Complementary material to manuscript:

Indicators for the evaluation of science, technology and innovation activities: a systematized review

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Abstract

The main purpose of this study was to develop a systematic review of the scientific literature about indicators for the evaluation of science, technology and innovation activities. For this, the Web of Science, Scopus and Google Scholar databases were used. Through the application of the SysteRe-HSS methodology, 96 publications were selected that formed the basis for a descriptive model of the science, technology and innovation indicators. The results of the research showed that there is a predominance of indicators related to the evaluation of innovation activities, human resources allocated to the activity of science, technology and innovation, financial resources and investments in research plus development, and indicators related to bibliometrics and scientometrics. However, challenges are faced related to measuring indicators of social innovation, linking insights from existing innovation measurement approaches with the essential features of social innovation, measuring the impact of social appropriation practices of science and technology, and the next generation metrics, responsible metrics and evaluation for open science, as well as alternative indicators for the evaluation of the social impact of research in web 2.0.

Keywords: Indicators; Science; Technology; Innovation; Research evaluation.

Table 1. List of indicators identified in the systematized review

CONTEXT INDICATORS	Definition
Population	Group of people who inhabit a certain geographical area.
Economically active population (EAP)	Comprises all persons who furnish the supply of labour for the production of

	economic goods and services as defined by the United Nations systems of national accounts and balances, during a specified time-reference period.
Gross domestic product (GDP)	Is the standard measure of the value added created through the production of goods and services in a country during a certain period.
INPUT INDICATORS	**Definition**
R&D Financial Resources	
R&D spending	Spending on R&D, both by the public sector and the private sector.
Expenditure on R&D in relation to GDP	Relative effort in R&D, taking GDP as a reference.
Expenditure on R&D per inhabitant	Expenditure on R&D in relation to the number of inhabitants.
R&D expenditure per researcher	Total R&D expenditure, divided by the number of researchers (calculated in equivalence to working day complete and in physical persons).
R&D spending by financing sector	Expenditure on R&D according to the source of financing. The values are expressed in percentages, in relation to the sum of the values of the categories available for this indicator.
Expenditure on R&D financed by the enterprise sector by type of enterprise	Expenditure on R&D financed by the enterprise sector by type of enterprise.
Expenditure on R&D by execution sector	Expenditure on R&D according to the sector that executes it. The values are expressed in percentages in relation to the sum of the values of the categories available for this indicator.
Expenditure on R&D executed by the enterprise sector by type of enterprise	Expenditure on R&D executed by the enterprise sector by type of enterprise.
R&D expenditure by type of costs	Expenditure on R&D according to the type of costs. The values are expressed in percentages in relation to the sum of the values of the categories available for this indicator.
Expenditure on R&D by type of cost, executed by the Government Sector	Expenditure on R&D by type of cost, executed by the Government Sector.
Expenditure on R&D by type of cost, executed by ENTERPRISE Sector (Public and Private)	Expenditure on R&D by type of cost, executed by ENTERPRISE Sector (Public and Private).
Expenditure on R&D by type of costs, executed by the Higher Education Sector	Expenditure on R&D by type of costs, executed by the Higher Education Sector.

Expenditure on R&D by type of cost, executed by Private Non-profit Organizations Sector	Expenditure on R&D by type of cost, executed by Private Non-profit Organizations Sector.
R&D Expenditure by Type of Research	Expenditure on R&D according to the activity type. The values are expressed in percentages in relation to the sum of the values of the categories available for this indicator.
Expenditure on R&D by type of research, carried out by the Government Sector	Expenditure on R&D by type of research, carried out by the Government Sector.
Expenditure on R&D by type of research, carried out by the Enterprise Sector (Public and Private)	Expenditure on R&D by type of research, carried out by the Enterprise Sector (Public and Private).
Expenditure on R&D by type of research, carried out by the Higher Education Sector	Expenditure on R&D by type of research, carried out by the Higher Education Sector.
Expenditure on R&D by type of research, carried out by the Private Non-profit Organizations Sector	Expenditure on R&D by type of research, carried out by the Private Non-profit Organizations Sector.
R&D expenditure by scientific discipline	Expenditure on R&D depending on the distribution of resources according to the scientific and technological disciplines on which their activities are focused.
Expenditure on R&D by scientific discipline, executed by the Government Sector	Expenditure on R&D by scientific discipline, executed by the Government Sector.
Expenditure on R&D by scientific discipline, carried out by the Enterprises Sector (Public and Private)	Expenditure on R&D by scientific discipline, carried out by the Enterprises Sector (Public and Private).
Expenditure on R&D by scientific discipline, executed by the Higher Education Sector	Expenditure on R&D by scientific discipline, executed by the Higher Education Sector.
Expenditure on R&D by scientific discipline, carried out by the Private Non-profit Organizations Sector	Expenditure on R&D by scientific discipline, carried out by the Private Non-profit Organizations Sector.
R&D Public Budget Credits by socioeconomic objective	Public financing of R&D based on information extracted from national budgets.
R&D Human Resources (Physical persons)	
R&D Personnel	Number of people involved in R&D, expressed in natural persons, according to their different functions.
Researchers per 1000 of the Economically Active Population	Number of researchers, expressed in physical persons, per thousand members of the country's available labor force or economically active population (EAP).

Researchers by sector of employment	Distribution of researchers, expressed in physical persons, according to the sector in which they carry out their activity.
Researchers by scientific discipline	Distribution of researchers, expressed in physical persons, according to the scientific discipline in which they work.
Researchers by level of training	Distribution of researchers, expressed in physical persons, according to their highest level of training attained.
Researchers by age group	Researchers, expressed in physical persons, by age group.
R&D Human Resources (Full Time Equivalency)	
R&D personnel	Number of people involved in R&D, expressed in natural persons, according to their different functions.
Researchers every 1000 of the EAP	Number of researchers, expressed in physical persons, per thousand members of the country's available labor force or economically active population (EAP).
Researchers by sector of employment	Distribution of researchers, expressed in full-time equivalency, according to the sector in which they carry out their activity.
Researchers by scientific discipline	Distribution of researchers, expressed in full-time equivalency, according to the scientific discipline in which they work.
Researchers by level of training	Distribution of researchers, expressed in full-time equivalency, according to their highest level of training attained.
Researchers by age group	Researchers, expressed in physical persons, by age group.
Human Resources R&D by Gender	
Female personnel in R&D	Distribution of R&D personnel, expressed in individuals, according to their function and classified by gender.
Female researchers by employment sector	Female researchers over the total number of researchers in each sector expressed in physical persons.
Female researchers by scientific discipline	Female researchers over the total number of researchers in each discipline expressed in physical persons.
Female researchers by level of training	Female researchers over the total number of researchers at each level of training reached expressed in physical persons.
Researchers by age group	Percentage of female researchers over the total number of age group researchers expressed in physical persons.

Female S&T personnel	Distribution of R&D personnel, expressed in full-time equivalency, according to their function and classified by gender.
Female researchers by employment sector	Female researchers over the total number of researchers in each sector expressed in full-time equivalency.
Female researchers by scientific discipline	Female researchers over the total number of researchers in each discipline expressed in full-time equivalence.
Female researchers by level of training	Female researchers over the total number of researchers at each training level reached expressed as full-time equivalence.
Researchers by age group	Percentage of female researchers over the total number of age group researchers expressed in full-time equivalency.
Financial Resources in S&T	
S&T expenditure	Expenditure made within each country in Scientific and Technological Activities, both by the public sector and by the private sector.
S&T expenditure in relation to GDP	Relative effort in terms of Scientific and Technological Activities, taking GDP as a reference.
S&T expenditure per inhabitant	Expenditure on Scientific and Technological Activities, in relation to the number of inhabitants.
S&T expenditure by financing sector	Expenditure on Scientific and Technological Activities according to the source of financing. The values are expressed in percentages in relation to the sum of the values of the categories available for this indicator.
Expenditure on S&T by execution sector	Expenditure on Scientific and Technological Activities according to the sector that executes it. The values are expressed in percentages in relation to the sum of the values of the categories available for this indicator.
S&T Activity Type	Total expenditure on Scientific and Technological Activities, according to the type of activity to which it is intended.
PATENT INDICATORS	**Definition**
Patent Applications	Number of patents applied for in the national intellectual property offices, according to the place of residence of the applicants.

Granted patents	Number of patents granted by intellectual property offices according to the holder's place of residence.
Dependency ratio	Coefficient between patents applied for by non-residents and by residents.
Self-sufficiency rate	Coefficient between patents applied for by residents and the total number of patents applied for.
Invention coefficient	Coefficient between patents requested by residents and the population of the country.
PCT patents	Number of patents applied for through the WIPO Patent Cooperation Treaty convention, according to the applicant's country of residence.
BIBLIOMETRIC INDICATORS	**Definition**
Publications in Web of Science	Number of articles registered in WoS.
Publications in SCOPUS	Number of articles registered in SCOPUS.
Publications related to Population, GDP and R&D Expenditure	
Publications in WoS per 100 thousand inhabitants	Number of articles registered in WoS per 100 thousand inhabitants.
Publications in SCOPUS every 100 thousand inhabitants	Number of articles registered in SCOPUS per 100 thousand inhabitants.
Publications in WoS in relation to GDP	GDP divided by the number of articles indexed in WoS.
Publications in SCOPUS in relation to GDP	GDP divided by the number of articles indexed in SCOPUS.
Publications in WoS in relation to R&D spending	Total R&D spend divided by the number of articles indexed in WoS.
Publications in SCOPUS in relation to R&D spending	Total R&D spend divided by the number of articles indexed in SCOPUS.
WoS publications per 100 researchers	Number of articles registered in WoS per 100 researchers expressed in physical persons and in full-time equivalence.
SCOPUS publications per 100 researchers	Number of articles registered in SCOPUS per 100 researchers expressed in physical persons and in full-time equivalence.
Publications according to discipline	
Percentage of publications in the selected databases according to discipline	Percentage of articles registered in the databases according to the disciplinary classification.
Publications with international collaboration	
Publications in databases in international collaboration	Percentage of articles registered in the databases signed in collaboration with institutions from another country.
Publications in databases in international collaboration according to discipline	Percentage of articles registered in the databases signed in collaboration with

	institutions from another country in each discipline according to the disciplinary classification.
Impact indicators of scientific publications	
Citation index	Frequency with which a publication is cited in other subsequent publications.
Journal Citation Reports	Es un producto de ISI Web of Science y es un recurso autorizado para datos de factor de impacto. Esta base de datos proporciona factores de impacto y clasificaciones de muchas revistas basadas en millones de citas.
SCImago Journal Rank	Measurement factor that establishes the quality of scientific publications 7ase don the number of citations obtained by each publication in the SCOPUS database.
H index	Author-level metric measuring both productivity and citation impact of publications, initially used for an individual scientist or academic.
Alternative indicators to measure the impact of publications (social impact and use)	
Usage metrics	Number of times a post summary has been viewed. Number of clicks on a URL. Number of times a publication has been downloaded. Number of times the full text of a post has been viewed.
Capture metrics	They capture tracking when end users bookmark, become a reader, become a watcher, etc. The captures indicate that someone wants to return to work. Number of times a job has been flagged. Number of times the job has been marked as a favorite. Number of times a person or post has been followed. Number of people who have added the work to their library/briefcase (reference managers). This includes the number of times the citation of a paper has been exported directly to bibliographic management tools or as file downloads, and the number of times the citation/abstract and

	full HTML text (if available) of a job have been saved, emailed, or printed. The number of people who have subscribed to receive an update. The number of people who look at the job for updates.
Mention metrics	Mentions are blog posts, comments, reviews, and wikipedia links about research. This category measures when people really get involved with the research. Number of blog posts written about the job. Number of comments made on a job (Reddit, Slideshare, Vimeo, YouTube). Number of threads in a forum that discuss the job. Number of news articles written about the job. Number of mentions found about a work (Q&A mention sites). Number of references found to the work. Number of reviews written about the artifact.
Social Media Metrics	Social media metrics refer to likes, shares, and tweets about research. Number of times a work has received likes (Vimeo, YouTube). Number of times a link was shared, liked, or commented on (Facebook). Number of recommendations a job has received. Number of votes on Reddit. Number of tweets and retweets mentioning the job.
Economic-social impact indicators of research results	
Economic-social impact	Prizes, recognitions, distinctions, awards or rewards granted to the partial or final results of research by different entities, agencies or organizations as proof of their scientific, economic and/or social contribution.
INNOVATION INDICATORS	**Definition**
Global Innovation Index	The Global Innovation Index (GII) is an indicator that makes it possible to determine the capacities and results in terms of innovation by country. It is calculated as the average of the subindices of inputs for innovation (which includes the pillars of:

	Institutions, human and research capital, infrastructure, market and business sophistication) and its results (with the pillars of: knowledge production, technology and creative production).
Manufacturing industry	
Spending on Innovation Activities - Manufacturing Industry	Spending on Innovation Activities - Manufacturing Industry.
Innovation Activities - Manufacturing Industry	Scientific, technological, organizational, financial and commercial activities that effectively lead, or are intended to lead, to the introduction of innovations.
Financing Sources - Manufacturing Industry	Financing Sources - Manufacturing Industry.
Innovative Companies - Manufacturing Industry	Firms that have implemented an innovation during the reference period, be it product and/or process and/or organization and/or marketing. Includes new innovations for the firm and/or the international market.
Innovative processes - Manufacturing Industry	Firms that have introduced a new, or significantly improved, production or distribution process. Includes significant changes in techniques, equipment and/or software.
Innovative process, novelty for the international market - Manufacturing Industry	Firms that have introduced a new, or significantly improved, production or distribution process. An innovation is new to the international market when the company is the first to introduce the innovation to all domestic and international markets and industries.
Innovative processes, novelty for the firm - Manufacturing Industry	Firms that have introduced a new, or significantly improved, production or distribution process. An innovation is new for the firm when the company introduces an innovation that has already been implemented by another domestic or international company.
Product Innovative Companies - Manufacturing Industry	Firms that have introduced a new or significantly improved good or service, in terms of its characteristics or in terms of its intended use. This definition includes the significant improvement of the technical specifications, of the components and materials, of the embedded software, or other functional characteristics.

Innovative Product Companies, novelty for the international market - Manufacturing Industry	Firms that have introduced a new or significantly improved good or service, in terms of its characteristics or in terms of its intended use. An innovation is new to the international market when the company is the first to introduce the innovation to all domestic and international markets and industries.
Innovative product companies, novelty for the company - Manufacturing Industry	Firms that have introduced a new or significantly improved good or service, in terms of its characteristics or in terms of its intended use. An innovation is new for the firm when the company introduces an innovation that has already been implemented by another domestic or international company.
Innovative Companies in commercialization - Manufacturing Industry	Firms that have implemented a new marketing method that involves significant changes in product or packaging design and/or in the company's delivery, pricing or product promotion policies.
Innovative Companies in Organization - Manufacturing Industry	Firms that have implemented a new organizational method in the company's business practice, work organization or external relations.
Obstacles to the innovation process - Manufacturing Industry	Factors that hinder the development of innovations in companies.
Information Sources for Innovation Activities - Manufacturing Industry	Areas of the company that contribute as sources of information for innovation activities, regardless of the results achieved.
Cooperation between the Company and its Environment - Manufacturing Industry	Firms that interact with their environment (including a formal agreement), with the aim of carrying out innovation activities.
Service sector	
Spending on Innovation Activities - Services Sector	Spending on Innovation Activities - Services Sector.
Innovation activities - Services Sector	Scientific, technological, organizational, financial and commercial activities that effectively lead, or are intended to lead, to the introduction of innovations.
Financing Sources - Services Sector	Financing Sources - Services Sector.
Innovative Companies - Services Sector	Firms that have implemented an innovation during the reference period, be it product and/or process and/or organization and/or marketing. Includes new innovations for the firm and/or the international market.

Innovative Process Companies - Services Sector	Firms that have introduced a new, or significantly improved, production or distribution process. Includes significant changes in techniques, equipment and/or software.
Innovative process companies, a novelty for the international market - Services Sector	Firms that have introduced a new, or significantly improved, production or distribution process. An innovation is new to the international market when the company is the first to introduce the innovation to all domestic and international markets and industries.
Innovative process companies, a novelty for the firm - Services Sector	Firms that have introduced a new or significantly improved good or service, in terms of its characteristics or in terms of its intended use. An innovation is new for the firm when the company introduces an innovation that has already been implemented by another domestic or international company.
Innovative Product Companies - Services Sector	Firms that have introduced a new or significantly improved good or service, in terms of its characteristics or in terms of its intended use. This definition includes the significant improvement of the technical specifications, of the components and materials, of the embedded software, or other functional characteristics.
Innovative product companies, a novelty for the international market - Services Sector	Firms that have introduced a new or significantly improved good or service, in terms of its characteristics or in terms of its intended use. An innovation is new to the international market when the company is the first to introduce the innovation to all domestic and international markets and industries.
Innovative process companies, a novelty for the firm - Services Sector	Firms that have introduced a new or significantly improved good or service, in terms of its characteristics or in terms of its intended use. An innovation is new for the firm when the company introduces an innovation that has already been implemented by another domestic or international company.
Innovative Companies in Marketing - Services Sector	Firms that have implemented a new marketing method that involves significant

	changes in product or packaging design and/or in the company's delivery, pricing or product promotion policies.
Innovative Companies in organization - Services Sector	Firms that have implemented a new organizational method in the company's business practice, work organization or external relations.
Social innovation indicators	
Financial resources (dedicated to social purposes)	
Monetary variables of the social economy	Share of spending by social economy organizations as a percentage of GDP (national sources, including foundation spending).
Social public spending	Total public social spending as a percentage of GDP.
Human Resources	
Professionalisation/creative workforce in the social field	Facilities that offer educational programs for the staff of social economy organizations (national analysis). Workforce reporting that they want to act "socially entrepreneurial."
Infrastructure resources	
Academic resources deployed in social innovation	Number of articles with the keyword "social innovation".
Relevant networks for social innovation	Number and size of social innovation networks, called "hubs" or "labs".
ICT and general infrastructure (as a basis for social innovation activities)	General infrastructure quality (World Economic Forum, Global Competitiveness Report). broadband subscribers. Electronic Readiness Index. ICT Usage Index (International Telecommunication Union, Measuring the Information Society). Government Online Services Index (United Nations Public Administration Network, e-Government Survey). Relationship between the penetration of broadband and the acceptance by citizens of electronic government services.
Policy awareness	
Political awareness on social innovation	National innovation strategies/government funded social innovation projects (national sources and analyses).
Business investment activities	
Investment in innovation by social economy organizations	Spending on innovation by company size (Community Survey on Innovation).
Collaboration and networks	

Citizen participation in business activities	Time dedicated to volunteering.
INDICATORS OF PUBLIC PERCEPTION OF S&T	**Definition**
Interest indicators	
Interest in S&T topics in general	Interest in S&T topics in general.
Interest in medical and health issues	Interest in medical and health issues.
Interest in environment and ecology issues	Interest in environment and ecology issues.
Informative perception indicators	
Information on S&T issues in general	Information on S&T issues in general.
Information on medical and health issues	Information on medical and health issues.
Information on environmental and ecology issues	Information on environmental and ecology issues.
Information consumption indicators	
Consumption of S&T information on television	Consumption of S&T information on television.
Consumption of SyT information in newspapers	Consumption of SyT information in newspapers.
Consumption of S&T information on radios	Consumption of S&T information on radios.
Consumption of S&T information in popularization magazines	Consumption of S&T information in popularization magazines.
Consumption of S&T information in popular books	Consumption of S&T information in popular books.
Consumption of S&T information on the Internet	Consumption of S&T information on the Internet.
Indicators of attitudes towards S&T	
Attitude towards future benefits of S&T	Attitude towards future benefits of S&T.
Attitude towards S&T risks	Attitude towards S&T risks.
Institutional Knowledge Indicators	
Knowledge of S&T institutions	Knowledge of S&T institutions.