poiesis

TRUST IN SCIENCE

D1.3: POIESIS Indicators of Trust in Science

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ABSTRACT:	This document presents POIESIS' inductive process of indicator construction, explains and contextualises its result – the two composite indicators TT100 and Gdwill100 – and introduces the concept of 'Cultures of Trust', a basis for synthesising the different quantitative and qualitative data streams of the POIESIS project.
Keyword List:	Indicator construction, quantitative data analysis, trust in science, cultures of trust, Eurobarometer surveys

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1.Introduction: towards 'Cultures of Trust'

The current deliverable, 'D1.3: POIESIS indicators of Trust in Science', outlines the progress of Work Package 1 (WP1) on survey data secondary analysis, primarily from Eurobarometer 95.2 (2021), towards developing POIESIS indicators and understanding Cultures of Trust. In the introduction, it revisits the core items identified in the Eurobarometer data, as discussed in deliverable "D1.2: Dataset on core trust items, climate science, and COVID-19" (Bauer et al. 2023)[1], and their relevance to the construction of indicators. Chapter 2 describes methods for analysing and constructing indicators from a general perspective. Building on this prospect, Chapter 3 details the specific process of our indicator construction (3.1), presents the resulting POIESIS trust indicators, "Technocracy Tolerance" (TT100) and "Goodwill" (Gdwill100) (3.2), and validates these indicators by demonstrating their correlations with socio-economic and cultural variables (3.3). Chapter 4 explains how these two indicators form an initial 2x2 grid defining 'Cultures of Trust' and further examines this concept (4.1). The chapter then starts contextualising our findings by comparing them with the national reports from D1.2 (4.2). The conclusion discusses the strengths and limitations of our indicator system and emphasises the importance of the next project phase, which will synthesise quantitative and qualitative research results from POIESIS for interpreting the outcomes. D1.3 not only presents our ongoing empirical work but also serves as the handbook for D1.4, which will be released as two annotated databases: national and regional, including our core items and various indicators. D1.4 is scheduled for publication in August 2024.

This introduction builds on the previous deliverables of WP1, providing a brief reminder of the POIESIS conceptual model (3i4t), the objectives of WP1, and the content of D1.2. It then reviews the objectives of D1.3 and D1.4 and addresses how the POIESIS 3i4t model and the indicators, which do not directly reflect the POIESIS core concepts of integrity and integration, relate to each other. The introduction concludes with a detailed presentation of the remaining sections of this deliverable.

The purpose of this report is not to review the field of indicators of trust, nor to synthesise the literature, but to illustrate the inductive construction of an indicator system to profile 'Cultures of Trust' based mainly on Eurobarometer data. To this end, we will illustrate the following considerations and steps:

1. Creating a model procedure of how to reduce and summarise Eurobarometer data (e.g. EB95.2, published in 2021) on trust in science at country and regional aggregate level;
2. Suggesting two dimensions of trust: Technocracy Tolerance (TT: trust in the systemic pillar of science) and Goodwill (Gdwill: trust in 'personal' or 'institutional' players);
3. Standardising indicators to a scale that is friendly to communicate (M=100, SD=25), resulting in TT100 and Gdwill100, which always stand in relation to the EU+ average;
4. Qualifying central tendencies on TT100 and Gdwill100 with measures of degree of consensus: polarisation, uncertainty, and ambivalence;
5. Validating TT100 and Gdwill100 with topical data from other sources (IRIS, Wellcome Global Monitor, survey items on COVID-19 and climate change) and socio-economic indicators (GDP, HDI etc.);
6. Suggesting an initial 2x2 grid of 'Cultures of Trust' which are high or low on TT100, and high or low on Gdwill100;
7. Profiling the 'Culture of Trust' in countries or regions on key trust indicators and qualifiers in combination with socio-economic indicators;
8. Being able to report on regional 'Cultures of Trust' as homogenous and heterogeneous within any one country.

[1] This deliverable will be referred simply referred to as D1.2 in the following. It is available on the POIESIS website: https://poiesis-project.eu/.

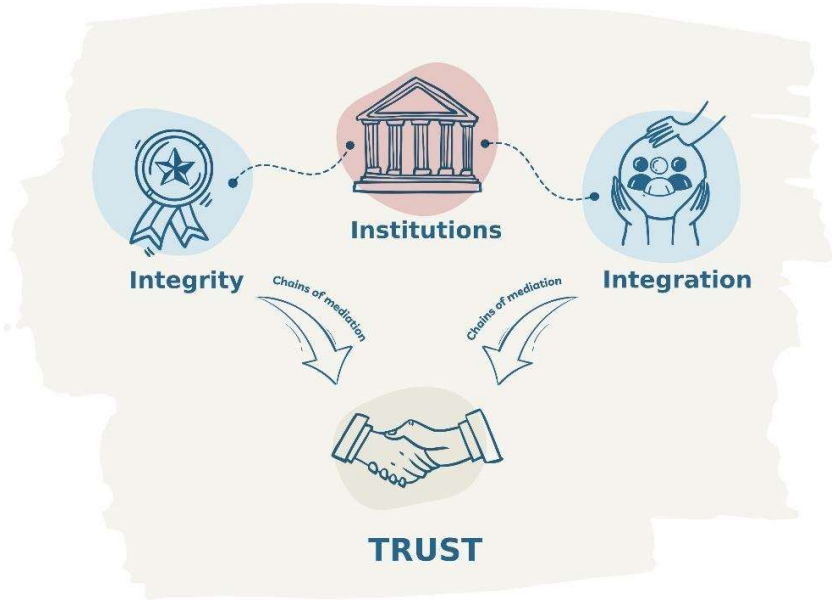
The overall achievement of this process is twofold: a) it avoids rank ordering or 'horse racing' countries or regions on 'trust in science' (we consider trust not to be a performance indicator), and instead b) characterising 'Cultures of Trust' as the communicative or strategic context for the governance of science, for mediators to communicate about science and for the conduct of science locally. In other words, stakeholders are working under these constellations of public sentiment and economic conditions in a particular region, and this might differ from the country as a whole (i.e., heterogeneity in national trust cultures).

1.1 The POIESIS 3i4t model and the objectives of WP1

The POIESIS project aims to explore the concepts and relationships between public trust in science and the adherence to research integrity on the one hand, and emphasising societal integration (i.e. the role of citizen and stakeholder engagement throughout various phases of the research cycle) on the other. Indeed, it is often assumed that issues related to research integrity and societal integration in the research process directly affect public trust in science. However, actual empirical evidence supporting this assumption is limited (see D1.2, chapter 4). This is where POIESIS comes in.

At the heart of POIESIS is the development and exploration of the '3i4t' model (3i = "integrity, integration, and institutions; 4t = for trust"). This working framework is designed to investigate how the three core concepts of trust, integrity and integration are interrelated and which role various chains of mediation, and especially different acting institutions of science (i.e., universities, research institutes, learned societies etc.), play in this regard.

Figure 1: The 3i4t conceptual model



WP1 of POIESIS aims to understand the nature and measures of public trust and distrust in science and to identify the factors influencing this relationship. To achieve this, WP1 follows two parallel paths: (1) working quantitatively on existing survey data to curate, (re-)analyse, and synthesise various data streams that reference trust in science, research integrity, and societal integration (public engagement), and (2) qualitatively assessing the safeguarding of trust in science from

different perspectives by organising three expert workshops. Both paths will converge and contribute to the final POIESIS recommendations at the project's conclusion.

This deliverable presents the ongoing results of our work on secondary data analysis, focusing mainly on citizens' and scientists' views on trust in science, research integrity, and societal integration, as well as POIESIS' two main thematic foci: climate change and COVID-19. It builds on D1.1, which outlines the planning and outcomes of WP1, and D1.2, the first content deliverable of WP1. D1.2 contains a description of the data collection process, selected core items to approach the concepts of trust, integrity, and integration, country reports providing detailed insights into the 'trust situation' in all seven POIESIS partner countries, and a literature report on empirical evidence between trust and integrity on one hand and trust and integration on the other. As the selected core items are crucial in constructing our POIESIS trust indicators, they are presented again in the following section.

1.2 The core items of D1.2

D1.2 is based on extensive data collection and review, including over 60 international and national surveys on citizens' and scientists' perspectives on trust, integrity, integration, climate change, and COVID-19. While many of these surveys were considered in the national reports in D1.2 (see chapter 3), the core items forming the basis for the POIESIS trust indicators predominantly originate from Eurobarometer surveys due to their comparability across 30+ countries and 300+ regions and over time. Eurobarometer is a unique source of data in that respect.

We selected core items to reflect POIESIS' core concepts: trust in science, research integrity, and societal integration in the research process (also called 'public engagement' in many discussions). It is important to note that the items presented here refer to these processes as 'perceptions of X'; they were not assessing these processes as performances of integrity or integration. They provide a glimpse of public opinion with reference to trust, integrity, and integration, and also in the context of climate change and COVID-19, and that in different contexts across Europe.

As a reminder, Table 1 displays the core items we selected and presented for D1.2.

Table 1: Core items to approach trust in science, research integrity and public integration (D1.2)

Concept	Item	Short name	Source	Year(s)
Trust	"The following is a list of characteristics that can be associated with scientists today. For each characteristic, indicate if you think it describes scientists well or describes them badly. Scientists ...Know best what is good for people."	deference	Eurobarometer (2021: EB95.2, Q12a.10)	2021
Trust	"We have no option but to trust those governing science and technology."	no option trust	Eurobarometer (2021: EB95.2, Q17.8)	2021
Trust	"We can no longer trust scientists to tell the truth about controversial scientific and technological issues because they depend increasingly on money from industry."	industry money	Eurobarometer (2010: EB73.1, Q8.3; 2021: EB95.2, Q11.1)	2010, 2021
Integrity	"The results of publicly funded research, such as scientific articles and data, should be made available online free of charge."	open science	Eurobarometer (2013: EB79.2, QD17t; 2021: EB95.2, Q9.5)	2013, 2021
Integrity	"The following is a list of characteristics that can be associated with scientists today. For each characteristic, indicate if you think it describes scientists well or describes them badly. Scientists are...Reliable"	reliable	Eurobarometer (2021: EB95.2, Q12a.1)	2021
Integrity	"The following is a list of characteristics that can be associated with scientists today. For each characteristic, indicate if you think it describes scientists well or describes them badly. Scientists are...Honest"	honest	Eurobarometer (2021: EB95.2, Q12a.5)	2021
Integration	"Scientists spend sufficient time meeting people like me to explain their work."	explain sufficiently	Eurobarometer (2021: EB95.2, Q9.3)	2021
Integration	"What level of public involvement do you think is appropriate when it comes to decisions about science and technology?"	expected public engagement	Eurobarometer (2010: EB73.1, Q4; 2013: EB79.2, Q6; 2021: EB95.2, Q7)	2010, 2013, 2021

Integration	"And now, a few questions on how you engage with science and technology issues. Do you…Talk about science and technology-related issues with family or friends?"	talk	Eurobarometer (2021: EB95.2: Q14.1)	2021
Integration	"And now, a few questions on how you engage with science and technology issues. Do you…Attend public meetings or debates about science and technology?"	attend	Eurobarometer (2010: EB73.1, Q3.1; 2021: EB95.2, Q14.6)	2010, 2021
Integration	"And now, a few questions on how you engage with science and technology issues. Do you…Actively take part in scientific projects by developing research questions, collecting data, discussing the findings with others, etc?"	take part	Eurobarometer (2021: EB95.2, Q14.12)	2021
Climate change	"In everyday life, we have to deal with many different problems and situations, where we feel more or less interested and confident. I am going to read you a number of statements. For each of them, please tell me whether you are interested (in…) Environmental problems including climate change."	interest	Eurobarometer (2010: EB73.1, Q1.4; 2021: EB95.2, Q2.6)	2010, 2021
Climate change	"Finally, for each of the following statements, please indicate whether you believe them to be true or false. If you don't know, you can just indicate so. Climate change is for the most part caused by natural cycles rather than human activities." (false = correct)	cause of climate change	Eurobarometer (2021: EB95.2, Q9.3)	2021
COVID-19	"Do you agree, disagree, or neither agree nor disagree with the following statement?": (1) "Vaccines are important for children to have." (2) "Vaccines are safe." (3) "Vaccines are effective."	vaccine index 2018 (index = being undecided or disagreeing with any of these three statements)	Wellcome Global Monitor (Q24 (1); Q25 (2); Q26 (3))	2018
COVID-19	"Vaccines are given to people to help prevent specific diseases. If a vaccine to prevent coronavirus was available right now at no cost, would you agree to be vaccinated?"	vaccine COVID (% agree)	Wellcome Global Monitor (WP21768)	2020

COVID-19	"Finally, for each of the following statements, please indicate whether you believe them to be true or false. If you don't know, you can just indicate so. Viruses have been produced in government laboratories to control our freedom." (false = correct)	virus CT	Eurobarometer (2021: EB95.2, Q20.11)	2021
Research Integrity	(Asked to scientists): "Do you think that research integrity policies help to improve the quality of your research?"	Improve	IRIS (2022)	2022
Research Integrity	(Asked to scientists): "How motivating would more trust in my research by the general public be in encouraging you to adhere to formal research integrity procedures?"	mtvtrstpub	IRIS (2022)	2022
3D attitude	"Science and technology makes our lives healthier, easier and more comfortable"	att1 health (agree)	Eurobarometer (1989: EB31.0; 1992: EB38.1; 2001: EB55.2; 2005: EB63.1; 2010: EB73.1; 2013: EB79.2; 2021: EB95.2)	1989, 1992, 2001, 2005, 2010, 2013, 2021
3D attitude	"Science and technology make our lives change too fast"	att3 too fast (disagree)	Eurobarometer (1989: EB31.0; 1992: EB38.1; 2001: EB55.2; 2005: EB63.1; 2010: EB73.1; 2013: EB79.2; 2021: EB95.2)	1989, 1992, 2001, 2005, 2010, 2013, 2021
3D attitude	"We depend too much on science and not enough on faith"	att2 faith (disagree)	Eurobarometer (1989: EB31.0; 1992: EB38.1; 2001: EB55.2; 2005: EB63.1; 2010: EB73.1; 2013: EB79.2; 2021: EB95.2)	1989, 1992, 2001, 2005, 2010, 2013, 2021
3D attitude	"How interested are you in new scientific discoveries?"	E sci int (interested)	Eurobarometer (1989: EB31.0; 1992: EB38.1; 2001: EB55.2; 2005: EB63.1; 2010: EB73.1; 2013: EB79.2; 2021: EB95.2)	1989, 1992, 2001, 2005, 2010, 2013[i]*, 2021
3D attitude	Various knowledge quiz items (true/false)	know13	Eurobarometer (1989: EB31.0; 1992: EB38.1; 2001: EB55.2; 2005: EB63.1; 2010: EB73.1; 2013: EB79.2; 2021: EB95.2)	1989, 1992, 2001, 2005, 2010[i], 2013[i], 2021

*[i]: scores are imputed by extrapolation, i.e., by regression based on scores from previous years.

1.3 D1.3 and D1.4 – from 3i4t to 'Cultures of Trust'

The current deliverable, along with D1.4 (the associated databases to be published in August 2024), present the results of our secondary data analysis on the Eurobarometer 95.2 2021 core items and beyond. Our objective with this deliverable is to establish a model of how to deal with this data, and maybe other data of a similar scope: we create 2 composite POIESIS indicators of trust in science, through which we aim to reduce the complexity of the vast amount of quantitative data (across 38 countries and 308 European regions) collected throughout our project. The aim is to be able to represent and put up for discussions different 'Cultures of Trust' across Europe in a 2x2 grid based on these two indicators. As our data arises from public perceptions, we are dealing in essence with perceptions of 'trustworthiness' of science in European societies.

The core items identified in D1.2, along with different response categories for 38 countries and 308 regions included in the Eurobarometer surveys, provide a substantial amount of information about public opinion on trust, integrity, and integration. While this data is highly interesting in micro detail, when combined, it risks becoming an unwieldy dataset unless we find a way of identifying useful patterns. Therefore, our objective with this deliverable is to reduce the complexity of our 'big data' and identify patterns in the core items to turn these into meaningful indicators (see also chapters 2 and 3).

Through the selection of our core items in D1.2, we identified all items in the Eurobarometer 95.2 survey that refer to the different elements of the POIESIS 3i4t model: trust, integrity, and integration. These core items, in all their detail, constituted the basis for our data mining leading to the construction of indicators. Our analysis inductively explored how these core items are related and to what extent they follow the same dynamics or logic.
As a first step, we examined our big data base, supplemented by additional socio-economic and cultural variables; we engaged a mainly inductive research process to explore ideas, data, and visualisations to understand what the data plausibly reveals about trust and trustworthiness of science in Europe.
This led to the calculation of our two composite indicators, each based on four core items and calculated following the factorial reduction: TT100 and Gdwill100. Both measure different levels of trust in science and together form the basis of what we call 'Cultures of Trust'. Unfolding the two composite indicators as a 2-dimensional space defines a 2x2 grid of Cultures of Trust around the EU+ average on either indicator. Each country and region can be situated within this 2x2 grid, allowing for visual analysis of cluster formations across geographic areas, as well as the identification of outliers and exceptions (see chapter 4).
This is all done at aggregate level, meaning that our indicators do not refer to individual opinions, but rather to the distribution of opinions within a geographical unit (i.e., a country or a region). One could say that our indicators measure the temperature of the water but not how individual molecules behave in the water. The advantage of analysis at the aggregate level is that different surveys can be compared and integrated without comparability at the micro level.

The indicator construction was an inductive research process based on existing secondary data (see chapters 2 and 3.1). Consequently, the results do not reflect any top-down conceptions by design but might well reveal to be consistent with conceptual ideas about trust and trustworthiness of science. This does not mean that our indicators and the POIESIS model are unrelated. What we introduce here as 'Cultures of Trust' (see chapter 4) actually establishes the (communicative) context in which all public-science relations occur. The overarching question we address is: what is the overall 'trust' sentiment towards science within a country or region? We answer this question along two dimensions of trust identified in our data. Therefore, it will be crucial to relate the quantitative results presented here to the qualitative data collected and analysed in WP2 and WP3 of the project, which explores the performances of integrity and

integration among institutional actors and mediators in the various countries. This will enable us to understand how trust, trustworthiness, integrity, and integration are interconnected and how they express the Cultures of Trust emerging from the Eurobarometer data. The synthesis of these different data streams will be the focal point of the subsequent project deliverable.

The remaining part of this deliverable consists of four main chapters and an Appendix. In Chapter 2, we explain briefly how we understand 'indicators', why we need them, and how we define different types of indicators for the present purpose. Chapter 3 then presents the step-by-step creation of our indicators, namely our two main ones: TT100 and Gdwill100. We explain their meanings and validate these by highlighting their inter-correlations with the socio-economic and other cultural variables in our extended database. In Chapter 4, we present and explore the idea of Cultures of Trust. To gain a first impression of how these Cultures of Trust might relate to POIESIS' core concepts of integrity and integration, we compare our current results for the POIESIS partner countries with the national reports based on numerous national survey results in D1.2. The conclusion summarises our main findings and provides an outlook on the way forward from this analysis. It emphasises the importance of avoiding 'horse race' type analysis of indicators of trust, and synthesising quantitative and qualitative data streams from the POIESIS project to profile Cultures of Trust in the overall research questions of the POIESIS project. The Appendix contains more information on our methodology and statistical results of our analyses.

2. The construction of indicators

In this chapter, we set out our rationale for developing indicators and explain their construction. We start with a brief discussion of the data used, followed by an explanation of the primary objective underpinning indicator construction, that is, complexity reduction. We then define different types of indicators that were used to construct the POIESIS indicators of trust in science. Our method is exploratory and inductive data analysis. The detailed process of our indicator construction is documented in Chapter 3.1, based on the more general explanations provided here in Chapter 2. Any indicator or data transformation that we considered as part of our secondary survey data analysis, yet did not use for the final POEISIS indicators of trust in science, are listed in the Appendix.

Data sources

The basis of indicator construction is a significant amount of data. We use our data based on D1.2. In D1.2, we curated a set of 'core items' – survey items referring to the integrity, integration, and trust elements of POIESIS' 3i4t model. Using these core items (see Table 1 above), we have constructed two working databases: the POIESIS National Database (38 countries) and the POIESIS Regional Database (308 regions). Both are constituted from Eurobarometer, Wellcome Global Monitor, Eurostat, and other sources covering the POIESIS partner countries and the wider European community. These databases are a seed core and can easily be extended as further relevant data becomes available at country and regional level.

Our datasets contain the response distributions of core items per country or region. For example, the statement *"We have no option but to trust those governing science and technology"* is a Likert item with a "don't know" option. Our national database records the distribution percentages for each available country, and our regional database does so for each available region. As such, we are considering *aggregate distributions* within given geographical units.

Indicators

Each D1.2 core item reflects attitude variation that merits careful attention of how to reduce it. Yet, in order to be able to characterise and compare the available distributions of public opinion on trust, we explored various ways to reduce this complexity. We re-describe and reduce attitude distributions with four types of indicators. For the present purposes, we name these the base indicators, derived indicators, meta-indicators, and composite indicators.

- *Base indicators.* These are the basic scale distributions of a questionnaire item, i.e., the Likert agree-disagree values in % of respondents, or YES, NO, or DON'T KNOW as % of respondents.

- *Derived indicators.* These are summary scores of the base indicator, such as 'acceptance' or 'polarisation' scores. Derived indicators characterise the item distribution in terms of slant or spread.

- *Meta-indicators.* These standardise the derived indicators so as to render them comparable, as in z-scores and t-transformations.

- *Composite indicators.* These combine several derived or meta-indicators, guided by a multivariate analysis (Principal Component Analysis, PCA).

Base indicators

In the POIESIS National Database, items are tabulated per answer option, e.g. a 5-point Likert scale (1 = Strongly agree, 2 = Tend to agree, 3 = Neither agree nor disagree, 4 = Tend to disagree, and 5 = Strongly disagree) as well as a "Don't know" (6 = 'Don't know') option. As an example of a base indicator, consider Figure 2 and Table 2 below. Both show different ways of visualising the distribution of responses to the 2021 Eurobarometer item statement *"We have no option but to trust those governing science and technology"* (Figure 2), and on the deference statement '*scientists know best what is good for people'* (Table 2). Figure 2, for example, shows the response distributions for 1000 respondents in each country on a 5-point Likert scale with a 'Don't know' option, and rank-orders all countries from those with the lowest mean to the highest mean from left to right. This makes visible the variation across European countries. Having many such items clearly poses a problem of overwhelming complexity of cross-country or regional variation that needs to be reduced to reveal meaningful patterns across many such base indicators.

Figure 2: Example, bar plot of 'no option trust' item, POIESIS National Database

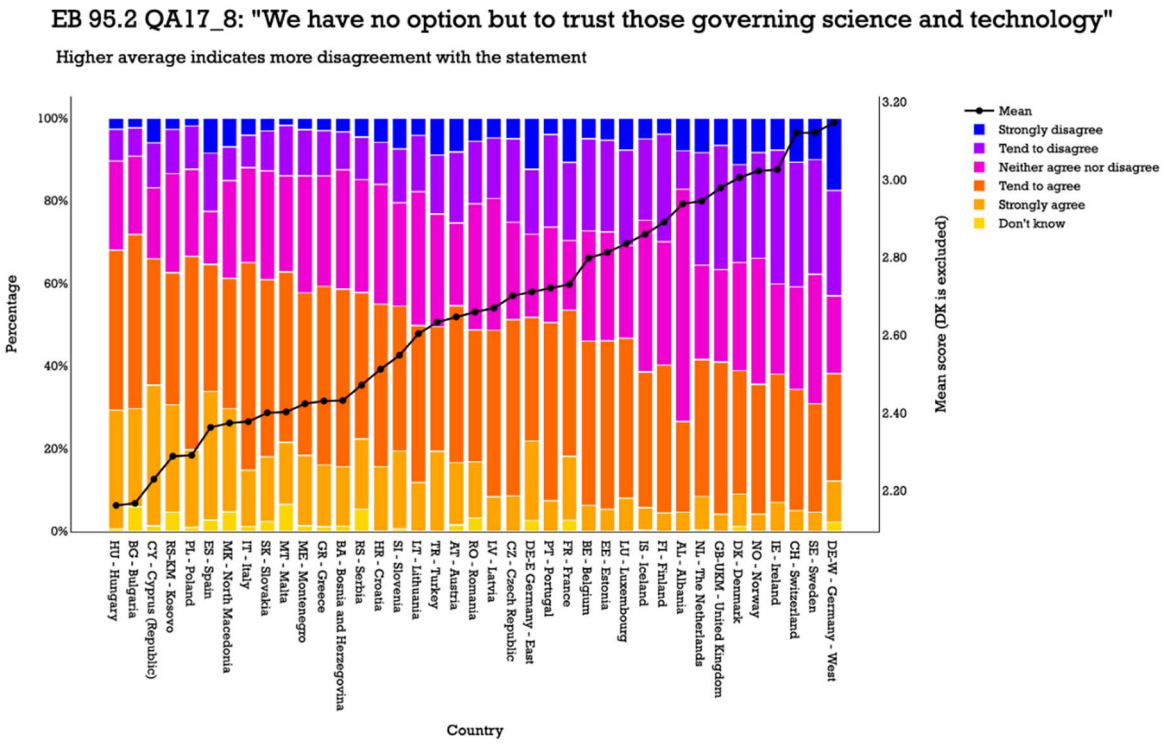


Table 2 shows another example of the distribution of answer options, here on the binary item called 'deference' ("Scientists know best what is good for people"[2]) for the POIESIS partner countries. The answer options are: (1) Describes well; (2) Describes badly, and (3) Don't know. Countries vary on the substantive answer and on 'Don't know'. As discussed below, the latter we take as an index of 'uncertainty' of the consensus.

[2] "*The following is a list of characteristics that can be associated with scientists today. For each characteristic, indicate if you think it describes scientists well or describes them badly. Scientists… Know best what is good for people.*"

Table 2: Example, response distribution of 'deference' ('know best') for POIESIS partner countries

Country	EB516_21_KnowBest _DescWell	EB516_21_KnowBest_ DescBad	EB516_21_KnowB est_Don't Know
Denmark	37.5%	54.6%	7.9%
France	33.6%	52.6%	13.8%
Germany	27.6%	51.2%	21.2%
Greece	67.8%	26.6%	5.6%
Portugal	51.2%	48.5%	0.3%
Spain	67.6%	18.0%	14.3%
United Kingdom	50.8%	48.7%	0.5%

Derived indicators

The next step based on base indicators is to create derived indicators. These are summaries of the base indicator at the aggregate level for a particular unit of analysis (i.e., per country or region). The purpose of derived indicators is to indicate the consent, polarity, uncertainty, and ambivalence in the distribution of a given item. Whilst we considered a broader range of derived indicators in our explorations, we report only on those that we finally used in the construction of our POIESIS composite indicators of trust in science, TT100 and Gdwill100. Specifically, we finally retained **agreement** and **disagreement** with the statement, **acceptance** of the statement, and **polarisation, uncertainty, and ambivalence** as qualifiers of the consensus in the country or region on this statement. Thus, there will be up to six derived indicators for each question item in the National and Regional Databases, in addition to the original baseline results.

Agreement

The Agreement indicator reflects the slant of responses, either the percentage of agreement on survey items with Likert scale answer options (i.e., tallying up the 'Totally agree' and 'Agree' percentages), or the answer option that semantically refers to agreement with the item statement (e.g., 'Yes (personal characteristic) describes (scientists) well', see Table 2). Agreement scores represent the level of total agreement with the statement within a geographical unit among those who express an opinion.

Range: 0-100%
Usage: to denote tendency or slant towards consent.
Interpretation: the Agreement indicator gives the ratio of agreement in a country to the survey item's claim. The percentage provides information about minority or majority opinion distributions.

Disagreement

The Disagreement indicator reflects the percentage of disagreement on Likert answer options (i.e., tallying up the 'Totally disagree' and 'Disagree' percentages) or otherwise the answer option that semantically refers to disagreement with the statement (e.g., 'No, (personal characteristic)

describes (scientists) badly'). Disagreement represents the level of total disagreement with the statement within a geographical unit among those who express an opinion.

Range: 0-100%
Usage: to denote tendency or slant towards dissent.
Interpretation: the Disagreement indicator gives the ratio of disagreement in a country to the survey item's claim or question. The percentage potentially provides information about minority or majority opinion distributions.

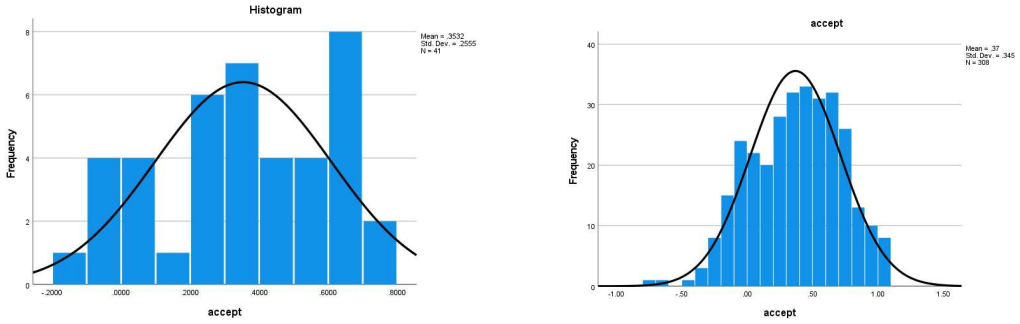
Acceptance

The Acceptance indicator is a widely used metric to summarise favourability statements, while ignoring non-opinions (middle option of 'Neither disagree nor agree' and 'Don't know's'). It is a helpful way of representing the ratio of agreement to disagreement within a geographical unit in a single number. It transforms the Agreements and Disagreements in the following way:

$$Acceptance = \frac{\%\ agreements - \%\ disagreements}{\%\ agreements + \%\ disagreements}$$

Range: $Acceptance \in (-1, 1)$
Usage: indication of slant towards consent
Interpretation: the Acceptance indicator captures the level of consent to a given statement in relation to the total expressed opinions. If positive, opinion in a certain country is favourable and accepting of a given statement; if negative, it is unfavourable and unaccepting. It is net of all other responses; it thus needs to be qualified by further considerations.

Figure 3: Example, distribution of 'acceptance' of item 'no option trust' for countries and regions



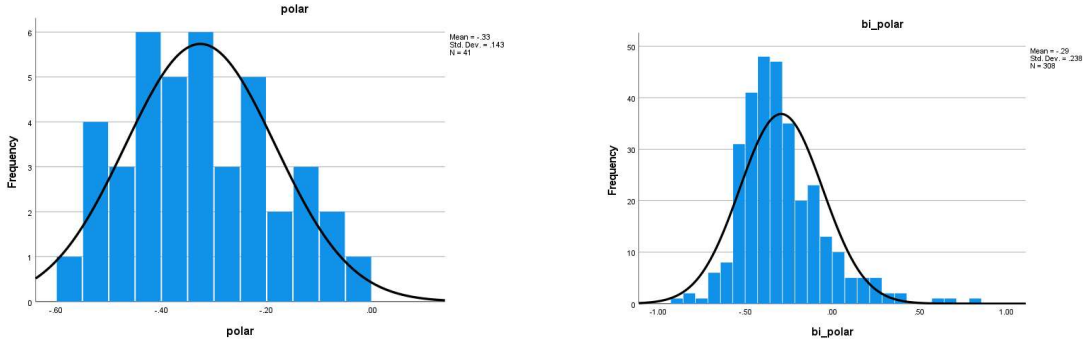
Polarisation

Polarisation measures the extent of polarity in a response distribution, calculated as the sum of percentages of extreme responses (e.g., 'strongly agree' and 'strongly disagree') minus the sum of moderate responses (e.g., 'agree' and 'disagree'). Being able to compare polarisation on a given item across various geographical units or across items is helpful, as the extent of divided opinions regarding a specific statement provides qualification of the consensus within each geographical unit. This indicator only arises with >3-point scales (i.e., Likert scales, ordinal or categorical answer options). In case of a Likert scale, we calculate Polarisation as follows:

$$Polarisation = (\%\ strongly\ agree + \%\ strongly\ disagree) - (\%\ agree + \%\ disagree)$$

Range: $Polarisation \in (-1, 1)$
Usage: indicator of polar spread; gives the degree of bi-modality of a survey item
Interpretation: positive values indicate polarisation towards the extremes and negative values indicate bulging towards the middle categories. It provides no indication of the slant of a given item but qualifies the slant.

Figure 4: Example, distribution of 'polarisation' of item 'no option trust' for countries and regions

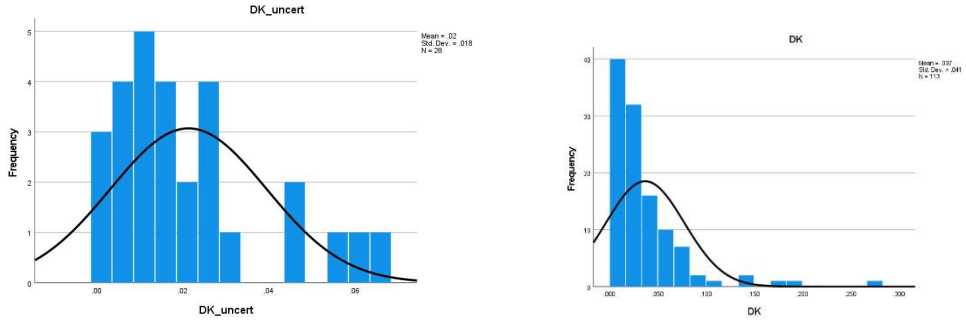


Uncertainty

The Uncertainty indicator is the percentage of 'Don't know' responses on a given survey item.

Range: 0-100%
Usage: indicator of uncertainty amongst respondents
Interpretation: the Uncertainty indicator reflects the ratio of respondents without an opinion or those who declare subjective ignorance on the matter. High uncertainty may also reflect data quality issues in some regions or on some items, for example bad translation, or question not understood, or a question thought to be sensitive and therefore refused to answer. It can also reflect field work interview practices that more or less accept 'Don't Know' responses without further probing.

Figure 5: Example, distribution of 'uncertainty' of item 'no option trust' for countries and regions

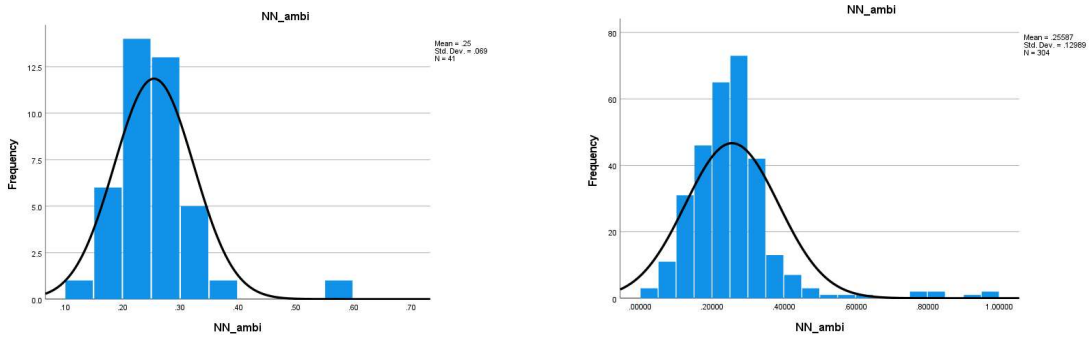


Ambivalence

The Ambivalence indicator is a direct reflection of the percentage of the middle category 'Neither disagree nor agree' on items with Likert scale response options.

Range: 0-100%
Usage: indicator of ambivalence amongst respondents
Interpretation: the Ambivalence indicator reflects the number of respondents who do express an opinion but do not position themselves: they hold on to an ambivalent opinion between agreement or disagreement. Again, very high ambivalence scores in a unit could indicate issues of data quality.

Figure 6: Example, distribution of 'ambivalence' of item 'no option trust' for countries and regions



Meta-indicators

The next step in our construction process creates meta-indicators from derived indicators. These help us to standardise and compare our indicators always to the EU+ average. Meta-indicators make it easier to understand and communicate the scores by putting everything on the same scale. This way, we can see how different indicators stack up against each other in a clear and straightforward manner. For example, acceptance scores for items will each be standardised to the EU+ average, thus placing them on the same scale relative to the EU+ average. Acceptance scores for all items are thus comparable to the same reference scale, below or above the EU+ average; the same applies to other derived indicators.

Z-score

The z-score standardises all derived indicators such that their scale is interpretable relative to the EU+ average. Z-scores always have a mean of 0 and a standard deviation of 1. It is calculated as follows:

$$Z = \frac{(x - M)}{SD}$$

Range: $Z \in (-1, 1)$
Usage: to standardise derived indicators to the EU+ average
Interpretation: if the z-score is below 0, this means that a given country or region scores below the EU+ average on that item; conversely, if the z-score is above 0, this means that a given country or region scores higher than the EU+ average on a given item.

T-transformation

T-transformations recalibrate the z-scores of derived indicators such that they are centred around a conveniently fixed mean and standard deviation. The definition of the mean and the standard deviation is entirely arbitrary, but usually will be chosen so that the communication of the final results is more intuitive. For example, standardised z-scores that range from -1 to +1 may be transformed so that the scale is entirely positive on a wider range, and any differences between become expressed in bigger numbers. A t-transformation does not, however, change the relative statistical value of any score. For our purposes, we define M = 100 and SD = 25, then:

$$T = 100 + 25 * Z$$

Range: usually between ca. 50 and 150 (i.e., most scores are within two standard deviations from the mean)
Usage: making distributions on polar and dense scales (e.g., from -1 to +1) more intuitive and interpretable by 'exploding' them over a larger scale and 'lifting them out' of the sub-zero area.
Interpretation: For our purpose, if the t-score is below 100, this means that a given country or region scores below the EU+ average. Conversely, if the t-score is above 100, this means that a given country or region scores higher than the EU+ average on a given item. The area 75-125 will contain two third of all scores. The purpose of this transformation is entirely given to communicative convenience.

3. POEISIS indicators of 'trust in science': TT100 and Gdwill100

In the previous chapter, we outlined how baseline data is transformed into indicators to highlight some of its features, specifically into derived and into meta-indicators. Chapter 3 will demonstrate the next step in this process, which involves the combination of several items into summative scores, termed composite indicators. Through exploratory-inductive work with derived and meta-indicators, we arrive at two composite indicators of trust in science: Technocracy Tolerance and Goodwill. We present these as scales with a mean (M) of 100 and a standard deviation (SD) of 25, relative to the EU+ average; and we gave them shorthand names: TT100 and Gdwill100.

With these two indicators we represent trust in science as an initial 2x2 grid where countries or regions can be located on two dimensions below or above the EU+ average, thus falling into one of the quadrants. We further profile these aggregate positioning of each country/region with further dimensions, such as polarisation, ambivalence and uncertainty of consent, and socio-economic information. Thus, any level of TT100 or Gdwill100 needs to be considered with qualifications. E.g. two regions can have the same level of TT100 consensus, but differ in their degree of polarisation, uncertainty or ambivalence about that consensus. This allows us to tell a nuanced story about trust in science within that given geographical unit. This manifold information will be used to profile the 'Culture of Trust' in a country and its regions in the next step (see chapter 4).

In what follows, we document the sequential steps by which our two composite indicators of trust in science – TT100 and Gdwill100 – were constructed (3.1). We then explain the indicators themselves and present the initial results (3.2), followed by validating and interpreting them on external correlates (3.3). Our process is best thought of as a model procedure that could be portable to other cross-national data sources by analogy where items are not strictly comparable at the micro-level.

3.1 TT100 and Gdwill100: construction of POIESIS indicators of trust in science

This section presents the different steps of our own indicator construction process. Further information, for example about other kinds of indicators, that we considered but did not use, is available in the Appendix.

1. Individual survey items (mainly but not only Eurobarometer EB95.2 (2021, N = ca. 37,000))

We started with individual survey items from EB95.2 (2021) in their raw form. As described above and expanded on in D1.2, we selected those items relevant to the POIESIS 3i4t model with these 'core items' forming the basis of the POIESIS National and Regional databases. EB95.2 was conducted in 2021, and our key indicators are based on data from this 2021 wave only. However, for validation purposes we will also use earlier Eurobarometer surveys and other data sources.

2. Create derived indicators at aggregate level (N countries = 38, N regions = 308)

Next, we created four derived indicators for each core item at the aggregate level as described above: Acceptance, Polarisation, Ambivalence and Uncertainty. This was done at both the

National and Regional database level. We chose these four derived indicators as they most meaningfully described the distribution of single items: Acceptance is always coded in such a way that high scores indicate high levels of agreement with a statement in question (whereas the Mean may occasionally show reverse patterns in case of a negating formulation); Polarisation indicates the extent to which the distribution in a given country is more polarised or otherwise centred around the mean; Ambivalence indicates the level of Neither Agree nor Disagree options where there was one, and Uncertainty indicates the level of 'Don't Know's. Together, these four derived indicators tell a comprehensive story of the distribution of single survey items. And by considering polarisation, ambivalence and uncertainty across a range of indicators, this indicates a feature of the way a country responds to these items, being close to or far from consensus.

3. Create meta-indicators (z-scores) from derived indicators

Next, we took the z-scores of these derived indicators, where the EU+ mean equals 0 and the standard deviation equals 1. This renders all derived indicators, which initially are on different scales, comparable. This transformation was again done at both the National and Regional database level.

4. Conduct an exploratory Principal Component Analysis (PCA)

We then conducted an exploratory Principal Component Analysis (PCA) to gauge the extent to which the core items from the National and Regional databases were correlated with each other, aiming to identify any potential underlying factors that contribute to the overall trust indicators. This step explores whether many items can be reduced to fewer dimensions because some of them are correlated. We conducted factoring in SPSS using PCA, considering Eigenvalue and scree plot, but were mainly guided by the emerging plausible interpretation by logic of abduction or inference to the most plausible concept. Below in Tables 3 and 4 we report the 2-factor structure matrix with the factor loadings of each item along two dimensions (KMO=0.59; 56% of variance). We consider negative factor scores not for indicator construction, but as correlates for indicator interpretation.

Table 3: Structure matrix with Oblimin rotation from PCA on POIESIS core items (EB95.2, 2021) in the POIESIS National database (k=38 country units)

Original phrasing of items (Acceptance score was used for PCA)	Short name in database	Component	
		1	2
(I) talk about science and technology-related issues with family or friends.	talk	-0.886	0.330
We have no option but to trust those governing science and technology.	no option trust	0.886	-0.054
Scientists know best what is good for people.	know best	0.834	0.259
Scientists spend sufficient time meeting people like me to explain their work.	explain sufficiently	0.670	0.280
We can no longer trust scientists to tell the truth about controversial scientific and technological issues because they depend increasingly on money from industry.	industry money	0.657	-0.422
The results of publicly funded research, such as scientific articles and data, should be made available online free of charge.	open science	-0.454	0.306
(Scientists are) honest	honest	-0.093	0.927
(Scientists are) reliable	reliable	-0.003	0.881
What level of public involvement do you think is appropriate when it comes to decisions about science and technology?	expected public engagement	-0.154	-0.552

(I) actively take part in scientific projects by developing research questions, collecting data, discussing the findings with others, etc.	take part	-0.347	0.461
(I) attend public meetings or debates about science and technology.	attend	-0.119	0.208

Note: the red and blue cells indicate which factor loadings were selected as the most relevant items to be part of a dimension.

Based on these results, we selected the items grouped in the PCA. The items that constitute component factors 1 and 2 were selected for two reasons: the factor loadings are highly and positively correlated with the factors (component 1 or 2), and they are theoretically consistent with the concepts of systemic trust in 'pillars' and trust in 'players' of science. This basic idea of **two levels of trust** was an implicit POIESIS idea in our explorations, which was made explicit in our exploration by way of abduction, i.e. inference to the most plausible idea consistent with the data. This logic is not conclusive and preliminary, and it thus constitutes a heuristic for further investigations not least in relation to other data streams of project POIESIS. Both component 1 and 2 consist of four items. We compared and stabilised PCA results for both the National and Regional databases. The factor loadings for the regional database are below in Table 4, unfiltered. These two PCAs differ slightly with the items on 'social integration of science'. However, the more we filter the regional data for units with very small n<50 (many regional units have less than 50 observations) the more the two factor solutions assimilate. We therefore conclude that we can work with the same component structure for national and regional analysis.

Table 4: Structure matrix from PCA on POIESIS core items (EB595.2, 2021) in the POIESIS Regional database (k=308 regional units, unfiltered)

Original phrasing of items (Acceptance score was used for PCA)	Short name in database	Component	
		1	2
(I) talk about science and technology-related issues with family or friends.	talk	-0.093	0.724
We have no option but to trust those governing science and technology.	no option trust	0.668	-0.569
Scientists know best what is good for people.	know best	0.772	-0.269
Scientists spend sufficient time meeting people like me to explain their work.	explain sufficiently	0.424	0.158
We can no longer trust scientists to tell the truth about controversial scientific and technological issues because they depend increasingly on money from industry.	industry money	0.668	-0.569
The results of publicly funded research, such as scientific articles and data, should be made available online free of charge.	open science	0.465	-0.026
(Scientists are) honest	honest	0.761	0.058
(Scientists are) reliable	reliable	0.795	-0.065
What level of public involvement do you think is appropriate when it comes to decisions about science and technology?	expected public engagement	-0.397	0.016
(I) actively take part in scientific projects by developing research questions, collecting data, discussing the findings with others, etc.	take part	0.039	0.870
(I) attend public meetings or debates about science and technology.	attend	0.001	0.814

Note: the red and blue cells correspond to the grouping of the factor loadings resulting from the PCA conducted on the National database.

5. Create summative scores of items that formed the two components

Once the dimensionality of the items has been ascertained, item combination was afforded. In order to work with only two components as suggested by PCA which explicate the implicit idea of two levels of trust in 'pillar' and in 'players', we added up the z-scores of each of the four items for both components to create summative scores. We do not consider negative loading for the definition of the components but use these to further interpret their meaning. In terms of reliability of the final scores we find: for component 1, the four items were strongly inter-correlated in both the National and Regional databases (Cronbach Alpha = 0.82 and 0.81 respectively). For component 2, the reliabilities in the National and Regional database were good or moderate (Cronbach Alpha 0.67 and 0.52 respectively). To reiterate, these correlations concern z-scores of Acceptance, which are aggregates within a geographical unit (i.e., a country or region). As such, they reflect overall tendencies or streams of opinion within a geographical unit, and do not reflect individual opinion. We must avoid the 'ecological fallacy' when interpreting these indicators: correlations between indicators do not reflect correlations between opinions of individuals, but patterns between streams of opinion in a unit of analysis. To make an analogy: people might eat a lot of meat and a lot of sugar in a region, i.e. meat and sugar are correlated in aggregate, but this does not mean that people put regularly sugar on meat in their individual diet.

6. Define and interpret the components

Next, we did interpretative work with the aim to understand why the selected survey items of each component showed strong correlations, involving interpretations of the survey items' meaning. These reflections resulted in the naming: 'Technocracy Tolerance' for the first component of systemic trust in 'pillars' of science (red in Tables 3 and 4) and Goodwill for the second component of trust in 'players' of science (blue in Tables 3 and 4). The idea of 'Technocracy Tolerance' was a second of our implicit ideas (Bauer 2024; Bauer et al. 2016) which our analysis rendered explicit. From now on, we will address these as 'composite indicators' to reflect the fact that their scores were created by adding up basic scores across several items. We elaborate in more detail below (see section 3.2).

7. Apply T-transformation to composite indicators

We thus had created scores for 'Technocracy Tolerance' and 'Goodwill' for each country and region. These scores show a distribution overall. To work with these scores, we again standardised them as z-scores that have an EU+ mean of 0 and a standard deviation of 1, meaning that there can be negative z-scores if a country falls below the EU+ average. As such, the summative z-scores from the components can also be negative, complicating their interpretation and wider communication as 'trust indicators' as it should be avoided to interpret negative values as 'negative trust' or even 'distrust' because it only shows 'below EU+ average'. Therefore, in order to render the composite indicators communication-friendly and to avoid misinterpretation, we applied a T-transformation to them. Following the formula outlined in the previous section, we transformed the summative z-scores such that they have a EU+ mean of M=100 (equal to the EU+ average in the database) and a standard deviation of SD=25.

Accordingly, we named the transformed composite indicator Technocracy Tolerance 'TT100' and Goodwill 'Gdwill100'. Every country and every region has two scores, one for TT100 and one for Gdwill100; most data points of TT100 and Gdwill100 fall between 50 and 150 (i.e., two standard deviations from the mean). Thus, TT100 and Gdwill100 are summative – or composite – measures of trust in science relative to the EU+ average, capturing trust at two levels. We consider these to represent public trust into the systemic 'pillars' and into the active 'players' of science respectively. TT100 and Gdwill100 are independent indicators, with little inter-correlations, as such they unfold

a 2-dimensional Euclidian space within which European countries and regions can be mapped and their similarities and dissimilarities can be explored as metric distances from each other (see chapters 3.2 and 4).

8. External validation of composite indicators

As a final step of our indicator construction, we further explored correlations of TT100 and Gdwill100 with other items in our database: derived indicators themed on 'scientists' perspectives', Covid-19 and climate change in the various countries, as well as socio-economic data (listed in section 3.3), in order to identify whether our understanding of both components patterns with other data. Meaningful relationships between the TT100 and Gdwill100 variables and other variables would validate our interpretation of the PCA outcomes. We report on various calculations below (see section 3.3).

3.2 TT100 and Gdwill100: semantic validation of the POIESIS indicators of trust in science

After detailing the process we followed to construct our indicators, this section explains the results of this process in more detail. It unfolds the composite indicators Technocracy Tolerance (TT100) and Goodwill (Gdwill100) as two dimensions of trust in science in Europe.

Technocracy Tolerance: trust in systemic pillars of science

This indicator is constituted of the acceptance scores of the following four statements, meaning that for each item, high scores indicate high agreement with the statement in question, and low scores indicate low agreement with the statement in question:

1. We have no option but to trust those governing science and technology.
2. Scientists know best what is good for people.
3. Scientists spend sufficient time meeting people like me to explain their work.
4. We can no longer trust scientists to tell the truth about controversial scientific and technological issues because they depend increasingly on money from industry.

As for items (1), (3) and (4), we see that these relate to *systemic* factors related to integration, integrity, and trust (concepts part of our 3i4t model). We argue that the items speak to the following sentiments: (1) we have no option but to trust science. Whilst this is not literally what the item lexically says, qualitative research suggests people generally interpret it this way (see Bauer & Falade 2024), suggesting a composite syllogism; (2) we recognise the epistemic authority of science; (3) we are satisfied with the degree to which scientists engage with us, the public. If one agrees with this statement, the current level of public integration is deemed sufficient, and (4) truth cannot arise from research funded by industry money.

It should be noted that the strong correlation of the fourth item ('industry money') with the other items took us by surprise: according to one line of argument, high levels of agreement with "we have no option but to trust science" should correlate with high levels of *disagreement* with "we can no longer trust scientists to tell the truth due to industry money". However, this interpretation would be wrongheaded according to our statistical results. Instead, perhaps this paradox resolves in a 'technocracy mentality,' where people simultaneously distrust industry-funded science but still believe in the necessity of trusting science overall (strictly without undue influences). This suggests

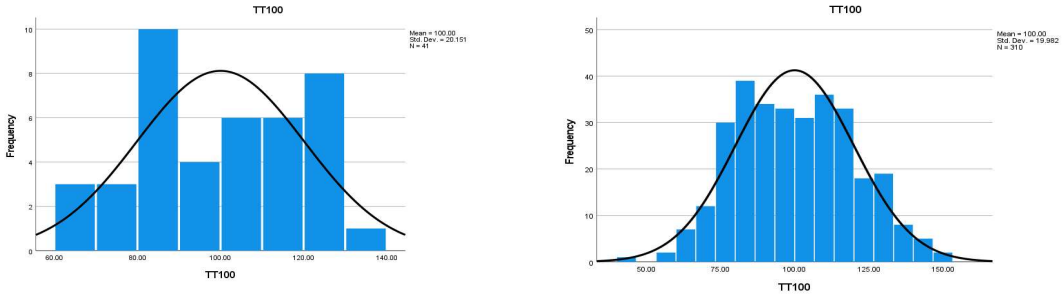
a distinction between general scientific trust and scepticism towards science influenced by industrial interests.

Together, these four statements appear to capture a sentiment that, if accepted, people are inclined to defer decision making authority upon scientists and thus 'tolerating technocracy'. Technocracy is a way of governance where public decisions are made by experts as the exclusion of politics. Like any form of governance, its legitimacy rests on public acceptance. Our indicator thus reflects the degree by which people in a country or region are happy to defer or not defer decision to expert authority. As such, high scores on this indicator would signal more inclinations to defer to expert authority, and low scores would indicate less such inclination compared to the EU+ average. We argue that the sentiment captured by the four internally correlated items speaks to a certain tolerance of technocratic decision-making, where scientists (indeed, only the publicly funded ones) are granted authority to decide what is best. Accordingly, we have termed this component 'Technocracy Tolerance' (see earlier work, Bauer et al. 2016; and Bauer 2024).

Finally, we wish to emphasise that the scores of TT100 in each country or region do not indicate whether it is a technocracy or not. However, in the court of public opinion, technocracy – defined as a form of governance giving experts with technical-scientific knowledge a privileged, if not exclusive, position in public decision-making – can be perceived as more or less desirable and legitimate. This perception is strictly the only interpretation we are making here.

Figure 7 below shows the distribution of TT100 scores across all countries and across all regions in our databases.

Figure 7: Distribution of TT100 for countries and regions



Goodwill: trust in personal-institutional players

This composite indicator is constituted of Acceptance scores of the following four items, meaning that for each item, high scores indicate consent with the statement in question, and low scores indicate low agreement with the statement in question:

1. (Scientists are) honest.
2. (Scientists are) reliable.
3. (I) actively take part in scientific projects by developing research questions, collecting data, discussing the findings with others, etc.
4. (I) attend public meetings or debates about science and technology.

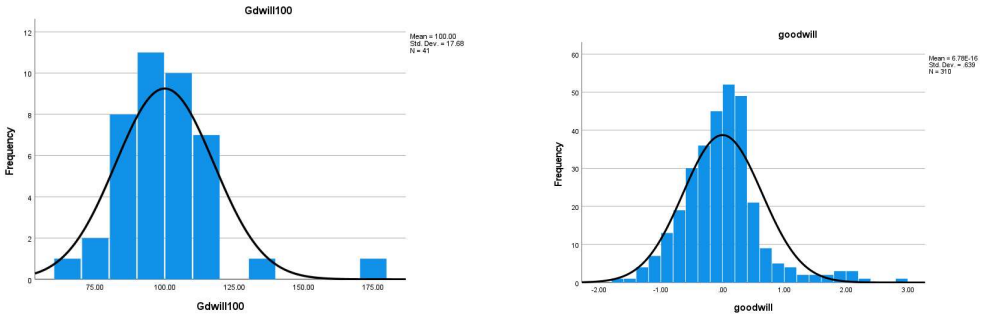
Compared to the items making up the Technocracy Tolerance indicator, these four items of Goodwill speak to a more personal relation of individuals with science actors, i.e. attribution of virtues to scientists as reliable and honest people and the inclination one might therefore have to

engage with such people. Items (1) and (2) unequivocally speak to virtue characteristics of scientists (being reliable and honest), and items (3) and (4) refer to active engagement with science (to be a 'citizen scientist' and to participate in debates about science issues). As such, high scores on the composite indicator of these statements indicate a high regard of scientists as well as a ready willingness to engage with science in the country or region. Accordingly, we have termed this component 'Goodwill' vis-à-vis 'players' of science.

Goodwill represents a positive sentiment and action orientation towards actors. The withdrawal of Goodwill can be likened to a form of 'industrial action,' where people refuse to collaborate and engage beyond the letter of the contract, potentially causing operational disruptions and malfunction of collective operations. This interpretation highlights the importance of Goodwill in maintaining a cooperative relationship between the public and the scientific community.

Figure 8 shows the distribution of Gdwill100 scores across all countries and across all regions in our databases.

Figure 8: Distribution of Gdwill100 for countries and regions



3.3 TT100 and Gdwill100: correlational validation of the POIESIS indicators of trust in science

In the previous section, we validated our indicators in terms of their semantics; they can be meaningfully interpreted (i.e., semantic or conceptual validation). In this section, we further validate the POIESIS indicators of trust in science, TT100 and Gdwill100. We do this through an analysis of the correlations of both indicators with other indicators from our National and Regional databases, including socio-economic indicators. Specifically, the socio-economic variables that we considered in our analysis are listed below in Table 5.

Table 5: Socio-economic variables used for the validation of TT100 and Gdwill100

Socio-economic indicator	Description
GDP/PC (2022, Eurostat)	Main GDP aggregates per capita.
GERD (2022, Eurostat)	Gross domestic expenditure on research and development (GERD). Includes expenditure on research and development by business enterprises, higher education institutions, government, and private non-profit organisations.
Educational attainment (2022, Eurostat)	Tertiary education attainment (Levels 5-8): Highest level of education successfully completed by the individuals of a given population (age 25-64).
SII (2023, European Commission)	Summary Innovation Index (SII): Quantifies the innovation performance of a country.
Human Freedom Index (2023, Cato Institute & Fraser Institute)	Quantification of the degree of freedom in a country. The Human Freedom Index (HFI) encompasses the indices of personal freedom and economic freedom, merged into a single value of human freedom.
Human Development Index (2021, United Nations)	A composite index measuring average achievement in three basic dimensions of human development—a long and healthy life, knowledge, and a decent standard of living.
Hofstede's Power Distance (Culture Factor Group)	Power Distance: This dimension deals with the fact that all individuals in societies are not equal - it expresses the attitude of the culture towards these inequalities amongst us. Power Distance is defined as the extent to which the less powerful members of institutions and organisations within a country expect and accept that power is distributed unequally.

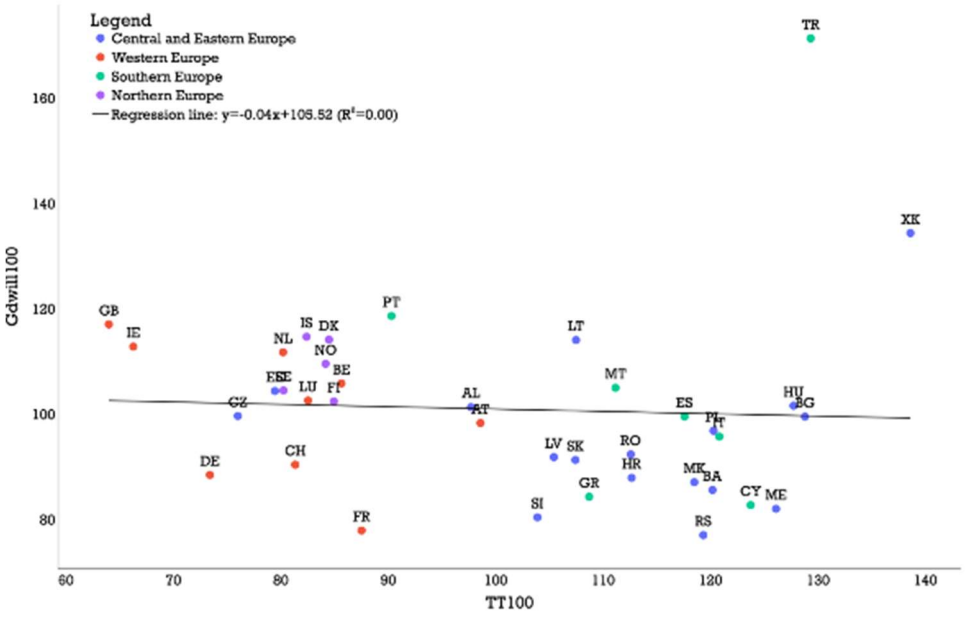
Note: Detailed references to these variables will be made available in the upcoming D1.4 (the National and Regional databases).

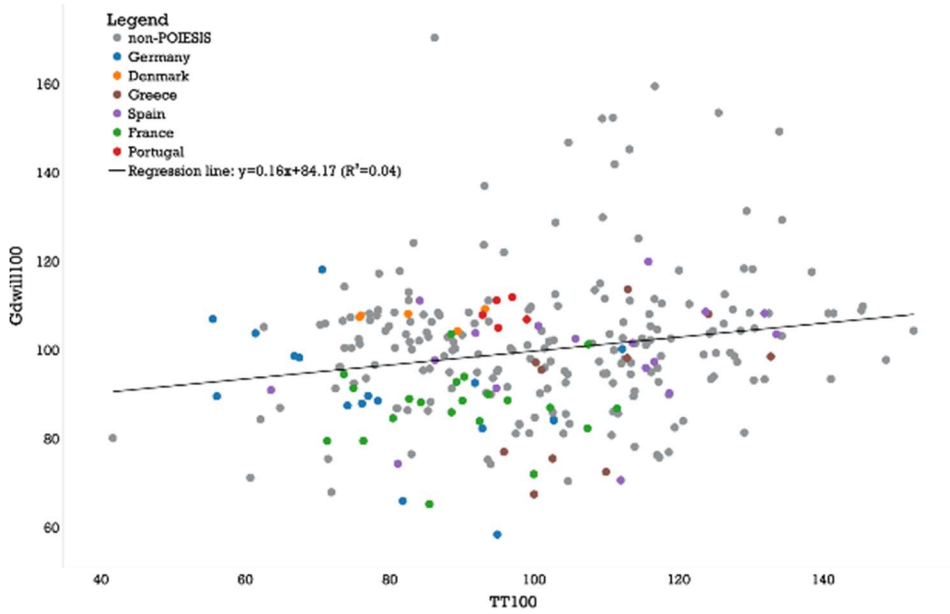
TT100 x Gdwill100

Before extending our analysis to external socio-economic variables, first, we look at the interplay of our two indicators TT100 and Gdwill100 (see Figure 9). Figure 9 shows a lack of correlation between TT100 and Gdwill100 in the National Database ($r < 0.10$; R-squared <0.01) and a very weak correlation in the Regional Database ($r = 0.20$; R-squared = 0.04). It should be noted, however, that

the two outliers (Turkey and Kosovo, TR and XK, respectively) may even inflate the correlation between the two indicators. Yet, their respective regions in the Regional Database are not outliers to the same extent. We conclude that TT100 and Gdwill100 are independent indicators of trust in science, they contribute unique and additional information each to characterising a country or a region.

Figure 9: TT100 x Gdwill100 in countries (above) and regions (below) of the POIESIS databases





In the upper part of Figure 9, displaying the country level, countries are grouped into either of four European regions: Central and Eastern Europe, Western Europe, Southern Europe, and Northern Europe. The scatter dots of each country have colours representing these regions. We note that the countries belonging to these regions tend to group together in aggregate response tendencies: Western and Northern European countries are located below the TT100 mean (M = 100), yet show more variance on Gdwill100, all being within one standard deviation from the mean (M = 100; SD = 25). Countries belonging to Central and Eastern Europe, in contrast, are spread out across both TT100's and Gdwill100's distributions. Finally, the Southern European countries apart from Portugal (that in aggregate response tendencies shows similar patterns to Western and Northern European countries), are similarly grouped together above the TT100 mean (M = 100), and again more distributed on Gdwill100, with Turkey being an outlier on this indicator.

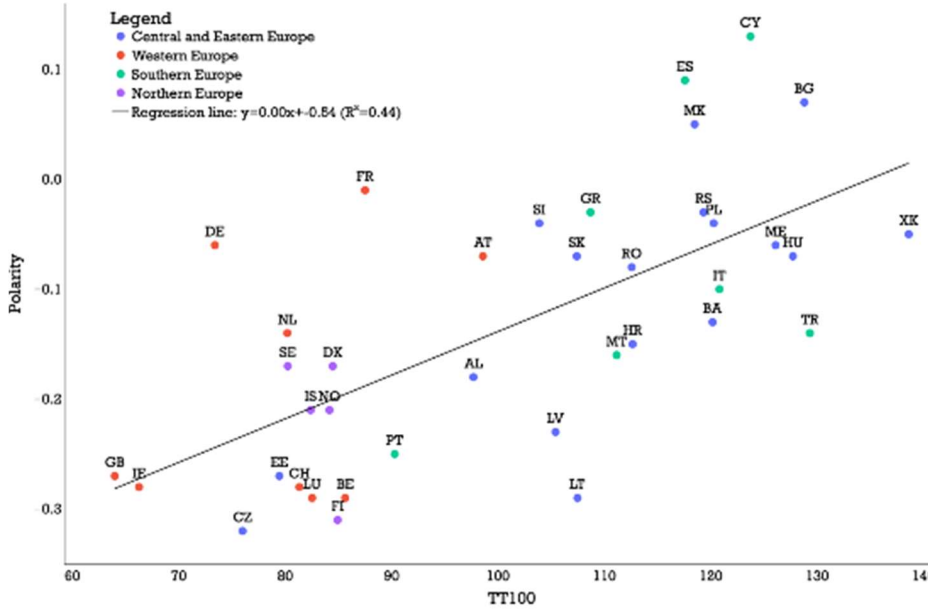
In the plot for the distributions of TT100 and Gdwill100 on a regional level (see Figure 9 below), we coloured the scatter dots of the POIESIS partner countries' regions. Non-POIESIS partner countries are coloured grey. For most POIESIS partner countries' regions, apart from the Danish and Portuguese ones, we observe considerably different scores on TT100 and Gdwill100, indicating a reasonable variability on these indicators within each country. We discuss regional variability further in chapter 4.

Overall, the minimal correlation between TT100 and Gdwill100 as shown in Figure 9 indicates that the overall tendency of deferring decision-making to techno-scientific authority (Technocracy Tolerance) and the overall inclination for engagement with highly regarded of scientists (Goodwill) are two statistically independent dimensions to characterise trust in science in a country. This will the basis of our initial 2x2 grid to Cultures of Science across Europe (see chapter 4).

TT100 & Gdwill100 x Polarity

We have argued that when considering trust in science in terms of country consent, we need to qualify any score of TT100 and Gdwill100 with the degree of that consent. Figure 10 shows the correlation between TT100 and the degree of polarisation across all items in the database. The Polarity indicator was constructed by taking all derived polarisation indicators and averaging them into a singular Polarity score. We take polarisation to be a general 'response set' that characterises a unit of analysis, not only in relation to the items that define TT100 or Gdwill100. Here we find a positive correlation for TT100 (r = 0.66, R-squared = 0.44 in the National Database). This means that a higher level of Technocracy Tolerance also comes with a higher degree of polarisation of opinions (i.e., a lack of consensus across survey items in the country or region). In the plot corresponding to the National Database, we observe patterns according to European regions: the Northern European countries are clustered in a space defined by lower-than-average TT100 scores, as well as relatively low Polarity. Western European countries, however, are more distributed along the Polarity axis, with five Western European countries (GB, IE, CH, LU, BE) scoring amongst the lowest Polarity scores, and the other four (DE, NL, FR, AT) demonstrating slightly higher Polarity scores. The Central and Eastern European as well as Southern European countries again vary considerably on both the TT100 and Polarity indicators, with Portugal again grouping together with the Northern and Western European countries.

Figure 10: TT100 x Polarity in POIESIS National Database

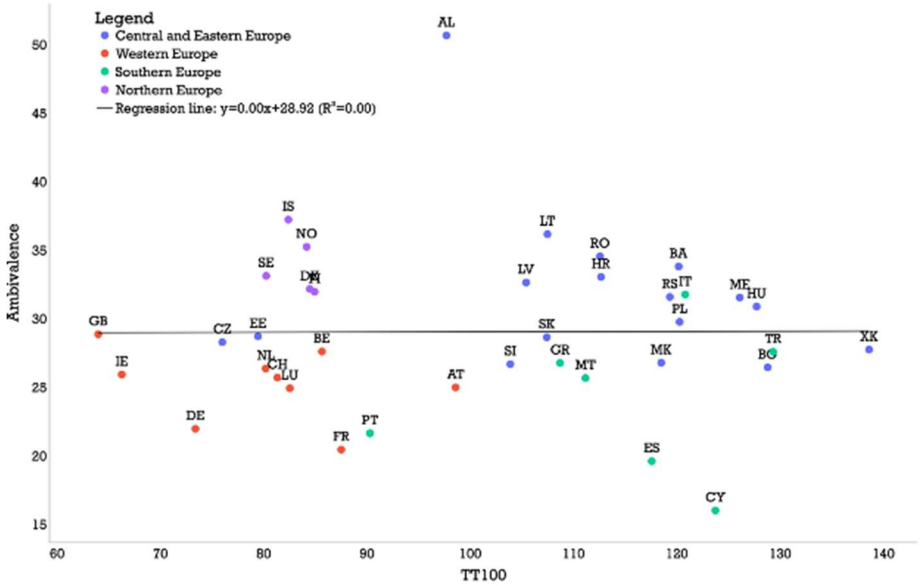


By contrast, Gdwill100 shows a slight negative correlation with polarisation (r= -0.36). This means that counties with less polarisation on these trust matters show more Goodwill in relation to science, countries with highly polarised opinions show less Goodwill towards science.

TT100 & Gdwill100 x Ambivalence

Figure 11 shows the degree of correlation between TT100 and Ambivalence, the latter of which represents the average level of ambivalent responses (e.g., 'Neither agree nor disagree') in the National Database. On a national level, we observe no correlation as indicated by the horizontal regression line (R-squared = 0). Generally, we observe that Ambivalence is a qualifying variable at each level of TT100.

Figure 11: TT100 x Ambivalence in POIESIS National Database



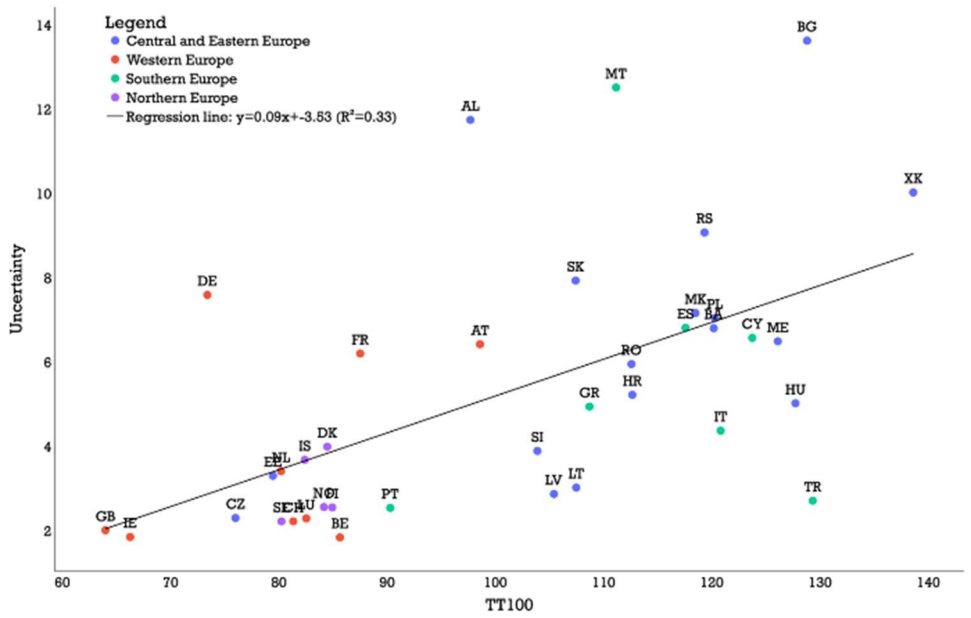
Equally, Gdwill100 shows no correlation with ambivalence across countries. Ambivalence in the response set of a country is independent of the level of Technocracy Tolerance or Goodwill vis-à-vis science, as such different degrees of ambivalence qualify the consensus at any level of Goodwill.

TT100 & Gdwill100 x Uncertainty

Figure 12 below shows the positive correlation between uncertainty of responses (i.e., the 'Don't know's') across several items and TT100 (r = -0.58; R-squared = 0.33). This correlation means that the higher the level of TT100, the more uncertainty the country's response set is presenting across all items. In turn, this implies that a high level of TT100 often needs to be seen to come with a high level of 'Don't know' responses. In countries where Technocracy Tolerance is high, the share of people having no opinions on these matters is also high.

The correlation with Gdwill100 is by contrast slightly negatively tilted (r= 0.25). This means that higher levels of uncertainty in these matters of trust are to be found in countries with lower levels of Goodwill vis-à-vis science; or the more Goodwill in a country, the less uncertainty about matters of trust.

Figure 12: TT100 x Uncertainty in POIESIS National Database



These correlations of TT100 and Gdwill100 with polarisation, ambivalence and uncertainty illustrate that the climate of opinion in each unit of analysis can and must be qualified further. Different levels of TT100 or Gdwill100 need to be considered in the light of these qualifiers when we characterise trust in science (see below).

TT100 & Gdwill100 x external socio-economic variables

We further validate our indicators TT100 and Gdwill100 by exemplary correlations with socio-economic variables (correlative validation). The socio-economic and cultural variables considered here and their correlations with TT100 and Gdwill100 are displayed in Table 6 below.

Table 6: Correlations between TT100, Gdwill100 and external variables in National database

Indicator	Correlation with TT100 (r)	Correlation with Gdwill100 (r)
European innovation index (SII, 2023)	-0.74	0.12
Human Development Index (HDI, 2021)	-0.71	0.19
Gross domestic product per capita (GDP pc)	-0.65	0.17
Hofstede's Hierarchy and Power Distance indicators	0.56	-0.33
Virus conspiracy item (EB95.2, 2021)	0.89	-0.18
Decreasing rejection of 'Industry funded research' (2010-2021)	0.76	0.12
Believe in vaccine safety (WGM, 2018)	0.72	0.27
Climate change fact denial (EB95.2, 2021)	0.72	-0.07
Scientists' view RI import for public trust in science (IRIS,2022)	0.53	-0.04
Scientists' adherence to RI principles to gain public trust (IRIS, 2022)	0.26	0.42

Regarding TT100, three of the correlations are negative: between TT100 and the European Innovation Index (SII), the Human Development Index, and the GDP per capita. In other words, the higher a country scores on these economic performance indicators, the lower they score on TT100. Further, we observe positive correlations between TT100 and seven indicators as outlined in Table 6: with Hofstede's Hierarchy & Power Distance; whether people belief in 'virus conspiracies' in the context of COVID-19; a time-series trend which shows that people increasingly warm towards industry funding for scientific research; belief in vaccine safety before the pandemic; climate change fact denialism; and the perspective of scientists in the country according to which Research Integrity is important to secure public trust in science, and whether this would motivate them to adhere to principles of integrity.

The correlation of Gdwill100 with all these indicators is generally lower than for TT100. This suggests that Goodwill towards science might be a more basic and more stable disposition of a Culture of Trust than Technocracy Tolerance; the later might be more fluid in response to emergency circumstances, such as the Covid-19 pandemic of 2020/22, or a situation of quasi-war in Europe since 2022 (Russia's attack on Ukraine in February 2022).
An exception to these lower correlations is scientists' adherence to RI principles to gain public trust that is positively correlated with Gdwill100 (r=0.42). The interpretation of this correlation clearly adds to our validation of the indicators: in countries where scientists believe that adhering to research integrity standards positively contributes to trust in science, there is also more Goodwill towards science.

Two of the correlations shown in Table 6 are visualised in the figures below. The negative correlation between TT100 and the innovation potential of a country (SII) is illustrated in Figure 13 by the European Index of Innovation Potential (r = -0.74; R-square = 0.55, National database).

Figure 13: TT100 x SII_23 (Innovation Index) in countries of the POIESIS National database

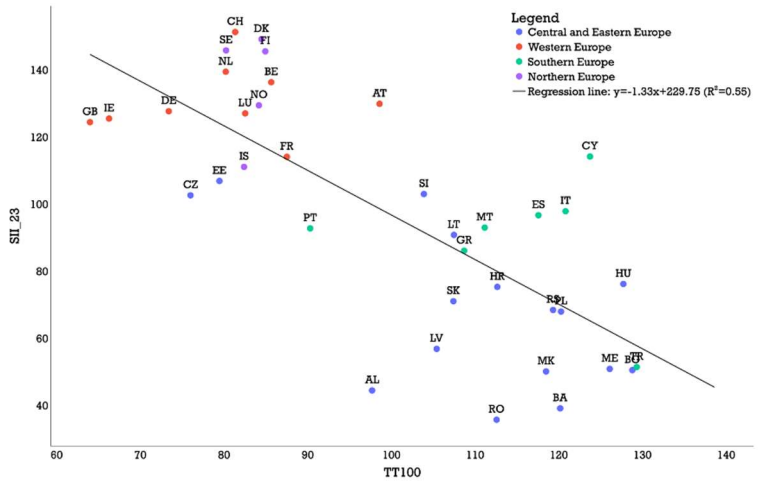
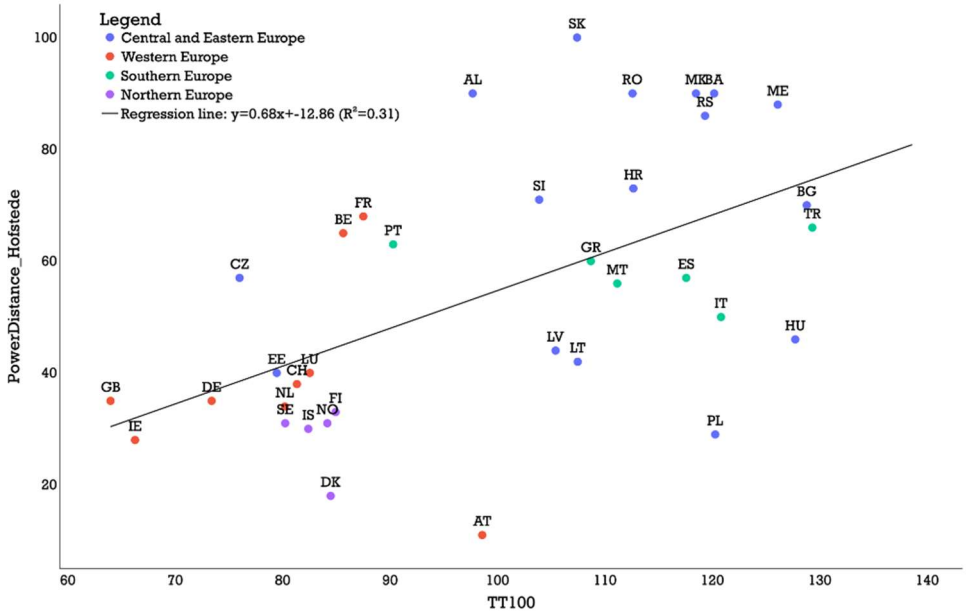


Figure 14 shows the Hofstede indicator of general culture of hierarchy and power distance in a country which is positively correlated with TT100. Interestingly for the interpretation of our indicator, the higher the Technocracy Tolerance in a country, the higher is also the respect of hierarchy of the distance of those in power and those who are not. TT100 thus captures a feature of a culture, not only related to the governance of science and technology, but to the style of interaction among people in everyday and in corporate life.

Figure 14: TT100 x Hofstede's Hierarchy and Power Distance indices in POIESIS National Database



Clearly, this table of 'correlational validation' of TT100 and Gdwill100 can be extended; as other indicators become available they can be simply added to our National and Regional databases.

As the end result of this validation exercise, we are able to characterise nations or regions on five indicators for which we know how they are correlated with socio-economic and cultural variables: Technocracy Tolerance, Goodwill, Polarisation, Uncertainty and Ambivalence (see Table 7). While a geographical unit might be 'Technocracy tolerant' and display Goodwill towards science, this local consensus comes with degrees of polarisation, uncertainty and ambivalence to consider.

Table 7: Descriptive statistics for the five indicators of Cultures of Trust

	T-transformation (M=100, SD=25)		Average variance across items		
	TT100	**Gdwill100**	**Uncertainty**	**Ambivalence**	**Polarity**
Mean	100	100	5.4	28.8	-0.13
Median	100	100	5.0	28.3	-0.1
Standard deviation	20.15	17.68	3.039	5.863	0.1192
Min	64	66	1.9	16.0	-0.32
Max	139	171	13.6	50.7	0.13
Range	75	106	11.8	34.7	0.45

4. Towards Cultures of Trust in Europe

In the previous chapters, we have outlined how we have constructed the two POIESIS indicators TT100 and Gdwill100; how they can be understood (semantic validation) and validated in relation to various socio-economic and cultural variables (correlational validation). We however do not want to use these two indicators stand alone and potentially ferment some kind of 'horse racing' discussion of who has the highest or lowest score of Technocracy Tolerance or Goodwill towards science. One-dimensional rankings might occasionally have 'scandal' value to stimulate a public debate in a country (an example for this are OECD PISA scores on national educational achievements), however, most of the time they are too simplistic and lead to hasty and misleading conclusions about the state of affairs in the respective geographical units. Instead, we make the argument that our two indicators together constitute 'Cultures of Trust' which can be mapped in a 2-dimensional Euclidian space by way of an initial 2x2 grid for each country and region included in our database. Doing so, we are able to group countries and regions and show patterns of similarity and dissimilarity regarding the interplay of TT100 and Gdwill100 (section 4.1) and can put these into context with additional data, for example national survey results we collected in the frame of D1.2 (section 4.2) or socio-economic data.

After section 4.1 explains the concept of 'Cultures of Trust' in more detail, section 4.2 provides additional context to our mapping of Cultures of Trust for the POIESIS partner countries at a descriptive level. An actual interpretation of what our mapping of Cultures of Trust means for trust in science in a specific national or regional context requires the further consideration of the qualitative data collected in the three empirical studies of WP2 and WP3 of the POIESIS project (public consultations, focus groups with institutional actors, expert interviews with researchers and mediators).

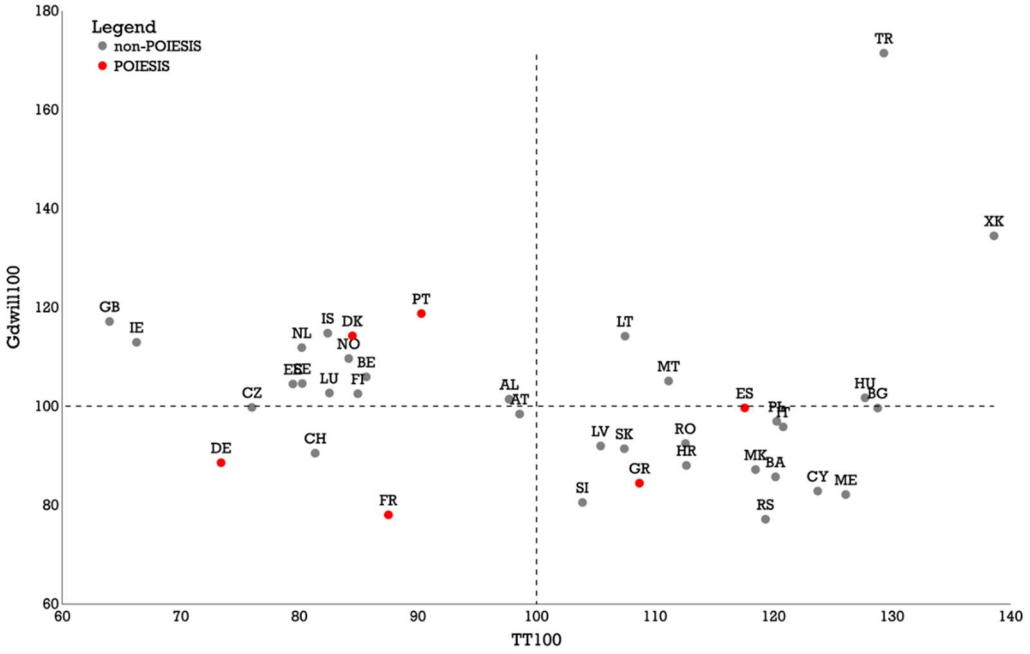
4.1 From country 'horse racing' to indicating 'Cultures of Trust'

Up until now, we have looked at the two POIESIS indicators of trust separately – TT100 on the one and Gdwill100 on the other hand. Having such indicators at hand, it is always tempting for communication purposes to consider them as 'performance' indicators which rank order countries or regions by their level of performance to answer questions like: who performs best and who performs worst, who is better than whom, and where do we stand? This agenda has its role to play in creating a field of competition or for purposes of resource allocation, it even has 'scandal value' to stimulate a public debate. This however is not our intention nor agenda with this process of indicator construction.

With our system of indicators, we have shown how TT100 and Gdwill100 are distributed across the countries and regions included in the Eurobarometer and how their results can be validated semantically and through correlations with other variables. As explained in chapter 3, TT100 and Gdwill100 represent two different dimensions of trust, i.e., at the 'pillar' and 'player' level of science. They are statistically independent of each other, but their meaning is not mutually exclusive. Mapped together, they represent a 2-dimensional Euclidian space of Cultures of Trust in which each country and region finds its position relative to the EU+ average. Doing so, we make statements about the patterns of trust in society within geographical units but also group together such units and identify patterns of similarity and dissimilarity between them and across Europe.

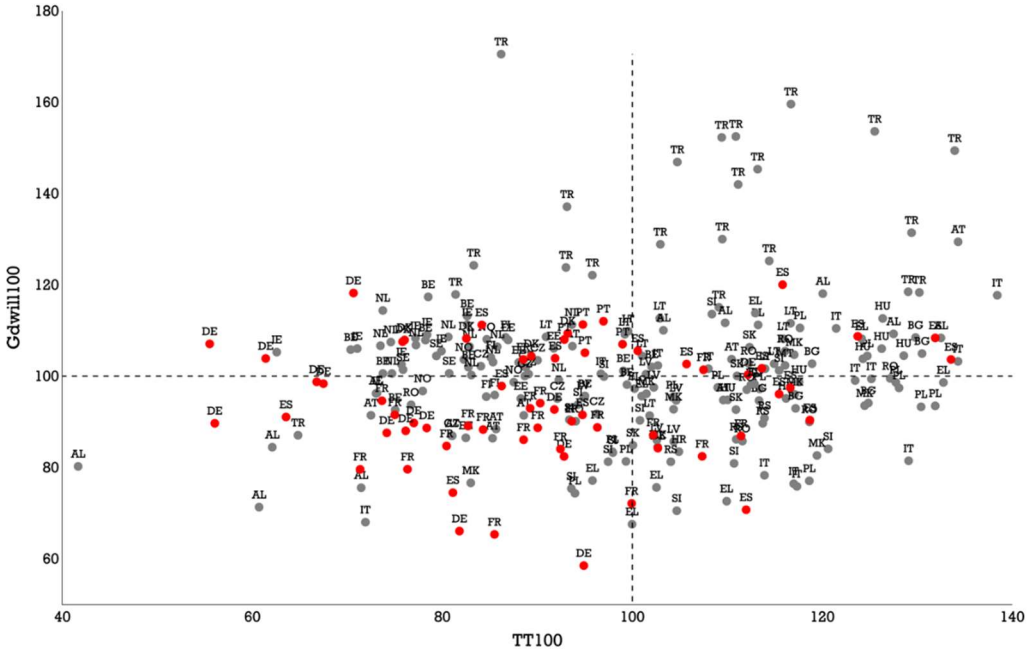
Figures 15 and 16 show this 2-dimensional space and the distribution of countries and regions that are part of the Eurobarometer survey within this space of Cultures of Trust.

Figure 15: Cultures of Trust: the 2-dimensional space of TT100 and Gdwill100 (national level)



Note: POIESIS partner countries are displayed in red, all other countries included in the Eurobarometer are displayed in grey.

Figure 16: Cultures of Trust: the 2-dimensional space of TT100 and Gdwill100 (regional level)



Note: Regions in POIESIS partner countries are displayed in red, all other regions included in the Eurobarometer are displayed in grey

As becomes visible in these two figures, displaying TT100 and Gdwill100 in a 2-dimensional space also defines a 2x2 grid with four quadrants, defined by the EU+ average, and this leads to the emergence of four potential fields of Cultures of Trust which are defined as follows in quadrants:

1. Low levels of Technocracy Tolerance and high levels of Goodwill (Ltt Hgw) – the upper left quadrant
2. High levels of Technocracy Tolerance and high levels of Goodwill (Htt Hgw) – upper right quadrant
3. Low levels of Technocracy Tolerance and low levels of Goodwill (Ltt Lgw) – lower left quadrant
4. High levels of Technocracy Tolerance and low levels of Goodwill (Htt Lgw) – lower right quadrant

Countries fall more or less clearly into one of these four quadrants which would warrant describing their 'Culture of Trust' in the terms defined by TT100 and Gdwill100 always relative to the EU+ average. Further multivariate analysis might be indicated here, such as hierarchical clustering to determine groupings beyond simple visual identification.

As explained in chapter 3, all scores on TT100 and Gdwill100 relate to the EU+ average (=100). The mapping needs to be interpretated accordingly: related to the EU+ average, in France and Germany we can find a culture of low Technocracy Tolerance in combination with low Goodwill. Portugal, the United Kingdom and Denmark can be found on the upper left of the grid, meaning that compared to the EU+ average, they have cultures of low Technocracy Tolerance in combination with high Goodwill. None of the POIESIS partner countries, and in general only very few countries in Europe combine high levels with Technocracy Tolerance and high levels of Goodwill. Spain and Greece have higher levels of Technocracy Tolerance than the EU+ average, combined with lower levels of Goodwill.

The same figure as for the distribution of countries across the four potential Cultures of Trust (see Figure 15) can be created for regions included in the Eurobarometer as well (see Figure 16). This figure is of course complex. Displaying the same distribution of regions in a table sorted by the four Cultures of Trust identified above, makes the clustering of regions clearer and more concrete (see Table 8 below). The tables show which regions fall into which of the four quadrants, and also whether different regions in a single country are homogeneous or rather heterogeneous in their Cultures of Trust, in other words, whether regions of a country fall into one quadrant and spread across several quadrants and thus across several types of Cultures of Trust.

Table 8: Distribution of Cultures of Trust across European regions

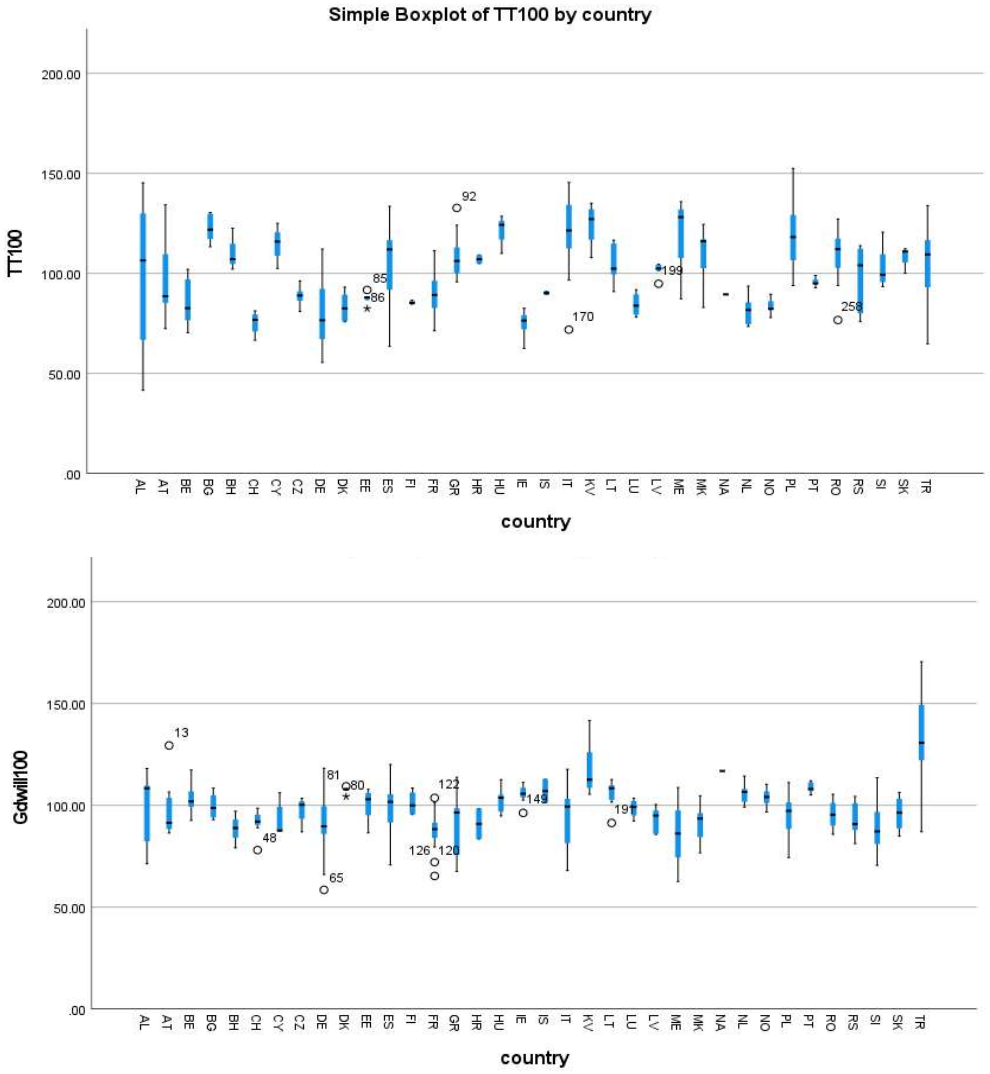
1 = Ltt Lgw	2 = Htt Lgw	3 = Ltt Hgw	4 = Htt Hgw
AL021 - Elbasan	AT21 - Kaernten	AT12 - Niederoesterreich	AL011 - Diber
AL031 - Berat	BG32 - Severen tsentralen	BE10 - Region de Bruxelles-Capitale / Brussels Hoofds	AL012 - Durres
AL032 - Fier	BG33 - Severoiztochen	BE21 - Prov. Antwerpen	AL013 - Kukes
AL033 - Gjirokaster	BG34 - Yugoiztochen	BE24 - Prov. Vlaams-Brabant	AL014 - Lezhe
AL035 - Vlore	BH01 - Federation of Bosnia and Herzegovina	BE31 - Prov. Brabant wallon	AL015 - Shkoder
AT22 - Steiermark	BH02 - Republika Srpska	BE32 - Prov. Hainaut	AL022 - Tirane
AT31 - Oberoesterreich	BH03 - Brecko Distrikt	BE33 - Prov. Liege	AL034 - Korce
AT32 - Salzburg	CY01 - Lefkosia/Nicosia	BE35 - Prov. Namur	AT11 - Burgenland
AT33 - Tirol	CY03 - Ammochostos/Famagusta	CZ01 - Praha	AT13 - Wien
AT34 - Vorarlberg	CY04 - Larnaka/Larnaca	CZ02 - Stredni Cechy	BE23 - Prov. Oost-Vlaanderen
BE22 - Prov. Limburg (BE)	CY06 - Lemesos/Limassol	CZ04 - Severozapad	BG31 - Severozapaden
BE25 - Prov. West-Vlaanderen	DE8 - Mecklenburg-Vorpommern	CZ05 - Severovyc hod	BG41 - Yugozapaden
BE34 - Prov. Luxembourg (BE)	EL30 - Attiki	CZ06 - Jihovyc hod	BG42 - Yuzhen tsentralen
CH01 - Region lemanique	EL51 - Anatoliki Makedonia ,Thraki	DE1 - Baden-Wuerttemberg	CY06 - Pafos/Paphos
CH02 - Espace Mittelland	EL52 - Kentriki Makedonia	DE5 - Bremen	DEC - Saarland
CH03 - Nordwestschweiz	EL53 - Dytiki Makedonia	DE6 - Hamburg	EL43 - Kriti
CH04 - Zurich	EL63 - Dytiki Ellada	DK01 - Hovedstaden	EL61 - Thessalia
CH05 - Ostschweiz	EL65 - Peloponnisos	DK02 - Sjaelland	ES23 - La Rioja
CH06 - Zentralschweiz	ES11 - Galicia	DK03 - Syddanmark	ES30 - Comunidad de Madrid
CH07 - Ticino	ES12 - Principado de Asturias	DK04 - Midtjylland	ES41 - Castilla y Leon
CZ03 - Jihozapad	ES42 - Castilla-la Mancha	DK05 - Nordjylland	ES43 - Extremadura
CZ07 - Stredni Morava	ES62 - Region de Murcia	EE001 - Pohja-Eesti	ES51 - Cataluna
CZ08 - Moravskoslezsko	FR22 - Picardie	EE006 - Kesk-Eesti	ES52 - Comunidad Valenciana
DE2 - Bayern	FR26 - Bourgogne	EE008 - Louna-Eesti	ES61 - Andalucia
DE3 - Berlin	FRA3 - Franche-Comte	ES22 - Comunidad Foral de Navarra	FR24 - Centre
DE4 - Brandenburg	HR03 - Jadranska	ES24 - Aragon	HU21 - Kozep-Dunantul (Central Transdanubia)
DE7 - Hessen	HR04 - Kontinentalna	FI18 - Helsinki-Uusimaa	HU22 - Nyugat-Dunantul (Western Transdanubia)
DE9 - Niedersachsen	HU10 - Kozep-Magyarorszag (Central Hungary)	FI1C - Etela-Suomi	HU31 - Eszak-Magyarorszag (Northern Hungary)
DEA - Nordrhein-Westfalen	HU23 - Del-Dunantul (Southern Transdanubia)	FR23 - Haute-Normandie	HU33 - Del-Alfold (Southern Great Plains)
DEB - Rheinland-Pfalz	HU32 - Eszak-Alfold (Northern Great Plains)	IE042 - West	ITC3 - Liguria
DED - Sachsen	ITC1 - Piemonte + ITC2 - Valle d'Aosta/Vallee d'Aoste	IE061 - Mid-West	ITC4 - Lombardia
DEE - Sachsen-Anhalt	ITF4 - Puglia + ITF5 - Basilicata	IE062 - South-East (IE)	ITF1 - Abruzzo + ITF2 - Molise
DEF - Schleswig-Holstein	ITG2 - Sardegna	IE063 - South-West (IE)	ITF3 - Campania
DEG - Thueringen	ITH2 - Provincia Autonoma di Trento + ITH1 - Provinc	IE041 - Dublin	ITG1 - Sicilia
EE004 - Laeaene-Eesti	ITH3 - Veneto	IE042 - Mid-East	ITI2 - Umbria
EE007 - Kirde-Eesti	ITH5 - Emilia-Romagna	IE043 - Midland	ITI4 - Lazio
EL54 - Ipeiros	ITI1 - Toscana	IS001 - Hofudborgarsvaedi	KV01 - FERIZAJ
EL64 - Sterea Ellada	ITI3 - Marche	IS002 - Landsbyggd	KV02 - GJAKOVA
ES13 - Cantabria	LT009 - Utenos apskritis	ITF6 - Calabria	KV03 - GJILAN
ES21 - Pais Vasco	LV003 - Kurzeme	LT003 - Klaipedos apskritis	KV04 - MITROVICA
ES53 - Illes Balears	LV005 - Latgale	LT007 - Taurages apskritis	KV05 - PEJA
ES70 - Canarias	LV008 - Vidzeme	LT00A - Vilniaus apskritis	KV06 - PRISTINA
FI1B - Lansi-Suomi	LV009 - Zemgale	LU3 - Centre	KV07 - PRIZREN
FI1D - Pohjois- ja Ita-Suomi	ME02 - South	LU1 - Est	LT001 - Alytaus apskritis
FR10 - Ile de France	MK03 - Jugozapaden (Southwest)	NA (re-identification potential)	LT002 - Kauno apskritis
FR21 - Champagne-Ardenne	MK04 - Jugoiztochen (Southeast)	NL11 - Groningen	LT004 - Marijampoles apskritis
FR25 - Basse-Normandie	MK05 - Pelagoniski (Pelagonia)	NL13 - Drenthe	LT005 - Panevezio apskritis
FR30 - Nord - Pas-de-Calais	MK06 - Polosh ki (Polog)	NL21 - Overijssel	LT006 - Siauliu apskritis
FR41 - Lorraine	MK07 - Severoiztochen (Northeast)	NL22 - Gelderland	LT008 - Telsiu apskritis
FR42 - Alsace	MK08 - Skopski (Skopje)	NL23 - Flevoland	LV007 - Pieriga
FR51 - Pays de la Loire	NL33 - Zuid-Holland	NL31 - Utrecht	ME01 - Center
FR52 - Bretagne	PL22 - Slaskie	NL32 - Noord-Holland	MK01 - Vardarski (Vardar)
FR53 - Poitou-Charentes	PL31 - Lubelskie	NL33 - Zuid-Holland	MT001 - Malta
FR61 - Aquitaine	PL34 - Podlaskie	NL34 - Zeeland	PL12 - Mazowieckie
FR62 - Midi-Pyrenees	PL41 - Wielkopolskie	NL41 - Noord-Brabant	PL21 - Malopolskie
FR63 - Limousin	PL43 - Lubuskie	NL42 - Limburg	PL52 - Opolskie
FR71 - Rhone-Alpes	PL51 - Dolnoslaskie	NO01 - Oslo og Akershus	PL63 - Pomorskie
FR72 - Auvergne	PL61 - Kujawsko-Pomorskie	NO03 - Sor-Ostlandet	RO31 - Sud - Muntenia
FRB1 - Languedoc-Roussillon	PL62 - Warminsko-Mazurskie	NO04 - Agder og Rogaland	RO42 - Vest
FRB2 - Provence-Alpes-Cote d'Azur	RO11 - Nord-Vest	NO05 - Vestlandet	SI033 - Koroska
IE041 - Border	RO12 - Centru	NO06 - Trondelag	SI038 - Primorsko-notranjska
ITH4 - Friuli-Venezia Giulia	RO 32 - Bucuresti - Ilfov	PT11 - Norte	SI03 - Stredne Slovensko
LU2 - Nord	RO41 - Sud-Vest Oltenia	PT15 - Algarve	SI04 - Vychodne Slovensko
LU3 - Sud	RS11 - Beograde	PT16 - Centro (PT)	TR10 - Istanbul
LV006 - Riga	RS12 - Vojvodina	PT17 - Area Metropolitana de Lisboa	TR21 - Tekirdag, Edirne, Kirklareli
ME03 - North	RS21 - Central-West Serbia	PT18 - Alentejo	TR31 - Izmir
MK02 - Istochen (East)	RS22 - South-East Serbia	SE1 - Stockholm/Ostra Mellansverige	TR33 - Manisa, Afyonkarahisar, Kutahya, Usak
NL12 - Friesland	SI031 - Pomurska	SE2 - Smaland med oarna/Sydsverige/Vastsverige	TR41 - Bursa, Eskisehir, Bilecik
NO02 - Hedmark og Oppland	SI034 - Savinjska	SE3 - Norra Mellansverige/Mellersta Norrland/Ovre	TR42 - Kocaeli, Sakarya, Duzce, Bolu, Yalova
NO07 - Nord-Norge	SI035 - Zasavska	TR22 - Balikesir, Canakkale	TR51 - Ankara
PL32 - Podkarpackie	SI043 - Goriska	TR32 - Aydin, Denizli, Mugla	TR61 - Antalya, Isparta, Burdur
PL33 - Swietokrzyskie	SI01 - Bratislavsky kraj	TR52 - Konya, Karaman	TR62 - Adana, Mersin
PL42 - Zachod niopomorskie	SI02 - Zapadne Slovensko	TR71 - Kirikkale, Aksaray, Nigde, Nevsehir, Kirsehir	TR72 - Kayseri, Sivas, Yozgat
RO21 - Nord-Est		TRA1 - Erzurum, Erzincan, Bayburt	TRB1 - Zonguldak, Karabuk, Bartin
RO22 - Sud-Est		TRB2 - Van, Mus, Bitlis, Hakkari	TRB3 - Samsun, Tokat, Corum, Amasya
SI032 - Podravska			TR90 - Trabzon, Ordu, Giresun, Rize, Artvin, Gumusha
SI036 - Posavska			TRB1 - Malatya, Elazig, Bingol, Tunceli
SI037 - Jugovzhodna Slovenija			TRC1 - Gaziantep, Adiyaman, Kilis
SI041 - Osrednjeslovenska			
SI042 - Gorenjska			
SI044 - Obalno-kraska			
TRB2 - Kastamonu, Cankiri, Sinop			

		trust_region				Total	
		LttLgw	HttLgw	LttHgw	HttHgw		
14	FR	16	3	1	1	21	
9	DE	11	1	3	1	16	
12	ES	4	4	2	7	17	
15	GR	2	6	0	2	10	
10	DK	0	0	5	0	5	
31	PT	0	0	5	0	5	74
6	CH	7	0	0	0	8	
34	SI	6	4	0	2	12	
2	AT	5	1	1	2	9	
1	AL	5	0	0	7	12	
30	PL	3	9	0	4	16	
3	BE	3	0	7	1	11	
8	CZ	3	0	5	0	8	
32	RO	2	4	0	2	8	
29	NO	2	0	5	0	7	
11	EE	2	0	3	0	5	
13	FI	2	0	2	0	4	
23	LU	2	0	2	0	4	
20	IT	1	8	1	7	17	
26	MK	1	6	0	2	9	
24	LV	1	4	0	1	6	
25	ME	1	1	0	1	3	
28	NL	1	0	11	0	12	
18	IE	1	0	7	0	8	
36	TR	1	0	6	15	22	
33	RS	0	4	3	0	7	
17	HU	0	3	0	4	7	
4	BG	0	3	0	3	6	
7	CY	0	4	0	1	4	
5	BH	0	3	0	0	3	
35	SK	0	2	0	2	4	
16	HR	0	2	0	0	2	
22	LT	0	1	3	6	10	
19	IS	0	0	2	0	2	
27	NA	0	0	1	0	1	
21	KV	0	0	0	7	7	
Total		82	73	75	78	308	

As an example, we can see that in Denmark and Portugal all regions of the same country can be found in the same cluster of lower Technocracy Tolerance and higher Goodwill than the EU+ average. French regions, however, are distributed across all four potential Cultures of Trust, with most of them having lower levels of Technocracy Tolerance and Goodwill than the EU+ average. The latter corresponds to the overall Culture of Trust for France visible in Figure 15.

But why diving into this rather messy analysis of the regional level then? If we want to get to the bottom of different Cultures of Trust and understand what characterises these, the analysis at the regional level is actually crucial because it provides us with the opportunity to see whether the sentiment towards science is homogenous within one country or whether there are regional divergences and how they look like. In a next step, these regional 'outliers' from the country average can then be analysed in more detail and under consideration of additional data. More valid conclusions about the state of trust within a single country become within reach in the end.

Figure 17: Regional ranges of TT100 and Gdwill100 for each EU country



Note: A large bandwidth suggests heterogeneous 'Cultures of Trust'.

For reasons of scope, we will not go any deeper into the analysis of regional Cultures of Trust in the rest of this deliverable but highly encourage respective further analysis with our data and will also take these results into account when synthesising our data streams with the qualitative results of the other POIESIS work packages.

4.2 Cultures of Trust in POIESIS partner countries

Our concept of Cultures of Trust departs from the idea that not multiple single concepts alone but rather a combination of different dimensions of trust captures the overall sentiment towards science in a given society best (see section 4.1). Cultures of Trust are different across countries and regions. The objective of this concept is however not to rank societies in 'who trusts more/better?' but to cluster geographical units with similar Cultures of Trust. It also allows to make statements about the homogeneity or heterogeneity of a given geographical unit, a country, a larger region (e.g. Northern and Southern Europe) etc. This concept of Cultures of Trust is not limited to our two main indicators TT100 and Gdwill100. On the contrary, it requires additional data for clear interpretation and each Culture of Trust becomes increasingly fine-grained when we look at it under consideration of other related variables.

4.2.1 Profiling countries - a more fine-grained analysis

Table 9: Profiling 'Cultures of Trust' in POIESIS partner countries

Country	TT	Goodwill	Polarity	Inconsistency	Power distance	SII 2023	GDP pc/ppp 2021	HDI 2018	Edu attain 2018	Freedom 2023	GERD 2018
DE	Low	Low	High	Low	Low	High	High	High	Low	High	High
FR	Low	Low	High	High	High	High	High	Mid	High	High	High
UK	Low	High	Low	High	Low	High	High	High	High	High	High
PT	Low	High	Low	High	High	Mid	Low	Low	Low	High	Low
DK	Low	High	Mid	Low	Low	High	High	High	High	High	Low
GR	High	Low	Mid	High	High	Mid	Low	Low	Low	Low	Low
ES	High	Low	High	Low	High	Mid	Low	Mid	High	Low	Low

Table 9 exemplifies how our national indicator system allows us to profile the Culture of Trust in all POIESIS partner countries. This could however be extended to any of the 30+ European countries in the database, or even to the 300+ regions. For the POIESIS partner countries under consideration, we use our indicator system compiling the composite indicators of trust in science, the qualifications of consensus in this regard in terms of polarity and inconsistency, and further the socio-economic and cultural variables (see section 3.3). This offers yet another way of representing and comparing the position of different countries by their similarities and differences across a number of criteria of comparison – and could again be extended to other variables of interest.

Taking the example of Spain and Greece, both countries have, compared to the EU+ average, higher levels of Technocracy Tolerance and lower levels of Goodwill. In Spain, however, polarisation is high and inconsistency low, while in Greece there is a medium level of polarisation but a high level of inconsistency. For Spain, this means that the share of extreme responses ("XY very much" and "XY not at all") is very high and that this is the case across all items. In Greece, on the other hand, the share of extreme responses to the initial items was overall lower, but there was more divergence in this regard than in Spain. These additional measures already paint a

more detailed picture of the existing Cultures of Trust in these two countries and could, on the basis of our data, be continued at the regional level. Additional socio-economic and cultural variables such as the Hofstede Power Distance Index, the European Innovation Index (SII) as well as Tertiary education attainment within a country can add additional information to these individual Cultures of Trust.

Methodologically, this opens a new avenue of comparison following the models of multiple case comparisons, qualitative comparative analysis (QCA) or fuzzy-set analysis in search of causality by combining quantitative and qualitative information about a mid-size number of cases in comparison (see Ragin 2014). The purpose of our current exercise is to reduce complexity in the data about public trust in science, and in doing so opening up new avenues for enquiries. We will pursue some of these new avenues that have opened up in the remainder of the POIESIS project, others will be left to other researchers on the basis of our data that will be made available Open Access. Quasi, by foreshadowing on particular avenues of further research, we will bring this overall approach into an initial synthetic commentary with regional and national evidence.

4.2.2 Cultures of Trust and survey measures of Trust, Integrity and Integration

It has already been stated several times, that for a more in-depth interpretation of how our Cultures of Trust concept speaks to the POIESIS 3i4t model, we need to consider the qualitative data collected in the course of the project. Nevertheless, we do want to take the opportunity to already contextualise our results a bit further by comparing them to the findings presented in the national reports authored for each POIESIS country in D1.2.[3] As a reminder, these national reports already provided some contextualisation for each POIESIS country related to the core items identified in the EB95.2 Eurobarometer wave and added additional information from mainly national but in selected cases also other international surveys. We aim to pursue this path by now contextualising our findings on the different Cultures of Trust in regard to these additional results.

As in D1.2, the national contextualisation is presented in alphabetical order of the POIESIS partner countries.

Denmark

In Denmark, similar to Portugal, we find an overall low level of Technocracy Tolerance and a high level of Goodwill. This means that people are not very inclined to defer authority to scientists, yet they hold a positive image of scientists and are motivated to participate in science themselves. The country exhibits a medium level of polarisation and low inconsistency, indicating that there are a few but not too many extreme responses and that this pattern holds across items. As one of two POIESIS partner countries, all Danish regions fall into the same cluster of Cultures of Trust.

The Danish attitudes towards science are characterised by a high knowledge index and generally very positive views. There is strong disagreement with the statements “we depend too much on science and not enough on faith” and “science and technology make our lives change too fast” when compared to the EU+ average. Trust in research conducted in Denmark is generally high and the Wellcome Global Monitor 2018 identifies 75% of Danish citizens as “Science Enthusiasts” agreeing that science benefits both themselves and other people in the country.

[3] All findings presented below directly refer to the selected results presented in the national reports of D1.2. This is not an exclusive list of survey items relating to the concepts of trust, integrity, and integration, though. An extensive list of surveys including relevant items can be found in the Appendix of D1.2.

There is limited data on integrity and public integration in Danish surveys. The Operate 2020 survey finds that Danish respondents generally disagree with the statement "Scientists cannot be trusted because they are subject to political or economic interests". This corresponds to TT100, suggesting that scientists can only be trusted if they reject industry money and are not influenced by hidden agendas. Alternatively, one could say that in Denmark, there is a more favourable view of privately funded research, such as conducted in companies. This perspective is further supported by findings related to public integration and decision-making on research topics in Denmark: A majority of respondents believes that it should be up to companies and universities to decide on the research topics in the country (TNS Gallup 2014 survey).

France

In France, the level of Technocracy Tolerance is similar to that in Denmark and Portugal. It is lower than the EU+ average, indicating that people are not very inclined to defer authority to scientists. However, the level of Goodwill is relatively low compared to the EU+ average, meaning that the image of scientists is not as positive and the willingness to personally participate in science is rather low. There is some regional heterogeneity, with most regions being situated in the low Technocracy Tolerance, low Goodwill cluster but the remaining five being dispersed throughout the three other cultural clusters. With regard to TT100 and Gdwill100, France shows high polarisation and but also high inconsistency, meaning that there are many extreme responses and significant variation across the response patterns of different items. This results in a non-homogeneous Culture of Trust within French society.

Attitudes towards science in France are settled closer around the EU+ average than in Denmark and generally show a less enthusiastic stance towards science. There is for example less interest in scientific discoveries and less approval of the statement "Science and technology make our lives healthier, easier, and more comfortable" compared to the EU+ average. However, there is a consensus that society does not rely too much on science at the expense of faith.

France has a long tradition of conducting trust surveys which makes long timelines available for some items. While general trust levels are high, there seems to be an increasing impression that science does humanity more harm than good, or at least as much harm as good (Les Français et la Science 2021). This speaks to the low level of Goodwill observed in France translating into public doubts about the orientation of scientific work towards the common good.

Regarding public integration, the same survey – Les Français et la Science 2021 – shows that most French respondents think that it is scientists who decide on the research agenda followed equally by the government and private companies. There is no clear indication of whether this is viewed positively or negatively, but the low Technocracy Tolerance suggests that the involvement of private companies in research agenda-setting may not be supported. A question of the already cited survey regarding the COVID-19 pandemic goes in the same direction showing low trust in statements from industry researchers. Trust in doctors and academic scientists is however very high.

Germany

Germany is situated within the same overall cluster as France, characterised by low Technocracy Tolerance and low Goodwill. However, Germany has overall much lower levels of Technocracy Tolerance and slightly higher Goodwill compared to France. The situation is quite different in East Germany however: East German regions show much higher Technocracy Tolerance - close to the EU+ average - but the lowest Goodwill across the entire Eurobarometer. This regional heterogeneity is also evident in the distribution of regions across the four different Cultures of

Trust. Regarding our indicators, Germany has high levels of polarisation and low inconsistency, meaning there is a significant share of extreme responses on either side and this pattern is consistent across items.

The country's attitudes towards science reflect a high knowledge index but only medium interest in new scientific discoveries. There is a clear rejection of the statement that society depends too much on science and not enough on faith, and a stronger-than-EU+-average rejection of the idea that science and technology make lives change too fast. However, there is not much agreement with the statement that science and technology make lives healthier, easier, and more comfortable, presenting an overall mixed picture.

Trust in science in Germany has been tracked through the annual Wissenschaftsbarometer survey for already ten years. During the COVID-19 pandemic, trust in science saw an important evolution: it rose significantly at the beginning of the crisis but then started to decrease again ever since. There is a high share of undecided respondents regarding different trust items, such as whether scientists work for the benefit of society. Here, it would be useful to have a look at other indicators calculated in the course of our indicator construction, for example uncertainty (see chapter 2) to see whether this is an overall pattern in the German Culture of Trust.

Regarding the COVID-19 pandemic, one can observe that opinions on COVID-related statements, such as "scientists do not tell us everything they know about the coronavirus", are strongly fragmented, matching the high polarisation observed in responses for Technocracy Tolerance and Goodwill. The overall level of Goodwill in Germany is not far from the EU+ average but still below it. This matches data from the Wissenschaftsbarometer 2022 showing that on the one hand, many respondents indicate that scientists can be trusted because they follow standards and procedures, though fewer people agree that scientists conduct research in the public interest.

A majority of respondents further believes that a strong reason to distrust scientists is the latter's dependence on research funders, corresponding to the low levels of Technocracy Tolerance we find in our data: people have the impression that scientists are influenced by external interests, do not make decisions independently, and therefore should not be granted too much authority.

Greece

In Greece, the level of Goodwill is comparable to that in Germany, situated below the EU+ average. However, Greece exhibits a much higher level of Technocracy Tolerance, making it, along with Spain, one of the two POIESIS partner countries with higher Technocracy Tolerance than the EU+ average. We can observe a medium level of polarisation but high inconsistency in Greece, meaning that while there are not many extreme responses overall, this pattern varies significantly across different items included in the composite indicators. The eight regions of Greece are distributed across three different Cultures of Trust with the pattern 6:2:2. This indicates stronger regional heterogeneity in Greece compared to the other countries described so far: in Denmark, all regions are situated in the same cluster, and while France and Germany have regions in all clusters, there is still one clearly dominant one across the country.

In terms of attitudes towards science, fewer people in Greece than in other European countries disagree with the statement "Science and technology make our lives change too fast". Additionally, Greeks more often believe that "We depend too much on science and not enough on faith" compared to respondents in other countries. The other statements align closely with the EU+ average.

Regarding other trust items, a majority of Greek respondents (56%) believes that scientists' work benefits most people in Greece, according to the Wellcome Global Monitor 2018. This places Greece among the countries where this opinion is the strongest. This sentiment is also reflected in the high trust people placed in the committee of experts during the COVID-19 pandemic (Interview 2020). One could deduce that Greek citizens are generally inclined to believe that experts will make the right decisions which corresponds to Greece's high level of Technocracy Tolerance observed in our data.

Overall, in Greece there is a strong level of trust towards science and scientists, coupled with a willingness to defer authority to them. However, there is not a pervasive feeling that all changes resulting from scientific progress are positive. The country further shows significant heterogeneity in terms of regional Cultures of Trust.

Portugal

Portugal's positioning regarding Technocracy Tolerance and Goodwill is close to that of Denmark, with slightly higher scores on both dimensions compared to the EU+ average. This challenges the recurrent notion of a clear cultural divide between Northern and Southern Europe. Portugal has low levels of polarisation but a high level of inconsistency, meaning there are not many extreme responses overall, but the response pattern varies significantly across different items. Similar to Denmark, Portugal's regions are very homogeneous, all fitting within the same cluster.

In terms of attitudes towards science, Portugal has seen a significant increase in both the knowledge index and interest in new scientific discoveries between 2013 and 2021. There has also been a marked shift in the disapproval of the statement "We depend too much on science and not enough on faith", moving from below to far beyond the EU+ average over time. Other statements remain around the EU+ average, indicating that while people know more about science and show increased interest, they do not necessarily view all scientific achievements as beneficial.

While national trust data specific to Portugal is unavailable, the Wellcome Global Monitor 2018 places Portugal among the top 12 countries where people are most likely to have high trust in scientists. However, the country also has a relatively high share of people with low trust (11%) compared to other countries in the ranking. Most respondents in the Eurobarometer survey EB95.2, which is also at the basis of our indicator construction, indicate that science and technology benefit "people like me". This reflects an overall high level of trust and also corresponds to the high level of Goodwill found for Portugal: people are convinced of the benefits of science and believe scientists work towards societal benefit without suspected any hidden agendas.

Regarding public integration, the already cited Eurobarometer surveys from 2021 shows that a majority of respondents believes that involving non-scientists in scientific developments is good and necessary. This might correspond to Portugal's relatively low level of Technocracy Tolerance, indicating that people are not inclined to defer much authority to experts and prefer to see other actors involved in scientific decision-making.

Spain

Spain, along with Greece, is one of the countries with higher Technocracy Tolerance than the EU+ average, and Spain's level of Technocracy Tolerance is significantly higher than Greece's. Goodwill in Spain is very close to the EU+ average. This indicates that people are relatively willing to defer authority to experts and they also have a positive view of scientists and are motivated to take

part in science themselves – even though not at the decision-making level. Spain has high levels of polarisation, with many extreme responses across various items and low inconsistency, meaning this pattern is consistent across all items. The country shows the highest heterogeneity regarding its regions among the POIESIS partner countries: the Spanish regions are distributed nearly equally across all four cultural clusters, making it challenging to define a single 'Spanish Culture of Trust'.

In terms of attitudes towards science, Spain exceeds the EU+ average in interest and knowledge of science, as well as in approval of the statement "Science and technology make our lives healthier, easier, and more comfortable". However, many Spanish respondents also believe that science makes life change too fast, similar to sentiments in Greece. This indicates that high Technocracy Tolerance does not necessarily correlate with a wholly positive view of the societal consequences of scientific progress.

Trust in science is high in Spain, with two surveys (FECYT 2020 & 2022) showing that a large majority of Spanish respondents believes that scientific knowledge is the best basis for developing laws and regulations. This reflects the high level of Technocracy Tolerance in Spain, with people being ready to defer authority to experts and support the influence of scientific knowledge also in political decision-making processes. Most respondents also believe that the benefits of science and technology outweigh the harms. Interestingly, during the COVID-19 pandemic, a majority of respondents saw citizens' responsibility as the most crucial factor in ending the crisis, rather than government management or scientific discoveries.

Regarding integrity, an increasing majority of respondents in the FECYT surveys agrees with the statement that "those who pay for research can influence scientists to reach conclusions that suit them". This finding could correspond to the fact that scoring high in Technocracy Tolerance also means strong suspicion towards the influence of industrial money on research.

In terms of public integration, the FECYT 2020 survey indicates that nearly 60% of respondents believe citizens should have a greater role in decisions on science and technology that directly affect them, while only slightly more than 20% disagree. This does not entirely align with the high Technocracy Tolerance observed in Spain and the resulting willingness to defer authority to experts at a systemic level. However, when asked if they personally would like to be involved in decision-making on scientific issues, most respondents prefer to leave this to others, as long as scientists are involved. This is also in line with the above-mentioned conviction that scientific knowledge should underpin laws and regulations.

In summary, Spain has a high level of Technocracy Tolerance and Goodwill, leading to a quite high willingness to defer authority to experts and a desire to see scientific findings and scientists involved in decision-making processes. However, the country is also highly polarised and fragmented in terms of Cultures of Trust at the regional level.

United Kingdom

The UK is situated within the same cluster as Denmark and Portugal, sharing the characteristics of above-average Goodwill and below-average Technocracy Tolerance. However, the level of Technocracy Tolerance is very different from the other two, being the lowest among all countries in the Eurobarometer. This indicates that people in the UK are very reluctant to defer authority to experts. However, their Goodwill is above the EU+ average, suggesting that they have a positive image of scientists and are motivated to participate in scientific activities themselves. The UK seems sceptical with regard to the 'pillars of science', however more positively inclined towards its 'players'.

There is no available data for British regions in the Eurobarometer, making it impossible to comment on inner-country heterogeneity. The UK exhibits low polarisation in responses to the composite indicators but high inconsistency, meaning that generally there are not many extreme responses on either side but also that response patterns vary significantly across different items.

In terms of attitudes towards science, one can state that particularly the UK's knowledge index and the disagreement with the statement "we depend too much on science and not enough on faith" are particularly high in the UK and that many more people than on EU+ average also disagree with the statement that "Science and technology make our lives change too fast". This indicates that overall attitudes towards science and scientific progress are very positive in the UK.

Trust in science has steadily risen in the UK over the last few decades, according to the Ipsos Veracity Index. A majority of respondents in the Ipsos MORI 2020 survey states that the benefits of science to the UK are greater than its harmful effects. Among those who perceive science as beneficial on balance, a large majority also sees scientists as "generally trustworthy". Generally, the Ipsos MORI 2020 survey shows that a majority of respondents in the UK view scientists as trustworthy, which aligns with the rather high level of Goodwill in the country. Nevertheless, scientists advising the UK government on actions to deal with the COVID-19 pandemic enjoy slightly less public trust, which might, in turn, reflect the public's reluctance to defer decisions to scientists. This highlights the nuanced relationship between Technocracy Tolerance and Goodwill in the UK.

5. Conclusion, limitations, and outlook

This deliverable has reported on the process and main findings of our indicator construction based on the core items identified in D1.2. As a reminder, these core items have been chosen from the Eurobarometer survey EB95.2 (2021) to approach the concepts of the POIESIS 3i4t model: trust in science, research integrity and public integration (see chapter 1). We have worked further with these items, inductively exploring how they relate to one another and how to meaningfully reduce the complexity of the data at hand (see chapter 2). This has led us to the identification of two main composite indicators – TT100 and Gdwill100 (see chapter 3) – and, taken together, to the introduction of the concept of 'Cultures of Trust' (see chapter 4).
This conclusion will first of all address the main contributions our work makes to the field of trust in science, methodologically and content-wise. It will then discuss limitations of our findings and as a last important step provide an outlook towards possibilities of future analysis and the synthesisation of quantitative and qualitative data in the POIESIS project.

Development of a model procedure for indicator construction at the aggregate level

From a methodological point of view, our presented empirical work provides a model procedure for indicator construction that can be applied to all kinds of other survey data that is not necessarily comparable at the micro level, and we thus seek to encourage similar indicator construction for example for other rounds of (upcoming) Eurobarometer survey data – also but not exclusively related to trust in science.

Complexity Reduction: Chapter 2 and 3.1 trace in detail the procedure of how to reduce and summarise Eurobarometer data (in our case EB95.2) on trust in science at the country and regional aggregate level, combining indicators that are highly correlated and that make sense as a combination. As a result, two different levels of trust were identified in the data.

Standardisation and Transformation: After the identification of these relevant levels of trust (pillars and players), the indicators were standardised and transformed to a scale that is easily understandable and ready to be communicated. This involved a t-transformation with a mean of 100 and a standard deviation of 25, resulting in TT100 and Gdwill100, which are always presented in relation to the EU+ average.

Qualification of Results: The results of TT100 and Gdwill100 were qualified with measures of the degree of consensus within a country, such as polarisation, uncertainty, and ambivalence. It was found that comparing the levels of TT100 and Gdwill100 with such qualifications is crucial, as contexts such as high TT combined with high polarisation or ambivalence differ significantly from a high TT with consensus within society.

Semantic Validation and Correlational Validation with External Data: TT100 and Gdwill100 were then validated using data from other surveys, such as IRIS, Wellcome Trust, COVID, and Climate surveys, as well as socio-economic indicators like GDP and HDI, ensuring robustness and reliability and providing already some contextualisation to the initial indicators.

This procedure, as well as turning these separate indicators into a matrix of larger dimensions of interest – as in our case 'Cultures of Trust' – can be applied to other data and also other research topics of interest and therefore constitutes an important methodological contribution we make to the field of indicator construction.

From country ranking to 'Cultures of Trust'

From a content-perspective, our work represents the continuation of a process started in the beginning of the POIESIS project by collecting trust items throughout various surveys, identifying core items in the Eurobarometer survey of EB95.2 (2021) to approach the POIESIS concepts of the 3i4t model – trust, integrity and integration – and now analysing these core items in-depth to understand what patterns they show.

Levels of Trust: The inductive data analysis process described above has led to the identification of two distinct levels of trust towards science: **Technocracy Tolerance**, representing the willingness to defer authority to scientists and a sort of systemic trust in the 'pillar' of science, and **Goodwill**, representing a high regard of scientists as well as a ready willingness to engage with science. Goodwill relates to trust in 'personal players' of science.

'Cultures of Trust' grid and comparative matrix: To avoid a simple – and often misleading – ranking on individual indicators and to take the analysis one important step further, we then suggested a 2x2 grid of 'Cultures of Trust' based on high and low levels of the two dimensions Technocracy Tolerance and Goodwill. Countries and regions can be individually situated within this grid and be further profiled using these key indicators in combination with socio-economic variables, providing a nuanced understanding of trust dynamics in particular geographical contexts. This creates a comparative matrix on multiple and extendable criteria, allowing to explore similarities and dissimilarities in the logic of multiple-case comparison or qualitative comparative analysis (QCA).

Regional Science Cultures: The analysis of countries can be extended by analogy to regions. Thus, reporting on regional 'Cultures of Trust' reveals their homogeneity and heterogeneity within individual countries, highlighting and harnessing the diversity of trust cultures across different regions, and also in relation to further indicators in a larger comparative matrix.

Cultures of Trust as a crucial context variable for researchers and mediators: How does the concept of Cultures of Trust relate to the POIESIS model? First of all, the composite indicators TT100 and Gdwill100 are the result of an inductive data analysis based on items approaching but not concretely measuring the concepts of trust, integrity and integration. The two resulting dimensions of trust might hint to the fact that the overall trust sentiment in society does not function according to separate concepts such as integrity and integration but rather to superordinate dimensions creating an overall trust sentiment towards science. However, the concept of Cultures of Trust goes much further than this finding: as said, Cultures of Trust give an impression of an overall trust sentiment towards science in a given geographical context (a country, a region etc.). In this regard, Cultures of Trust can be characterised as the communicative context for the governance of science. Knowing and understanding this context is essential for the conduct of scientific activities, for mediators communicating about science etc. The identification of Cultures of Trust actually means that all kinds of stakeholders in the public-science relationship work under varying circumstances of public trust sentiments toward science within different geographical contexts, sometimes regionally differing from national trends. Our model of Cultures of Trust can therefore be seen as providing crucial context information for successfully performing any kind of activities within the public-science relationship.

Limitations of the present indicator system

Of course, working with indicators always has limitations. First of all, our indicators are based on data at the aggregate level. One needs to be mindful of and avoid the 'ecological fallacy' of inferring from aggregate data, i.e. country or regional indicator of trust-in-science, what individuals A or B might think in that particular context. E.g. living in a culture of high Technocracy Tolerance and low Goodwill does not mean that every individual living in that area shares that attitude of trust. To illustrate this by analogy: living in a place with a 'high sugar diet', does not mean that everybody eats lots of sugar.
Secondly, our indicator construction is based on cross-sectional data. It will be desirable to compare TT100 and Gdwill100 across different Eurobarometer surveys, upcoming and maybe past, if analogous indicators can be constructed.
Thirdly, this will reveal the difficulties of comparing 'measures relative to the EU+ average' over time. Doing so will only reveal shifting positioning of unit within the data, not any absolute shift over time. Further investigations will need to be undertaken to ascertain historical trends with this methodology.
Fourthly, the presented exercise of indicator construction is based on items of the Eurobarometer survey EB95.2 (2021) alone. Future research could replicate these procedures of creating trust indicators with other multi-national data and future Eurobarometer surveys to validate the results and to map changes over time.
Finally, a limitation is of geographical nature: our Cultures of Trust are validated within Europe, as all indicators are defined relative to EU+ average. Thus, our scores are only comparable within Europe. For any extended application, a new standardisation process would be necessary.

Brief outlook

It is the purpose of this process of indicator construction to reduce complexity to identify patterns of trust in science across Europe, but also to open up new avenues of further enquires.

It will be further revealing of the dynamics of trust in science across Europe to merge the aggregate indicators TT100 and Gdwill100 with individual micro level data and conduct multi-level analysis. This will allow answering questions of how individual attitudes are constituted in the context of particular 'Cultures of Trust'. The individual dynamics of trust are however not necessarily the purpose of the present project, whose focus is more the institutional analysis of how trustworthiness of science is secured in different contexts. Public trust thus becomes a context indicator rather than a focus of analysis in itself. The POIESIS project locates the problem of trust not in public opinion, but in the performance of institutions, thus avoiding the facile 'deficit model' of public attitudes and opinion.
Also, with regard to grouping of countries and regions, further multivariate analysis might be indicated, such as hierarchical clustering to determine groupings beyond simple visual identification.

From a very general point of view, this report presents an ongoing work of survey data exploration and analysis in the context of the POIESIS project. Therefore, the here presented results should be seen as an important but not the final piece of work in this work package. The in-depth interpretation of what our different Cultures of Trust mean in different contexts clearly requires more – and qualitative – data. The next very important step in our analysis is therefore to synthesise our quantitative findings with the qualitative research results of the public consultation, focus group and expert interview studies (WP2 and WP3). This will allow us to address questions like: how do mediators work and reflect the problem of trust in science in the different

contexts we identify? How do scientists think about the problem of public trust in these different contexts? Do their impressions match our classifications? What role do particular factors of research integrity and public integration play in the respective contexts?

Beyond our own efforts, we also highly encourage other researchers to use our data and continue the analysis of Cultures of Trust, for example regarding the classification of different regions, correlations with other external variables (especially at the regional level) etc. This will be made possible by the publication of our National and Regional database in an open-access format in the end of August 2024.

In this exercise of constructing indicators of trust in science, two implicit ideas were in the background of our explorations: trust in science arises on two levels, at the systemic level of 'pillars of science' and at the action level of 'players of science'. It seems that TT100 and Gdwill100 are plausibly consistent with this intuition. This duality deserves further investigation. Furthermore, TT100 is guided by another intuition, that of Technocracy Tolerance as a variable of public sentiment. Again, this idea requires further examination both with regard to the legitimation function of public opinion and with regard to models of 'technocratic governance' in historical contexts such as rising political populism. As an unnamed historian recently remarked informally: *'technocratic temptation is a historical constant among scientific elites, what is variable is whether they get away with it'.* Clearly more theoretical work and further empirical investigations flow from our present in-depths explorations of European attitudes to science in and about 2021.

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Appendices

A1: Derived indicators and meta-indicators considered, but not used

	scale type	5-point Likert + DK	YES/NO	3-point Likert + DK
	preparation	none	Don't Know/NN=middle	none
slant	% agreement/Yes	x	x	x
	% disagreement/No	x	x	x
	Mean scale	x	x	x
	Acceptance	x	x	x
spread	Polarisation	x	x	x
	Entropy	x		
uncertain	Uncertainty % Don't Know	x	x	x
	Ambivalence % NN	x		
	Z-scores	x	x	x
	T-transformation	x	x	x
	Index 100	x	x	x
	Ranking	x	x	x
	Similarity index	x	x	x

MEAN

The Mean indicator is calculated by weighting the percentage values from all answer options of a survey item. Each column's percentage is multiplied by a specific weight that increases incrementally (e.g., from 1 to 5), starting from the first column. The weighted values are summed up to obtain the Mean indicator. The Don't know answer options are excluded in this calculation.

Example for Likert item: $M = A\% * 1 + B\% * 2 + C\% * 3 + D\% * 4 + E\% * 5$

Range: 1.00 – 5.00

Usage: central tendency, mean value on scale
Interpretation: the Mean indicator provides a classic interpretation of the distribution and is a robust indicator of central tendency.

ENTROPY

Entropy is a measure of uncertainty or randomness, often used to quantify diversity in information theory. We use Shannon's Diversity Index to calculate entropy, where higher values represent greater diversity in any given dataset. As an analogy, one can liken high entropy to a

messy room with items scattered everywhere, whereas low entropy is a tidy room with everything in its place. We calculate entropy (the Shannon Diversity Index, notated as *H*) as follows:

$$H = -\sum_{i=1}^{n} p_i log_2(p_i)$$

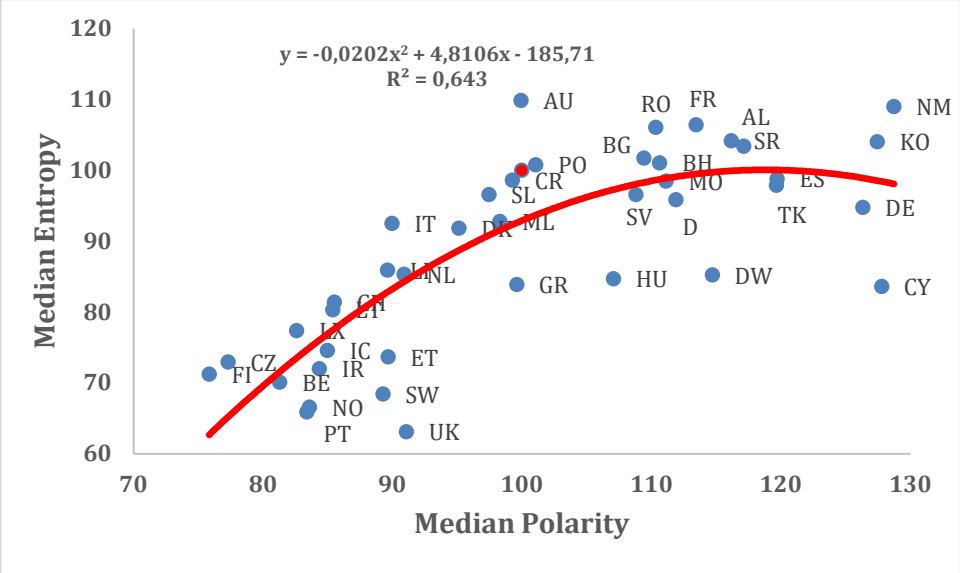
Range: 1.2-1.8 (in our datasets)

Usage: indicator of spread

Interpretation: Entropy values are relative; they do not have a fixed scale and are therefore only interpretable in relation to other entropy values within the same distribution.

Figure A1 shows the non-linear relation between entropy and polarity, both on t-transformation M=100 and SD=25. Above mean polarity, entropy does not vary any more. We did not pursue this line of enquiry any further.

Figure A1: the relation between polarity and entropy across items



RANKINGS

Ranking scores order all countries or regions in the database on a given criterion, and number them from 1 to k. Rankings can be standalone or added across different indicators, the latter of which would provide another index of 'accumulated rank position'. It can also be used to create an average ranking across a number of indicators to measure the consistency of positioning of a country or region in relation to others.

Range: 1 – k countries
Usage: to order countries relative to each other

Interpretation: the relative position of countries or region compared to others is central to the interpretation of the ranking.

INDEX to 100 (OR SIMILAR)

Definition: take any country as reference=100 and express all others as % of the reference X. If country X = 100 <=> then country Y = (Y/X)*100

Range: 0 < X < 200

Usage: relative measure to any reference country; a way of standardising different score to the same scale around 100.

Interpretation: allows to compare countries against a base-line country

CULTURAL SIMILARITY

Definition: (e.g. Mutukrishna)

Usage: measure of similarity distance from a reference country

Interpretation: similarity of a country in relation to a reference country on a scale that orders all countries; the similarity is based on variability on several indicators

TRUSTWORTHINESS INDEX

Definition: e.g., Trustworthiness = (competence + integrity) * benevolence

Range: empirical

Usage: various attempts to combine aspects of trust into a mathematical relation that considers substitutability (sum of aspects, if 0, other aspects can compensate for it) and necessity (multiplication => if 0, all 0)

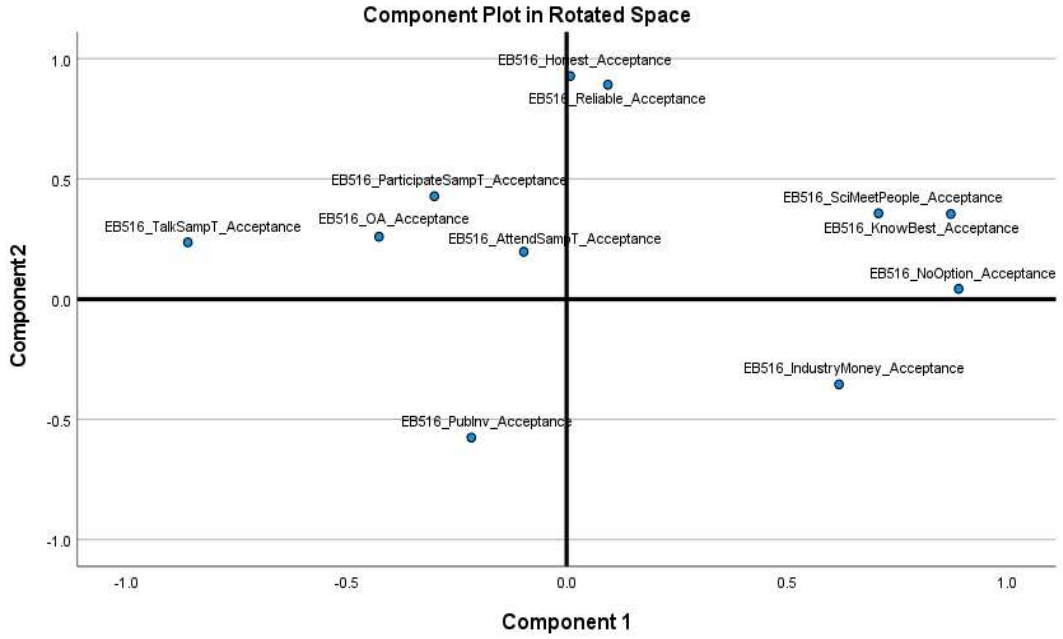
Interpretation: translates a substantive theory of 'trust' and how its components work together

A2: Basic results on TT100 and Gdwill100 and Qualifiers

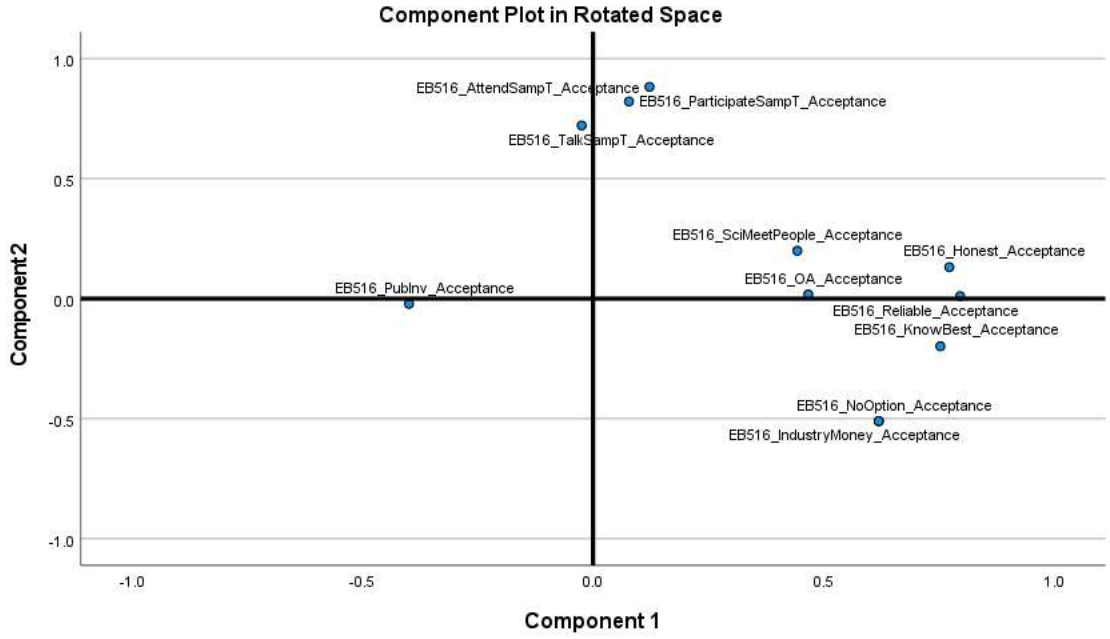
			t-transform [EU m=100 / sd=25]		polarity of standards 100/25	consistency of standards 100/25	mean z-values EU M=0 EU SD=1				
		Country	TT100	Gdwill100	MD	range	TT	Gdwill	% DK uncertain	% NN ambivalence	average polarity
AL	1	Albania	98	101	117	182	-0.09	0.06	11.76	50.7	-0.18
AU	2	Austria	99	98	100	75	-0.06	-0.06	6.44	25.02	-0.07
BE	3	Belgium	86	106	81	71	-0.57	0.24	1.86	27.64	-0.29
BH	4	Bosnia and Herzegovina	120	86	111	156	0.81	-0.57	6.82	33.84	-0.13
BG	5	Bulgaria	129	100	109	76	1.15	-0.01	13.64	26.48	0.07
CR	6	Croatia	113	88	99	65	0.51	-0.48	5.24	33.08	-0.15
CY	7	Cyprus	124	83	128	127	0.95	-0.69	6.59	16.04	0.13
CZ	8	Czech Republic	76	100	77	59	-0.96	-0.01	2.32	28.32	-0.32
DK	9	**Denmark**	**84**	**114**	95	53	**-0.62**	**0.57**	4.01	32.2	-0.17
ET	10	Estonia	79	105	90	84	-0.82	0.18	3.32	28.74	-0.27
FI	11	Finland	85	103	76	75	-0.6	0.1	2.57	32	-0.31
FR	12	**France**	**88**	**78**	113	93	**-0.5**	**-0.88**	6.22	20.48	-0.01
D	13	**Germany**	**73**	**89**	112	60	**-1.06**	**-0.46**	7.61	22	-0.06
DE	14	**Germany East**	**92**	**66**	126	65	**-0.34**	**-1.38**	8.59	26.34	0.02
DW	15	**Germany West**	**69**	**94**	115	59	**-1.24**	**-0.24**	7.37	20.98	-0.08
GR	16	**Greece**	**109**	**84**	100	96	**0.35**	**-0.62**	4.96	26.8	-0.03
HU	17	Hungary	128	102	107	77	1.11	0.07	5.04	30.92	-0.07
IC	18	Iceland	82	115	85	88	-0.7	0.59	3.7	37.26	-0.21
IR	19	Ireland	66	113	84	80	-1.35	0.52	1.87	25.96	-0.28
IT	20	Italy	121	96	90	83	0.83	-0.17	4.39	31.8	-0.1
KO	21	Kosovo	139	134	127	140	1.54	1.38	10.04	27.78	-0.05
LT	22	Latvia	105	92	85	68	0.22	-0.32	2.89	32.68	-0.23
LI	23	Lithuania	107	114	90	52	0.3	0.57	3.04	36.2	-0.29
LX	24	Luxembourg	83	103	83	48	-0.7	0.11	2.31	24.96	-0.29
ML	25	Malta	111	105	98	45	0.45	0.2	12.53	25.7	-0.16
MO	26	Montenegro	126	82	111	175	1.04	-0.71	6.51	31.58	-0.06
NM	27	North Macedonia	118	87	129	124	0.74	-0.51	7.18	26.82	0.05
NO	28	Norway	84	110	84	66	-0.63	0.39	2.58	35.28	-0.21
PO	29	Poland	120	97	101	74	0.81	-0.12	7.06	29.8	-0.04
PT	30	**Portugal**	**90**	**119**	83	88	**-0.39**	**0.75**	2.56	21.68	-0.25
RO	31	Romania	113	92	110	88	0.5	-0.3	5.97	34.58	-0.08
SR	32	Serbia	119	77	116	157	0.77	-0.91	9.09	31.62	-0.03
SL	33	Slovakia	107	91	97	60	0.3	-0.34	7.95	28.68	-0.07
SV	34	Slovenia	104	81	109	87	0.16	-0.78	3.91	26.72	-0.04
ES	35	**Spain**	**118**	**100**	120	58	**0.7**	**-0.01**	6.83	19.64	0.09
SW	36	Sweden	80	105	89	83	-0.79	0.18	2.24	33.16	-0.17
CH	37	Switzerland	81	91	85	90	-0.75	-0.38	2.24	25.74	-0.28
NL	38	The Netherlands	80	112	91	54	-0.79	0.47	3.43	26.4	-0.14
TK	39	Turkey	129	171	120	182	1.17	2.86	2.73	27.62	-0.14
UK	40	**United Kingdom**	**64**	**117**	91	80	**-1.44**	**0.69**	2.03	28.9	-0.27
EU+	41	EU+ average	100	101	100	0	0.01	0.05	5.25	29.14	-0.13

A3: Factor analysis (PCA) of items to form TT100 and Gdwill100

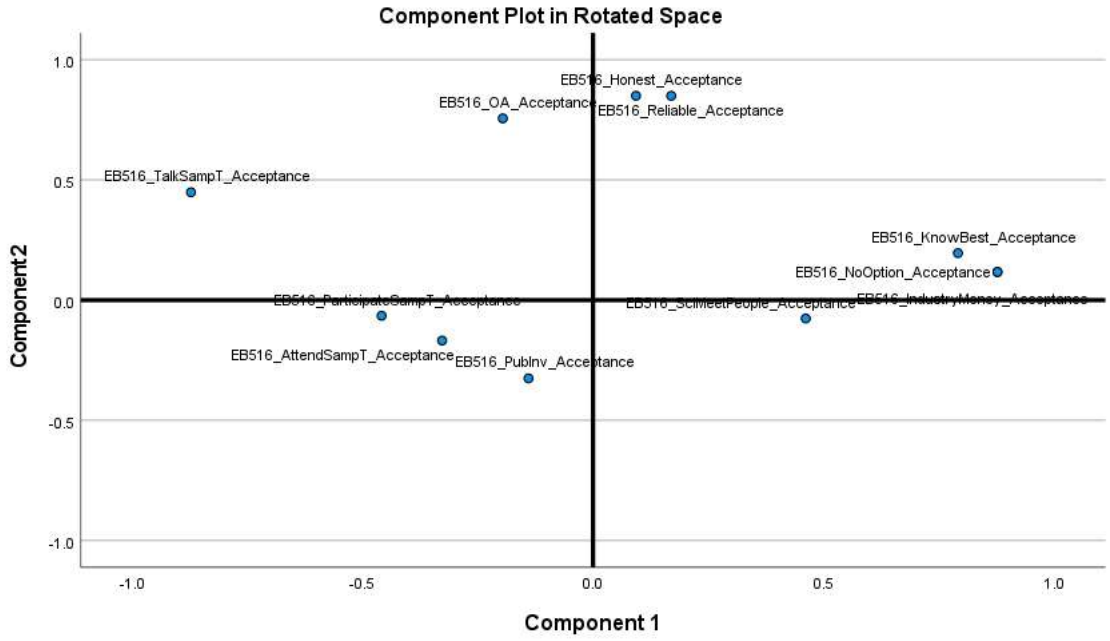
For countries (n=38)



For regions, n=301



For regions (filtered for n respondents in region >60, n=201)



Correlations

		EB516_EnvProblems_Acceptance	EB516_CliChangeCause_Acceptance	EB516_VirusGovControl_Acceptance
TechTolerance	Pearson Correlation	-.392	.445	.554
	Sig. (2-tailed)	<.001	<.001	<.001
	N	309	310	310

A4: Definitions and SPSS coding of TT100 and Gdwill100

compute TechTolerance = (zEB516_KnowBest_accept + zEB516_NoOption_accept + zEB516_IndustryMoney_accept + zEB516_SciMeetPeople_accept)/4.

compute TT100 = 100 + 25 * techTolerance.

Cronbach Alpha = 0.82 (country) / 0.81 (region)

compute Goodwill = (zEB516_Reliable_accept + zEB516_Honest_accept + zEB516_ParticipateS&T_accept + zEB516_Attend S&T_accept)/4.

Compute Gdwill100 = 100 + 25*Goodwill.

Cronbach Alpha = 0.68 (country) / 0.52 (regions)

A5: Items considered in the analysis

1	EB516_KnowBest_acceptance	scientists know best (TT)
2	EB516_NoOption_acceptance	we have no option but to trust (TT)
3	EB340_industryMoney_acceptance	2010 no longer trust because depend on industry money
4	EB516_IndustryMoney_acceptance	no longer trust because depend on industry money (TT)
5	EB516_OA_acceptance	results should be made available free of charge
6	EB516_Reliable_acceptance	scientists are reliable (Gdwill)
7	EB516_Honest_acceptance	scientists are honest (Gdwill)
8	EB516_SciMeetPeople_acceptance	sufficient meeting people to explain their work (TT)
9	EB340_PubInv_Acceptance	2010: being involved, high expectation (listen, heeded)
10	EB401_PubInv_Acceptance	2013: being involved, high expectation (listen, heeded)
11	EB516_PubInv_acceptance	being involved, high expectation (listen, heeded)
12	EB516_TalkS&T_acceptance	regularly talk with family or friends
13	EB516_AttendS&T_acceptance	Attend meetings about science and technology (Gdwill)
14	EB516_ParticipateS&T_acceptance	take part in scientific projects, citizen science (Gdwill)
		Validating specific indicators
15	EB340_10_EnvProblems_acceptance	2010: interested and confident resolving environment problems (Environ)
16	EB516_EnvProblems_acceptance	2021: interested and confident resolving environment problems (Environ)
17	EB516_CliChangeCause_acceptance	Climate change is caused by natural cycle (true, denial)
18	EB516_VirusGovControl_acceptance	Viruses produced in lab to control our freedom (true, CT)
19	IRIS_improve_acceptance	Integrity policy improves quality of research (IRIS)
20	IRIS_mtvtrstpub_acceptance	Public trust would motivate to adhere to integrity (IRIS)