 a una muestra representativa de 7 637 personas. Los análisis AF derivaron tres factores: *Noción de progreso*, *Cotidianidad y modos de vida*, y E*xternalidades sociales y medioambientales*; con adecuados índices de ajuste en particular en su fase exploratoria (RMSEA= .07; CFI= .971; TLI= .928). Estas dimensiones exponen la ambivalencia apreciativa sobre CyT y reconocen por un lado su importancia como fuente de progreso e innovación para el país, no obstante declarar incertidumbre que su desarrollo desregulado conlleva para su vida cotidiana y el trabajo en particular en el daño al medioambiente, la tensión en la supresión de empleo y la transgresión de las fronteras éticas.

Palabras clave
Análisis factorial; ciencia y tecnología; desarrollo integrado; cambio tecnológico; cultura científica; educación ciudadana

ABSTRACT

The social and political concern regarding Science and Technology (S & T) has gained relevance, both because of its contributions to the labor and medical field and because of its negative externalities linked to deregulated development. In this public policy landscape, States define S & T as a line of development and implement various interventions to educate and raise awareness among their population. In order to investigate the beliefs and values of Chilean citizenship, this article aims to validate through Factorial Analysis, in its Exploratory and Confirmatory modalities, a set of attitudinal reagents collected by the first version of the Survey of Social Perception on Science and Technology (SSPST), applied in 2015 to a representative sample of 7 637 people. The AF analyzes derived three factors: Notion of progress; Everyday life and ways of life; Social and environmental externalities with adequate adjustment indexes, particularly in the exploratory phase (RMSEA = .07; CFI = .971; TLI = .928). These dimensions expose the appreciative ambivalence on S & T, recognizing on the one hand its importance as a source of progress and innovation for the country, despite declaring uncertainty that its unregulated development entails for its daily life and work in particular in the damage to the environment, tension in the suppression of employment and the transgression of ethical boundaries.

Keywords
Factor analyses; Science and technology; Integrated development; Technological change; Scientific culture; Citizenship education

INTRODUCTION

The term "scientific culture and technology" refers to a set of beliefs, evaluations, attitudes, behaviors and practices that the citizens of the third industrial revolution have developed as a response to the progress of science and technology" (Rifkin, 2011) With the development of Science and Technology, the economic, social and political lifestyles have undergone exciting transformations besides increasing unprecedentedly the concern for its regulation and control (López, 2005). As a consequence, said concern constitutes a transversal topic of debate among experts, technocrats and government authorities but also among commoners who have become increasingly relevant stakeholders at the moment of defining Science and Technology political and social guidelines (Vogt and Polino, 2003).

While science reveals a world increasingly larger, profound and precise (Bunge, 2014), the commoner, when consulted on science, will hardly engage in a Cartesian discussion in regard to his connection with the world, the ontological rupture or the speculation and reason. However, the scientific diffusion and the technological appropriation of its findings make it possible to dissipate the uncertainty of the world, including among uninitiated or novices, through the use of devices, concepts and representations built by the scientific method (Apffel-Marglin, 1996).

Science and Technology are closely related to competitiveness and innovation (Núñez, 1999). They impregnated our daily lives as a response to the needs of the socioeconomic context (Landes, 1979; Chaves, 2004) and transited through developmental stages transforming our productive and social life, fostering the *second* (Comín, 2011), *third* (Rifkin, 2001) and possible *fourth technological revolution* (Schwab, 2016). While commoners value the different devices, their instrumental assessment has to cope with sustained ethical and social apprehensions deriving from the negative impact of the production, distribution and consumption of Science and Technology.

Science and technology have ruptured the discourse of development that carved the world stage after the Second World War that saw the United States of America emerge as the leader through programs such as the Marshall Plan and the Truman Doctrine, establishing privilege coordinates, identifying underdevelopment problems and more specifically defining orientation criteria in regard to human progress.

Science and Technology developed under this paradigm together with the capital, the distinctive feature of an advanced society with high levels of industrialization, material production and urbanization, modernization of agriculture, access to services and improvement of the living standards (Escobar, 2007). Through this search, a great amount of scientific and technological progress sprang among the great powers (U.S.A., Russia, Germany), who, after the civil society and their governments had reached a certain degree of tension, took over the responsibility for transparency, socialization and consultation in regard to common purposes, their externalities and collateral effects.

The production, distribution and consumption of science and technology affect, for better or worse, the economic, political and community dimensions of the current social life and its basic institutional domains, permeating the values and reshaped the cultural industry, entering beliefs, standards, social distinctions of good and bad, the significant, desirable and rightful (Holzner, Dunn and Muhammad, 1987). These impacts, both material and symbolic, are worth being studied in regard to the people that inhabit and co-create these dimensions in ongoing transformation, under the ensuing demand to establish indicators that measure them and account for their scopes, oriented preferably to the assessment of public perception.

As of the 50's, a series of international organizations emerged with the purpose of improving the relation between science and society, diffusing knowledge on Science and Technology among the population, regulate the negative externalities and face the ethical criticism after the Second World Ward, more specifically in regard to the weaponry development and genetic manipulation. It being understood, the scientific diffusion appears as the democratic principle that advocates the involvement of the population in that affecting its lifestyle and living conditions.

The scientific culture and technology not only nurture public participation but also have an implication as governance criterion (Renn, Webler and Wiedemann, 1995). Notwithstanding its nuances and contradictions, this term derives from the interest of knowing the representational, practical and evaluative state of Science and Technology on the activities of society (CONACYT, 2014). The first studies that structured the phenomenon of the social assessment of Science and Technology in the 60's, implied that the problems of communication with science were the result of a deficit in the society in mastering its fundamental contents which could be corrected by means of formal education (Vogt and Polino, 2003).

More favorable attitudes and greater appreciation of Science and Technology would derive from addressing this cognitive deficit, hence the increase of the population's support towards these activities (Cortassa, 2010). However, the overvaluation of the informational component would omit substantial problems when exaggerating the functional relation of knowledge with attitudes of concern or predisposition, and this would minimize the importance of the lack of interest of the population towards Science and Technology and would ignore that knowledge does not ensure per se a favorable or uncritical predisposition before the clear rifts science has with safety and risk (Beck, 1998).

When analyzing the communication phenomena and the development of our time, different notions of science and technology are assumed based on the theoretical perspective in reference, that is, of post-industrial paradigm (Bell, 1976), globalizing (Gidddens, 1999) of the information (Castell, 2004a), interconnected (Beck, 2006) or liquid (Bauman, 2015). This discussion, besides lacking concrete and solid benchmarks, brings the analysis to such a level of abstraction that it scarcely allows the population at large to participate.

As Beck expounds in his classic essay: *Risk Society: Towards a New Modernity* (1998), science is an essential part of our environment. Therefore instead of fighting it, we

should get involved in it as stakeholders co-responsible of its regulation and production. Before such unprecedented changes that Science and Technology have assumed for social life, it is necessary to account for, justify and limit specific uses of the knowledge they produce, their adverse effects and belligerent, environmental, energetic and bioethical conflicts that come into contact with it (Tapia, 2014), from an integrated vision among the different agents regardless of their position, situation or place, in their right as world citizens (Bauman and Lyon, 2013)

The foregoing resorts to the complex paradigm or *Public Understanding of Science* which goes beyond the perspective of cognitive deficit and, on the one hand, installs the need to know and direct the public opinion in connection with science and technologies, and sensitize in regard to wealth and wellbeing generated by their development. On the other hand, evaluating both perceptions and valuations as undesired externalities in people's lives, grants them a personal value as basis in the use they make, their impacts perceived and information they manage. Investigative disposition that enable government decision making that contribute towards new alternatives of management democratization and S&T public policy (Alan and Wynne, 2003).

To venture into citizen culture in terms of science and technology, defines an attitudinal profile, valuation, ideas and beliefs that the non-expert public has of them, constitutes a relevant input to substantiate with evidence the definition of proposals for innovation, technological appropriation and diffusion programs in regard to S&T, provided the analysis of the public opinion and of the cultural forms from which they derive are complex and heterogeneous as to reduce them to an one-dimensional construct.

On our continent, several attempts to measure the state of the population's scientific culture have been carried out. The most advantageous are Argentina, Brazil and Chile with more than a dozen state initiatives to promote S&T while Paraguay and Equator are lagging. Governments assume responsibility of technological appropriation notwithstanding the fact the first initiatives were oriented towards a communication approach deriving from the cognitive deficit paradigm (Polino and Cortassa).

Subsequent efforts to generate instruments and assess the scientific and technological culture, complement the traditional measure of literacy and attitudes, classical components of the cognitive deficit by addressing the assessment, appropriation and social participation in S&T from a more complex vision (CONICYT, 2014). Multidimensional perspective that considers the subject as part of a "social contract" for the political appropriation of science in citizens that must get involved in the territorial, human, environmental and cultural development of their societies (Montañes, 2010; Vaccarezza, 2008).

Along these lines and addressing the importance of the citizen opinion of consumers, users, beneficiaries and possible victims of the S&T development, the object of this paper is to explore the social perceptions the Chilean population has about the scientific and technological culture. Therefore, through the use of data reporting the first version of the National Enquiry of Social Perception of Science and Technology conducted between 2015 and 2016, an exploratory factorial analysis was conducted to define the latent relations that outline attitudes, valuations, beliefs and behaviors citizens have and

make in regard to S&T. The reduction analysis was supplemented by a factorial confirmatory analysis. Proof and validation of a set of items that bring evidence in the construction of a instrument to assess and predict citizen attitude about S&T in order to calibrate the projection of the former with the social perception and its priorities.

Methodology

Instrument

This paper makes use of the first version of the National Enquiry of Scientific Culture and Technology (EPSCT), applied in Chile between 2015-2016, which had the purpose of knowing perceptions, valuations and representations on science and technology as well as their appropriation capacities. The design, application and analysis of the instrument is under the responsibility of the Chilean National Scientific Research and Technology Commission (CONICYT), that has the support of the Directorate of Social Studies (DESUC, [Spanish acronym]) of the Sociology Institute of the Pontificia Universidad Católica de Chile [Pontifical Catholic University of Chile]. While public instrument, the access to the EPSCT database was facilitated by the Law on the Access to Public Information, or Transparency Act (Act 30.285).

It was a national enquiry and it covered a total sample of 7,637 people from 15 administrative regions of the country. The EPSCT was applied under the modality of personal interviews and consisted of 37 questions structurally segmented into four conceptually defined dimensions as Representational, Operationally practical, evaluative assessment dimension and Institutional system. For the purpose of this report and in the light of the objectives, the series of items corresponding to the evaluative assessment dimension was analytically processed.

Participants

In the 2016 EPSCT application, 7,637 people over 15 years of age with a national representation distributed over 151 communes of all the regions of the country participated which generated a total margin error +/- 1.1%, considering MORE and one +/- 2% under a complex Sampling. Urban and rural sampling benchmarks from the National Statistical Institute (INE [Spanish acronym]) in effect in 2015 were used to select the sample.

This was a stratified multistage sampling procedure (4 stages) with a 74.6% response rate and 11.1% rejection. The sampling results were weighed at national level based on a compound expansion factor by adjustment and probability criteria:

Table 1. Sample Characteristics

Number of people		**7 637**
Sex	Man	49.1%
	Woman	50.9%
Zone	Urban	87.1%
	Rural	12.9%
Age range	From 15 to 29 years of age	30.0%
	From 30 to 44 years of age	26.7%
	From 45 to 59 years of age	24.2%
	From 60 and more	19.1%
Religion	churchgoer	32.5%
	Non churchgoer	55.0%
	Atheist or agnostic	12.6%
Educational Level	Incomplete high school education or less	35.5%
	Complete High school education	37.6%
	Incomplete Higher education or more	26.8%

Source: own elaboration based on the National Commission of Scientific and Technological Research (CONICYT).

At national level, the sample of 7,637 people was balanced per sex (49.1% of men), residents of urban zones mainly (87.1%) with relative homogeneity per age group of interest where 56.7% do not exceed 45 years of age. Most of the people in the sample declare being believers (87.4%), catholic mainly, with elementary and high school education (73.2%).

Procedure

Based on the objectives of this paper, a series of thirteen items were selected. These items correspond to the evaluative assessment dimension (Module D) of the questionnaire, tied to assess the image that the interviewee has and makes of science and technology, more specifically of the perception in regard to the estimated risks and changes believed to have been fostered in the daily life. The reagents used are:

1) Science and technology contribute to improve the environment. (i1)

2) Science and technology have helped us to better face natural disasters (for example: earthquakes, tsunamis, rain floods) (i2)

3) Science and technology have helped us to improve our nutrition (i3)

4) Through science and technology applications, jobs are lost (i4)

5) Science and technology are responsible of most of the current environmental problems (i5)

6) The scientific-technological development will help reduce social inequalities (i6)

7) Science and technology is better developed by women than by men (i7)

8) Science provides more reliable knowledge of the world (i8)

9) Science and technology make our lives easier and more comfortable (i9)

10) Science causes too rapid changes in our lifestyle (i10)

11) Scientists make very little effort to inform the public about their work (i11)

12) Science and technology produce an artificial lifestyle (i12)

13) We depend too much on science and not enough on faith (i13)

These thirteen items are formulated using a Likert type scale with five levels of intensity transmitted from "Strong disagreement" to "Strong agreement". For the purpose of the analysis, only the valid categories and the set of complete responses have been considered; that is, for a set of individuals provided they have complied with the thirteen items being analyzed. The actual percentage of global response reaches 96.1%.

The categorical assessment of the items semantically negative in regard to the attitude to assess (item 4, 5, 10, 11, 12 and 13) was reoriented in order to maintain the consistency of the construct in such a way that the highest score assigned to the item response represents a favorable assessment of the S&T regardless of its initial orientation.

The data analysis was conducted in two steps. The first step consisted in the exploratory analysis of the underlying structure and its reliability. This was done through an exploratory factorial analysis (EFA), searching to minimize the dimensionality that would explaining the variability and correlations observed among items. Unweighted least squares with maximum likelihood (ULSMV) were used as factor assessment procedure given the ordinality of the items and the size of the sample available.

The adjustment index was assessed through standardized root mean square residual (RMSEA), robust and reliable goodness of fit measure for large samples (Yuan, 2005). The fit was fixed at values lesser than .08 even though there are some authors that situate it below .05 (Herrero, 2010). Comparative fit (CFI) and Tucker Lewis (TLI) indexes were considered as supplements, demanding .90 as good fit expression for both figures. The direct Oblimin rotation was used to facilitate the interpretability of the factors and their items in a simplified structure, which does not assume the orthogonality among factors (Elosua and Zumbo, 2008).

The second step consisted in making a validation of the factorial structure assessed in the exploratory phase and the confirmatory factorial analysis (CFA) was used. Likewise,

ULSMV and RMSEA fit, CFI and TLI indexes were used as assessment procedure under the same conditions as EFA. Both phases were complemented with an instrument reliability test.

Given the limitations presented by Crobach's Alpha for such cases in which it is not possible to sustain the ongoing character of the variables, we chose to calculate the ordinal Alpha, expression of the internal consistency of the items with five levels of graduated response without underestimating the reliability (Elosua and Zumbo, 2008).

The sample was divided in two segments to conduct the EFA and CFA analysis. Their representational equivalence was ensured through a uniform randomness and every sub-sample was constituted by approximately 50% of the participants distributed randomly. The Mplus version 7 statistical software was used for this procedure.

Analysis and Results

Science and technology have become an indivisible part of our daily life and of the social discourse. In spite of the nuances and impact levels, people are exposed to their concepts, uses and results. To think socially in technology involves expressing ourselves through it, receiving and sharing information, impressing each other for good or for worse with its advances that tense our precepts and modifies our habits. To listen to science is not always synonym of truth, trust and progress, since, from the perspective of the subject, its advances have nuances that expose us to risks and opportunities. By addressing it, assessments, ideas and conceptions the population has in regard to science and technology are explored through the EPSCT instrument, validating a set of items that claim to unveil an underlying structure which testing phase allows defining future attitudinal profiles.

a) EFA Results

By assuming the presence of an underlying multidimensional structure with a number of unknown factors we proceeded to conduct an EFA with ULSMV and direct Oblimin rotation. We chose to expound different models or solutions with their corresponding fit indexes and to do so we used 50% of the sample duly randomized.

In fact, we explored a total of eight options of factorial structure and a combination of number of factors and items was used as criterion. The original scale was analyzed and the solution of two or three factors was considered; these solutions were supplemented by models that incorporate the elimination of one, two and three items which presented problems of recurrent consistency. Based on the fit indexes, we opted to solve three factors and only ten items from the original scale (Model 4) since it was the factorial solution that registered the best EFA fit indexes despite of not complying with the recommendation of containing a minimum of three items per dimension (Lloret, Ferreres, Hernández and Tomás, 2014) as with our model third factor:

Table 2. Fit Indexes According to the Revised Model

	Mod 1	**Mod 2**	**Mod 3**	**Mod 4**
RMSEA	.096	.084	.081	.07
CFI	.905	.942	.954	.971
TLI	.824	.884	.898	.928
Chi^2	15624,1	15215,8	13407,4	11802.5
DF	78	66	55	45

Note: Model 1 incorporates the original scale of thirteen items, differing in the factorial solution; Model 2 excludes item seven; model 3 excludes item 7 as well as item 13 (*We depend too much on science and not enough on faith*); model 4 excludes items 7, 13 and 8 (*Science provides the most reliable knowledge of the world*). The items were excluded in an iterative process since it shows a low consistency with the factorial solutions proposed.

Given the official character of the data and of the authorship of the formulation of the scale that searches to measure the citizens' attitudes toward science and technology, first of all, we worked on the entirety of the items of the original scale, under the assumption of the strict integrality and testing of these instruments before their application by renowned agencies such as the Chilean National Science and Technology Commission. While considering this integrality of instrument, solutions of two and three factors were shaped and both deficient fit indexes were presented. Within the scheme of thirteen items, the best shaped solution was that of the three factors (Model 1); however, fit indexes far below those recommended (RMSEA=.096; CFI= .905; TLI= .824).

Given the weaknesses observed in the original instrument, we opted for an iterative elimination process based on a combination of criteria: (1) statistical meaning; (2) reduced factorial charges; o (3) double charges or undetermined, exploring fit indexes to solve two and three factors, which data are also shown in Table 2.

The solutions of two factors, with or without the elimination of items, do not improve the fit substantially and do not comply with the criteria of admissibility besides presenting very low or shared factorial charges. By carrying out the iterative modeling processes and rejecting poorly efficient solutions, we proceeded to select Model 4 which consists of a three factor solution with a total of ten items.

This solution stands out among the revised alternatives and provides adequate and efficient fit indexes in spite of the elimination of items. Model 4 fit indexes are RMSEA_ .07; CFI= .971; TLI= .928; besides, it has a Chi2 and pertinent degrees of freedom.

Table 3. Factorial Charges, three factors and ten items solution (Model 4)

		Factors			MA-A
	Items (α= .767)	I	II	III	
i1	*Science and technology contribute to improving the environment.*	**.730**	.030*	-.052*	51,4
i2	*Science and technology have helped us better FACE natural disasters (for example: earthquakes, tsunamis, rain floods)*	**.664***	.149*	.019	65,0
i3	*Science and technology have helped us improve our nutrition*	**.717***	-.092*	.071*	46,5
i6	*Scientific and technological development will help reduce social inequalities*	**.420***	-.107*	.091*	28,7
i10	*Science make our lifestyle change too quickly*	.034*	**.876***	-.036*	74,7
i12	*Science and technology are producing an artificial lifestyle*	-.121*	**.665***	.181*	78,8
i9	*Science and technology are making our lives easier and more comfortable.*	.175*	**.644***	-.033*	72,2
i11	*Scientists make very little efforts to inform the public about their work*	-.086*	**.529***	.067*	61,2
i5	*Science and technology are responsible for most of the current environmental problems*	.020*	**-.021***	.814*	54,2
i4	*Science and technology applications are causing the loss of jobs.*	.048*	**.226***	.501*	64,6

Note: MA-A = percentage of agreement and agreement with the item.
Source: own elaboration based on the National Commission of Scientific and Technological Research (CONICYT).

In the EFA, the three factors with ten items solution (Model 4) showed marked and significant factorial charges with their respective dimensions, seven of which register scores above .60. Item 6 alone (*The scientific and technological development will help reduce social inequalities*) showed a charge below .5 (.420). We also observed definite unifactorial charges in the items in regard to the agglomeration factor.

On the other hand, the inter-factorial correlations are low (F1-F2= .32; F1-F3= .12) to the exception of the correlation existing between factors two and three, which is

positioned at a .47 index. These reduced indexes allow sustaining the underlying dimensions that tend to be independent and no simple disintegrations of a same theoretical component. The semantic analysis of the factors according to the items that compose them allows defining them synthetically under the denominations of *Notion of S&T Progress* (F1, integrated by items 1, 2, 3 and 6), *Everyday life and lifestyles* (F2, items 10, 12,9, 11), and *Social and Environmental Externalities* (F3, items 5 an 4).

By taking into consideration the metric character of the five ascending levels for the reliability analysis of the items in this first part of the EFA, Ordianl Cronbach's Alpha index were calculated (Elosua and Zumbo, 2008) and Omega (Gerbing and Anderson, 1988), that, according to the literature, represent better than Cronbach's Alpha the covariance in non-continuous variables (Ventura-León, 2018).

Ordinal Apha values are .723 (F1), .733 (F2) and .579 (F3); Omega shed indexes of .775 (F1), .783 (F2) and .614 (F3), set of values, at least in regard to factors one and two, are considered adequate in terms of reliability (Campos-Arias and Oviedo, 2008; Ventura and Caycho, 2017), is an expression of internal consistency in regard to the homogeneity and equivalence between the response of the items and subjects and indicator of the unidimensionality of the construct measured by the scale.

In more disintegrated analytical terms, the factorial structure proposed is constituted by:

- **Factor 1**: integrated by items 1, 2, 3 and 6, which are linked as a whole to the *Notion of S&T Progress*. These, through their findings and applications, extend the boundaries of knowledge, and at a citizen level, they express themselves concretely in the opinion that the development of science and technology may anticipate natural disasters, improve the environment and Nutrition, providing a more reliable and consistent knowledge of the natural world, which behavior they achieve to predict and use to their benefit.

- **Factor 2**: made up of items 9, 10, 11 and 12. It explores the set of perceptions on *Everyday Life and Lifestyles*. S&T development has global impacts on the different spheres of the social life materialized in the constant modification of our lifestyles, sociability and conduct clues that, in spite of the immediacy and suppression of temporary and special boundaries, offers certain features of artificiality and superficiality to the social link, accelerates our lifestyles and invades everyday life generating uncertainty, notwithstanding making existence somewhat more comfortable and easier than in the past.

- **Factor 3**: joins items 4 and 5, it mentions what we have simply called *Social and Environmental Externalities*. The technological and scientific progress brings along as counterpart risks and costs that are transferred to society and is expressed by the fear of losing jobs to the hands of technology and the degradation of the environment due to the large-scale industrial development fostered by the intensive use of technology and knowledge, set of changes that generate uncertainty and anxiety in many citizens.

b) CFA Results

With the purpose of corroborating the consistency of the factorial solution found in the EFA exploratory phase, we proceeded to conduct a confirmatory factorial analysis (CFA) with the remaining 50% of the randomized sample consisting of a total of 3,770 subjects. The thirteen items original model were reworked and the ten items were edited (Table 3) and the indexes were compared to validate the empiric sustainability of the theoretical model proposed (Magaña, Aguilar and Vásquez, 2017).

The CFA original model exhibits fit indexes more precarious than those obtained in the exploratory phase. Its estimated RMSEA reaches .14, especially when the literature establishes .08 as maximum acceptable value (Kline, 2015; Byrne, 2013). Furthermore, their incremental fit indexes also fall short sine the CFI is positioned at .699 and the TLI at .628, both figures being far below the acceptable figure (>=.9). The team of fit estimators that confirmed what has been evidenced in the exploratory phase and it gives account of the presence of items with low communalities, situation that caused the elimination of items in order to improve the fit of the model established by the EFA.

Table 4. Fit Indexes according to the type of analysis and model

	EFA 3F		**CFA 3F**	
Index	**Original**	**Edited**	**Original**	**Edited**
RMSEA	0.096	0.07	0.140	0.095
CFI	0.905	0.971	0.699	0.907
TLI	0.824	0.928	0.628	0.870
Chi^2	15624,1*	11802,5*	15566,4*	11794,6*
DF	78	45	78	45

*Significance <,01
Source: own elaboration based on the National Commission of Scientific and Technological Research (CONICYT).

In regard to the edited model (Model 4 in EFA), the values fluctuate between acceptable and moderate, besides the fit is better supported by its structure. Even when RMSEA slightly exceeds the general admissibility parameters by reaching .095 between the measure model and the entered data structure, they can be interpreted as tolerable fit values between .0 and .10 (González and Bacjhoff, 2010). While CFI and TLI slightly diminish, and are at the lower acceptability limits which according to the literature should not be lower than .9 (Herrero, 2010); therefore, the model borders the admissibility based on the data organization proposed.

BY following CFA structural organization, items 1, 2 and 3 show satisfactory levels of association with factor 1 which we have denominated based on its structural axis *S&T Notion of Progress*. The idea of development captured in the collective imaginary ties scientific and technological progress with set of *inputs* derived from the manipulation of nature and the expansion of the boundaries of knowledge. The applied version of S&T is linked to the role its impact plays in safeguarding and preserving the environment of both, people and the ecosystem, the prediction and confrontation of natural disasters besides its contribution to nutrition and quality if life.

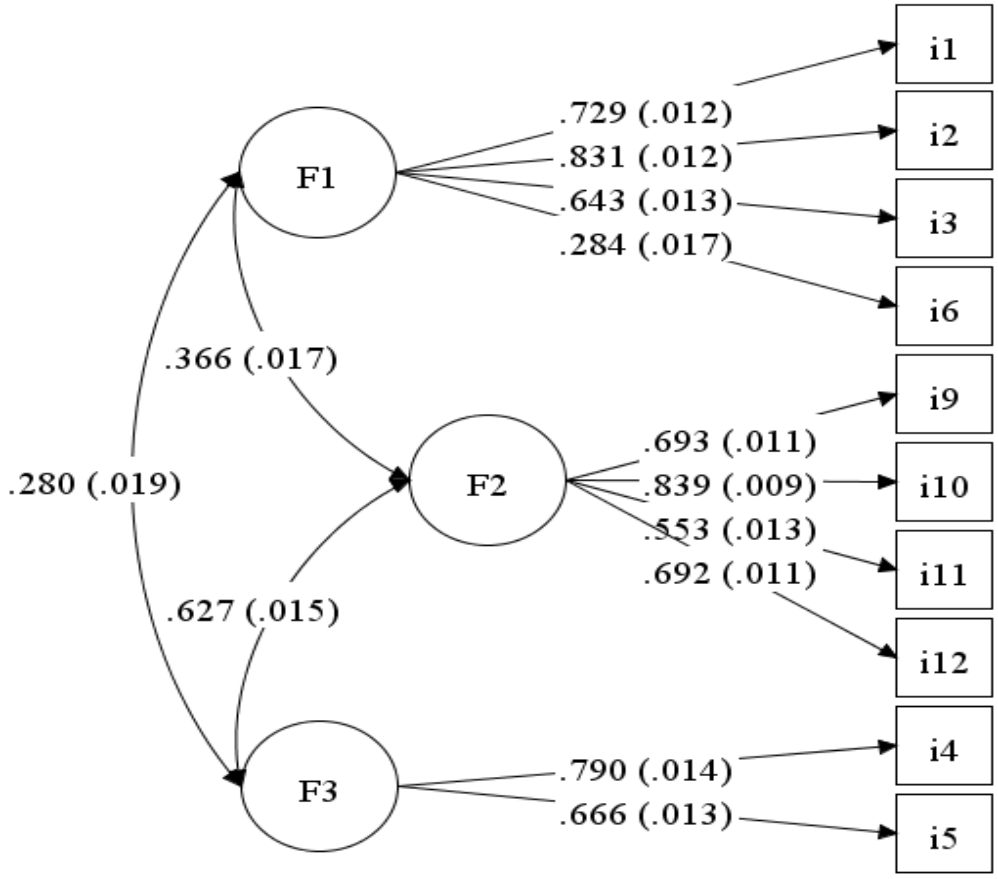

Diagram 1. Confirmatory Factorial Analysis of social perceptions on science and technology.
Note: F1= S&T Notion of Progress; F2= Everyday life and lifestyles; F3= social and environmental externalities.
Source: own elaboration based on the National Commission of Scientific and Technological Research (CONICYT).

Perceptions associated to the idea of S&T development are strongly segmented. A significant contingent together with the impression that the S&T innovation will contribute to reducing the ecological impact caused by the productive and commercial activity of societies, improving the environment (51.4% Agree-Strongly agree).

On the other hand, a less optimistic conglomerate (23.3% disagree-strongly disagree), underlies the notion that appropriate progress of technology applied to the industrial activity generates the deterioration of the environment and the quality of life. We cannot ignore that technology permeates everything and it is impossible to find any activity, whether beneficial or detrimental, in which it technology does not play an important role (Gil and Vilches, 2004).

This ubiquity would explain that contradiction of progress and detriment coexist closely in the notion of development the population has in regard to S&T, where the dominance

of nature in benefit of humanity concomitantly contributes to the greenhouse gas emission, the smog in cities and environmental, hydric and carbon footprints as material expressions of this contradiction.

Major consensus exists in regard to the prevention and control of natural disasters such as earthquakes, tsunamis, hurricanes (65% Agree-Strongly agree). The expansion of the boundaries of knowledge given the development of science offers us the possibility to understand the functioning of the natural world for our benefit under the assumption the S&T have invested intensively notwithstanding the weaknesses encountered to diffuse said advances and their solutions to the non-expert public.

The notion of development of S&T is also familiar with the activity of the food industry. A significant function is acknowledged in the improvement of our nutrition (46.5% Agree-Strongly Agree) even though doubts persist about quality, safety for the environment and the absence of risks for human health. Biotechnology, in its evolution, has stopped registering and applying hastily technologies which impacts have been sufficiently studies in spite of the increase in the production implied by its use. (Gil and Vilches, 2004).

A second factor composed of items with factorial charges between .84 and .55 are called *Everyday life and lifestyles*. Sometimes intentionally – and in other no – the development of S&T has resonated in the lifestyles of current societies. The notion of change, artificiality, facility and convenience are strongly tied for good or worse to its development, transforming itself in the greatest institution of our society, the most important structuring and constituting element of our culture (Ziman, 2003). As supplement, technologies transform reality and penetrate everyday life spaces to become extensions of the human being and even create new realities that challenge the notion of human, whether in their trans-humanism or post-humanism variants (Molinuevo, 2007).

The technological irruption and massification have not only intervened in natural but also in urban and relational spaces, hence the discussion on challenges and progresses has inevitably reached the population and the public at large, and has incorporated the ethical, political and cultural problem to its evolution (Gartner, 2009). While the population assimilates new technologies at different stages, according mainly to economic characteristics (Larraín, 2005), soon or later, these propagate to the rest of the population and modify behavioral patterns and habits once conventional.

Everyday life activities such as communication, consumption and leisure are saturated by innovation, which make us feel part of a simulation of what is real (Baudrillard, 2002). Along these lines, the interviewees strongly agree that science and technology produce an artificial lifestyle (78.8%) that changes too rapidly (74.7%); expressions that strangely coexist with the generalized impression that S&T make our life easier and more comfortable (72.2%). This apparent paradox does not conceive but rather reveal the intrinsic lights and darkness of the scientific development and technological innovation.

This perception of the impact of S&T on lifestyles in sociological terms, coexists with the debate on social identifications and discourses, In this sense, the identity and its

means of conveyance alter the traditional cultural categories of identification which fade among social discourses and surrealist images surreptitiously articulates in such a way that they drag the subject out of his center and strip him away of the certainties of their comfort zone (Lyotard, 1995). However, the subject in his everyday life does not disappear but rather adjust and adapt to these new scenarios, devices and apparatus which they integrate and make them part of their lifestyle (Larraín, 2001).

As third and last component of the scale of social perception on science and technology, we encounter the third factor consisting of items 4 and 5 with factorial charges of .79 and .67 respectively which we have classified as *Social and Environmental Externalities*. The imminence of risk in scientific activities affect key areas such as work, health and the ecosystem and has an impact on the social world in different ways generating uncertainty on people's way of life.

Resistance to mistrust is inherent to the irruption of innovation since it puts a strain on the transition from custom to adaptation, especially in groups with notorious gap between their real capacities and the new demands. Resistance to innovation is a phenomenon that accompanies the historical development of humanity.

In fact, one of the first movements reluctant to the inclusion of technology at work was luddite integrated by C19 English workers who opposed the pervert effect said inclusion would have in substituting manpower in companies and industries (Rifkin, 2001; Castells, 2004b; Jones, 2006). While scientific and technological development has rendered a new societal paradigm possible on line, intensive in information and knowledge, mutating as structuring economic axis the industrial production towards services. Said change has not derived in great masses of unemployed as initially predicted (Castells, 2004b)

The technological change generates a manpower substitution effect and even puts a strain on the obsolescence of certain activities and the disappearance of occupations. However, the main reasons for unemployment are linked to the dynamics inherent to the economy and growth, the swings of recession and the failure of education to adapt to personal and salary expectations (Tokman, 2002; De La Hoz, Quejada y Yánez, 2012).

Despite the fact that unemployment rates in developed and developing countries are defined, the fear before the probability of being substituted by technology persists before the accelerated and permanent change. Individuals declare their uncertainty when constantly redefining their role in society and performing in a new labor world where it is no longer possible to sustain the comprehension of oneself which once provided work (Polanyi, 1989; Sennett, 199; Flores and Gray, 2003). In a similar context, 64.6% of the Chileans interviewed, indicate that the S&T applications cause the loss of work positions.

These undesired S&T externalities or effects are also correlated to environmental issues where more than half of the interviewees (54.2%) accuse S&T of being directly responsible of the great majority of the ecological issues we currently have. It is precisely this responsibility attribution that leads the public to oppose certain forms of

technological development such as the nuclear energy, genetic engineering and the dam installation.

While this reluctance may be explained by informational components such as those stated in the Cognitive Deficit Model where lesser the information, greater the citizen opposition (Blanco and Iranzo, 2000), it is nonetheless true that there is evidence of ancient and recent disasters that corroborate these fears and give account that the flow of truth does not transit unidirectionally from science to technology and society but also in reverse direction (Ziman, 1984)Therefore, the levels of opposition do not directly result from the ignorance of the upstart public who, from the non-expert position, maintain a critical and apocalyptic vision of science and technology.

This suspicious behavioral profile towards S&T is based on the historical role of passive agents of the public in general who suffer from externalities and negative consequences instead of searching to obtain some benefit from this development. The improvement of this citizen behavior profile before S&T implies making them participate in the decision making in regard to their development and mitigates their prejudices and makes them aware of their externalities, and goes beyond technological literacy to venture into the generation of capacities and empowerment as ethical and social imperative, desirable and necessary.

Conclusions

Science and technology permeate all the spheres of activities in modern societies and introduce changes that become embedded evermore profoundly in people's everyday life and impact their ways and styles of life. Notwithstanding their ubiquity, there is still a certain rift between the average citizen and S&T. Not only does their knowledge as an upstart public tend to be scarce and limited, so is their level of intervention and participation in their development despite being the one who ultimately suffers from their most negative externalities.

In order to address the importance of the current knowledge of citizen culture on science and technology in democratic societies, the Chilean National Scientific and Technological Research Commission (CONICYT, [Spanish acronym]), applied the Social Perception of Science and Technology Survey (EPSCT, [Spanish acronym]) in an unprecedented way. This article makes use of the EPSCT database which carried out a validation process of the *Evaluative Value* component on which the survey is structured. More specifically, this article proceeds to conduct a factorial analysis of its exploratory and confirmatory phases in order to elucidate the latent structure that shapes the citizens' perception about S & T.

It should be mentioned that it is the first time nationwide that an estimation regarding the citizens' perceptions and valuations about S & T is conducted. Currently, there are only technical and descriptive reports made exclusively by the institution responsible of its execution; therefore, this article is a pioneer in using and addressing EPSCT from a factorial perspective and exploring the instrumental metric capacity to unveil the

underlying structural dimensions of the citizens' perceptions about S & T and the capacity to adjust the model proposed based on its level of consistency.

An EFA was conducted in the first part with 50% of the sample duly randomized. The fit indexes of eight models were contrasted. These models considered both, the original scale and its items and factors reduction variants. Based on parsimony criteria, fit indexes and theoretical significance, we finally chose the EFA solution that considered three factors and ten items (Model 4) for which we obtained the appropriate fit indexes (RMSEA = .07; CFI= .971; TLI= .928). The exploratory phase was contrasted by means of a confirmatory factorial analysis (CFA) and the result showed that remaining 50% of the randomized sample corroborates the relevance of the decision taken in the preliminary phase with fit values slightly lower than those obtained in EFA (RMSEA = .095; CFI= .907; TLI= .870).

In both EFA and CFA, model 4 shows marked and significant factorial charges with their respective dimensions besides low interfactorial correlations showing underlying dimensions relatively independent. If the ordinal metric character of the items was taken into consideration in the Apha Ordinal reliability analysis for EFA, the coefficients were .723 (F1), .733 (F2) and .579 (F3); while the Omega analysis, reported values of .704 and .730 (F1), .786 and .792 (F2) and .690 and .695 (F3) respectively. These indexes as a whole are an expression of the appropriate internal reliability or consistency levels at scale level. Lastly, the factorial structure consists of:

a) *The S & T Notion* of Progress is the first factor of the scale made up of items 1, 2, 3, and 6. It is linked to the role it plays in the scientific and technological development in extending the boundaries of knowledge and dominating nature in benefit of humanity.

b) *Everyday life and lifestyles* is the second factor which is made up of items 9, 10, 11 and 12. It refers to the impact that the use of information, knowledge and devices have on lifestyles and the relation people have. More specifically, it explores the responsibility attributed to S & T in regard to articulators of an artificial and changing life notwithstanding the benefits and comfort they report.

c) *Social and environmental externalities* are the third factor consisting in items 4 and 5. It sets out the risk sensation that the population has in regard to the impact and deterioration that the development, implementation and use of S & T causes on the labor market and on the environment. Beyond the reduced factorial charges reported, the thematic relevance of this dimension for the modeling of behavioral profiles recommend incorporating a greater quantity of items of this sort to the instrument which would allow complying with the methodological criteria of dimensional segmentation and would improve the weight of the factorial charges.

To sum up, the treatment of social perceptions about science and technology should, at the political and programmatic levels, involve the different social agents. The role S & T plays in contemporary and complex societies, its undesirable historical effects and the

increasing interference of social groups makes it more necessary to move from an informational paradigm that provides literacy to lay publics to and updated paradigm that tends to promote not only favorable attitudes but also critical postures covered by generating skills and empowerment, by having the population participate in the paradigm benefits and making them co-responsible of its effects. To outline an instrument that allows knowing the assessments, perception and representations that citizens have about S & T, constitutes, in this regard, a relevant input in decision making.

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