

Camarero Orive, Alberto; Parra Santiago, José Ignacio; Esteban-Infantes Corral, María Magdalena; González-Cancelas, Nicoletta

Article

Strategic analysis of the automation of container port terminals through bot (business observation tool)

Logistics

Provided in Cooperation with:

MDPI – Multidisciplinary Digital Publishing Institute, Basel

Suggested Citation: Camarero Orive, Alberto; Parra Santiago, José Ignacio; Esteban-Infantes Corral, María Magdalena; González-Cancelas, Nicoletta (2020) : Strategic analysis of the automation of container port terminals through bot (business observation tool), Logistics, ISSN 2305-6290, MDPI, Basel, Vol. 4, Iss. 1, pp. 1-14,
<https://doi.org/10.3390/logistics4010003>

This Version is available at:

<https://hdl.handle.net/10419/310098>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by/4.0/>

Article

Strategic Analysis of the Automation of Container Port Terminals through BOT (Business Observation Tool)

Alberto Camarero Orive *, José Ignacio Parra Santiago,
María Magdalena Esteban-Infantes Corral and Nicoletta González-Cancelas

Department of Transport Engineering, Urban and Regional Planning; Universidad Politécnica de Madrid, 28040 Madrid, Spain; joseignacio.parra.santiago@alumnos.upm.es (J.I.P.S.); magdalena.estebanic@gmail.com (M.M.E.-I.C.); nicoleta.gcancelas@upm.es (N.G.-C.)

* Correspondence: alberto.camarero@upm.es

Received: 18 December 2019; Accepted: 31 January 2020; Published: 4 February 2020



Abstract: The port system is immersed in a process of digital transformation towards the concept of Ports 4.0, under the new regulatory and connectivity requirements that are expected of them. As a result of the changes that the industrial revolution 4.0 is imposing, based on new information technologies and the change of energy model, the electrification of modes of transport from alternative energies and the total digitalization of the processes is occurring. This conversion to digital, intelligent, and green ports requires the implementation of the new technologies offered by the market. The inclusion of these enabling tools has allowed the development of automated terminals under a functional approach. This article aims to offer the responsible entities a new methodology (BOT) that allows them to successfully undertake the automation of terminals, taking into account the reality of the conditions of the environment in which they are developed. By quantifying the factors that facilitate or impede implementation, it will be possible to determine the strategy to be followed and the necessary measures to be adopted in the project; constituting, therefore, a novel management and planning tool.

Keywords: container automated terminals; BOT; strategy; automation

1. Introduction

Automated container port terminals have proliferated since the Europe Container Terminals (ECT) in Rotterdam, which began to be automated in 1984 [1]. Automation carried out in existing and operational terminals (brownfield) and in new terminals (greenfield), such as Total Terminal International (TTI) Algeciras, inaugurated in 2010, found a solution adopted in the Global Container Terminal (New York/New Jersey). Thus, there are currently around 60 automated terminals in the world, mainly in Europe and Asia, with forecasts to reach 200 in the next 5 years [2], among which are the new container terminal at the port of Valencia and the incorporation of eight automated RTG (Rubber Tyred Gantry Crane) in the container terminal of Belfast (BCT), turning it into a semi-automated terminal.

Although the automation process is not exclusive to container terminals, the intrinsic characteristics of these terminals, such as their high degree of specialization and standardization (both in the transport element and in the way of handling the goods), and technological advances have protected the development of a high degree of automation in the equipment and processes of these facilities [3]. These characteristics, together with the increase in competition in the port industry, have encouraged the development of automated terminals with the aim of reducing operating costs (OPEX), mainly in terms of labor, and seeking improvements in terms of productivity, safety, and environmental sustainability.

However, it is also true that in some terminals the productivity can be reduced after automation due to inadequate phase-in.

Therefore, the objectives of this article are to use a methodology (Business Observation Tool (BOT)) to help automated terminals develop their short- and long-term strategies and to answer research-related questions, such as “What characteristics are needed to be considered for the implementation of automation in a terminal?”.

2. Types of Automated Terminals

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) [4], laying the foundation for automated terminal planning. 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) [5]. 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 [6].

The concept of “automated terminal” was coined after the commissioning, in 1993, of ECT Delta Terminal in the Port of Rotterdam, referring to the terminal in which operations relating to yard movements, storage equipment, and quay–patio interconnection have been automated [7].

According to the different degrees of automation of the main movements (yard, dock-yard) the terminals are classified into automated, semi-automated and manual terminals. A semi-automated terminal will be one in which the storage or interconnection equipment is automated. However, the term “semi-automatization” is also associated with the management of equipment by assisted control or the systematization of some of the functions of the equipment by means of minor or partial automatizations [3].

Following this classical classification, Figure 1 presents the main automated terminals, which are numbered according to the chronological order of operation. Based on this chronology, Table 1 shows the automation technology and the handling equipment used by them, such as ARMG (Automated Rail Mounted Gantry), C-ARMG (Cantilever ARMG), ASC (Automated Stacking Crane), ARTG (Automated Rubber Trued Gantry Crane), or AGV (Automated Guide Vehicle).

The terminal column represents the name (company) and country of the study terminal; the equipment column represents the set of equipment that make up the terminal; and the type column represents the type of terminal according to its degree of automation, (A) being the fully automated and (S) being the semi-automated.

The traditional conception of an automated terminal responds to the use of automated equipment mainly in the storage subsystem and in the interconnection subsystem. However, the delivery and reception system is where the highest degree of automation has been implemented, particularly in processes such as container and truck identification or weighing [8].

Finally, the loading and unloading system, in which the docking subsystem may be included, is the least automated. Although there are terminals that use STS cranes (Ship To Shore gantry crane) in the ship-to-shore operation, as is the case in the Rotterdam World gateway and APM Terminal Maasvlakte II terminals in Rotterdam [9]. Similarly, mooring is also subject to the replacement of moorers through the use of vacuum systems or adhesion to the hull, an example of this system was installed, for the first time in Europe, in 2013 in a mineral terminal in the port of Narvik, Norway.

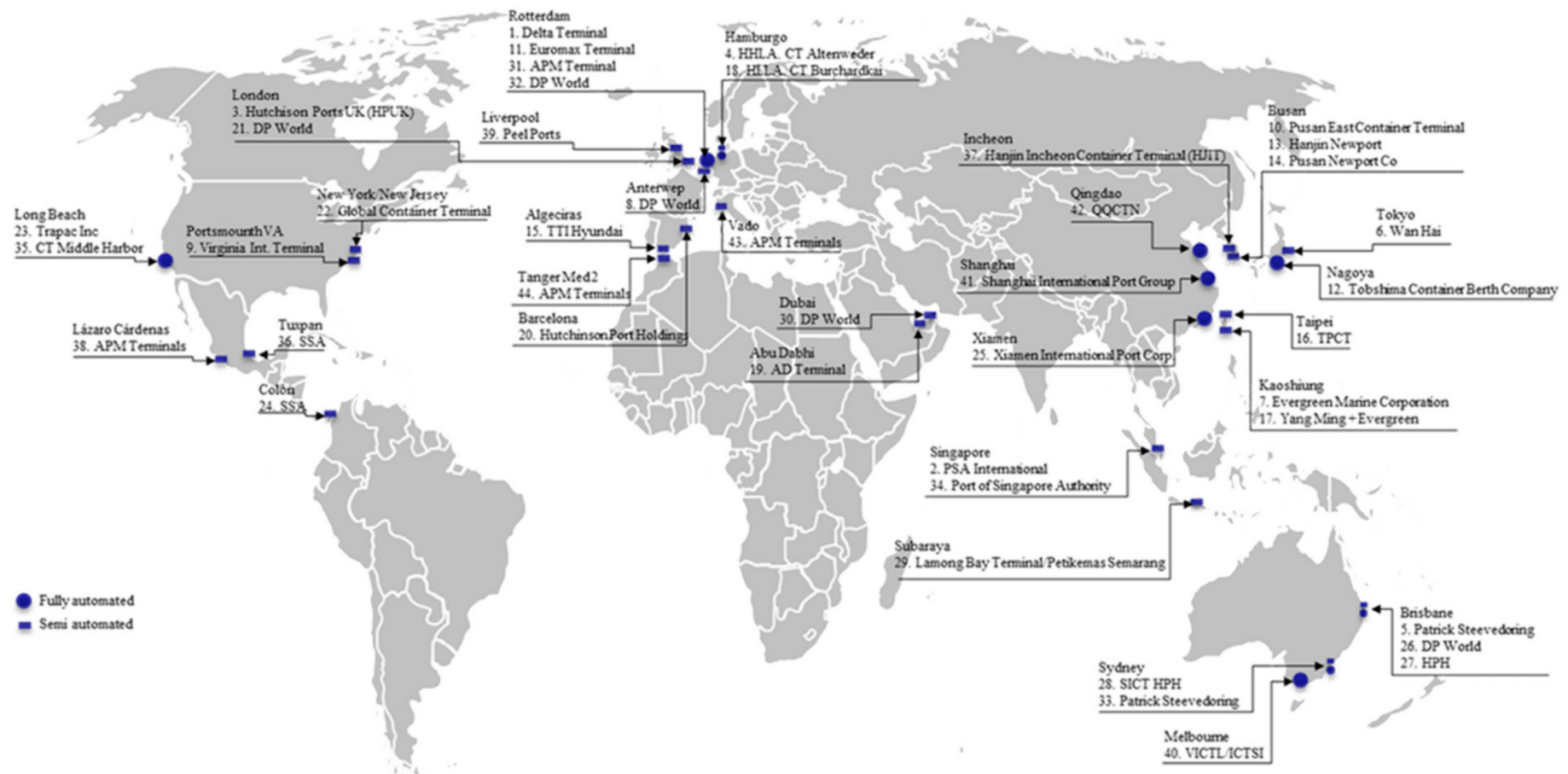


Figure 1. Main automated and semi-automated terminals in the world.

Table 1. Main automated (A) and semi-automated (S) terminals in chronological order.

Terminal	Equipment	Type
ECT Europa Container Terminal –Rotterdam. Delta Terminal (1993)	137 ARMG / AGV	A
PSA International—Singapur. Pasir Panjang Terminal (1997)	15 OHBC Manual tractor (M.T.) + chassis	S*
Hutchison Ports UK (HPUK)—London Thamesport (2000)	18 ARMG M.T. + chassis	S
HHLA—Hamburg. CT Altenwerder (CTA) (2001)	52 ARMG / AGV	A
Patrick Stevedoring—Brisbane. Fishermans Island Terminal (2002)	27 Auto SC / Auto SC	A
Wan Hai—Tokyo. Ohi Terminal (2003/06)	8 CARMG M.T. + chassis	S
Evergreen Marine Corporation—Kaoshiung. Evergreen Marine Terminal (2005)	6 CARMG M.T. + chassis	S
DP World—Amberes Antwerp Gateway (2007)	14 ARMG / ShC manual	S
Virginia International Terminal (VIT)—Portsmouth. VA Virginia int. Gateway (2007)	30 ARMG Manual cassettes	S
Pusan East Container Terminal—Busan. Korean Express Brusan CT (2007)	6 ARMG M.T. + chassis	S
ECT Europa Container Terminal—Rotterdam. Euromax terminal (2008)	58 ARMG / AGV	A
Tobshima container berth (TCB) company—Nagoya. Tobishima Pier South (2008)	12 ARTG AGV	A
Hanjin Newport—Hyundai Merchant Marine—Busan. Pusan Newport (2009/10)	41 + 36 ARMG M.T. + chassis	S
Pusan Newport Co (DP World)—Busan. Pusan Newport (2009/12)	32 + 38 CARMGM.T. + chassis	S
TTI Hyundai—Algeciras. Isla Verde (2010)	32 ARMG / ShC manual	S
TPCT—Taipei Port Container Terminal (2010)	40 CARMG M.T. + chassis	S
Yang Ming+Evergreen—Kaoshiung. Kao Ming Container Terminal (2010/11)	22+40 dual CARMG M.T. + chassis	S
HHLA—Hamburg. CR Burchardkai (CTB) (2010/17)	15—12 ARMG SHC manual	S
AD Terminals—Abu Dhabi. Khalifa Container Terminal (2012)	42 ARMG / ShC	S
Hutchinson Port Holdings—Barcelona. BEST (2012)	48 ARMG / ShC	S
DP World—London Gateway 1,2/3 (2013/2016)	40 + 20 ARMG / ShC	S
Global container Terminal—New York/New Jersey. Global Terminals (2014)	20 ARMG ShC	S
Trapac Inc - Long Beach. Trapac (2014)	27 ARMG/ ShC	A
SSA—Colón Manzanillo Int. Terminal (2014)	22 ARMG	S
Xiamen International Port Corp—Xiamen. Halcang + Fujijang (2014)	16 ARMG / 18 AGV	A
DP WOrld—Brisbane (2014)	14 ARMG / ShC	S
HPH—Brisbane Container Terminal (2014)	12 ARMG / ShC	S
SICT HPH—Sydney Inter. Container Terminal (2014)	12 ARMG / ShC	S
Lamong Bay Terminal/Petikemas Semarang—Surabaya. Pelindo III (2014/16)	20 ARMG + 11 ARTG	S
DP World—Dubai. Jebel Ali Container Terminal 3/4 (2014/18)	60 + 35 ARMG	S
APM Terminal—Rotterddam. APMT Maaskvlakte II (2015)	54 ARGM 36+Lift AGVs	A
DP/World—Rotterdam World Gateway (2015)	32 ARMG / AGV	A
Patrick Stevedoring—Sydney Autostrad (2015)	44 AutoSC / AutoSC	A
Port of Singapur Authority—PSA PPT 3-1a T%, 3-1b, 3-2b (2015/2016)	22+34+72 CARMG M.T. + chassis	S*

Table 1. Cont.

Terminal	Equipment	Type
Long Beach CT Inc.—CT Middle Harbor (2016)	32 ARMG	A
SSA Mexico—Tuxpan Port Terminal (TPT) (2016)	8 ASC / M.T. + chassis	S
Hanjin Incheon Container Terminal—Incheon (2016)	14 ARMG	S
APM Terminals - Veracruz Lázaro Cárdenas T2 (2016)	22 ARMG	S
Peel Ports—Liverpool2 (2016)	22 CARMG	S*
VICTCL/ICTSI—Melbourne. Victoria Int. CT (2016/17)	32 ARMG / 11 AutoShC	A
Shanghai International Port Group—Shanghai. Yangshan Fase 4 (2017)	40 ARMG / 50 AGV	A
QQCTN—Qingdao. Qianwai CT (2018)	38 ARMG / 38 AGV	A
APM Terminals—VADO. Liguere (2019)	21 ARMG M.T. + chassis	S
APM Terminals—Tanger Med 2 (2019)	32 ARMG / ShC	S

* Ports with semi-automatic terminals but with equipment they use for experiments. Source: Own elaboration with data from “Puertos del Estado”.

A paper investigates crane scheduling problems for a new type of automated container terminal system, which is based on multi-storey frame bridges. For the new design concept, the paper studies how to schedule two types of cranes, i.e., quay cranes and bridge cranes that transfer containers between different storeys [10]. Another paper makes an explorative study to identify the challenges and opportunity for it to be applied in transshipment hubs [11].

Most of the operational problems in container terminals are strongly interconnected. A paper study of the integrated Berth Allocation and Quay Crane Assignment Problem in seaport container terminals can be found in [12].

3. Methodology

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.

In this article, the BOT methodology has been used as an alternative to traditional analyses such as PESTEL or the development of the SWOT (Strength-Weaknesses-Opportunities-Threats) matrix. The use of this tool allows us to establish the current scenario on which to act to achieve a correct implementation of port terminals, addressing and considering both micro and macro environmental aspects.

This article is the first inclusion of the BOT methodology in the port sector. The possibility of being used as a tool for strategic decision making has been cited in the hotel sector to study its economic and financial viability [13] and to analyze the inherent risks; and in the construction of an entrepreneurial culture in Ecuador [14].

The BOT. is a tool that is widely used in the business sector, but can be applied to any sector, provided that the methodology defined by the BOT. is used correctly. It is therefore applicable in the port sector when terminal operators make decisions to automate (to a greater or lesser degree) their port terminals.

3.1. Step 1: BOT Analysis

Based on the state of the art, description of the BOT analysis in a figure, with the four qualities to be studied within the analysis and how they relate to each other (Figure 2).

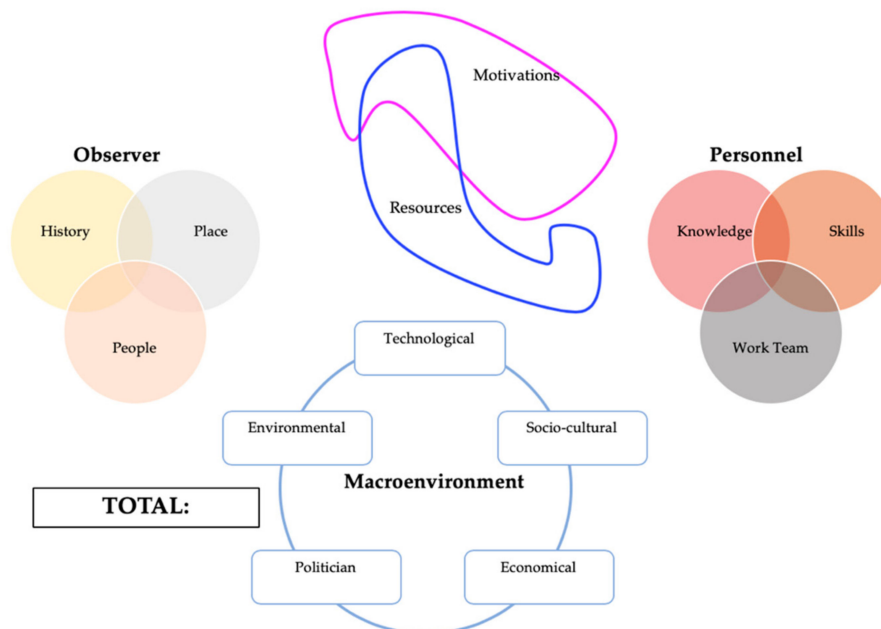


Figure 2. Business Observation Tool (BOT) Analysis. Source: own elaboration based on slideshare.net Álvaro Morales.

3.1.1. Motivations and Resources to Advance

Motivations and resources are usually the most important scenarios. Therefore, they usually allow the viability of the project and to be able to execute it with a high impact. The development of the project requires determining the motivation to opt for such a solution and the study of available resources for which the following questions must be answered: What is the motivation to develop the project and do it with a high impact? What resources are available to develop this project?

3.1.2. Establishment of the Working Team

Through the analysis of the composition of the labour network, taking into account both the knowledge and skills of each agent involved (port operators and agents related to port operations) and the shortcomings they may have to carry out the plan, the work teams are configured, determining the needs and requirements of the team members, in order to achieve the success of the project. In other words, this scenario must respond to What are and how can the talents of each team member be harnessed in favor of the project?

3.1.3. Characterize and Understand the Development Environment

The understanding of the environment, thanks to the determination of those external factors that indicate its implementation and development, facilitates the establishment of the implementation mechanism and strategies. Their determination is addressed by answering the following question: What external characteristics to the project can alter decisions and strategies formulated in the future?

3.1.4. Macroenvironment Analysis

The study of the macroenvironment, also known as the generic environment, is based on obtaining those technological, socio-cultural, economic, political and environmental factors that may condition

or intervene in the achievement of the project: What characterizes the observed environment; and; How it can be used to favor the project?

3.2. Step 2: Selection of Indicators

Once the scenarios that make up the analysis have been completed, the indicators with the greatest impact on the business model are selected to measure the activity of the automated operations.

Table 2 presents the indicators selected to characterize the four scenarios.

Table 2. Definition of the characterization indicators based on BOT scenarios.

Scenarios	Indicator	Definition
Motivations	Operational improvement	Increased productivity, thanks to a better occupation and layout of the yard and the development of methodical and orderly operations. Faced with these improvements, the little flexibility they present requires the establishment of mechanisms to facilitate decision-making in unscheduled situations.
	Economic profitability	Reductions in operating costs should allow the high initial investment required to be amortized.
	Safety	The elimination of the human factor makes it possible to reduce errors in the handling of goods, and therefore, an increase in safety.
	Sustainability	Sustainability criteria established in the port system, need to decouple the growth of the sector with the negative effects on the social environment and the environment
Resources	Institutional support	Organisms and public entities advocate for the transformation and incorporation of new technologies in order to achieve a more competitive system.
	Economic agents	Cross investment confluence
	Enabling tools	Availability in the market of the necessary technology.
Knowledge	Experience	Personnel not equipped with experience in the performance of new roles
	Formation	Inadequate and obsolete in the face of new needs
	Information	Lack of access to correct information
Skills	Flexibility	Difficulty adapting, reacting and responding. The flexibility comes from a cooperative agreement between the terminal operator and the liner shipping company [15].
	Goods handling	Interference of operations. Automation allows to reduce the number of housekeeping movements.
	Incident management	Align people with the strategy, communication between the various members and between all levels of the organization
Work Team	Implication	Inclusion and internalization of the project
	Communication	Align people with the strategy, communication between the various members and between all levels of the organization.
	Information processing	Exchange of documents in physical and digital format, with a multitude of interfaces between sender and recipient
History	Paradigm shift	Evolution of the "Port" concept
	Ports 4.0	Digital, intelligent and smart ports
	Technological Incorporation	Transposition of technology applied to other sectors (blockchain)
People	Multiplicity of agents	Port community conformed of private and public agents.
	Acceptance of change	Opposition of stevedoring personnel to automation
	Collaboration between agents	Disparate objectives that do not converge, resulting in a conflict of interest [16]
Place	Link in logistics chains	Acceptance of the port as a node in the logistics chain, eliminating bottlenecks.
	Maturity of the port system	Consolidation of ports
	Transparency	System opacity

Table 2. Cont.

Scenarios	Indicator	Definition
Technological	Technological maturity	Solid fundamentals and verified developed solutions
	Obsolescence	Emergence of new technologies as a result of research
	Implementation mechanisms	Lack of protocols and methodology to facilitate the implementation of technology
	Research	Research initiatives must be accompanied by pilot tests certifying their adequacy.
Socio-cultural	Training of personnel	Unskilled personnel
	Support for trade union strength	The current union strength in the ports and their reluctance to change is a handicap for the adoption of automated terminals.
	Reconversion	The change in the management model of the terminals implies a reconversion of the workers to technological profiles
	Safety	The elimination of the human factor in operations means an increase in safety, however, in many terminals today people interact with automated and manual equipment, increasing the probability of error
Environmental	Decarbonization	The European Environment Agency (EEA) [17] estimates that shipping has increased its greenhouse gas emissions by 22% from 1990 to 2016. Faced with this increase, the OECD (Organization for Economic Cooperation and Development) has established measures supported by the use of new technologies to achieve the decarbonization of maritime transport by 2035 [5].
	Reduction of externalities	Negative externalities, such as congestion, accidents and pollution (atmospheric, acoustic, and visual) can be mitigated with the implementation of automated terminals due to the more rational use of space, the use of electrical equipment, and the programming of removal operations in such a way that they do not intervene in the operation of the terminal.
	Energy efficiency	Many ports and terminals endeavor to enhance energy efficiency as energy prices have increased through years and climate change mitigation is a key target for the port industry [18].
Political	Institutional Impulse	Organisms and public entities advocate for transformation.
	Regulatory requirements	Hardening of regulations
Economical	Lobbies	Faced with the possibility of a new economic slowdown and the risk of implementing automated terminals, investments have been reduced.
	Financing	Search for alternative financing
	Community aid	European funding with high requirements for its granting.

Source: Own elaboration.

3.3. Step 3: Qualitative-Quantitative Analysis

Qualitative-quantitative analysis will be carried out on the basis of the selected indicators. Depending on the scope or level of the achievement of each indicator considered, each indicator will be scored qualitatively and quantitatively. These scores will be made by a group of experts in the sector in which they score the indicator according to the ratio and impact required for automation:

- High degree of achievement: “High”—5
- Medium range: “Medium”—2.5
- Low range: “Low”—1

The quantification of each indicator and, therefore, of each scenario, through its weighting, forms the basis on which strategic decisions must be taken for the implementation and achievement of objectives.

4. Expected Results and Discussion

4.1. BOT Analysis

4.1.1. Motivations and Resources to Move Forward

Ports are subject to new requirements in terms of sustainability, costs, safety, and efficiency. In order to meet these requirements and maintain their competitiveness, they must evolve and move towards the concept of Port 4.0. This conversion involves, among other measures, the automation of processes.

The automation of port terminals is motivated by the benefits obtained from this process, such as a reduction in operating costs (OPEX), mainly due to a reduction in the workforce, an increase in terminal safety, or environmental benefits, as these are terminals with a higher density of containers that make better use of space and operate with electrical equipment.

Additionally, there are high investment costs associated with automation compared with traditional settings.

In order to carry out the automation of the processes, institutional support is available, as well as the desire of the Port Authorities and national and international bodies required to implement them, the interest of economic agents and operators in investing in new developments, and the tools and enabling technologies that the market offers to undertake the project.

4.1.2. Establishment of the Working Group

The achievement of the objectives lies in the involvement of the many agents, both public and private, in the fluidity of the data transmission between them, and in the processing and handling of this information. This requires a reconversion of the labor network, since the personnel do not have the necessary qualification and experience for the new technological developments.

4.1.3. Characterize and Understand the Development Environment

Since 2010 we have been in the third generation, which is based on a more efficient exchange of information and the integration of intelligent procedures, allowing a conversion of the concept “Smart port” to “Ports 4.0”. (Connected ports with high digitalization and sensorization).

The transformation of the port system requires greater transparency [19] and collaboration between the agents involved, starting by assuming and internalizing the need for change and regeneration.

4.1.4. Macro-Environment Analysis

- **Technological.** The automation and rationalization of port procedures has been made possible by digitalization and the integration of information technologies (IT) and innovative information systems (IS). The dynamism of the technological industry requires the establishment of implementation mechanisms that allow the inclusion of the new tools available and adaptation to new developments arising from research, such as the inclusion of autonomous vessels [20].
- **Socio-cultural.** In a sector with an important trade union strength, the automation of the terminals causes a social conflict, as it implies a reduction in the traditional required labor force.
- **Economical.** The Spanish port system has established a plan to boost entrepreneurship for innovation in the port sector, endowed with a fund of 25 million euros [21]. On the other hand, the European Sea Ports Organization, ESPO, has developed the “Connect Europe” program (2021-2028), with the aim of financing new port developments. Within this program, it is estimated that European ports will have investment needs of around 48,000 million euros between 2018 and 2027, caused by external factors such as the growth of trade flows, new trends in the maritime industry, decarbonization, digitalization, automation, urban development, and security [22].

- Political. Political actors and institutions advocate the incorporation of automation in maritime transport.
- Environmental. The European Union aims to reduce greenhouse gas emissions [23] through a change in energy models, so decarbonization will be a key element for maritime transport [24].

4.2. Qualitative-quantitative Analysis

Based on the observed reality, we proceed, taking into account the degree of implementation, to score each selected indicator (Table 3).

Table 3 represents the score made in the Delphi panel by a group of six experts in the field, which is made up of members of the public, private, and R+D+i company. The experts had to score from 1 to 5 the importance of the indicator according to its importance within the study.

Figure 3 presents the results obtained for each scenario, which allows us to identify the aspects that require more attention.

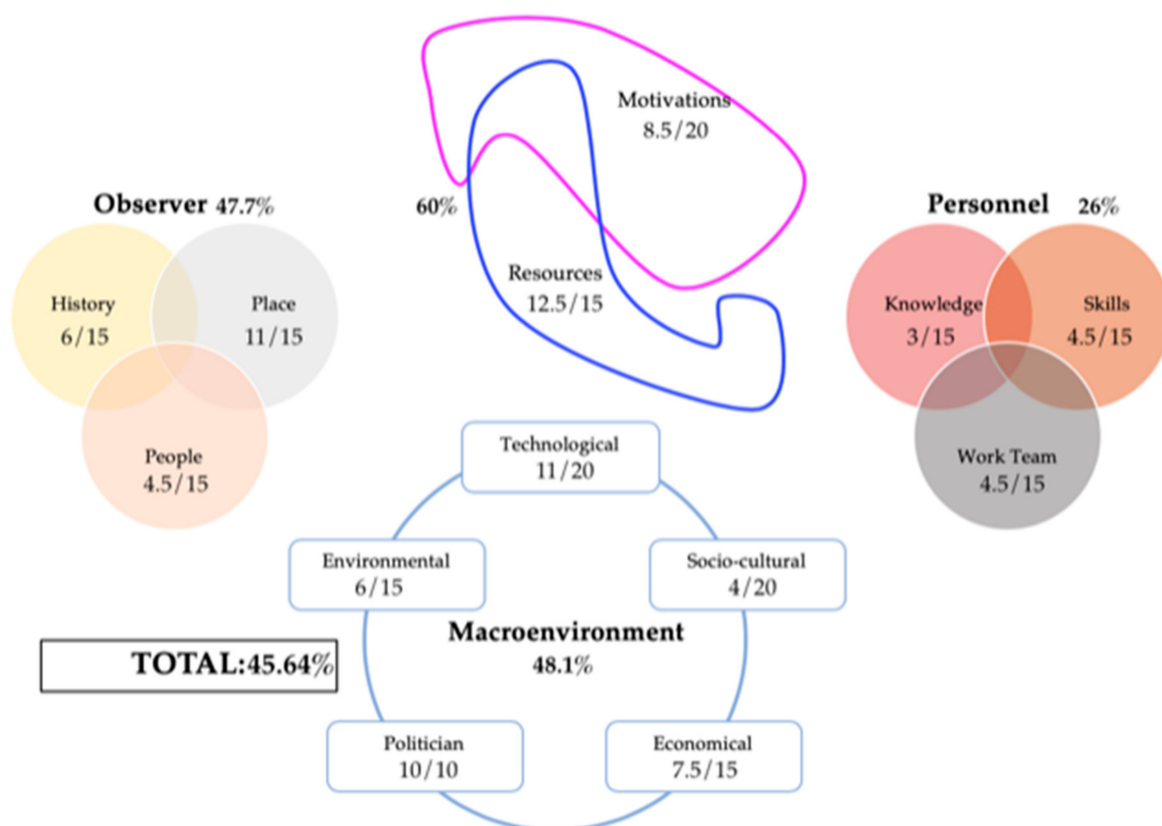


Figure 3. BOT analysis results. Source: Own elaboration based on slideshare.net Álvaro Morales.

Table 3. Score of the indicators.

sTAGE	Indicator	Qualitative	Quantitative
Motivations	Operational improvement	Medium	2.5
	Economic profitability	Medium	2.5
	Safety	Low	1
	Sustainability	Medium	2.5
Resources	Institutional support	High	5
	Economic agents	Medium	2.5
	Enabling tools	High	5
Knowledge	Experience	Low	1
	Formation	Low	1
	Information	Low	1
Skills	Flexibility	Low	1
	Goods handling	Medium	2.5
	Incident management	Low	1
Work Team	Implication	Low	1
	Communication	Low	1
	Information processing	Medium	2.5
History	Paradigm shift	Medium	2.5
	Ports 4.0	Low	1
	Technological Incorporation	Medium	2.5
Place	Link in logistics chains	High	5
	Maturity of the port system	High	5
	Transparency	Low	1
People	Multiplicity of agents	Medium	2.5
	Acceptance of change	Low	1
	Collaboration between agents	Low	1
Technological	Technological maturity	High	5
	Obsolescence	Medium	2.5
	Implementation mechanisms	Low	1
	Research	Medium	2.5
Socio-cultural	Training of personnel	Low	1
	Support for trade union strength	Low	1
	Reconversion	Low	1
	Safety	Low	1
Economical	Lobbies	Medium	2.5
	Financing	Medium	2.5
	Community aid	Medium	2.5
Political	Institutional Impulse	High	5
	Regulatory requirements	High	5
Environmental	Decarbonization	Low	1
	Reduction of externalities	Medium	2.5
	Energy efficiency	Medium	2.5

Source: Own elaboration.

5. Conclusions

In this article, the BOT methodology has been used as an alternative to traditional analyses, such as PESTEL or the development of the SWOT matrix. The use of this tool allows us to establish the current scenario on which to act to achieve a correct implementation of port terminals, addressing and considering both micro- and macro-environmental aspects.

The motivations and available resources are the fundamental axes for executing the project. Within this central scenario, a greater participation of economic agents must be achieved through transparency, so that, together with a regeneration of the personal scenario, the benefits derived from automation can be obtained.

The critical point of successful implementation is in socio-cultural factors. Complete automation will only be possible through dialogue and communication with trade 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 according to their capabilities.

As a conclusion, a global perspective map of the aspects considered in the implementation of automation in the terminals is presented. It indicates the current degree of incidence and the desired degree to carry out the project successfully. All this is presented in Figure 4.

	TODAY	SHORT TERM	LONG TERM
INNOVATIVE MARKET Innovation in value	 Technology  Decarbonization	 Technology  Decarbonization  Transparency  Cybersecurity	 Technology  Decarbonization  Cybersecurity  Transparency
Value improvement		 Involvement and communication	 Involvement and communication
Imitation in value IMITATING MARKET	 Collaboration  Institutional support and encouragement	 Collaboration  Institutional support and encouragement	 Collaboration  Institutional support and encouragement

Figure 4. Map of perspective. Source: Own elaboration.

It is clear that cybersecurity is a primary issue in the short term, while transparency is considered in the longer term.

Decarbonization (the responsible consumption of fossil fuels and the reduction of CO₂ and greenhouse gas emissions), which is now a policy issue across Europe, is increasing over time and is becoming increasingly important.

It should also be noted that collaboration is an important issue when automating a container terminal, as from the private perspective (the terminal operator) there has to be communication and willingness on the part of the port authority (public party), as without a good understanding it cannot benefit the operation.

In addition, collaboration between the parties is essential, as the exchange of data is a basic pillar of automated operations. Therefore, Figure 4 shows that collaboration should increase as time goes by or as it is planned.

Author Contributions: Study conception and design, A.C.O., J.I.P.S., M.M.E.-I.C. and N.G.-C.; material preparation, data collection and analysis, A.C.O., M.M.E.-I.C., N.G.-C. and J.I.P.S.; writing—original draft preparation, J.I.P.S.; writing—review and editing, A.C.O., J.I.P.S., M.M.E.-I.C. and N.G.-C. All authors read and approved the final manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Vis, I.F.; De Koster, R. Transshipment of containers at a container terminal: An overview. *Eur. J. Oper. Res.* **2003**, *147*, 1–16. [[CrossRef](#)]
2. Alho, T. Latest Automation Technology Developments for Ports and Terminals. In Proceedings of the ANESCO Automation Conference, Madrid, Spain, 19 February 2019.
3. Martín-Soberón, A.M.; Monfort, A.; Sapiña, R.; Monterde, N.; Caldach, D. Automation in Port Container Terminals. *Procedia Soc. Behav. Sci.* **2014**, *160*, 195–204. [[CrossRef](#)]
4. 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, 22–24 August 2012; pp. 25–35.
5. 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, 4–7 January 2017.
6. 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. [[CrossRef](#)]
7. Camarero, A.; González, N. *Cadenas Integradas de Transporte*; Fundación Agustín de Betancourt: Madrid, Spain, 2006.
8. Camarero, A.; González-Cancelas, N. *Logística y Transporte de Contenedores*; Fundación Agustín de Betancourt: Madrid, Spain, 2007.
9. Geerlings, H.; Van Duin, R. A new method for assessing CO₂-emissions from container terminals: A promising approach applied in Rotterdam. *J. Clean. Prod.* **2011**, *19*, 657–666. [[CrossRef](#)]
10. Zhen, L.; Hu, H.; Wang, W.; Shi, X.; Ma, C. Cranes scheduling in frame bridges based automated container terminals. *Transp. Res. Part C Emerg. Technol.* **2018**, *97*, 369–384. [[CrossRef](#)]
11. Zhen, L.; Lee, L.H.; Chew, E.P.; Chang, D.-F.; Xu, Z.-X. A Comparative Study on Two Types of Automated Container Terminal Systems. *IEEE Trans. Autom. Sci. Eng.* **2011**, *9*, 56–69. [[CrossRef](#)]
12. Iris, Ç.; Pacino, D.; Røpke, S.; Larsen, A. Integrated Berth Allocation and Quay Crane Assignment Problem: Set partitioning models and computational results. *Transp. Res. Part E Logist. Transp. Rev.* **2015**, *81*, 75–97. [[CrossRef](#)]
13. Solórzano, M.C.; Fernández, R.I.; Zambrano, D.C.; Administrativa, V. Plan de marketing en Pymes. In *Estrategias Exitosas Para Empresas Comerciales*; Universidad Laica Eloy Alfaro de Manabí: Manabí, Ecuador, 2018.
14. Dorado Gómez, S. *Proyecto y Estudio de Viabilidad Económico Financiero y Riesgos de Complejo Hotelero y Resort*; Universidad Internacional de la Rioja (UNIR): Logroño, Spain, 2014.
15. Iris, Ç.; Christensen, J.; Pacino, D.; Ropke, S. Flexible ship loading problem with transfer vehicle assignment and scheduling. *Transp. Res. Part B Methodol.* **2018**, *111*, 113–134. [[CrossRef](#)]
16. Morrall, A.; Rainbird, J.; Katsoulakas, T.; Kolioussis, I.; Varelas, T. E-Maritime for Automating Legacy Shipping Practices. *Transp. Res. Procedia* **2016**, *14*, 143–152. [[CrossRef](#)]
17. Agencia Europea Medio Ambiente. Emissions of Air Pollutants from Transport. 2019. Available online: <https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-air-pollutants-8/transport-emissions-of-air-pollutants-6> (accessed on 26 May 2019).
18. Iris, Ç.; Lam, J.S.L. A review of energy efficiency in ports: Operational strategies, technologies and energy management systems. *Renew. Sustain. Energy Rev.* **2019**, *112*, 170–182. [[CrossRef](#)]
19. Meyer-Larsen, N.; Müller, R. Enhancing the Cybersecurity of Port Community Systems. In *Pharmaceutical Supply Chains-Medicines Shortages*; Springer Science and Business Media LLC.: Bremen, Germany, 2018; pp. 318–323.

20. Resolución del Parlamento Europeo, de 15 de enero de 2019, sobre la conducción autónoma en los transportes europeos (2018/2089(INI)). Available online: http://www.europarl.europa.eu/doceo/document/TA-8-2019-0005_ES.html (accessed on 6 March 2019).
21. Fondo Puertos 4.0. 2019. Available online: <https://www.europapress.es/economia/transportes-00343/noticia-puertos-espanoles-crean-fondo-25-millones-euros-promover-proyectos-innovadores-logisticos-20190408210157.html>. (accessed on 24 May 2019).
22. O'Reilly, E.; ESPO. The Infraestructura Investment needs and financing challenge of European Ports. In *Port Investments Study*; ESPO: Brussels, Belgium, 2018; Available online: https://www.espo.be/media/Port%20Investment%20Study%202018_FINAL_1.pdf (accessed on 3 February 2020).
23. Venturini, G.; Iris, Ç.; Kontovas, C.A.; Larsen, A. The multi-port berth allocation problem with speed optimization and emission considerations. *Transp. Res. Part D Transp. Environ.* **2017**, *54*, 142–159. [CrossRef]
24. OECD. Decarbonising Maritime Transport: Pathways to Zero-Carbon Shipping by 2035. 2020. Available online: https://www.oecd-ilibrary.org/transport/decarbonising-maritime-transport_b1a7632c-en (accessed on 31 January 2020).



© 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).