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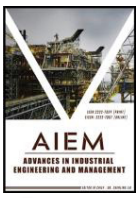

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ARTICLE

METHODOLOGY BASED ON A SWOT-DELPHY-CAME ANALYSIS FOR THE EVALUATION OF AUTOMATED CONTAINER TERMINALS IN PORTS

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ABSTRACT

The current trend, in terms of container terminal operations worldwide, describes an increase in the number of partially or fully automated terminals (3 per cent of all terminals worldwide). The methodology used, SWOT-DELPHI-CAME, is a new and little used methodology, of business origin, which helps in the decision making process. This methodology shows important or significant aspects of automated container terminals. The main conclusion is that cybersecurity, transparency or staffing are the main issues that currently arise when assessing an automated port terminal. Furthermore, the existence of an automated container terminal improves the port in terms of efficiency and competitiveness, and opens up new commercial expectations.

KEYWORDS

Port Container Terminal, Automation, Methodology, SWOT-DELPHI-CAME, Evaluation, Cybersecurity.

1. INTRODUCTION

The concept of Smart Port comes from Smart Cities and is mixed with concepts of Industry 4.0, which is also applied in the ports (Ports 4.0), where there is talk of automation of software and industrial systems [1,2]. In other words, knowledge and available resources are used, and with the help of Information and Communication Technologies (ICT), the aim is to improve quality of life, efficiency, innovation and competitiveness, all under the umbrella of sustainability, in terms of not compromising future needs in economic, governance, social and environmental aspects [3].

Due to the large number of port operations carried out daily, any improvement in the profitability of any aspect of the port sector will have a major impact on port planning and management. This is why the application of the Smart concept to this sector is particularly noteworthy, so that the term Smart Port has emerged and is of great interest to today's ports, as it is considered the basis for their future development and survival [4].

Today, we find ourselves on a world stage where the concept of transport and logistics has been revolutionised. Port infrastructures are scarce, energy consumption is fundamental, international regulations regulate climate change and pollution, and technology allows processes to be automated; all of this entails an economic and social change in business models. Technologies open up multiple opportunities and their advancement in the maritime transport sector is reflected, among others, in automated container port terminals [5].

A port terminal is defined as the set of physical elements (works and facilities) and activities (services and organizations) that allow man to take advantage of a more or less favourable place on the coast to perform operations of exchange of goods between land and sea traffic [6]. Thus, it is a critical element in the supply chain that must ensure the transfer of goods in the best conditions of speed, safety and economic and environmental efficiency [7].

The improvement objectives are to optimize the loading/unloading times of a ship, the horizontal transfer movements and the stacking movements of the containers, in terms of minimizing them and making them more competitive [8]. This means a shorter stay of the ship in port, a saving in dead time costs and a better productivity of the manpower and machinery available. All these systems, since the end of the last century, have been technologically improved, providing them, to a certain extent, with automated systems, data management systems and information management.

Initially, automation has focused mainly on the development of the horizontal transfer system between the dock and the yard, and also on the stacking of containers in the yard. But there are also new processes in which a certain degree of automation can be implemented, such as berths for ships, mooring services or even loading and unloading at terminals with railway connections.

There are two main types of terminals according to their degree of automation [9,10]: semi-automated and fully automated. Semi-automated terminals simply automate the container yard stacking system and leave the transfer system between the quay and the yard to manual means. However, the fully automated terminals have both processes fully automated, i.e. from ship unloading the containers are transported by automated means until they are stacked in the yard without manual intervention, both horizontal transfer and stacking, with automated equipment such as ASCs (Automated Stacking Cranes) and AGVs (Automated Guided Vehicles).

Due to the boom in world trade, port authorities are looking into ways of making existing facilities more efficient. One way to improve efficiency, increase capacity, and meet future demand is to use advanced technologies and automation in order to speed up terminal operations. In this paper, we design, analyze, and evaluate four different automated container terminal (ACT) concepts. These concepts include automated container terminals based on the use of automated guidance vehicles (AGVs), a linear motor conveyance system (LMCS), an overhead grid rail system (GR), and a high-rise automated storage and retrieval structure (AS/RS). We use future demand scenarios to design the characteristics of each terminal in terms of configuration, equipment and operations [11].

Since Rotterdam began automating its Europe Container Terminal (ECT) in 1984, more and more terminals have opted for systems that automate their processes to a greater or lesser degree [12]. In 2012 there were a total of 33 terminals with some degree of automation spread across Europe, Australia, the United States of America, Korea, Singapore, etc. Today, the number of automated or semi-automated terminals represents 3% of the total, i.e. the remaining 97% still use labour for the movement of goods through their terminals.

In Spain only Algeciras and Barcelona have some of their terminals with a partial degree of automation, but Valencia plans to implement this automation technology to its future terminal, and some hand terminals that are analysing their transformation, in different phases, to automation [13].

2. STATE OF ART

The first step of the digital transformation (first generation) was taken in the 1980s with the emergence of electronic data interchange (EDI) systems and the development of the first terminal operating systems (TOS), laying the foundation for automated terminal planning [14]. The adoption by operators of new handling technologies (sensors and laser technologies) and the integration of data obtained from them led to the establishment of automated terminals in the 1990s and in 2000 (second generation) [15]. The performance of the ports of Hong Kong and Singapore is close to meeting the definition of fifth generation criteria. On the contrary, in light of the majority of the evaluation criteria's performance, the ports of Busan and Shanghai are still behind the 5GP stage [16].

A container terminal is an important logistical node in the transport of containers, from giant container ships to smaller vessels, or changing modes of transport to trucks or trains [17]. Containers need to be loaded and unloaded at the terminal and temporarily stored before continuing their route. Normally all port operations are subdivided into different subsystems: ship loading and unloading, storage, land movements and interconnection. In addition, all administrative processes, documentaries, inspections, etc. must be considered. Although there is no defined standard in the configuration, the design of a port terminal is done thinking about low costs, higher speed, staff safety, cargo security and having the appropriate equipment.

Vessel traffic is a key element determining port safety and capacity. The growth of port calls and cargo can have implications in port operations. Decision makers need to take decisions to anticipate any future capacity drop or increase in nautical risks [18].

In order to achieve terminals that increasingly have to withstand a higher workload and be more competitive, it is necessary to improve cost and time efficiency and, in addition, high requirements in terms of safety at work and environmental sustainability must be achieved. This leads to the evolution and renovation of terminals and process automation. In logistics optimisation, two options are assessed, either to add new resources to the system or to optimise existing ones to the maximum. Resources are always very scarce and very expensive, so the trend is to reuse what you have and reduce process times and intermediate waiting times, which are usually the performance indicators. Basically, the objectives pursued are to minimize the permanence of ships in the port, minimize the permanence of the container in the port and reduce handling costs, both economic and time, all thinking about maximizing the operation of the terminal and make it more competitive with other terminals.

The use of new technologies to transform traditional port services into interactive and dynamic services, increasing their efficiency and transparency are the basis of the Smart Port concept [19]. The use of these technologies will allow the port system to walk hand in hand with data transport and big data systems, whose implementation will allow a complete transformation [20]. Digitization and automation of ports to reach 4.0 ports are currently two major drivers of change in port management systems [21].

In many aspects, many port automation systems have already been adopted, such as dynamic lighting on platforms, automatic license plate recognition, video surveillance, water and climate monitoring, etc. These measures are gradually becoming common in all terminals, although the idea remains when talking about automation in port terminals, that only refer to the complete suppression of human labour in the loading, unloading and storage of goods. In this sense, the opportunities for improving port and logistics operations, making better use of infrastructures and specialisation in these operations, require a high level of industrial and ICT technological development, robots, autonomous vehicles, electronic data analysis, artificial vision, virtual reality, e-commerce, integration with other modes of transport, international integration in the logistics chain, etc. And with this, a new aspect arises that must be kept in mind: cybersecurity, both in mechanical operations and in the protection against possible external attacks.

The paper titled "Cybersecurity Risks and Automated Maritime Container Terminals in the Age of 4IR" presents a case study of automated maritime container terminals (CTs). It has the aim of demonstrating that the risks derived from the use of technology associated with the Fourth Industrial Revolution (4IR) are both real and dangerous. The work explains the critical function of CTs in the global supply chain and outlines the economic and social consequences that could result if their operations were to be disrupted. The motivations of a range of threat-actors are presented, and it is established that there are feasible scenarios in which any one of the major threat-actor categories may wish to cause disruption at CTs. The vulnerabilities of yard cranes are investigated, and it is concluded that there are likely to be exploitable vulnerabilities in the industrial control system (ICS) networks used on these cranes. The paper argues that many CT operations are likely to be exposed to significant cyber-based risks and that this exposure will increase with the roll-out of further 4IR technologies unless appropriate control measures are implemented [22].

There is a wide range of technologies to achieve the objective of implementing a degree of automation in each of the subsystems that make up the terminal. At the berth, there are automatic mooring equipment and STS (Ship to Shore) cranes, capable of being operated by remote control. In the interconnection and storage of containers, equipment such as AGVs and ASCs, fully automated and 100% electric vehicles and unmanned cranes have been developed. In the reception and delivery of goods, sufficient technology is available to automate the entry and exit of vehicles from the terminal (OCR-Optical Character Recognition), as well as to facilitate the work of customs teams, through scanners and a fast geometry.

In the port of Manta (Ecuador), for the study of the development of the strategic plan, a methodology based on SWOT analysis supported by an expert criterion was used for the subsequent quantitative weighting in a Delphi panel [23]. A methodology that we improved in our article, because we added the CAME strategy analysis tool. This support tool serves to make decisions when dictating a business strategy against the results provided by the SWOT.

The application of strengths, weaknesses, opportunities and threats (SWOT) analysis to formulation of strategy concerned with the safe carriage of bulk liquid chemicals in maritime tankers. A qualitative investigation using SWOT analysis has been implemented successfully for ships that are designed to carry liquid chemicals in bulk. The originality of this study lies in the use of SWOT analysis as a management tool to formulate strategic action plans for ship management companies, ship masters and officers for the carriage of dangerous goods in bulk. With this transportation-based SWOT analysis, efforts were made to explore the ways and means of converting possible threats into opportunities, and changing weaknesses into strengths; and strategic plans of action were developed for safer tanker operation [24].

Other paper uses the BOT methodology [21], the analysis and diagnosis of automated container terminals has been approached using the BOT (Business Observation Tool) model. It is a management tool, an alternative to PESTEL (Political, Economic, Social, Technological, Ecological, Legal), which allows, through observation, for the initiation and recognition of those minimum elements that must be considered to formulate and implement the business idea. The model is based on the establishment of four main scenarios: Motivations and Capacities (resources) to advance, Establishment of the working group, Characterize and understand the development environment, and Macro-environment analysis; through which, the boundary is obtained and the conditions of the BOT analysis are carried out, identifying the conditioning factors of the automation in the terminals and requirements that must be raised to achieve automation in the ports.

3. METHODOLOGY

This study is based on a pooling of several experts from the port sector to determine the scenario of an automated container terminal with respect to different aspects of cargo management and transport strategy.

The SWOT analysis of a company allows the design of the strategy on which the company will be based to face its future in the short, medium and long term. It is a map through which the weaknesses, threats, strengths and opportunities of the organization are established. An internal and external analysis of the environment in which the activity is carried out to improve its profitability, operation and market positioning.

The experts are in charge of obtaining a diagnosis of the scenario being studied. A SWOT matrix has been elaborated as a means of prospecting, both in the internal part of the system (Weaknesses and Strengths) and the external part (Threats and Opportunities), considering the most important aspects according to their impact and probability of their occurrence. Later, the two to two relationships between the internal and external aspects of the SWOT matrix were evaluated numerically. All of this is done through the DELPHI method, which allows the experts' opinions to be weighted numerically. Finally, by making an analysis of the results it is possible to check which are the most relevant aspects, the least significant and the strategy that should be taken for the development of an automated container terminal (Figure 1).

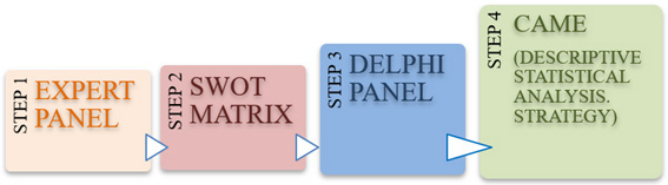

Figure 1: Methodological process.

3.1 Expert panel

In the expert group, before the SWOT analysis, the issues that may affect the development of an automated terminal have been examined. These experts are recognized within the industry to discuss the different aspects that can be included in the SWOT matrix. The experts, in addition to defining the aspects included in the SWOT, have scored the matrix in order to draw the conclusions and strategies to be followed by the terminals.

The experts are part of private companies related to the maritime sector, by the public company in charge of the Spanish port management, prestigious research and academic staff, and independent consultant assistant experts. Among all of them, in equal parts, they were given a share in the weighting of the aspects included in the SWOT.

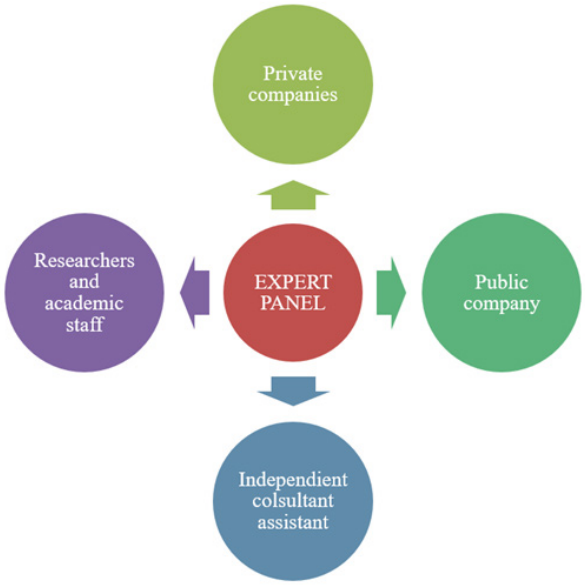

Figure 2: Expert panel.

3.2 Analysis SWOT

The SWOT methodology allows us to determine, in a consensual way between experts, the different aspects or possible scenarios for the implementation of an automated container terminal. Thus, we can analyse the four sections represented by a SWOT matrix; its Weaknesses and Strengths, from an internal analysis of the system itself; and its Threats and Opportunities, from the external point of view to the system. All this allows us to define the container terminal G-system, know how it is currently without automation and know how it can be affected when implementing automation.

The Strengths focus on the strong points that the system provides, that is, those characteristics that make the system consolidate the structure of which it is made, enhancing those aspects that stand out positively. On the contrary, the Weaknesses are the most delicate aspects to consider, that is to say, aspects that can tear down the system. It is necessary to keep them in mind in order to minimize them as much as possible.

Threats are elements outside the system, which may harm (seriously or to some degree) one or more actors who play a role within the system. This is something that must be prevented or minimised in order to avoid damage to the system. On the other hand, Opportunities are those events that can be used to improve and increase certain capacities that were not fully consolidated.

The development of the matrix has been treated under three considerations: socio-economic, environmental and operational, thus trying to encompass the main aspects involved in an automated terminal in a sustainable manner.

Figure 3: SWOT matrix.

3.3 Panel DELPHI

The DELPHI panel consists of a numerical weighting of the internal and external relations that exist in the SWOT matrix previously carried out. The relationships are scored in order to determine how automation affects a terminal and the strategy to follow.

Two to two aspects of the SWOT matrix have been related, one of internal character of the system with another external one, that is to say, Weaknesses are related to Threats and Opportunities; and Strengths to Threats and Opportunities. The weights should be integers between 1 and 5, with 1 being the lowest, meaning that it has little relationship; and 5 the highest, indicating that the relationship is high. The results of the answers of all the experts are put together in a single panel (Table 1.).

3.4 Analysis CAME

After having extracted the data from the DELPHI panel, with the descriptive statistics the results are processed and analysed. Each box corresponds to the geometric mean, which is the nth root of the product of all the numbers that intervene in it. Values are obtained that may be atypical within the results matrix (not concordant values, very low values with respect to those around them, etc.) [25].

From these results and conclusions, it is possible to assign the strategy to follow, that is, applying a CAME (Correct, Adapt, Maintain and Explore) model in terms of promoting the best aspects, minimizing threats, taking advantage of opportunities, correcting weaknesses, etc. (Table 2).

The analysis tool used in an article related to nursing residents, draws conclusions from the SWOT-CAME analysis that was used to set objectives to improve aspects of the nursing home based on experience, to draw lines for further development and to be able to improve future promotions [26].

Table 1: Description of the CAME analysis.

SWOT-CAME	Opportunities	Threats
Strengths	Potentiate-offensive (ex-ploit opportunities)	Evaluate-defense (main-tain strengths)
Weaknesses	Decide-reorient (correct weaknesses)	Know-survival (facing threats)

4. RESULTS

After having carried out the DELPHI analysis and putting them together in a single panel as a result, the following values have been obtained, which appear in the Figure 3, Figure 4.

Table 2: Aspects extracted from the SWOT.

Strengths	Threats
F1. Cost savings	A1. Technological dependence.
F2. Energy efficiency	A2. Other terminals.
F3. Improvement of personnel	A3. Shipowners' demands and trends.
F4. Transparency	A4. EU Regulation.
F5. Better yields	A5. Cyberattacks.
Weaknesses	Opportunities
D1. High economic investment	O1. Improved competitiveness.
D2. Conflicts with the stevedoring sector	O2. New business models.
D3. Rigidity and consolidation of operations	O3. Standardized criteria.
D4. Technological obsolescence	O4. Greater job security.
D5. Resistance to change	O5. Technological development.

	O1	O2	O3	O4	O5		A1	A2	A3	A4	A5		TOTAL
F1	4,8	3,4	3,0	2,9	3,7	17,8	2,8	3,0	2,6	2,0	1,5	11,8	29,6
F2	4,0	3,7	4,3	2,6	3,6	18,1	2,9	3,4	2,7	3,0	1,5	13,4	31,5
F3	3,9	3,1	2,0	4,8	3,2	17,0	3,4	3,8	2,0	2,6	1,3	13,1	30,1
F4	3,7	3,6	2,9	2,8	2,5	15,5	1,6	2,5	2,2	2,4	2,0	10,6	26,1
F5	4,8	3,3	3,2	2,7	4,3	18,3	4,3	4,1	2,6	2,3	1,9	13,2	33,6
	21,2	17,0	15,5	15,8	17,3	86,8	14,9	16,8	12,1	12,3	8,2	64,2	151,0
D1	4,3	3,5	2,8	2,7	4,6	17,9	4,1	3,8	3,9	2,0	3,8	17,7	35,6
D2	3,9	2,4	1,9	3,6	2,9	14,6	2,9	3,1	3,1	4,3	1,4	14,9	29,5
D3	4,1	4,1	2,8	2,7	3,6	17,4	4,3	4,2	3,1	2,6	2,1	16,3	33,7
D4	3,2	2,7	2,6	2,6	4,8	15,8	5,0	3,3	3,1	2,0	3,0	16,4	32,2
D5	4,1	3,4	2,6	3,1	3,7	16,9	2,8	3,5	3,2	2,4	2,5	14,4	31,3
	19,7	16,1	12,6	14,7	19,6	82,6	19,1	18,0	16,5	13,3	12,8	79,7	162,3
TOTAL	40,9	33,1	28,1	30,4	36,8	169,4	33,9	34,7	28,6	25,6	21,0	143,9	313,3

Figure 3: SWOT results by quadrants.

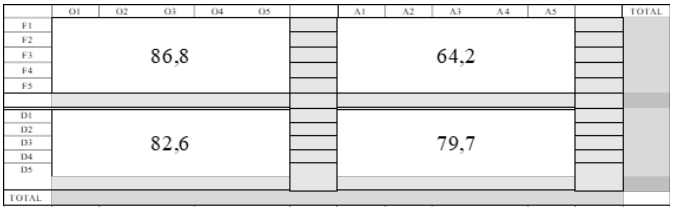

Figure 4: Results of the CAME-SWOT.

It is observed that the first quadrant, the one that relates Strengths with Opportunities is the one that obtains the greatest value, which applied to the CAME analysis supposes that the strategy to follow should be offensive, exploiting the opportunities that present themselves.

Also, the second quadrant, which corresponds to the relationship of Strengths with Threats, is the one with the lowest score. This means that they are points to be improved, to be considered in the face of factors that are to be corrected in the future. It supposes a defensive strategy against the change that is going to be carried out, but preserving its own strengths.

At the time of analysing the results, several outstanding values have been detected that can be commented.

In the first quadrant, the relationship F3 (Improvement of personnel) with O3 (Standardized criteria) has obtained a 2. Personnel are key when it comes to obtaining standardized criteria such as the so-called smartport, greenport, etc., which means that the personnel in an automated terminal should be more qualified personnel and prepared to work for the performance of their functions, and thus obtain international recognition of the terminal with the criteria mentioned above.

In the second quadrant, the relationship between F3 (Improvement of personnel) and A5 (Cyberattacks) obtained the lowest score of the entire panel, 1.3, highlighting the poor relationship between the two.

In the fourth quadrant, the relationship between D4 (Technological Obsolescence) and A1 (Technological Dependence) has obtained a 5 (which means that all experts have scored a 5 for this relationship). This means that the relationship is very high between technological obsolescence and dependence on an automated terminal. The world is evolving very fast and technologies are evolving at the same time, so the level of technology required by an automated terminal must always be among the most advanced, and must not remain out of step with other advances that arise continuously.

Finally, it should be noted that Threat 5 (Cyberattacks) obtained the lowest result of the entire panel. This means that the cyberattack is currently a critical point, an issue that must be considered as a priority, since problems in this sense have negative effects on the operation of the terminal, on the reliability of the goods or on the security of the information handled. As was the case of Maersk in 2017, in which the Danish company suffered a cyberattack that caused losses between 171 and 256 million euros, affecting mainly APM Terminals, Maersk Line and Damco, where it was noticed significantly in the two-week volumes in July 2017.

As a result of the CAME, the methodology used shows the strategy to be followed by the terminal, either to implement the automation, or to maintain or improve it, or not to implement it. The CAME serves as a

starting point for future decision making.

Finally, this methodology shows the strategy that a container terminal must follow in order to become a semi or automated terminal. This requires heavy investments in equipment, as these are expensive, and an improvement in personnel, making it even more qualified. Also, this methodology shows us the route of improvement in terms of network security, since cybersecurity is a global issue, large companies invest a lot of capital in optimizing their processes and systems, and especially in software that prevent access to their databases.

5. CONCLUSIONS

Several conclusions are highlighted in this study. Firstly, it is found that the methodology used provides results that are fairly agreed upon with the experts. These experts have made it possible to define and evaluate the importance and consequences of automatic container terminals. Thanks to the forward-looking combination of the SWOT method and the cross-evaluation of concepts, the results give a fairly accurate picture of the subject matter. It would thus be possible to associate actions to correct weaknesses or strengthen strengths, depending on the objectives set.

There are three main lines of action in a container terminal: 1. Cybersecurity. This is one of the elements most valued by experts. As it did not exist before, it requires an effort of adaptation to implement it throughout the operation and maintain its good functioning without compromising other functionalities. Hackers always try to get hold of information in order to be able to negotiate with it, or sometimes they try to bring the system down in order to paralyze the entire operation. 2. The staff. The issue of personnel is fundamental. On the one hand, it makes the working conditions for the handling of goods much safer, more precise and specific. On the other hand, the reduction of human personnel may conflict with the interests of the stevedoring sector, which should be much more specialized and focused on control tasks. Currently, the stevedoring sector has a great deal of power in the terminals, as it is an important pillar of daily operations.

Transparency. The third strength of automation is to achieve greater transparency of information on many documentary, administrative, management and other processes taking place in the port terminal. This directly affects the exchange of data by the operator, as it can facilitate optimal and improved operational analysis.

Through transparency, a greater involvement of economic agents must be achieved, so that, together with a regeneration of the personal scenario, the benefits of automation can be obtained.

The critical point for the success of the implementation is in the socio-cultural factors. Full automation will only be possible through dialogue and communication with the unions, involving them in the project and providing them with the information and training necessary for their retraining, so that workers acquire the necessary skills in accordance with their abilities.

Of course, the existence of an automated container terminal improves the port in terms of efficiency and competitiveness, and opens up new commercial expectations. But the high investment costs mean that it does not have to be the only alternative to improving the port.

Currently, the most consolidated operational ratios are those of the automated terminals, as they allow uninterrupted operation in days of even 24 hours.

REFERENCES

[1] Fernández, P., Santana, J., Ortega, S., Trujillo, A., Suárez, J., Domínguez, C., Sánchez, A. Smart port: A platform for sensor data monitoring in a seaport based on FIWARE. Sensors (2016) 16(3): 417.

[2] González, A.R., González-Cancelas, N., Serrano, B.M., Orive, A.C. Smart ports: Ranking of Spanish port system. World Scientific News (2020) 144: 1-12.

[3] UNE 178201. Ciudades inteligentes. Definición, atributos y requisitos (2016).

[4] Belfkih, C.D., Sadeg, B. The Internet of things for smart ports: Application to the Port of Le Havre. In International Conference on Intelligent Platform for Smart Port (2017).

[5] CTN 178 ciudades inteligentes. UNE Asociación Española de Normalización.

[6] Camarero, A., González, N. Cadenas integradas de transporte. Fundación Agustín de Betancourt (2006).

[7] Woo, S.H., Pettit, S., Beresford, A.K. Port evolution and performance in changing logistics environments. Maritime Economics & Logistics (2011)13(3): 250-277.

[8] Zeng, Q., Yang, Z. Integrating simulation and optimization to schedule loading operations in container terminals. Computers & Operations Research (2009) 36(6): 1935-1944.

[9] Manzey, D., Reichenbach, J., Onnasch, L. Human performance consequences of automated decision aids: The impact of degree of automation and system experience. Journal of Cognitive Engineering and Decision Making (2012) 6(1): 57-87.

[10] Balogh, I., Ohlsson, K., Hansson, G.Å., Engström, T., Skerfving, S. Increasing the degree of automation in a production system: consequences for the physical workload. International Journal of Industrial Ergonomics (2006) 36(4): 353-365.

[11] Liu, C.I., Jula, H., Ioannou, P.A. Design, simulation, and evaluation of automated container terminals. IEEE Transactions on Intelligent Transportation Systems (2002) 3(1): 12-26.

[12] Hentschel, M., Ketter, W., Collins, J. Renewable energy cooperatives: Facilitating the energy transition at the Port of Rotterdam. Energy Policy (2018) 121: 61-69.

[13] Martín-Soberón, A.M., Monfort, A., Sapiña, R., Monterde, N., Calduch, D. Automation in port container terminals. Procedia-Social and Behavioral Sciences (2014) 160: 195-204.

[14] Boer, C.A., Saanen, Y.A., Gunther, H.O., Kim, K.H., Kopfer, H. Testing, tuning and training terminal operating systems, a modern approach. In Proceedings of the International Conference on Logistics and Maritime Systems (LOGMS), Bremen, Germany (2012) 25-35.

[15] Heilig, L., Schwarze, S., Voss, S. An analysis of digital transformation in the history and future of modern ports. In Proceedings of the 50th Hawaii International Conference on System Sciences, Hawaii, HI, USA (2017).

[16] Lee, P.T.W., Lam, J.S.L., Lin, C.W., Hu, K.C., Cheong, I. Developing the fifth-generation port concept model: An empirical test. Int. J. Logist. Manag (2018) 29: 1098-1120.

[17] Camarero, A., González-Cancelas, N. Logística y transporte de contenedores. Fundación Agustín de Betancourt (2007).

[18] Olba, X.B., Daamen, W., Vellinga, T., Hoogendoorn, S.P. Multi-criteria evaluation of vessel traffic for port assessment: A case study of the Port of Rotterdam. Case Studies on Transport Policy (2019).

[19] Heilig, L., Lalla-Ruiz, E., Voß, S. Digital transformation in maritime ports: analysis and a game theoretic framework. Netnomics: Economic Research and Electronic Networking (2017) 18(2-3): 227-254.

[20] Heilig, L., Voß, S. A holistic framework for security and privacy management in cloud-based smart ports. In 15th International Conference on Computer and IT Applications in the Maritime Industries-COMPIT '16, Lecce Italy (2016).

[21] Orive, A.C., Santiago, J.I.P., Corral, M.M.E.I., González-Cancelas, N., Strategic analysis of the automation of container port terminals through BOT (Business Observation Tool). Logistics (2020) 4(1): 3. https://doi.org/10.3390/logistics4010003

[22] Beaumont, P. Cybersecurity risks and automated maritime

container terminals in the age of 4IR. In Handbook of Research on Information and Cyber Security in the Fourth Industrial Revolution, IGI Global (2018) 497-516.

[23] Párraga, M.M., Gonzalez-Cancelas, N., Soler-Flores, F. DELPHI-SWOT tools used in strategic planning of the Port of Manta. Procedia-Social and Behavioral Sciences, (2014) 162: 129-138.

[24] Arslan, O., Er, I.D. SWOT analysis for safer carriage of bulk liquid chemicals in tankers. Journal of Hazardous Materials (2008) 154(1-3): 901-913.

[25] Awad-Núñez, S., González-Cancelas, N., Camarero-Orive, A. Application of a model based on the use of DELPHI methodology and multicriteria analysis for the assessment of the quality of the Spanish Dry Ports location. Procedia-Social and Behavioral Sciences (2014) 162: 42-50.

[26] Gutiérrez, I.L., Hernando, B.S., Quiñones, M.G., Gonzalo, C.G., Hernández, M.C. S. Análisis CAME-DAFO del primer semestre como residentes de enfermería familiar y comunitaria. Metas de Enfermería (2013) 16(5): 62-66.

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