
INDUSTRY 4.0 AND E-PUBLIC PROCUREMENT: A PROFITABLE COEXISTENCE

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Abstract: *Public procurement is an important component of public finances in the E.U. and the Member States. Therefore, their management is a challenge for the trustworthy relationship of citizens with the public sector authorities. Existing electronic public procurement optimization tools in the E.U., such as T.E.D., electronic forms, e-invoices, and electronic portals of Member States, are systematically attempting to standardize procedures by improving access to information and transparency in its management. Nevertheless, the next day requires the enlightenment of the transition roadmap to modern tools and technologies of the fourth industrial revolution. According to the E.U. objectives achievement degree, the comparison between the existing e-procurement tools 3.0 and the expectations from the possible uses of the emerging technologies 4.0 will indicate the appropriate points where strategic priority should be given through the implementation of the digital transformation process. The study presents this comparative analysis of empirical data based on the relevant literature in e-P.P. 3.0 and current case studies in e-P.P. 4.0 in a summary figure whose logic originated from the Balanced Scorecard and Hoshin Kanri matrix.*

Keywords: *e-public procurement; industry 4.0; emerging technologies*

1. INTRODUCTION

As a critical governmental function, public procurement has the basic goal of supplying products and services in a timely, cost-effective, and efficient way to achieve its missions. The study of public procurement is a field that greatly influences public finances and business activity. Over 250 000 public bodies in the European Union spend roughly 14% of their G.D.P. on services, works, and supplies (European Commission 2019). Rational and transparent management of public finances strengthens citizens' faith in governance. Public procurement is an important part of public finances in E.U. and the Member States, and therefore their management is a challenge for the relationship of citizens with the public sector authorities. The Recovery and Resilience Facility (R.R.F.), €723,8 billion in current prices, the political priorities of the 2021-2027 period, and the COVID-19

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pandemic crisis reset the framework of public procurement challenges Industry 4.0 revolution progress. There is a necessity for more transparency and efficiency to manage the spending of R.R.F. and E.U. Strategic Framework 2021-2027 funds at the national level.

E-Public Procurement (e-P.P.) increased transactional efficiency for both providers and governments. Transparency in government procurement reduces government expenses, improves value for money, and reduces corruption. e-P.P. may result in high cost and administrative savings and increased market access and accountability. In this way, e-P.P. contributes to economic growth. In the E.U., it is necessary to forecast how the time and means will be required for the transition from technologies 3.0 to 4.0 to meet the E.U.'s public procurement objectives effectively. The research aims to set the proper priorities in the digital transition from e public procurement 3.0 to e public procurement 4.0. The resources of a digital transition are not unlimited; therefore, strategic priorities should be set. The contribution of this study is to provide the Technology Forecasting as a framework for a debate among experts to design the strategic transition through a Technology Roadmap.

2. SUPPORTING THEORIES AND RELEVANT LITERATURE

2.1 The E.U.'s e-Public Procurement 3.0 goals and tools.

European Commission as the administrative supervisor of the supranational institution seeking to gain a granular view of procurement practices by its member states, thereby enforcing best practice compliance to specific policy axes. The vital role of Public Procurement in the E.U. and its Member States stems from their significant influence on the G.D.P. of Approximately 2 trillion euros and 13% of the E.U.'s G.D.P.(Panayiotou, Gayialis, and Tatsiopoulos 2004) and their potential for dynamic integration of strategic parameters into the implementation of public policy. They set critical political objectives such as a) improving the efficiency of public resources by improving business competition, b) ensuring transparency -accountability, and open data. Also, using the procurement framework for defining the needs, specifications, and award criteria, strategic objectives serving social responsibility, environmental protection, and the innovative development of the competitiveness of enterprises. The Directive 2014/24/E.U. is an example that has set new rules in e public procurement about electronic delivery of notifications, electronic access of procurement documents, electronic filing of requests for participation, and tenders. Electronic advertising has been done by e-submission of notices in the Official Journal of the European Union (O.J.E.U.). Tenders are listed on Tenders Electronic Daily (T.E.D.). The Publications Office plays an essential role with two modules: in the reception of notices, a) e-Notification (e-Notices, e-Sentool, and T.E.D.) and b)e-Access refers to electronic access to procurement papers (TED-e Tendering). T.E.D. uses e-Forms, an E.U. legal standard for procurement data, to issue announcements on Tenders Electronic Daily. European Single Procurement Document (E.S.P.D.) makes the public procurement process more accessible. It is a self-declaration of a company's eligibility, financial position, and capabilities used as preliminary evidence in all public procurement procedures over the E.U. threshold. E-Certis is the mapping application that assists participants in public procurement operations in identifying and comparing various certifications required in procurement procedures across the E.U. It is integrated with E.S.P.D. Open e-PRIOR is a free, open-source e-Procurement platform that enables government agencies to build interoperable

electronic services. E-Invoicing Directive established a European standard for e-invoicing to solve the issue of e-invoice format diversity. E-invoicing is quite mature but not entirely implemented and monitored by the member states.

2.2 The emerging Technologies in e-P.P. 4.0.

The Study of the Directorate-General for Internal Market, Industry, Entrepreneurship, and S.M.E.s about emerging technologies in public procurement worldwide is an important base for our research (Deloitte and European Commission 2020). Emerging technologies have the potential to revolutionize public procurement. New technology can allow smarter decisions, save costs, and promote transparency by automating repetitive administrative tasks and providing remarkable data analysis on spending patterns and supply project execution. Big Data Analytics (B.D.A.), Business Intelligence (B.I.), Machine Learning (M.L.) and Artificial Intelligence (A.I), Blockchain, Internet of Things (IoT), Robotics Process Automation(R.P.A.), Augment Reality and Virtual Reality, 3D Printing are the Industry 4.0 (I.D 4.0) emerging technologies that there are current cases studies (Accenture 2019; World Bank 2021).

2.3 Innovation diffusion Theory (Model)

Many studies have found that key perceptions of technological traits, referred to as innovation, impact technology adoption choices. The objective of innovation diffusion theory is to comprehend the mechanism through which inventions spread within a social system(Rogers 1995). Rogers (1995) lists five criteria of an invention generic to the degree of adoption in a social system. Relative advantage, compatibility, complexity, observability, and trialability are some of these critical variables. Relative advantage can be operationalized or assessed regarding the innovation's utility in achieving work goals, the quality of work results, increased convenience, and social prestige. To measure relative advantage, we selected E.U.'s public procurement goals. So, in this way, we can find the level to which the emerging technologies of ID 4.0 are superior to the current e-P.P E.U.'s tools.

3. METHODOLOGY, RESEARCH DESIGN

In order to facilitate the forming of the study, we focus our study on the public procurement area of the Member States of the European Union and define as a criterion for comparing efficiency the objectives set by the Commission itself regarding public procurement. The Technology Forecasting (T.F.)(Quinn 1967) about emerging technologies and e-P.P. must eventually anticipate whether technical systems will be able to attain or exceed important performance levels or parameters by a specific date in the future. The selection and prediction of these characteristics are thus at the heart of the forecasting process. The chosen criteria to check technological potentials and the diffusion of the emerging technologies in e-PP are a)the relative advantage of e-P.P. 4.0 technologies in satisfying the main public procurement goals. The chosen criteria (variables) are based on the Innovation Diffusion Theory (Model)(Rogers 1995). The tools of the existing technologies that were examined concerning the implementation of the above objectives were applied or have been launched to be applied shortly.

The comparative theoretical analysis of the influence of existing e-procurement tools on those of emerging technologies has two sources. A) The ontological potentials are derived by definition from the previous studies' theoretical approaches of the previous studies. B) The empirical findings come from relevant case studies. The combination of the two above results is summarized in an estimation comparative evaluation scale representing the degree of influence in achieving the goals between -1 and 2. With -1 the specific tool or technology has no influence or correlation with the specific goal. With 0 the correlation will be neutral. With 1 the additional influence is small, and with 2 the additional influence is large and immediate in achieving the goal. If we do not have sufficient data, we place the letter x. The sum grade shows the relative priority by examining the potential relative advantage of emerging technologies compared to current e-P.P. 3.0 EU's tools.

The main research question of this study is:

The evaluation of the impact of applicable e-public procurement technologies based on current cases in Industry 4.0 according to:

I. E.U. public procurement goals. (relative advantage)

The outcome is a summary figure representing the estimation conducted by literature review and case studies. The study results are presented in a summary figure, a hybrid construction of the Balanced Scorecard and Hoshin Kanri matrix (Dias and Tenera 2020). This is the proper base to reach Technology Roadmapping (T.R.M.) through Technology Forecasting (T.F.). Martino defines it as: "A prediction of the future characteristics of useful machines, procedures or techniques" (Martino 2003). The necessity for technology forecasting is critical for successful technology transfer.

A Future-oriented technology analysis method based on expert opinion (Delphi) of this study's estimation figure could support a proper Technology Roadmapping (T.R.M.) (Porter 2010). A technological roadmap will outline when the previous system will be phased out and when the new one will be put in place. A technological roadmap will assist policymakers in determining which technologies to advance and how to put them into practice (Harold A. Linstone and Murray Turoff 2008).

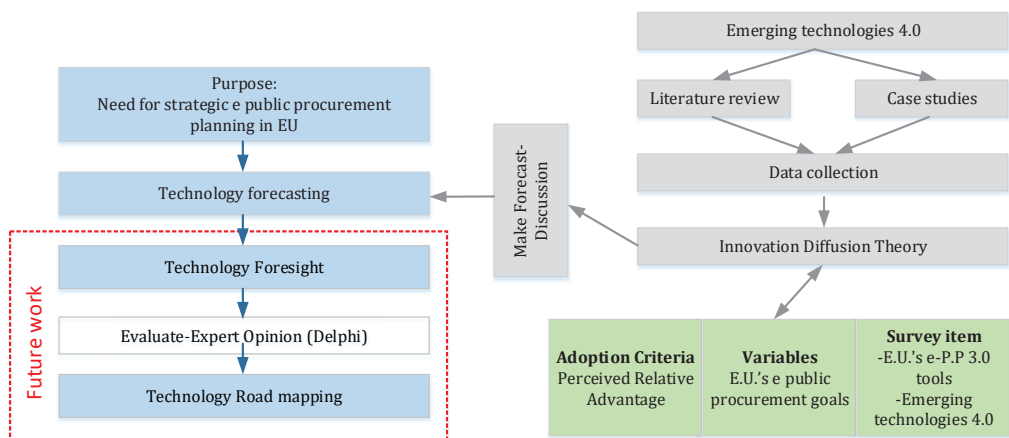


Figure 1. Current and Future research concept map.

4. DATA DISCUSSION

The concluding analysis of the literature results and the recording of case studies follow at this point in the study. Its visual representation is summarized in Figure 2. The given model will be accepted, challenged, or completed at a future research stage using the Delphi method(Harold A. Linstone and Murray Turoff 2008).

1.Transparency/ security/accou ntability (Europe closer to citizens)	2.Equal treatment/opportu nities for SMEs/cross border trade (Competive Europe)	3.Reduce Fraud Corruption	4.Remove legal and administrative barriers	5.Green Procure (Greener Economy)	6.Social Procure (Social and Inclusive Europe)	7.Innovation(Smarter Europe)	Total Score	B.Strategic goals in Public Procurement 2014- 2020_Policy Priorities/Objectives 2021-2027
								A.e- public Procure 4.0
2	2	2	2	1	1	1	11	1.Blockchain
2	2	2	1	2	2	2	13	2.Big Data
2	2	2	2	2	2	2	14	3.Business Intelligence
1	1	1	1	2	2	2	10	4.Artificial Intelligence-Machine Learning
2	0	1	0	2	0	2	7	5.Internet of Things (IoT)
1	0	2	2	1	1	1	8	6.Robotic process automation
1	1	1	1	1	0	2	7	7.Augmented Reality and Virtual Reality
1	1	0	0	1	1	1	5	8.3D printing
								corellation/contribution/impact
								-1 negative
								0 neutral
								1 indirect/low/relatively positive
								2 direct/high/positive
								X no evidence more research needed

Figure 2 . Summary of visualized comparative analysis between e public procurement technologies 3.0 E.U. and 4.0. , according to E.U.'s objectives

4.1 Blockchain and E.U.'s goals.

A1.B{1-4} A blockchain is a form of digital trust(Bertrand Maltaverne 2018). Blockchain has a critical impact on transparency, equal treatment, reducing fraud, and removing bureaucratic barriers because when blockchain technology is used in procurement creates a "data backbone."(Deloitte and European Commission 2020; Iansiti and Lakhani 2017).As a "data backbone" that can be used to foster interoperability, paving the way for increased automation and "interconnections" between physical and financial supply chains(Bertrand Maltaverne 2018).

A1.B {5-7}The green social and innovative criteria could be satisfied if we examine, for instance, the case of Digipolis as an "experimental procurement" in Uyarra and Flanagan's four-fold typology. This means that it involves the procurement of adapted technical (software) solutions, where the supply of inputs comes from a "community of specialists" (i.e., the startup community) and the clients' demands are precise and heterogeneous (i.e., the Antwerp public sector)(De Coninck, Viaene, and Leysen 2018).

4.2 Big Data Analytics and E.U.'s goals.

A2.B1 Big data visualizations contribute to the complete understanding of data content easily and comprehensively, adding value to transparency as critical information comes to the shareholders(Auditors 2019)

A2.B2 Market research is more reliable and quicker because it is not dependent on suppliers but the contracts. This accurate market research supports economic efficiency, equal treatment, and the improvement of procurement planning (World Bank 2021).

A2.B3. It is possible with big data analytics to flag high-risk sections for more investigation or suspicious transactions for audit or additional analysis (Mihály Fazekas et al. 2018).

A2.B{5-7} The methodology of preparing the big data before they are analyzed helps prevent distortion of data from various sources. Big data analytics facilitate benchmark quick and trustworthy participation requirements, award criteria, subcontracting conditions, and contract modifications, so there is a positive relation between green social and innovative procurement (Babica, Sceulovs, and Rustenova 2019).

4.3 Business Intelligence and E.U.'s goals.

A3.B{1-4} Business Intelligence contributes to the availability of information in the form of understandable graphs, diagrams, and charts that appears to be more precise and opens up more opportunities for deep and significant understanding to all stakeholders. Bidders, for example, may monitor how much their governments spend (transparency), what they spend it on, how long the procurement process takes, where the bottlenecks are, and how projects and services are procured and delivered using B.I. (OCDEX 2020). Obtaining these patterns and insights gives suppliers, contractors, and locators a strategic edge in planning bids or determining whether to invest in a certain local government depending on the procurement trends(Williams 2016).

A3.B{5-7} B.I. can transform data into useful, real-time, fact-based information that aids and simplifies decision-making. This capacity can assist Public Authorities and businesses in resolving some long-standing information-related issues. It also informs suppliers about the criteria used to evaluate themselves and their competitors, fostering competitiveness. These criteria could be green social, or innovative as key metrics (Williams 2016). For instance, the BI Prozorro module may filter, classify, and analyze data using dozens of criteria in each part(Bugay, Yuriy 2016).

4.4 Artificial Intelligence, Machine Learning and E.U.'s goals.

A4.B{1-2} Suppose we avoid getting caught up in algorithms that lead to "black boxes" and promote our request to suppliers in a clear and explanatory way. In that case, we certainly have a practice that directly contributes to transparency and fair distribution of opportunities (Acemoglu and Restrepo 2018). The predictive information that a system creates by collecting data, e.g., Tender documents, and organizing them in patterns increases transparency in public procurement (Ash, Galletta, and Giommoni 2020). Technical and procedural explainability are the critical parameters to ensure transparency and equal opportunities.

A4.B3. Using machine learning algorithms, A.I. as a risk analysis selector can monitor vast amounts of public tender data and detect any irregularities, such as unexpected changes in purchase prices and fraud complaints. A.I. can gather and analyze millions of various data sources to create a clearer picture of procuring entities' and bidders' characteristics and habits, allowing them to determine and forecast whether or not a certain partner is trustworthy(Iain Batty and Veronika Kovács 2020).

A4.B{3-4} Although the empirical research is limited; algorithmic governance can produce predictions or risk scores and help through decision support the elimination of bureaucratic barriers (Goldenfein 2019). Another practical case refers to extracting data from contracts and invoices with A.I. Moreover, for example, an advanced chatbot has the potential to become the single point of contact for internal and external queries. In this way, A.I. can reduce both fraud and bureaucracy (Deloitte 2020; Surya 2019)

A4.B{5-7} There are records where machine learning can help support procurement decisions in public bodies using multi-criteria methods. So this means that it is possible to integrate environmentally innovative and community-based criteria into public procurement (Goldenfein 2019). A.I. may assist public purchasers in finding the green or sustainable public procurement criteria that will produce the greatest improvements assessed against any key performance indicator, such as CO2 footprint (Gailhofer et al., 2021). Generally, A.I. overcomes human information processing limitations and helps generate innovations in public procurement (Haefner et al. 2021).

4.5 Internet of Things (IoT) and E.U.'s goals.

A5.B1 IoT provides real-time access to public procurement information and increases efficiencies and transparency (Micheli, M et al. 2019; Wirtz, Weyerer, and Schichtel 2019).

A5.B3 Tracking the inventory items' position and receiving low-stock alerts or notifications if a product is missing by introducing linked sensors and data storage systems. Allowing the rapid and precise acquire product data across the supply chain reduces the fraud possibilities in setting a need for purchase (Micheli, M et al. 2019; Wirtz, Weyerer, and Schichtel 2019).

A5.B5 Discerning circular economies and green procurement because IoT could confirm purchasing criteria while using the product (Legenvre, Henke, and Ruile 2020).

A5.B7 Augmented reality cases potentially help plan a project as well as we can collect, analyze and visualize data and interact with them by making several scenarios. The progress of complex and dynamic ecosystems between IoT big data analytics and A.I. support strategic partnerships and contribute to innovation (Alam, Vats, and Kashyap 2017; Micheli, M et al. 2019)

4.6 Automation R.P.A. and E.U.'s goals.

A6.B1. Subjective feelings do not affect bots, which provide an objective and transparent output based on predetermined criteria. R.P.A. adopters and consultancies agreed that the rate of process mistakes lowers dramatically and tends to zero if the bot is properly programmed (Flechsigt, Anslinger, and Lasch 2021).

A6.B2. R.P.A. tendering standardization; increased openness (Flechsigt, Anslinger, and Lasch 2021; R. Uskenbayeva et al. 2019) and allows S.M.E.s for fair participation in e-P.P.

A6.B3. R.P.A. bots can perform data processing, transfer, and administration activities, preventing unauthorized access to sensitive information, applying anti-fraud checks and special filtering award criteria (Flechsigt, Anslinger, and Lasch 2021; R. Uskenbayeva et al. 2019).

A6.B{5-7} R.P.A. could help public sector enterprises with service specifications, i.e., bots would create predetermined parts of the description and process standard tenderer

requests. These predetermined criteria in tendering and supplier evaluation phase could be green, social, or innovative (Flechsig, Anslinger, and Lasch 2021; R. Uskenbayeva et al. 2019).

A6.B7 R.P.A. accelerates the continuous digital transformation and shift of e-PP from its traditional operational position to a more strategically oriented and involved business function by facilitating an innovative corporate culture (Van Poucke et al., 2019).

4.7 Augmented -Virtual reality and E.U.'s goals.

A7.B{1-3}. Augmented reality can contribute to transparency and the fight against corruption in public procurement as the simulation of public projects can involve citizens in some planning choices. They are checking the correct execution of the terms of a contract afterward during the implementation of a public project (Bakken 2018).

A7.B{2,4}. The contribution of augmented reality to creating business opportunities and removing administrative barriers may not be directly demonstrated through specific projects. Still, there is a possibility that potential suppliers will be able to have better information, even though from a distance, on the specifications and the distinct nature of a public contract project (Gregory Curtin 2017).

A7.B{5-7} A.R. is, by definition, green technology as it reduces the environmental footprint that would create some wrong choices in public works or goods procurement and optimizes the final decisions through scenarios by choosing the most innovative solutions. Augmented reality cases potentially help plan a project as well as we can collect, analyze and visualize data and interact with them by making several scenarios endorsing several criteria green, social, and innovative (Accenture 2019; Deloitte and European Commission 2020; Gregory Curtin 2017).

4.8 3D Printing and E.U.'s goals.

A8.B1 At Deutsche Bahn Group, critical printing spares now have a viable alternative for buying spare components, boosting its bargaining strength with suppliers and lowering procurement costs (Josephine Cordero Sapién 2021).

A8.B2 3D printing is a small-scale production process used by small and medium-sized businesses. However, it is not certain that they will have the requisite capital resources or expertise to compete in this area. Additionally, Additive Manufacturing (AM) enables total design independence and local, flexible production (Berman 2012; Ngo et al. 2018).

A8.B5. 3D Printing prototypes contribute to evaluating the viability of several alternatives and may refine the service concept, create a service offer for a new or enhanced service, or select the proper one according to the final results. This technique is naturally ecologically beneficial since it lowers the quantity of material wasted and optimizes the proper good or supplier (Berman 2012; Shuaib et al. 2021).

A8.B6 3D printers allow small E.U. social enterprises to engage in supply competitions with specific creative ideas by producing prototype projects or manufacturing customized items to fulfill an order for a Public Authority (Ngo et al. 2018).

A8.B7 By shortening the trip from an abstract concept to a physical item, 3D printing offers new avenues for invention and creativity by transforming data into products and from products data (Shuaib et al. 2021).

5. CONCLUSION

Public procurement is a strong instrument for government agencies to spend public funds in an effective, transparent, sustainable, and strategic way.

Emerging technologies in ID 4.0 offer the opportunity to completely rethink how public procurement is organized. However, we can not ignore the opportunities that new technologies can create in public procurement. The transformation roadmap should optimize current technologies and tools compared to emerging technologies. This study contributes as the first step to future dialogue between experts about which emerging technologies are more effective and compatible to serve the goals and the public procurement operational stages. The technologies with the greatest overall comparative influence in achieving the goals related to public procurement in the E.U. using emerging technologies are Business Intelligence, Big Data Analytics, Blockchain, and Artificial Intelligence-Machine Learning. The common feature of the former technologies is related to their structural ability to support in the procurement process critical areas of decision making. The decision-making process consists of the collection, filtering, analysis, formation, and comparative performance of alternatives, with the ultimate goal of selecting the best possible procurement process that achieves the strategic goals of E.U.

The significant contribution to the literature in using this analysis model is that it prepares a Technology Forecasting path by using the relative advantage from Innovation diffusion Theory (Model) as a variable. The limitation of this model results is that it is only applied theoretically based on literature review and case studies. Further research using Delphi Method will help test the validity of the results and integrate this model with managerial implications and a Technology Road-mapping framework for the public and private sector shareholders. The estimates presented for each type of technology with the type of goal they serve may be revised in the future with the implementation of new case studies. However, the specific characteristics of some technologies make them more efficient in all strategic objectives of the E.U.

Nevertheless, this does not mean that possible synergies cannot lead to cumulative results with a higher rate of return on achieving each goal separately. A profitable transition to public procurement 4.0 in the European Union cannot be done without priorities and randomly. Therefore, mapping all possible points drawn from any technology and their potential interdependencies should be a dynamic field of continuous research and optimization.

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