



Article

# Artificial Intelligence Research and Its Contributions to the European Union's Political Governance: Comparative Study between Member States

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**Abstract:** In the last six decades, many advances have been made in the field of artificial intelligence (AI). Bearing in mind that AI technologies are influencing societies and political systems differently, it can be useful to understand what are the common issues between similar states in the European Union and how these political systems can collaborate with each other, seeking synergies, finding opportunities and saving costs. Therefore, we carried out an exploratory research among similar states of the European Union, in terms of scientific research in areas of AI technologies, namely: Portugal, Greece, Austria, Belgium and Sweden. A key finding of this research is that intelligent decision support systems (IDSS) are essential for the political decision-making process, since politics normally deals with complex and multifaceted decisions, which involve trade-offs between different stakeholders. As public health is becoming increasingly relevant in the field of the European Union, the IDSSs can provide relevant contributions, as it may allow sharing critical information and assist in the political decision-making process, especially in response to crisis situations.

**Keywords:** artificial intelligence; intelligent decision support systems; decision-making; European Union; Portugal; Greece; Austria; Belgium; Sweden; political governance

## 1. Introduction

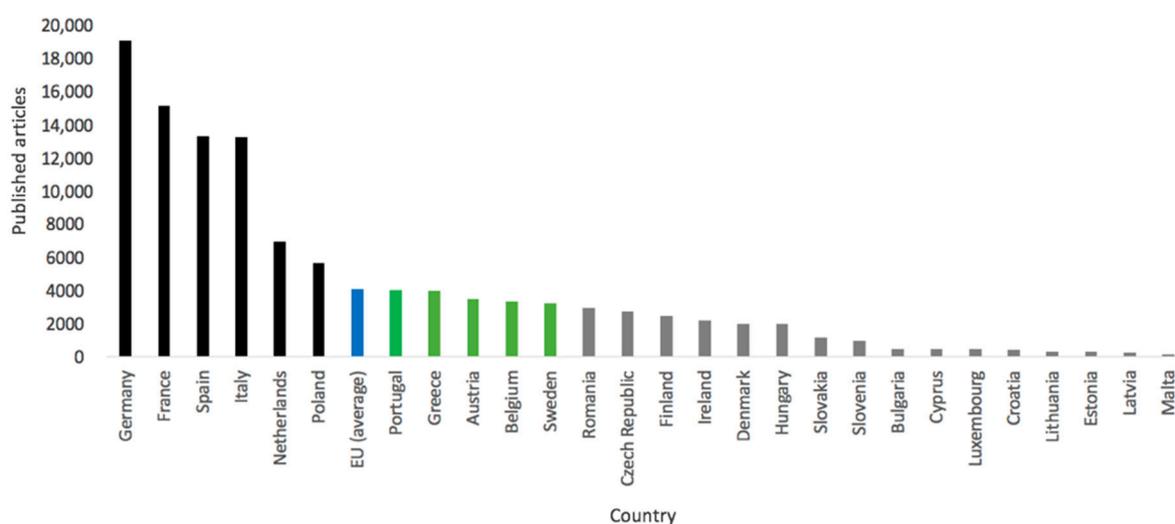
Haenlein and Kaplan (2019) have recently published an article that focuses on the brief history of artificial intelligence (AI). According to these authors, AI has essentially gone through three milestones: (1) the first milestone may have been in the 1940s, when Isaac Asimov published the science fiction tale *Runaround* that focused on the story of an intelligent robot; Asimov's work ended up inspiring notable scientists, such as the American Marvin Minsky, who co-founded the AI laboratory at MIT, or the Englishman Alan Turing, who developed the well-known code-breaking machine called *The Bombe*, which made it possible to decipher the Enigma code, used by the German Army in the Second World War; in 1956, Marvin Minsky and John McCarthy hosted the Dartmouth's summer research project on AI, where the term was formally coined. With approximately 60 years old, AI has gone through moments of transition, from computer sciences, to the domain of business and public sphere. The past decade has seen countless predictions made about the next AI revolution and its impact on all aspects of society, business and life in general (Makridakis 2017; Reis et al. 2020a), such as smart homes, surveillance studies, etc. (Ahmed et al. 2020; Jalal et al. 2013, 2017; Mahmood et al. 2020; Tahir et al. 2020; Kim et al. 2019), which means that AI is evolving towards solving real-life problems (Osterland

and Weber 2019; Shokri and Tavakoli 2019; Susan et al. 2019; Tingting et al. 2019; Wiens 2019; Zhu and Miao 2019).

While many definitions of AI have been coined in the literature, there is still no consensus. Thus, we think that the definition used by the European Commission is the most appropriate in the context of this article; AI is seen as the set of “technologies that combine data, algorithms and computational power”, which allows the European Union to become a global leader in innovation in the economy of data and that will bring benefits to the whole society (European Commission 2020c, p. 2).

The government and public administration may be a promising research area (Batarseh et al. 2017), while these domains need to keep pace with the technological progress when compared with the private sector. The literature also provides limited answers to the question of how to achieve political governance in the European Union through AI (Wirtz et al. 2020). Therefore, this study analyzes the impact of AI on politics through a comparative analysis on similar states of the European Union in terms of scientific research in the areas of AI. To the best of our knowledge, there are no similar studies to date, with the exception of a broader research that compares the AI approach in the United States of America (USA), European Union (EU) and United Kingdom (UK) (Cath et al. 2018) or a preliminary research which focuses on the Portuguese reality (Reis et al. 2020b), but leaves out a comparative analysis between similar EU countries. In light of the above, we determined the following research question: How does the scientific research on AI in the member states of the EU contribute to the political governance of the Union?

Given the daunting task of analyzing in detail 27 EU member states, we had to select a handful of EU members. The selection of five driver EU states is justified by the relative position in terms of scientific research. Thus, we made a preliminary search on 27 July 2020, in Scopus with the term “Artificial Intelligence” in the title, abstract, and/or keywords, which identified 351,362 scientific documents from 159 countries, where the first were from the United States of America (75,155 publications), the People’s Republic of China (54,968 publications) and the United Kingdom (24,222 publications). These countries were followed by EU states, such as: Germany—5th position (19,112 publications); France—6th position (15,175) and Spain—9th position (13,313 publications). Next, we present Figure 1 adapted from Reis et al. (2020b), who presented a summary of the 27 EU countries.



**Figure 1.** European Union’s research potential (adapted from Reis et al. 2020b).

From Figure 1, it is clear that Portugal, Greece, Austria, Belgium and Sweden (green color) are positioned between the great research powers (on the left: black color) and the smaller ones (on the right: gray color). Although these countries (green) are situated below average for scientific research in the EU (blue), they have the potential to move on to the group that does the most research if they cooperate intensively in their scientific research projects in AI. Focusing on the research potential rather

than on the size of EU states seems appropriate, since the academic literature appears to be diverse and fragmented in this regard (Thorhallsson and Wivel 2006), with no formal agreement on the definition of small/large states.

This article is divided into five sections: the first section briefly introduces the topic, compares similar articles and presents a research question; below, we make some practical considerations about the state-of-the-art of the various EU states selected for the study. The third section presents the research design, as well as the filters used in the systematic literature review for transparency and replicability. The results section follows next, which reports on the results of a bibliometric analysis and content analysis technique. Finally, the conclusions focus on the contributions to theory and practice, the limitations and perspectives for future research.

## 2. Exploratory Overview

This section reports on data gathered by the European Commission (EC) and consulting companies to display the knowledge of AI experts, while the theoretical conclusions are presented on the following sections.

Early 2018, the EC presented a workshop report that focused on the member states activities in the field of AI (European Commission 2020b). With regard to Portugal, the report makes reference to the Portuguese Association for Artificial Intelligence (APPIA), in particular with regard to the dissemination of knowledge through international conferences and national symposia. Later in 2018, a broader report focused on the European AI landscape, making reference to the academic, industrial and fudging ecosystems (European Commission 2020b). The latter report is twofold: it presents the perspective of the private sector, arguing that 72% of the Portuguese companies are found in the tertiary sector, with the exception of some start-ups, such as Talk Desk (call centers), Heartgenetics (healthcare), Movvo (trade) or Loqr (security); from the public sector perspective, it states that the funding to support research comes mainly from the EC through Horizon 2020 and from several national agencies, such as the Portuguese National Funding Agency for Science, Research and Technology (FCT). The report left behind several relevant developments in the Portuguese public sphere, such as: the governmental initiative “INCoDe 2030”, which is an integrated public policy initiative dedicated to strengthening digital skills (INCoDe 2020); and the Agency for Administrative Modernization, which is a public institution under the sphere of the Portuguese Ministry of Modernization and Public Administration (AMA), aiming to modernize the public administration by simplifying government processes through a digital transformation policy (AMA 2016). An example launched by the Modernization Agency is the 24/7 virtual assistance chatbot, called SIGMA, which provides answers in writing to frequently asked questions (FAQ) by the Portuguese citizens; if SIGMA recognizes that the citizen’s answer is not adequate, it will request to the user if she wants to talk to a human being and connect to her by phone or email (OECD 2019).

In Greece, it is still necessary to create the conditions to accelerate the technological diffusion and, in that regard, Greek legislators will have to define an AI vision and design a viable plan to promote and accelerate economic and social growth (Accenture 2019). According to the report of the European Commission (2020a), Greece intends to develop a national AI strategy, by the end of 2020, followed by an action plan for AI. This report adds that Greece’s goal is to combine academic and scientific knowledge to real production, in order to boost the Greek economy. Within the scope of the AI strategy, there are still a number of vital issues that need to be addressed, such as the necessary legislative adjustments, adaptation to ethical AI issues, the development of data collection infrastructures, as well as the implementation of advanced systems for the incorporation of AI technologies in the public sector (European Commission 2020a).

In Austria, one of the most relevant institutions is the Robotics and Artificial Intelligence Council (ACRAI Austrian Council on Robotics and Artificial Intelligence), which is an advisory board of the Austrian Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK 2020) and is composed of specialists who discuss current and future opportunities, risks and challenges

arising from the use of robotics and autonomous systems and AI ([ACRAI Austrian Council on Robotics and Artificial Intelligence](#)). Since October 2018, the Austrian government issues the Austria 2030 Artificial Intelligence mission, which defined the first steps towards an official national AI strategy, identifying the following areas of priorities: research and innovation; infrastructure for industrial leadership; qualification and training; AI in the public sector; AI in the economy; society, ethics and labor market; AI governance, security and law ([AIM 2018](#)).

Belgium has positioned itself on the European AI scene through the multidisciplinary team (AI4Belgium) that issued a political recommendation report, constituting the first step towards an ambitious and official AI strategy in Belgium ([European Commission 2020a](#)). As AI4Belgium has the objective to position Belgium in the European AI landscape ([AI4Belgium 2020a](#)), they claim in their most recent report that the country needs an appropriate strategy to support the development, implementation and use of AI. In this regard, the AI4Belgium experts argued that citizens and businesses are not reaping enough benefits from AI technologies; universities and start-ups lack the means to grow, and public institutions are not acting as accelerators of innovation, but as bottlenecks ([AI4Belgium 2020b](#)). Despite the most critical prospects, the Belgian government is increasingly starting to develop AI-based service policies. This policy, as a rule, requires a high involvement of citizens to understand their needs. A good example are the platforms for digital participation through AI, which have put Belgium as a case study on the international scene. Knowing that it is not enough to establish a digital participation platform, since data analysis made by humans is time-consuming, expensive and sometimes inaccurate, CitizenLab160 was developed. CitizenLab160 is a civic technology company that aims to train public officials and provide them with improved processes of machine learning that will help them analyze citizens' opinions and make better decisions ([OECD 2019](#)). For example, the Belgian citizens are often asked to submit their ideas, comments and votes on a given initiative. Following this, the CitizenLab16 platform classifies these ideas, by highlighting emerging topics, summarizing trends or grouping similar contributions by themes and demographic characteristics. After the platform's analysis, one may observe, for instance, that a particular neighborhood may prioritize better roads, while its neighbor is requesting additional traffic stops ([OECD 2019](#)). In practice, the recommendations of the Belgium citizens serve as a basis for political decision-making.

With regard to Sweden, [Frid et al. \(2017\)](#) argued that this country is well positioned in terms of digital development, but there are indicators that it is losing pace, unless a broad discussion is started on the best actions to make the most of technological advances. In light of the above, the McKinsey Global Institute identified six technology trends that are having a major impact on the economy of Sweden. These technologies are grouped into two overarching groups: automation and advanced data analysis (technologies: automation of knowledge work, advanced robotics, autonomous mobility); connectivity, cloud services, and communications (technologies: mobile Internet, cloud services and Internet of things) ([Averstad et al. 2018](#)). In 2017, the Sweden Government commissioned Vinnova, which is the Sweden's innovation agency, to map and analyze the application of AI and machine learning in Swedish industry, the public sector and Swedish society to investigate the potential, opportunities and challenges of those technologies ([Vinnova 2018](#)). In early 2018, the Swedish Ministry of Enterprise and Innovation released its AI strategy, acting as a guidance document with announcements of policies and strategies priorities for all AI players in Sweden ([Van Roy 2020](#)).

Following this, we present a table that explores the network activities declared by each country, both internally and at the European level. The next section will explore ways in which different countries can join efforts to enhance AI research.

From [Table 1](#) it is evident that, internally (IC), the strategy of the EU member states is to increase the enterprise competitiveness through AI and long-term relationships. Long term relationships usually refer to working as an ecosystem (universities, enterprises and states), where universities support companies through scientific research and the state through incentives for the creation of laboratories and facilities for testing the most promising technologies. In addition to political initiatives that support local, regional and national dynamism, the demand for supranational policy initiatives

(EU level) is also increasingly stressed by companies, as research institutes that seek to scale their ambitions and have greater opportunities within an international community.

**Table 1.** Declared networking activities.

<b>Portugal</b> retrieved from the <a href="#">European Commission (2020a)</a>	
IC	Extension of Collaborative Laboratories (CoLabs) and Digital Innovation Hubs (DIHs) (e.g., current DIHs in Portugal are: Produtech (production technologies), iMan Norte Hub (manufacturing) and HUB4AGRI (agriculture))
	Fostering of long-term collaboration between academia and companies through framework contracts and data/technology sharing platforms
S	Increase partnerships with other Member States through joint participations on Electronic Components and Systems (ECSEL), High-performance Computing (EuroHPC), and the Quantum Flagship (H2020)
	Participation in European Networks, European AI excellence centers and other European DIHs (e.g., DIH on cybersecurity at Leon or the DIH on Internet of Things (IoT) in Salamanca)
<b>Greece</b> retrieved from the <a href="#">European Commission (2020a)</a>	
	In progress (to be released by the end of 2020)
<b>Austria</b> retrieved from the <a href="#">European Commission (2020a)</a>	
IC	Set up a Belgian Innovation Hub
	Set up partnerships with industry and public sector to allow AI and PhD students to work on practical applications
S	Create a confederation of Belgian laboratories and join European initiatives (ELLIS, CLAIRE)
	Develop an independent Belgian data-sharing platform
<b>Belgium</b> retrieved from the Austrian <a href="#">BMK (2020)</a>	
IC	Enhance research and innovation, which includes education, qualification and training
	Forest long-term collaboration with public and private sector in order to boost the economy
S	Within the scope of AI Governance, Security and Law the European cooperation plays a particularly important role in the governance of AI
<b>Sweden</b> retrieved from the <a href="#">European Commission (2020a)</a>	
IC	Foster strong collaborations and partnerships between business, the public sector and research in AI
S	Develop collaboration and partnerships on the use of AI applications with other countries

IC—In country; S—Supranational.

### 3. Research Design

This research is built on a systematic literature review in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA), which is based on a 27-item checklist and a four-phase diagram (Fink 2019; Moher et al. 2015). In the identification phase, we analyze the most appropriate search terms and identify peer-reviewed manuscripts in all fields of research in the Scopus database (Table 2). The search was conducted on 27 July 2020 with the search terms “Artificial Intelligence” and the selected states from the EU States “Portugal”, “Greece”, “Austria”, “Belgium” and “Sweden”. Then, we carried out a screening based on a series of inclusion–exclusion criteria. In this regard, English language was chosen because it is universal and widely used by the academic community and, on the other hand, because it facilitates the reading and the articles’ interpretation. Additionally, we also selected journal articles, since they are usually of higher quality when compared to e.g., conference proceedings or book chapters. However, we are aware that, by excluding the latter manuscripts, we may be limiting our search and eliminating relevant research. On the eligibility phase our intention was to eliminate repeated articles (4 articles), articles wrongly identified by Scopus

(24 articles), as well as those to which we did not have full text access (8 articles). The last phase intended to give the opportunity to include articles that might have been considered relevant and that had been left out of the research, which was not verified. After applying the PRISMA protocol, we ended up analyzing 359 articles (Table 2).

**Table 2.** Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) Protocol.

Search Terms—SCOPUS	PRISMA	Identification	Screening	Eligibility	Included
Artificial Intelligence AND Portugal	Records	33,519			
	Title-Abs-Key		179		
	English		177		
	Articles		67		
	Journals		65	63	
Artificial Intelligence AND Greece	Records	35,509			
	Title-Abs-Key		209		
	English		209		
	Articles		111		
	Journals		107	106	
Artificial Intelligence AND Austria	Records	37,877			
	Title-Abs-Key		149		
	English		139		
	Articles		55		
	Journals		52	25	
Artificial Intelligence AND Sweden	Records	34,501			
	Title-Abs-Key		183		
	English		182		
	Articles		114		
	Journals		113	111	
Artificial Intelligence AND Belgium	Records	32,709			
	Title-Abs-Key		87		
	English		84		
	Articles		35		
	Journals		34	30	
				Total	335

The analysis of a field of study can be carried out using two broader approaches (Coombes and Nicholson 2013): first and foremost, through an objective approach, based on a bibliometric analysis; second, by a more subjective approach, based on a qualitative analysis of the literature. These approaches have several advantages over the traditional ones, since: (1) they provide greater transparency (Jesson et al. 2011), as the research design is carried out in stages and can be replicated by other researchers; (2) they allow the generalization of results, as they provide a holistic view of the literature through a systematization and synthesis of knowledge (Petticrew and Roberts 2008); and (3) finally, they allow one to answer a research question that covers a gap in the literature (Torgerson 2003). The number of publications in the identification phase (33,519) is different from Figure 1, since the search in Scopus was carried out with the keyword “artificial intelligence” combined with the term “Portugal”; that is, it seeks only articles that, although they are dealing with AI issues, are also focused on the reality of that country. Meanwhile, the first search (Figure 1), on the other hand, addresses scientific production, whether the research is focused on the reality of that country or not. Moreover, our result also differs from that of Reis et al. (2020b), given that we considered affiliations other than Portugal and we only considered articles in English.

To analyze such a large number of articles, it was challenging to carry out a manual analysis, for this reason, we used NVivo, a qualitative data analysis software. At first, we read all the articles,

then the articles were uploaded into the software, so that we could easily identify the most relevant phrases and ideas, proceeding to the identification of categories. In a second phase, we found patterns in the generated codes and categories to identify the relevant topics and build a map that could provide a general overview. From that moment on, the data started to make sense and we were able to extract the results that are presented in the next section.

#### 4. Findings

This section analyzes articles that emerged from the systematic literature review and is twofold: first, we performed a bibliometric analysis, where graphs and their description are presented; second, we carried out a qualitative and descriptive content analysis, where the articles' texts are analyzed in order to identify the most relevant patterns and ideas.

##### 4.1. Quantitative Approach

Figure 2 reveals the research growth in AI, allowing one to trace the research profile of each country and, at the same time, to explain its evolution. Since 2014, with the exception of 2016, Sweden has kept its scientific research stable, focusing mainly on healthcare issues and forest management scenarios. In healthcare, Sweden focuses its research on the development of smart tools for early disease detection (Block et al. 2020; Nakajima et al. 2018; Sadikov et al. 2017), on the support of medical decision-making (Shemeikka et al. 2015; Srivastava et al. 2020), as well as the post-treatment surveillance and medical-pharmacological follow-up (Henriksson et al. 2015; Skeppstedt et al. 2014). To illustrate with some examples, the article by Sadikov et al. (2017) investigates the feasibility of using AI resources to monitor and evaluate data from Parkinson's patients to learn how to predict the "cause" (bradykinesia or dyskinesia) of upper limb motor dysfunction so that their quality of life is improved; or, Shemeikka et al. (2015), who tested in the outpatient and hospital environment a clinical decision support system (CDSS) that supports the prescription of drugs in patients with reduced kidney function, not only based on the manufacturer's official pharmaceutical information, but also with real clinical data. A CDSS is intended to improve healthcare delivery by enhancing medical decisions with targeted clinical knowledge, patient information, and other health information. Modern CDSSs are based on AI technologies and algorithms (Kim et al. 2016; Sutton et al. 2020).

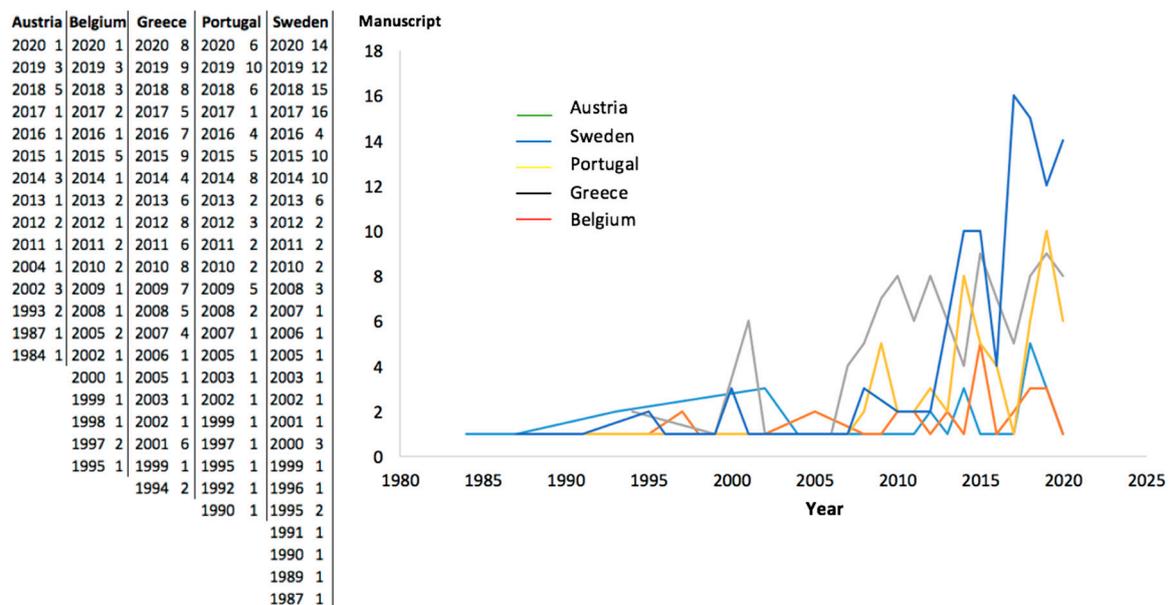


Figure 2. Documents by year.

Sweden has also made a notable advance in relation to current forest management approaches to mitigate climate change (Lodin et al. 2020) and to balance forest management between wood production and biodiversity (Eggers et al. 2019, 2020; Saad et al. 2015). The scientific advances have sought to understand how the various forest management options can affect economic, ecological and social sustainability. In order to support a sustainable development, smart decision support technologies have been developed to assist an efficient forest management.

Although the scientific research is far from being continuous over time, since 2018, Portugal and Greece have been increasing their research potential. Regarding Portugal, our observations are in line with Reis et al. (2020b), whereas the research focus on population aging (Serrano-Jiménez et al. 2018; Serrano-Jiménez et al. 2019), climate change (Fonseca and Santos 2019), green energy (Huertas Tato and Brito 2019) and water resources (Pereira et al. 2019), representing the typical social issues in Portugal. However, a new area of research is emerging with great potential and, therefore, part of the research potential begins to be migrate to the healthcare services, as is evidenced by the articles of Rais et al. (2018) or Ferreira et al. (2020), which is bringing Portugal closer to Sweden. In Greece, the research interest is not much different from the Portuguese ones, particularly on the incidence in healthcare services (Chatzakis et al. 2018; Grekousis and Liu 2019) and water management services (Alamanos et al. 2018; Athanasiou et al. 2018); however, we note a strong investment in renewable energy—of the 25 articles published in 2018, 10 of which are related to clean energy (Polemis and Spais 2020; Vlachokostas et al. 2020).

Belgium and Austria are the countries with the lowest research production, but remain in the same line as the previous countries, in that they have shown a trend towards research in the healthcare services. After analyzing the research timeline, Figure 3 displays an overview of the research areas, where the most significant are in: engineering (123 articles); computer science (98 articles); environmental sciences (93 articles); business, management and accounting (59 articles); and medicine (51 articles). Although we claim that the focus of AI is increasingly focused on the area of health services, it is not surprising that this research is also related to engineering and computer science, since the latter provide the necessary tools for the prevention, diagnosis and disease treatment. An example of this is the research of Chatzakis et al. (2018), who had the objective to describe the development of an Electronic Health Record (EHR), with integrated computerized decision support system for the diagnosis of pediatric cardiovascular diseases.

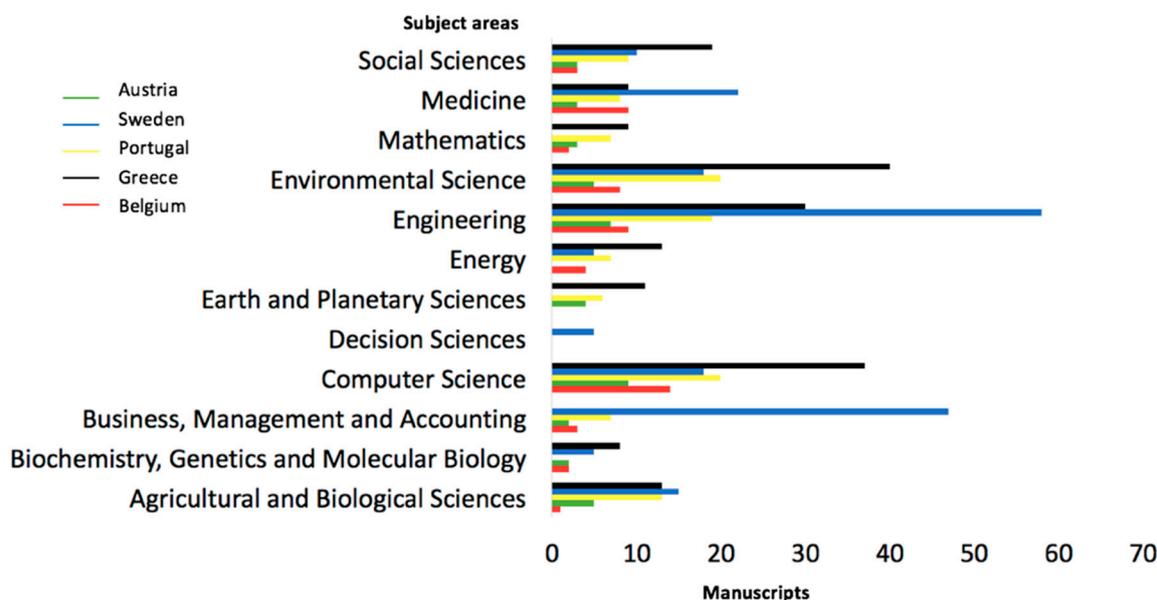


Figure 3. Documents by subject areas (Top 10).

Regarding Figure 3, medical advances in Sweden are expected to continue increasing, similarly with recent years; as well as investments in sustainability and forest management, the latter falling within the field of environmental sciences and which will lead Sweden getting closer to Greece. From a business point of view, Sweden will continue to stand out from the rest of the countries. With regard to Portugal and Greece, although the latter has a greater number of publications, both countries stand out in very similar areas, such as environmental sciences, renewable energies and computer sciences. Austria and Belgium do not have great disparities in terms of scientific production and research areas, although Belgium stands out in the field of medicine. To conclude this section, we will briefly analyze the main funding agencies that will give us a perspective of financing with national or supranational funds.

From Figure 4, it is clear that the Portuguese Foundation for Science and Technologies (FCT), a public agency that supports science, technology and innovation in all scientific domains, under the responsibility of the Ministry for Science, Technology and Higher Education (FCT 2020), is the one that most promotes scientific research in Portugal. Followed by the EC, which directly financed all countries (except Sweden) or, indirectly, through programs, such as: The European Regional Development Fund or the 7th Framework Program that was followed by the Horizon 2020 and which are well described by Guerrero (2018), and its successor, Horizon Europe.

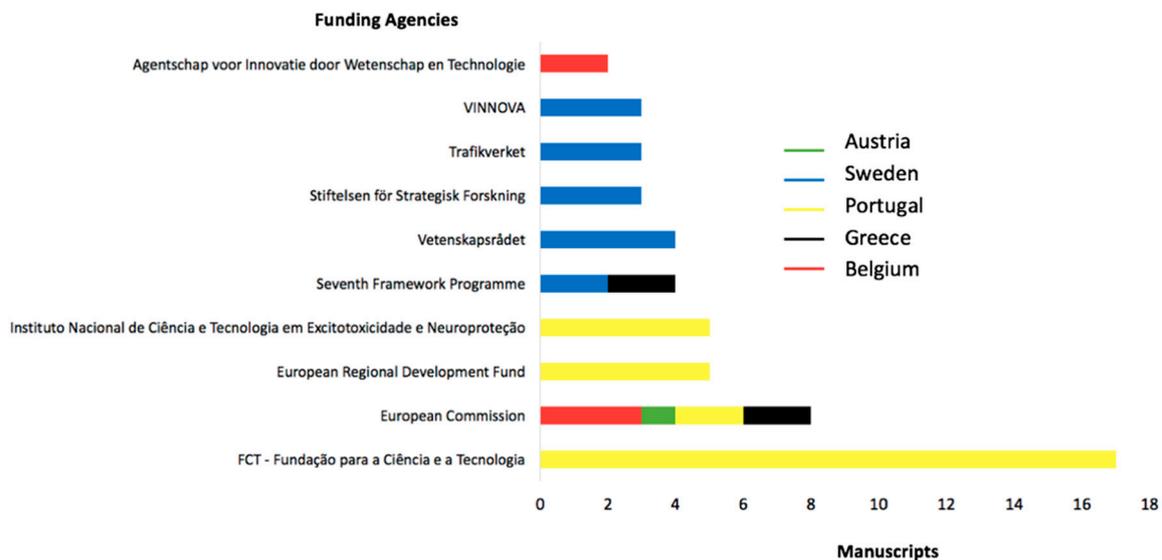


Figure 4. Documents by funding agencies (Top 10).

If we consider only these top 10 funding agencies, the balance tends towards Portugal, leading with national funding (22 articles), followed by Sweden (17 articles), and supranational funds that arrived to a greater or lesser extent to all countries and that resulted in 17 articles. Not counting the top 10 funding agencies, Sweden surpassed all countries with a total of 61 agencies financing its national research, while Portugal had 42 agencies, Austria 40, Greece 36 and Belgium 11. In view of the number of publications and funding for research, Greece has done a remarkable job in the field of AI.

#### 4.2. Qualitative Approach

After reading all the articles, we notice that prior to our research, Cohen and Nijkamp (2002) carried out a comparative study of Information and Communication Technologies (ICT) policies in European cities (Austria, Spain and The Netherlands). In this research, the authors mentioned that public and private actors intended to explore the expected benefits of developing ICT. At the time, the survey results suggested that, within a European city, the citizens could have a different understanding of their urban reality, while, on the other hand, cities with different characteristics may present similar

problems. For this reason, they suggested expanding research into the field of AI in EU countries, in order to illustrate the complex process of formulating AI policies.

In the light of the studies by [Cohen and Nijkamp \(2002\)](#), some challenges persist, namely: (1) there is limited knowledge about the research potential of EU countries, especially in the field of AI, which requires further studies; (2) EU-funded research has not always succeeded in converting research outputs into marketable products and commercial success stories ([Giannakis et al. 2016](#), p. 246); (3) there is a need to align commercial outputs within the EU political governance and European interests.

While AI is a priority for the EU, the EU's interest is clearly to involve countries with similar ideas in research forums, in order to establish common approaches. What happens is that these partnerships are not evident in the AI publications that we analyzed. In other words, we found that, in terms of research potential, the countries analyzed in this article are comparable, and that there are also very similar areas of study; however, no clusters of partnerships have been identified between them. It is for this reason that we argue about the need to promote clusters of AI specialization within the EU; that is, the EU should foster partnerships between countries in which the research core is identical, to enhance its results in accordance with the national policy of each State, but also according to the interests of its population. For instance, studies such as those by [Sotirov et al. \(2019\)](#) may be relevant to define guidelines within the EU. [Sotirov et al.'s \(2019\)](#) research, which was based on the main decision-making theories, discussed evidence-based behavioral models using owner perceptions and forest management, and how they can be used to analyze forest management behavior, and the ability to respond to political and socioeconomic developments. In other words, the authors compared the results of a standard forest decision support system (DSS) modeling with exemplary results using the agent-based structure in terms of long-term simulations of wood production and biodiversity conservation. What we mean by showing this example is that European funding must be in line with the objectives of the EU or to make practical contributions to member states' clusters, rather than being aligned with national political lobbying or research groups formed for certain national purposes ([Andersson et al. 2018](#); [Eggers et al. 2020](#)).

Another relevant issue is the need to convert the research results into marketable products and, at the same time, align these technological innovations with the objectives of national and EU political governance. For example, in the context of COVID19, virologists, immunologists and epidemiology experts have made important contributions in supporting national political governance and, consequently, have resulted in political decisions with practical implications for populations. The balance between expertise and data analysis by AI is increasingly present in the political roadmap, because without intelligent decision support (IDSS) systems in place, data analysis becomes less efficient, with implications for the outcome of political action. Intelligent decision support systems (IDSS) have transformed human decision making, as they combine research in artificial intelligence, information technology and systems engineering. In this sense, communication and coordination between dispersed systems can provide just-in-time information, real-time processing, collaborative environments and globally updated information for a human decision maker ([Phillips-Wren and Ichalkaranje 2008](#)). The sharing of information through smart systems in the EU is also essential, as it makes it possible to reach faster decisions. Those fast decisions were not a reality, well evidenced by the initial questions about the effectiveness of facial masks, the closure of universities, social distance, among other aspects. The issue of IDSS is so relevant that we found it necessary to validate the results through a statistic analysis of the keywords referenced in all the articles. We then found that "decision support systems" was the keyword most used for all the analyzed countries, except Austria. Unsurprisingly, the keywords that competed with DSS were AI techniques, such as "neural networks", "fuzzy logic" and "machine learning". Thus, with regard to the content analysis, we found patterns with clear indications that DSS are moving to intelligent systems, that is "intelligent decision support systems", which being a subset of artificial intelligence are beginning to be widely investigated in the EU.

In the fields of business, management and accounting (Figure 3) with regard to the use of AI, Sweden has been an example of success, as was the use of energy management of hyper-scale data centers using predictive modeling (Islam et al. 2019). In Islam et al.'s (2019) research, real data were used from a Facebook data center located in Luleå, Sweden, which allowed managing energy for better management through machine learning techniques, such as an artificial neural network (ANN) and a system adaptive inference neuro fuzzy (ANFIS). The increasing adoption of automation in public services and the intensive use of data is leading to the need for more energy to keep data centers running. Therefore, it is crucial not only for large IT companies, but also for state services, to monitor the energy efficiency of their facilities. In short, from a holistic business perspective, it is essential to increase profits from AI development and innovation.

As we mentioned earlier, the EC and its member states have been funding universities and research centers to carry out studies in the context of AI. Although these studies fell on the domains of engineering and computer science, we begin to apply knowledge acquired in these disciplines into areas that are less explored, such as public services. In particular, with regard to the role of states and social challenges, the health services remain the Achilles' heel in many public services. It is in this regard that engineering, robotics and computer science can make an essential contribution in terms of the better management of public health services. As is the case with the use of high-performance AI algorithms for breast cancer detection (Schaffter et al. 2020), the development of electronic medical record with an integrated computerized decision support system for the screening of pediatric cardiovascular diseases (Chatzakis et al. 2018), just to name a few. As well as some challenges that are already beginning to be overcome, such as the establishment of a general data protection regulation, there are others in the area of health that need to be overcome, such as the development of a European platform for sharing patient data or cooperation in the implementation of data collection measures and specific ethics for the health area.

Bearing in mind the research question, we found that, for complex and multifaceted decisions involving many stakeholders, such as social, economic and ecological groups, IDSS are essential tools for political decision-making. In addition, decisions in many disciplines, such as environmental sciences, are based on multidisciplinary knowledge bases, incorporating natural, social, political and ethical sciences (Pavloudakis et al. 2009). Because it is easy to use and with easily visible results, the IDSS can become vital for a quick and effective political decision (Fernandes et al. 2014). In fact, complex decision-making generally involves trade-offs between pressure groups and political decisions affect different stakeholders. For example, in response to the COVID-19 pandemic, governments and their policy makers had to decide whether to impose restrictions on the freedom of movement or choose not to implement such restrictive measures so as not to harm the country's economy. In other words, making decisions that involve such complex systems requires a logically well-structured process, avoiding unfair decisions that can subject some citizens to even more extreme restrictions and isolation or decisions that can be harmful to future generations.

In light of the above, IDSS can assist in political decision-making, both in member states and in the EU. As in similar research (Reis et al. 2020b) we found that, although AI is gaining greater research potential in public health services, new challenges are arising in the political sphere. For instance, the establishment of new protocols to protect patient data are needed if the associated technological advances involve the sharing of clinical information between member states of the EU. The IDSS can help national governments pool resources and share data, with a view to ensure access to modern, efficient and coordinated healthcare across all EU countries, so that disease prevention and response to crisis situations are faster and more effective.

## 5. Conclusions

This article suggests strategic partnerships between member states of the European Union, mainly to be made by those with the same research potential in AI and who work in similar areas of knowledge. The great advantage in terms of research is that academics with different experiences can share acquired

knowledge with partner states and find new research avenues. This argument is in line with the strategic interests outlined by the five countries analyzed, where they propose as a supranational objective the development of collaborations and partnerships in the use of AI applications with other member states or to cooperate in the scope of AI governance, security and law.

A key finding of this study is that the decision support systems are vital in both the clinical and the political spheres. While computerized clinical decision support systems (CDSS) are used to assist the medical act and its complex decision-making processes, intelligent decision support systems (IDSS) can be vital in political decision-making and, in particular, in areas related to public health services, both at the national and European level. Despite the great majority of studies going backwards in the field of smart decision support systems (DSS), the difficulty still lies in converting the research results into real products that can be easily operated and safely shared among all the member states of the EU, in particular, with regard to critical data. In this regard, scholars like [Batarseh and Yang \(2017\)](#) made a notable contribution by arguing that reactive decision-making is not enough, because intelligence data systems allow for proactive activities, bringing benefits such as: improved citizen services, reduced delivery inefficiencies, lower costs, better policy making, just to name a few.

This research has some limitations due to its methodological design. The systematic literature review provides a snapshot of reality over a given period of time, while Scopus remains constantly updated and, due to short cycles of technological innovation, it is likely that some concepts will evolve quickly, requiring permanent updating. Scopus was selected for this research from a significant number of available databases, such as Web of Science or EBSCO, because of its broader coverage of AI journals than similar databases ([Reis et al. 2019](#)). Other databases, with a strong focus on AI (i.e., IEEE Xplore), presented more technical articles that depart from our field of research, which is the social and political sciences. In this case, as a multidisciplinary database, we believe Scopus is more suitable for the aforementioned research domain. In line with other systematic reviews, we also excluded known search engines, such as Google Scholar, since our priority was to select peer-reviewed articles, which increases the quality and gives higher confidence to the analysis ([Reis et al. 2020b](#)).

As proposals for future research, we suggest analyzing the use of IDSS in making political decisions in response to public health crises. Recent studies have analyzed the use of electronic health records as a tool to support the clinical needs of a health system that manages the COVID-19 pandemic ([Reeves et al. 2020](#)). Our suggestion for future research involves analyzing the use of IDSS to make political decisions in adopting appropriate measures that are proportional to the need of facing increasing levels of risk. Another alternative is to build on recent AI advances to propose an embedded approach and take the first steps towards the development of a more focused project based on an intelligent decision-making support system (i-DMSS). Finally, it would be interesting to expand the studies to other regions, such as the Asian continent, in order to verify whether these results are restricted to the EU or also applicable to other geographical areas.

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