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Review

The Use of Artificial Neural Networks in the Public Sector

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Abstract: Artificial intelligence (AI) is an extensive scientific field, part of which is the concept of deep learning, belonging to broader family of machine learning (ML) methods, based on artificial neural networks (ANNs). ANNs are active since the 1940s and are applied in many fields. There have been actions around the world for the digital transformation of the public sector and the use of new innovative technologies, but the trajectory and degree of adoption of artificial intelligence technologies in the public sector have been unsatisfactory. Similar issues must be handled, and these problems must be classified. In the present work, preparatory searches were made on Scopus and IEEE bibliographic databases in order to obtain information for the progress of the adoption of ANNs in the public sector starting from the year 2019. Then, a systematic review of published scientific articles was conducted using keywords. Among the 2412 results returned by the search and the application of the selection/rejection criteria, 10 articles were chosen for analysis. The conclusion that emerged after reading the articles was that while the scientific community has a lot of suggestions and ideas for the implementation of ANNs and their financial effects, in practice, there is no appropriate use of them in the public sector. Occasionally, there are cases of implementation funded by state or non-state bodies without a systematic application and utilization of these technologies. The ways and methods of practical application are not further specified, so there are no indications for the systematic application of specialized deep learning techniques and ANNs. The legal framework for the development of artificial intelligence applications, at least in the European Union (EU), is under design, like the necessary ISO standards from an international perspective, and the economic impact of the most recent AI-based technologies has not been fully assessed.

Keywords: financial effects; artificial neural networks; public sector; machine learning; artificial intelligence; deep learning

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1. Introduction

As mentioned in [1], artificial intelligence (AI) and robotics have the potential to enrich our lives and further our capabilities, for individuals and common good. AI systems are self-contained, can run without human intervention, and can learn and recognize patterns in order to make actions and reach various conclusions based on the analysis of various scenarios [2]. Developments in AI are unfolding at a fast pace. Whereas AI has already played a part in our daily lives for a few years, AI and robotics are boosting innovation, leading to new business models and playing a key role in transforming our societies and digitalizing our economies in many sectors, such as industry, healthcare, construction, and transportation [3].

The implementation of AI technology in the public sector is a top priority recommended by both the European Union (EU) and OECD (Organisation for Economic Co-operation and Development). Observatories are monitoring the implementation of AI technologies and public sector innovation worldwide and providing guidelines on how to help government officials understand AI and navigate considerations specific to the public sector. The OECD's observatory records national initiatives around the world about the adaptation of AI technologies [4].

International agreements such as The G20 AI Principles, The Declaration of Cooperation on artificial intelligence, and The Declaration on Artificial Intelligence in the Nordic-Baltic Region are conducted.

The United States and China have realized the value of AI for the public sector and their global competitiveness. Similarly, the National congress of China's State Council released a guideline on AI technologies, aiming to become a global innovator in this domain with a total spend of 1 trillion yuan ($147.8 billion) by 2030 [5].

The above agreements show the awareness at European and global level of the adoption of strategies oriented to the adaptation of artificial intelligence technologies. A common element of these strategies is to ensure that they are implemented in an ethical, credible, and secure manner to invest in education and mainly focus on the use and application of artificial intelligence in the innovation and the digital transformation of the public sector.

This raises the reasonable question of what the reaction of the public sector to this new 'digital' landscape is and how the public sector uses these new technological tools for the benefit of the citizens, offering and improving services but also managing to control/supervise this new landscape.

In 2010, for example, hospitals in England (Hampshire) implemented an illness-monitoring system based on machine learning algorithms (MLA), which resulted in a 90% reduction in coronavirus breakouts [6].

The Australian Tax Authority installed a chatbot in 2016 to assist people with tax questions, which increased contributions in the first interconnection rate to 80 percent, surpassing the expected standard of 60–65% [7].

In the current paper, an attempt is made to record/map both globally and at a European level the use of artificial neural networks but also possibly the strategies that have been launched by governments of countries oriented to the utilization of artificial intelligence applications in public sector services [8,9].

Based on the above, a research and systematic literature review in order to investigate the progress of AI implementation in the public sector seems to be of paramount importance. The results will constitute a useful guide to what is implemented and what is missing towards the AI adoption in this area.

The rest of the paper is organized as follows: Section 2 presents the materials and methods used towards this research and review. The main results are analyzed and discussed in Section 3, whereas some concluding remarks and future directions are given in Section 4.

2. Materials and Methods

2.1. Systematic Literature Review

Systematic literature review (SLR) is a method of retrieving answers from a very large amount of information, by identifying, selecting, and critically appraising research with the help of a clearly formulated question (research question—RQ). The systematic review should follow a clearly defined protocol or plan where the criteria are clearly stated before the review is conducted. It is a comprehensive, transparent search conducted over multiple databases and grey literature that can be replicated and reproduced by other researchers. It involves planning a well-thought-out search strategy, which has a specific focus or answers a defined question. The review identifies the type of information searched, critiqued, and reported within known timeframes. The search terms, search strategies (including database names, platforms, and dates of search), and limits all need to be included in the review.

It also maps areas of uncertainty and identifies those areas where there is a gap and new studies are needed [10].

A systematic literature review should be conducted for a variety of reasons. The most frequent justifications are:

- To synthesize the empirical evidence of the advantages and disadvantages of a certain agile method, for example.

- To locate any gaps in the existing body of knowledge and recommend topics for additional research.
- To offer a foundation or context that will let new research initiatives be positioned effectively. However, thorough literature studies can also be carried out to determine whether or not empirical data support or refute theoretical assumptions or even to help researchers come up with new hypotheses [11,12].

The present research tried to find the gaps of the extracted papers in order to suggest specific domains for future research in the context of AI usage and adoption in the public sector.

As suggested by [12], manual searches both on the world wide web (www) and in internationally recognized bodies as well as in large private companies operating in the field of information technology in general were conducted.

According to [3], it is necessary to define a specific protocol that will define all the steps to be followed. Without a specific protocol, there is a risk that the researcher will be biased in selecting the results. More specifically, the protocol includes (1) the research question (RQ), (2) the search strategy (SS), that is, the search and selection of the relevant primary studies, (3) inclusion and rejection criteria (inclusion/exclusion) not related to the research question, and (4) methods of extracting the data and synthesizing them using quality assessment tools.

2.2. Search Strategy and Research Questions

Following the SLR, in this paper, we have performed searches in the related databases [12]. Towards this end, the set of words with binary logic operators (string with Boolean Combinations) used by authors was adapted to the requirements of the present work and are shown below:

(“public sector” OR “public administration” OR “government”) AND (“neural network”)

The searches in each database were oriented to the titles, abstracts, and keywords, and the search terms were applied using the structures presented below.

More specifically, the following search in Scopus returned 2011 results:

TITLE-ABS-KEY ((“public sector” OR “public administration” OR “government”) AND (“neural network”))

Regarding IEEE, the initial string needed to be configured according to its mode of operation and returned 401 results:

((“Abstract”:neural network) AND ((“Abstract”:public sector) OR (“Abstract”:public administration))) OR ((“Document Title”:neural network) AND ((“Document Title”:public sector) OR (“Document Title”:public administration)))

2.3. Inclusion and Exclusion Criteria

The inclusion criteria in the context of the present work are the following:

- Selection of results using the English language.
- Due to the publication of [10], which concerned a period of time until the end of 2018, this search focused on the years 2019, 2020, and 2021 (until 21 April 2021).
- Select results labeled “Open Access” so that the information to be extracted is available to everyone.
- Selection of scientific publications (Article) in a complete state (Final).
- The Scopus bibliographic database includes the scientific field of Public Administration in the field of Social Sciences and in the code 3321 Public Administration Social Sciences & Humanities. The corresponding scientific field (Subject Area) Social Sciences was selected.

In the case of Scopus, by applying the inclusion criteria, the results were 36, while for IEEE the results were 11.

The exclusion criteria are listed below:

- Articles that focus on the private sector or private organizations without clearly identifying potential use by the public sector or potential benefit to citizens.
- Articles oriented to the technical characteristics of ANN's operation, such as modes of operation or the optimization of algorithms.
- Articles that are proposals for possible utilization of ANNs and do not record actual implementation and use by the public sector.

After reading the titles and summary (title and abstract) of the relevant articles, the exclusion criteria were applied and the final selection from Scopus and IEEE contained 10 results. The study was performed in the first quarter of 2022.

2.4. Data Extraction and Synthesis

For the analysis of the results, the preferred reporting items for systematic reviews and meta-analyzes (PRISMA) protocol [13] was applied, which consists of four stages: (1) identification, (2) screening, (3) eligibility, and (4) inclusion. The schematic representation of the procedure according to the PRISMA protocol is depicted in Figure 1.

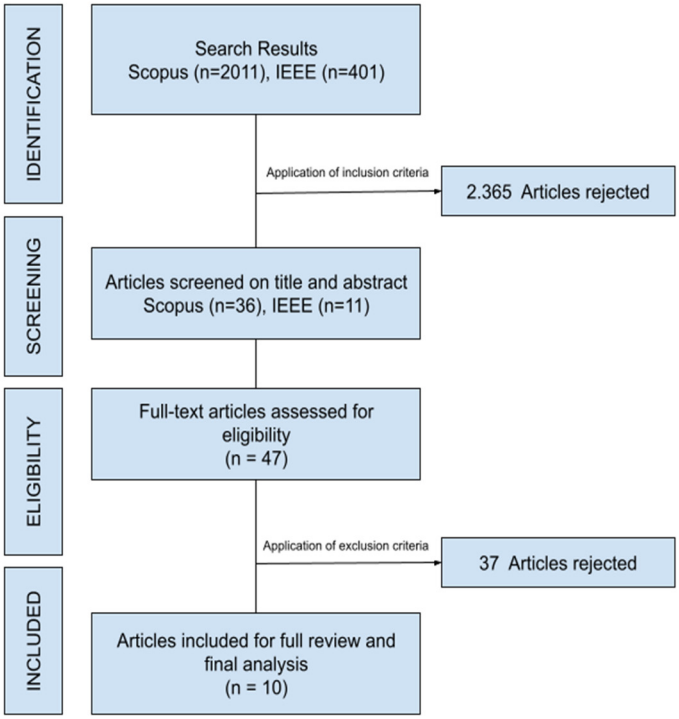

Figure 1. Schematic representation of the procedure according to the PRISMA protocol.

3. Results

This section presents the results of the performed SLR. A discussion of the outcomes and analysis of the current situation of AI implementation in the public sector is presented.

Table 1 summarizes the 10 articles emerged from the databases based on the current research, whereas Table 2 presents more details on these articles. Table 3 shows the sources of funding for the preparation of the articles and the countries of origin. The countries of origin for this study are China (5), the United States (2), Thailand (1), Canada (1), and Malaysia (1). China's pioneering role in the field has been observed by [14]. In this paper, the unique ability to coordinate between different services at all levels of administration is highlighted. The applications in the public sector are presented in the article [15] using the categorization according to the function/activity of the state developed by the OECD (Organization for Economic Co-operation and Development). The Classification of the Functions of Government (COFOG) categorization is used worldwide by large organizations such as OECD, European Union, and International Monetary Fund.

Table 1. Summary of the 10 articles that emerged from databases where each article has a serial number for future reference.

	Authors	Title	Year	DOI
1	[16]	Evaluating China's air pollution control policy with extended AQI indicator system: Example of the Beijing-Tianjin-Hebei Region	2019	10.3390/su11030939
2	[17]	A SEM-neural network approach to predict customers' intention to purchase battery electric vehicles in China's Zhejiang Province	2019	10.3390/su11113164
3	[18]	For Whom the Bot Tolls: A Neural Networks Approach to Measuring Political Orientation of Twitter Bots in Russia	2019	10.1177/2158244019827715
4	[19]	Modeling the trend of coronavirus disease 2019 and restoration of operational capability of metropolitan medical service in China: a machine learning and mathematical model-based analysis	2020	10.1186/s41256-020-00145-4
5	[20]	Vehicle energy consumption estimation using large scale simulations and machine learning methods	2019	10.1016/j.trc.2019.02.012
6	[21]	Estimating China's trade with its partner countries within the belt and road initiative using neural network analysis	2019	10.3390/su11051449
7	[22]	A forecasting model for economic growth and CO_2 emission based on industry 4.0 political policy under the government power: Adapting a second-order autoregressive-SEM	2019	10.3390/joitmc5030069
8	[23]	Distribution of urban blue and green space in beijing and its influence factors	2020	10.3390/su12062252
9	[24]	Earth observation and artificial intelligence for improving safety to navigation in Canada low-impact shipping corridors	2020	10.3390/ijgi9060383
10	[25]	Potential utilisation mapping of state-owned assets in the form of land and building lease in Palangkaraya city	2019	10.21837/pmjournal. v17.i9.591

Table 2. Further details of articles in Table 1.

Article	Limitation	Methodology	Main Findings	Type of Research
1	13 cities of the BTH region from February 2015 to January 2018	Back Propagation (BP) Neutral Network	China's Beijing-Tianjin region. The pollution control policies have improved the air quality of Beijing by 55.74% and improved the air quality of Tianjin by 34.38%, while the migration of polluting enterprises from Beijing and Tianjin has caused different changes in air quality in different cities	Primary
2	(a) There are many other factors that may affect citizens' intention to purchase BEV (b) this study only considered citizens in Zhejiang Province	Combining the structural equation model (SEM) and neural network (NN)	Chinese government results: (a) Citizens with high education level and high-income level were more likely to accept the purchase and use of BEV (b) Citizens have a positive attitude towards BEV, and it can significantly enhance citizens' willingness to purchase BEVs	Secondary (on line survey)
3	Demonstrating examples of politically charged bot activity public domain only	Neural network (NN) multilayer perceptron (MLP)	Russian government political activity of bots is always going to be a two-step process	Primary

Table 2. *Cont.*

Article	Limitation	Methodology	Main Findings	Type of Research
4	(a) Open source data, (b) model cannot be applied to the special population distribution such as welfare institute, (c) model is unable to accurately predict the epidemiological trend of COVID-19 under the cases of viral mutation and the development of specific anti-virus therapy, (d) increment of medical professionals involved and beds capacity followed an un-uniform growth pattern, which cannot be simulated by our models, (e) the psychological factors may cause a bias to our predictive models, as patients' intention to seek medical care would be reduced under the shadow of the epidemic	Neural network models (NNs)	The number of infected people and deaths would increase by 45% and 567%, respectively, given that the government only has implemented traffic control in Wuhan without additional medical professionals. The epidemic of Wuhan (measured by cumulative confirmed cases) was predicted to reach turning point at the end of March and end in later April 2020. After the end of epidemic, medical centers located in these metropolises may face 58,799 (95% CI 48,926–67,232) additional hospitalization needs in the first month.	Primary
5	Cars and light trucks produced for sale in the United States, and charged the U.S. Department of Transportation (DOT) with establishment and enforcement of these standards	Neural network models (NNs)	U.S. Department of Transportation (DOT) results confirm that the proposed large-scale learning and prediction process is able to greatly accelerate prediction and analysis of fuel economy and financial profit.	
6	Datasets only from government sources	Neural network models (NNs)	Chinese government results based on the analysis and comparison have demonstrated the ability of the neural network to predict efficiently and more effectively the bilateral trade flow using other economic variables.	Primary
7	Limitation of this research is that some causal factors could not be taken into account because the government does not allow those factors to float freely in the economy. For instance, all oil prices in the country are subject to government intervention from time to time, so they do not reflect the J. Open Innov. Technol. Mark. Complex. 2019, 5, 69 19 of 21 actual prices from a global market	Back propagation neural network (BP model)	The Thai government results of the long-term analysis indicate that the current political policy (Politi) will result in continuous economic growth, where the gross national product (GNP) growth rate will climb up to 6.45% per annum by 2035, while the environment is being negatively affected. The study predicts that CO_2 emissions will rise up to 97.52 Mt CO_2 Eq. (2035)	Primary
8	Street view photos from Government, different dates, points, etc.	Image Cascade Network (ICNet) neural network model.	Government of China (1) The spatial distribution of Beijing's blue–green space area proportion index showed a pattern of being higher in the west and lower in the middle and east. (2) There was a positive correlation between the satellite remote sensing normalized difference vegetation index (NDVI) and the proportion index of green space area, but the fitting degree of geospatial weighted regression decreased with an increasing analysis scale. (3) There were differences in the relationship between the housing prices in different regions and the proportion index of blue–green space, but the spatial fitting degree of the two increased with the increase of study scale. (4) There was a negative correlation between the proportion index of blue–green space and population density, and the low-population areas per unit blue–green space were mainly distributed in the south of the city and the urban fringe areas beyond the Third Ring Road.	Primary
9	The approach demonstrated only CNN or RF; this research can be continued by developing a larger collection of training data to build a model that can be applied to various images.	The convolution neural network (CNN) and random forest (RF) classification	The Government of Canada used CNN model with a large training set led to faster processing times without the need to train individual image with high accuracy.	Primary

Table 2. *Cont.*

Article	Limitation	Methodology	Main Findings	Type of Research
10	This research took place in Palangkaraya, the largest city in Indonesia	Geographical information system (GIS) and artificial neural network (ANN)	The Ministry of Finance of the Republic of Indonesia (MoF) focused on the mapping of potential assets by collecting and analyzing the information database of the assets to come up with the most effective in accordance to generate revenue through ANN. The government assets which can be exploited are about 14,302 m^2 of land with the potential revenue of USD 86,040/year, and 141 rooms which are predicted to generate around USD 106,342/year, with appropriate occupancy rate in the market.	Primary

Table 3. The sources of funding for the preparation of the articles and the countries of origin.

Article	Funding	Country
1	Guanghui Yuan is financially supported by the National Natural Science Foundation of China (grant number 71271126) and the Graduate Innovation Fund of Shanghai University of Finance and Economics. Weixin Yang is financially supported by the Humanities and Social Sciences Research Fund of the University of Shanghai for Science and Technology, and the Decision-making Consultation Research Project of Shanghai Municipal Government	China
2	The work has been supported by the National Natural Science Foundation of China (No. 71840014, No. 51875503, and No. 51475410).	China
3	NYU Social Media and Political Participation (SMaPP) lab from the National Science Foundation (Awards SES-1248077; SES 1756657), the William and Flora Hewlett Foundation, the Rita Allen Foundation, the Knight Foundation, the Bill and Melinda Gates Foundation, Craig Newmark Philanthropies, the Democracy Fund, the Intel Corporation, the New York University Global Institute for Advanced Study, and Dean Thomas Carew's Research Investment Fund at New York University	USA
4	National Science Fund for Distinguished Young Scholars (81525002), Program for Shanghai Outstanding Medical Academic Leader (2019) and National Ten-Thousand Talents Program (2017).	China
5	The output of this study is used by the US government to evaluate the impact of its R&D funding on energy security and CO_2 emission as well as for the setting of Corporate Average Fuel Economy (CAFE) standards.	USA
6	No	China
7	No	Thailand
8	Strategic Priority Research Program of Chinese Academy of Sciences, Grant Numbers: XDA23100200, XDA20010202, XDA19040301; National Key Research and Development Plan Program in China, Grant Numbers: 2016YFB0501502, 2016YFC0503701	China
9	Government Related Initiatives Program of the Canadian Space Agency	Canada
10	No	MALAYSIA

Table 4 categorizes the selected articles according to the function of the state (COFOG).

There is a focus on actions related to environmental protection (5), noting that four of the five articles come from China. Following are articles on safety, defense, economics, and finally health (from China) on COVID. In all the emerged articles, it is proposed according to [12] to evaluate the methodological perfection based on certain criteria. The results of this evaluation are used to synthesize the results at a later stage.

The evaluation was performed using questionnaires [12] including predefined questions, where the answers are limited to a predetermined set ("yes", "no", "to some extent"). Each answer has a numerical weight (1 = "yes", 0 = "no", 0.5 = "to some extent"), and the sum of the questionnaire weights is considered as the final evaluation for each article.

Table 5 shows the answers and the related scores for each article. The results of the quality analysis show that most of the studies scored 1 for all the questions and only two studies scored 0.5 for two questions (Q2 and Q3). The first study [22] scored 0.5 for the question related to technologies that were not identified clearly. For the same reason, Ref. [25] scored 0.5. Additionally, the ways of data collection were not described well in article [22].

Table 4. Categorized selected articles according to the function of the state (COFOG).

COFOG	Articles
F1. General public service	-
F2. Public order and safety	1
F3. Defense	1
F4. Economic affairs	1
F5. Environmental protection	**5**
F6. Housing and community amenities	-
F7. Health	1
F8. Recreation, culture, and religion	-
F9. Education	-
F10. Social protection	-

Table 5. Answers recorded and the score of each article.

Question		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Q1:	The objectives are adequately defined	1	1	1	1	1	1	1	1	1	1
Q2:	The technologies used are identified	1	1	1	1	1	1	0.5	1	1	0.5
Q3:	The ways of data collection are described	1	1	1	1	1	1	0.5	1	1	1
Q4:	Research questions are answered	1	1	1	1	1	1	1	1	1	1
	Summary:	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**4**	**4**	**3.5**
	(1 = "yes", 0 = "no", 0.5 = "at some point")										

The use of neural network algorithms by the Chinese government improved the pollution and the air quality in Beijing. At the same time, such control policies have caused different changes in air quality in several cities in China [16]. Additionally, it has implemented a number of regulations to encourage the purchase and use of battery of electric vehicles (BEVs) as part of its growing efforts to avoid and regulate motor vehicle pollution. The goal of the study [17] was to streamline marketing and planning initiatives in order to establish tactical strategies that encourage the use and purchase of BEVs. Towards this end, data have been collected through a questionnaire survey. In order to investigate the research model, a multi-analytical strategy that incorporates networks was used; it offers a novel method for resolving analytical issues in other pertinent research disciplines. Moreover, the authors in [19] estimated the COVID-19 pandemic trend in Wuhan and other representative Chinese metropolises and predicted when the regular medical system will recover from the epidemic. Additionally, the authors built a better mathematical model using information on population mobility to assess how traffic limitations affect migrant patients, estimating the operational burden on urban medical facilities when the outbreak is over. Neural network model-based analysis predicts that during the epidemic's active phase, there will be a maximum of 80,000 infected patients nationwide. Since 70% of patients in Beijing's tertiary hospitals are cross-regional cases, a sizable influx of migrant patients would present difficulties for local epidemic control in the period immediately following the containment of COVID-19. The authors suggest that authorities need to plan

their health inspection and quarantine procedures. The findings also highlight the value of a hierarchical healthcare system that uses local hospitals to triage patients. In order to meet the demand for a continuous space of vehicle fuel economy and a more effective simulation process, the U.S. Department of Transportation recommends a unique large-scale learning and prediction process (LSLPP) using machine learning methodologies. The study [20] was used by the US government to assess how its R&D funding has affected energy security and CO_2 emissions, as well as to set corporate average fuel economy (CAFE) regulations.

Another study [21] calculates the bilateral commerce between China and its African partners using the gravity model and the neural network and compares the results to the actual trade data to determine which estimation approach more closely matches the actual data. Results from the research and comparison show that the neural network can predict the bilateral trade flow more accurately and effectively using other economic variables. Its ability to record nonlinear relationships between features underlies this. Using the same set of features, the neural network can also predict the Gravity Model's performance more accurately, with a test set R2 score of 0.15. This was a really helpful tool for analysts and government policymakers. One method for partner countries to gauge the impact and potential longevity of their collaboration is the estimation of these trades using a neural network model.

The Thai government research [22] aims to forecast future economic and environmental growth for the next 16 years (2020–2035) according to the government's strategic using neural networks model. The results showed that the effect of such a policy will put the environment at risk, and the government must take immediate action to respond to this urgency.

The Canada government's Convolution Neural Network (CNN) and Random Forest (RF) classification are two AI methodologies that are investigated utilizing deep learning and machine learning techniques. The study examines how well the two models distinguish shoals in satellite images from Sentinel-2 and WorldView-2. The findings demonstrate that over two study sites, CNN and RF models can both detect shoals with accuracies ranging from 79 to 94%; however, WorldView-2 images provide results with higher accuracy and fewer omission errors. While building a CNN model with a large training set may result in shorter processing times without the requirement to construct a deep learning model, employing high-resolution imagery and deep learning models may not be necessary to swiftly scan photos for shoals [24].

Another work [25] discusses how the Directorate General of State Assets Management (DGSAM), as the state-owned asset manager, under the Ministry of Finance of the Republic of Indonesia, analyses the best-suited strategy to map public assets. The authors collected the data on the government assets through the program of country's asset revaluation at the end of the year 2017 using algorithms of neural networks. In Palangkaraya, the combined effective non-tax income from land rental and lodging comes to $192,382.68 annually. The authors suggest that the DGSAM acts in order to maximize land and building utilization in light of this research, and they expect that the DGSAM will develop this method in many cities and for various forms of utilization as well. It appears that using this strategy will make DGSAM a revenue center more quickly.

4. Discussion

There is a series of initiatives at the level of strategic planning for the development of AI applications from almost all OECD countries, which records developments in the field through a special observatory. From the recording of the international situation as observed from almost all OECD countries but mainly from the protagonists of this race for AI (AI race) such as China, the United States, and the European Union, it is deduced that there is an intense activity mainly at the stage of creating the background for technology development of AI. This activity includes:

- The specification of strategic objectives in the form of National Strategies and Frameworks.

- The use of innovative public procurement procedures (e-procurement) aimed at accelerating the adoption of AI applications, a landscape particularly complex in recent times in the effort to limit COVID-19 [26].
- The drafting of instructions to the financial services of the State regarding the supply of AI services [26].

According to the outcomes of the present research, the countries that use AI (NN) in the public sector are China (5), the United States (2), Thailand (1), Canada (1), and Malaysia (1). This finding more or less confirms the above work [26]. More specifically, it is mentioned that the EU countries are not included in the present work, although OECD and EU recommendations urge to adopt the "AI for society" policy approach.

The article in [27] observes that the scientific community, with increasing interest studies in the application of AI in the public sector, identifies five broad categories in the literature (articles) regarding the implementation of AI in this sector: (1) AI government financial services, (2) working and social environment influenced by AI, (3) public order and law related to AI, (4) AI ethics, and (5) AI government policy, particularly in the economic domain. It is highlighted that all the papers in our study include the aforementioned fields of financial services [21,22,25], social environment [16,22], public order and law [17,18], AI ethics [24], and AI government policy [19,20,23].

Starting from the articles [16–25], a systematic review of the literature was carried out in order to find the facts of ANNs use in the public sector from 2019. From the number of results both initially and after applying the selection/rejection criteria and then reading the final articles, the conclusion was that while the scientific community has too many suggestions and ideas for the implementation of ANNs, in fact, there is no systematic use of them in the public sector. Occasionally, there are cases of implementation funded by state, as we found in our study [16–20,23,24] or non-governmental organizations [21,22,25] without the systematic application and utilization of these 'not so new now' technologies. The ways and methods of practical application are not further specified, so there are no indications for the systematic application of specialized deep learning techniques and ANNs.

As reported in [28], despite the increasing cases of AI adoption in the public sector, the evidence for the real results is very limited. This fact is not surprising since the authors characterize that the practices/solutions related to the development of AI technologies are at a very early stage. The fundamental motivations for the adoption of AI (NN) in the public sector, both initially and afterwards in its history, are the achieved financial aims through effectiveness, productivity, reduction, and simplicity, as stated in [21,22,25].

These public entities (municipalities, hospitals, financial services, etc.) are increasingly realizing that technologies as AI [18,19] can enable more cost-effective and efficient service delivery, drastically increasing the value of the public sector as many authorities move toward higher levels of being intelligent.

Obstacles and problems for the adoption of AI technologies in the public sector exist [29], and standardization [30], which is a key element for supply of services in the public sector, is still in progress. These problems were fully demonstrated in [21,25] underlining the lack of experience and knowledge of the workers compared to the ones in the private sector.

The present paper also investigated the application of a specific technology (NN) in the public sector, the operation of which is determined by laws and regulations. However, the reference to a global operating framework, where there are different policies such as "AI for profit" or "AI for Control" leads to different approaches for the use of AI and consequently for the creation of different regulatory frameworks related to the operation of the public sector worldwide [17,18]. For example, in the case of China, according to [31], the growth of AI technologies is taking place without serious consideration of ethical and human rights issues.

The OECD recommendations (OECD Principles on Artificial Intelligence—Organization for Economic Co-operation and Development, 2019) and the EU adopting the "AI for

society" policy approach raise the bar and set principles for the operation of AI technologies such as respect for the rule of law, human rights, transparency, and accountability.

However, there are obstacles that concern both the operation of the public sector and the technology itself that should be applied.

4.1. Public Sector

The public sector should serve the citizens in the best possible way and, for this reason, there is a need for IT systems and projects that are no longer manufactured "in-house", but their supply is "outsourced" with the operation of modern procurement methods called "Public e-procurement". Technical specifications that describe the operation of the service to be implemented and not the use of specific technologies should be drafted [17,20].

For instance, in Greece, the implementation of Directive 2014/24 of the EU about Public Procurement is active based on [32], as amended by [33]. More specifically, in article 54 of [32] that concerns the technical specifications, paragraph 4 states:

> *'The technical specifications, unless justified by the subject matter of the contract, do not contain a reference to a specific construction or origin or particular manufacturing method that characterizes the products or services provided by a particular economic entity or to a trademark, patent, type or origin or production which would result in certain companies or products being favoured or excluded.'*

The same law (paragraph 3b) concerning the formulation of the technical specifications' states:

> *'with reference to technical specifications and, in order of priority, to national standards transposing European standards, to European technical approvals, to common technical specifications, to international standards, to other technical reference systems established by European standardization bodies or where they are not exist in national standards, national technical approvals or national technical specifications in the field of design, calculation and execution of works and use of goods, each reference shall be accompanied by the term or "equivalent";'*

The conditions contained in paragraph 3b, such as national and international standards, European technical approvals, or common technical specifications, in the field of application of AI technologies, such as NN, are still at a very early stage as shown in the findings of the present work in EU countries.

4.2. Artificial Intelligence Technologies

Artificial intelligence technologies and especially NN will have to meet the requirements of the public sector in order to be able to be adopted in the future. Issues related to the transparency of decision-making procedures and the obligation of accountability of the public services are conditions that are not yet fully met as [23] noted in the related paper.

For example, if a deep learning system using ANNs made a decision at time A and another decision at time B, a possible implementation in the public sector should be fully documented, and most of the articles in this work demonstrate all these things [17,19,20]. In [34], it is stated that in the case of MLA, the complexity and opacity of the operation of AI systems (NN) makes it difficult for people to understand the operation and the results. This opacity, as per [21,22], reduces human responsibility and accountability. The European Parliament strongly agrees on this new technological approach and underlines the huge benefits of using AI and specific NN against climate change, pandemics, and in the labor market [35]. Beijing's air quality has been improved due to pollution control measures and neural network technology implemented by the Chinese government [16].

Additionally, the Commission's AI strategy heavily relies on maximizing resources and coordinating efforts. The Commission intends to invest €1 billion per year in AI through the Digital Europe and Horizon Europe programs. Over the course of the digital decade, it will mobilize additional investments from the private sector and Member States to reach an annual investment volume of €20 billion. The newly adopted recovery and

resilience facility makes €134 billion available for digital. This will be a game-changer, allowing Europe to expand its ambitions and become a global leader in developing cutting-edge, reliable AI [36]. The above, however, is not confirmed by the articles we found in this work.

Moreover, AI shows enormous potential for labor time savings. In this context, Delloitte selects the base mean of the change in labor inputs to each government task and adjusts it according to intrinsic task characteristics. They then simulate changes to task labor inputs by sampling from the normal distribution using the adjusted mean, with standard deviation chosen using O*NET values. Given low, medium, and high levels of government resourcing and investments in AI, their simulations generate the scenarios. The authors of [18,25] support that even low levels of effort behind AI adoption could save government workforces between two and four percent of all their labor hours. With middling investment levels, much bigger savings become possible. The midrange scenario, which they consider realistic, is based on our experience with public and private sector automation projects [37].

Another study [38] provides a strong economic rationale for using NN systems as an assistive tool to screen for diabetic retinopathy in a public hospital in Singapore and analyses a case using AI in a public hospital. It seems that a patient with diabetes would incur a 12-month total cost of $77, $62, and $66 for the human assessment, semi-automated, and fully automated screening models, respectively. These data are translated into cost savings against the human assessment model of $15 (reduction of 19.5%) and $11 (reduction of 14.3%) per patient for the semiautomated and fully automated models, respectively. The cost of human graders, screening specificities, and IT-related costs were the most influential variables. All the other are equal, as long as human graders costing more than $7.80 remain the least expensive option. Likewise, the semi-automated model would be preferred over the human assessment model if specificity remains above 70% for the semi-automated model. The one-way sensitivity analysis revealed that if the human grading cost was more than $11.80 or if the specificity of the fully automated model was greater than 58.8%, all else being equal, the fully automated model was less expensive than the human assessment model. Specificity was the most important factor affecting the cost differentials, because the higher rate of false positives drives up costs due to a greater number of consultations for diagnosis [38]. Furthermore, [19] emphasizes on the tremendous difficulties that the Chinese healthcare system faces, when a public health emergency, such as COVID-19, occurs. The findings inform public health officials to develop preparedness plans in order to address the unmet medical needs of other diseases in the context of the COVID-19 pandemic and at the same time save money by making use of neural network algorithms.

5. Conclusions

The implementation of ANNs in the public sector should follow the broader goals that have been set for the implementation of AI in the public sector. It has been confirmed that neural networks are in frequent use in different countries by their governments, and there are four pillars of application in the public sector: (1) government financial services, (2) environment, (3) public order, (4) health ethics, (5) government policy, particularly in the economic domain.

The lack of a legal framework is evident in the very recent feasibility study [34] in which the Council of Europe lays the groundwork and sets out the roadmap for the necessary legal framework for the development, design and implementation of artificial intelligence technologies based on democracy, protection of human rights, and the rule of law. EU countries are not included in the present work, although OECD and EU recommendations urge to adopt the "AI for society" policy approach. Maybe the use of NN should be widely known in EU countries and their governments should promote more of these technologies. As [39] mentioned in their article, in actuality, AI technologies are used in the EU for a variety of, albeit limited, purposes. A clear overview of the various benefits and drawbacks for each governance function allows for more in-depth research on the use of AI, as there may be additional motivators, obstacles, effects, and risks for each specific deployment in addition to the general risks that are applicable

to "all" AI. This is an important addition that will help scholars and decision-makers better understand the possible effects of AI on the public sector in Europe and as a benchmark for other parts of the world.

Artificial neural networks are one of the many techniques of machine learning in the field of artificial intelligence. It would be interesting to look for the reasons and criteria for selecting techniques depending on the application in the public sector, perhaps also against state functions within the framework of the adoption of NN by the public sector as suggested by [26].

The lack of drafting technical specifications for public procurement by public bodies, due to difficulty of composing, in combination with the lack of know-how and the lack of the necessary resources make the application of NN, if not impossible, very difficult.

Additionally, the outcomes of our research and also [40] suggest that the public authority that implemented the funding program might take remedial measures to enhance the results. The application of the suggested approach (NN) could enhance the decision-making procedure and start adjustments to administrative problems in the financing programs already accessible. Another problem in order to implement NN is the reducing human responsibility and accountability but at the same time NN can save labor time in public sector if its use is proper.

A plethora of studies, as mentioned above, highlight the tremendous economic impact that NN will have. According to the aforementioned studies as well as the European Parliamentary Research (2019), which covered 12 industrialized economies and collectively accounted for more than 0.5% of the global economic output rates of yearly growth in the world economy, the world economy will have reached its peak by 2035. Governments should invest in new technologies and more specifically NN, in order to achieve productivity and service effectiveness.

The present work also has some limitations. Firstly, due to the different theoretical frameworks that the articles used, this study does not distinguish between actual usage and intention to use in terms of adoption. To acquire more accurate analysis results, future research may separate those two aspects of adoption exposure. Secondly, to acquire analysis from other data sources, new studies may use other databases, such as Web of Science or Google Scholar. For instance, Google Scholar will produce more results from various sources and journal levels because of its extensive indexing coverage. Additionally, we strongly recommend that the date range should be different.

NN has significant potential to boost economic growth and productivity, but at the same time, it creates serious risks. Countries' policymakers need to create the necessary conditions for nurturing the potential of NN, while considering how to address the risks it involves. There is also a scientific gap using NN for governments. Through this research we did not find the use of NN for specific domains as education, general public service, social protection, recreation, culture, and religion, housing and community amenities. Future works could focus on these domains in order to increase productivity in the public sector. Even if the financial effects of the most recent AI-based technologies (NN) have not been fully assessed, expectations are relatively high.

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