On the Automation of Ports and Logistics Chains in the Adriatic Region

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Abstract. Recently, automation is gaining an even more important role in the port and maritime industry. In particular, several technological innovations are changing both the freight and passenger transport sector. The introduction of these technologies in port terminals (smart ports) require involved stakeholders to adapt their asset and organisations in order to improve the economic competitiveness in global markets. The geographical context where new technologies are put in place can also influence their deployment and foreseen impacts. Hence, in order to take the proper decisions at a strategic level and maximize the positive effects in a selected scenario, a feasibility analysis is essential. In the present study, this challenge is addressed for the Adriatic region by proposing a procedure for evaluating and selecting the most promising innovations. Several relevant stakeholders from the selected area are inquired to assess the relevance and deployment difficulties for a set of new technologies dealing with automation in port areas. Then, the impacts on technical operation and labour market are assessed, thus, providing valuable information to support the regional organisations in facing the change and deploying procedures to be potentially replicated in other geographical areas.

Keywords: Automation · Smart ports · Adriatic region · Strategic decisions

1 Introduction

In the last decades, the port and maritime industry has experienced a radical change due to the digital revolution, which is still ongoing. Focusing on port terminals and on the maritime transport chain, digitalisation offers significant opportunities for improvement. Hence, the involved organizations (e.g. port authorities, transport and logistics providers, shipping companies, etc.) should be able to understand the change and gain advantage from its exploitation. Generally, the introduction of innovations can be of two types, e.g., incremental and disruptive. The first one consists of small improvements on existing products and services. Considering the transport sector, characterised

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by a large set of organisations competing in a global market, incremental innovations are essential to maintain a competitive position. On the other hand, disruptive innovations are the most radical and revolutionary ones [1]. In the first stage, they represent costly solutions which serve a niche in the market. Then, if they reach a wide application becoming a mainstream product, they perform the "disruption", thereby introducing strong changes in processes, procedures or replacing previous state-of-the-art solutions. In this context, automation is one of the main innovation trends applicable to ports and maritime transport chains [2]. Automation enables to perform a process or procedure with minimal human assistance. Automation progresses through the development of technology and its application in order to control and monitor the production and distribution of goods and services, while performing tasks that were previously carried out by humans [3]. Ever since the introduction of automated stacking cranes at the Rotterdam Container Terminal in 1990, automation in ports has firmly progressed [4]. Automation has developed into almost all terminal functions, ranging from sea-side to land-side; from ship-to-shore activities straight across the terminal and including the handling activities related to the land transport modes.

New technologies in this field are now emerging, thus, it is essential to early identify and develop the most promising ones. The present work aims to address this topic in a specific geographical area: the Adriatic region. The main objective is to select the most relevant automation technologies for the area and assess the issues and risks possibly hindering their deployment. The work has been carried out by enquiring experts and relevant stakeholders from the Adriatic region. Eventually, the study aims to guide the regional organisations in the selection and deployment of innovations, fostering the automation of the port terminals and the whole maritime transport chain.

2 Methodology

The present study has been carried out based on the methodology drafted in [2]. It is divided into three main phases: desk research, innovation ranking and impact analyses.

In the first phase, desk research has been carried out to identify the main innovations concerning automation, which might have an impact in the Adriatic Region. In this process, several experts, stakeholders and public authorities have been inquired applying a multidisciplinary approach in order to thoroughly investigate both the passenger and freight transport sectors. Emphasis has been put on different aspects, e.g. automation in port facilities, automation of the logistic chain and development of unmanned technologies and vehicles. All the selected innovations have been collected in a common repository including a brief description of the technology.

In the second phase, a questionnaire has been prepared and submitted to a set of relevant stakeholders from the Adriatic Region. The objective of the questionnaire was to rank the innovations selected in the previous phase by importance and to assess their deployment easiness/difficulty. A five-step scale has been adopted for innovation relevance, namely:

1. not at all relevant;
2. not very relevant;

3. no opinion;
4. relevant;
5. extremely relevant.

The stakeholders have also been required to justify their answers by highlighting the benefits foreseen for each technology. The efforts required for innovation deployment in the Adriatic Region have been defined according to another five-step scale:

1. very difficult to implement;
2. somehow difficult to implement;
3. no opinion;
4. somehow easy to implement;
5. very easy to implement.

Motivations have been required in order to highlight the main obstacles hindering technology deployment in the selected area.

According to the rank coming out from stakeholders' responses, the most promising innovations for the Adriatic area have been selected for more detailed analyses, which have been carried out in the third phase. Here, impact analyses have been conducted focusing on both the impacts on technical operations and on the labour market. The impact analyses have been carried out by consulting experts and they include brief guidelines for the regional stakeholders on how to react and be ready for the change. In the impact analysis, the current scenario is compared with the expected one after the innovation deployment, focusing on the following main aspects:

- Consequences/repercussions: assessment of the expected changes due to innovation deployment;
- Required modifications: assessment of what should be modified to cope with expected changes;
- Potential risks: an assessment of potential risks, e.g., identifying most problematic changes from technical, organizational and stakeholder viewpoints.

Hence, the impact analyses will help stakeholders to rapidly react and face the digital revolution in port and maritime passenger/freight transport, thus, fostering the development of the automation technologies in the Adriatic region.

3 Technologies and Ranking

In the present section, the innovations identified mainly through desk research are briefly presented. Then, the ranking results are provided for both the relevance and deployment easiness/difficulty based on the opinion of several stakeholders of the Adriatic region.

3.1 Selected Technologies

The innovations selected through desk research are hereinafter briefly described. They can be divided into five macro-areas: smart passenger terminals, smart freight terminals, automated warehouses, logistic chain automation and autonomous vehicles.

Automation is expected to be even more applied in the passenger sector in port facilities as well as onboard of large passenger vessels. In the near future, the development of robotics could move the simplest jobs (e.g. cooking, cleaning, serving, etc.) from humans to robots by developing the so-called *Unmanned services*. Seemingly, automation can improve passenger management activities so as to simplify boarding and unboarding operations. In this context, smart sensors (biometrics), Internet of Things (IoT) solutions, computer vision and personal mobile devices can be exploited to develop an Automatic *Digital identification of passengers,* which can reduce the need for manual authentication and identification. Finally, automation can enable costs saving and lower environmental impacts through the adoption of *Automated lighting and air-conditioning systems*. In internal spaces, the lighting system and the load of the conditioning system can be optimised based on the actual number of people detected through sensors, thus, reducing the global energy demand.

In freight terminals, especially container ones, automation can play an even more significant role, simplifying cargo handling and reducing the waste of time and resources. *Unmanned bulk terminals* are already in operation (e.g. in Shanghai) and also *Fully automated container terminals* are in rapid development, integrating several different technologies already available on the market [5]. These ranges from *Remote cranes*, *Smart connected lift trucks* to *Automatic Stacking Cranes (ASC)*, *Automatic lashing platforms* moving forward fully *Automatic container carriers/truck handling systems*. All these technologies are usually managed by Terminal Operating Systems (TOSs), which play an essential role in the integration of the adopted automated technologies. However, container terminal automation is still at relatively early stage since, currently, only 1% of terminals are fully automated and 2% are semi-automated [6]. Still considering container terminals, other innovative automated systems for container storing and handling are present on the market. Among them, one of the most promising is the *High Bay Storage Systems (BOXBAY)*, where containers are placed in individual racks instead of stacking them on top of each other in order to make each one directly accessible [7]. Technology can also foster the environmental impact reduction in freight terminals. To this end, *Electrified lift solutions* and, in general, electric vehicles inside the port area can be adopted. Moreover, Remotely Piloted Aircraft Systems (RPAS) can be used to measure the emissions of sulphur determining whether a particular vessel is compliant with the rules in force. *RPAS Drones* equipped with a gas sensor, known as a "sniffer", can fly in the ship's plume to estimate the amount of sulphur in its fuel; then, the collected data are forwarded to public authorities for review.

Warehouses are critical nodes in the transportation and logistics processes. Their automation can increase the efficiency of freight logistics substantially [8]. For instance, the *coupling of voice technologies with Warehouse Management System (WMS)* is growing in the number of adoptions, since it increases personnel efficiency during picking operations. The avoidance of looking at monitors and the feeling of listening

instructions by a human voice decrease the alienation and foster the speed, allowing the operator to use both hands. In many cases, completely *Unmanned warehouses* are already in place. They exploit autonomous robots capable to move mobile storage racks weighing from 500 to 1500 kg and controlled by the WMS. Finally, the adoption of *Drones connected to the WMS* has been recently proposed [9], especially for periodic inventory procedures. Thanks to drone technology, it is possible to check the consistency of stock more frequently and during the night, when there is no/less activity inside the warehouse.

Among the analysed automation technologies, the most challenging are the ones devoted to improving the automation of the whole logistic chain, which include ports as main nodes but it is extended to a wider port community including shippers, shipping companies, multimodal transport operators etc. [10]. In this context, the first selected solution is *Event data certification* that manages scheduled data validations within a database. Information is added to the database by importing it from third-party technologies or manually, then checked for accuracy and certification. The program generates a checklist for data verification. The data certification is done following a specific certification calendar and the certification activities are created and assigned automatically. Focusing on port operations, the management of vessel arrival and departure times is one of the key factors for port logistics operations as well as for the whole maritime transport chain [11]. Estimation of arrival and departures times are essential for operations planning on all levels and departments. *Estimated Time of Arrival (ETA)* technology allows very accurate predictions of ships' arrival and departure time, thus, increasing the efficiency of all the port operations (berthing, cargo handling) and enabling resource allocation optimisation. In addition, data provided by ETA can also be integrated into third parties applications in order to optimise the other stages of the logistic chain. For instance, transport providers can gain benefit from the introduction of *Deliverables Planning* systems based on machine learning algorithms [12]. In fact, better planning of deliveries based also on real-time and predicted traffic conditions can help to save travel time/cost and improve reliability through the selection of pre-trip and en-route travel routes. For these systems, the quality and the reliability of input data is essential, thus, requiring thrusted external sources. In general, greater benefits can be obtained enhancing the data exchange between all the actors along the transport chain. In fact, the transport of a single good usually involves a large number of different organisations. With automated processes to exchange reliable information, the *maritime transport chain* becomes a network where carriers, ports and freight forwarders are interconnected in the movement of goods. Customers and stakeholders in the port and maritime industry demand more speed, lower cost, more transparency, higher security, lower environmental impact, higher efficiency, which are the main metrics for digital project success. These goals can be achieved by streamlining all these aspects of the transport chain process. Technologies such as blockchain [13] or a distributed electronic ledger system can allow transactions to be verified autonomously by every party involved in cargo transportation. Another promising technology exploits IoT devices [14], which are already present in several parts of the transport chain, either as smart sensors, controllers, embedded devices in cargo manipulation machines and even ship themselves. IoT devices provide the necessary intelligence for improving handling operations and risk mitigation. Hence, the

improved automated data exchange along the transport chain can help to face the most critical issues in the transportation industry, such as long paperwork paths, inefficient use of resources and an increasing cargo amount.

Finally, special attention is due to another disruptive innovation that is expected to have a deep impact on port operations and navigation in the next decade: the autonomous vehicles. In the near future, terminals shall be capable to cope with different types of autonomous vehicles. First, *Autonomous vehicles confined in the port area* can be more easily adopted, including cargo handling systems or busses in the freight and passenger sector respectively [15]. Moreover, in case of widespread application of *Autonomous Trucks/Busses* outside the port areas, the terminals shall define specific procedures and processes to deal with them [16]. Eventually, the fast development of autonomous vessels represents the most relevant challenge for port facilities. This concept can be developed with different degrees of automation up to the *Unmanned ships*: a vessel without any crewmember onboard, based on completely automated or remote-controlled systems. *Autonomous vessels for coastal navigation* are already in operation for short repetitive routes, but a wider application in near future is expected, provided that some open issues, mainly legal and regulatory, will be solved [17]. However, the economical benefits (ship's life cycle cost could decrease by minimum 5–22% mainly due to fuel and crew cost reduction [18]) and safety-related benefits (reduction of casualties connected to human error) will certainly lead to a wider application of remote-controlled vessels [19] and finally to fully autonomous ones. From a terminal viewpoint, this can foster the introduction of other collateral technologies such as *Autonomous tugboats* and *Automated mooring systems*, which could be easily interfaced with the autonomous vessels approaching or living the berth.

3.2 Questionnaire Results

The selected innovations have been used to prepare the questionnaire, which has been submitted to regional stakeholders. Responses have been collected from 24 organizations, divided into different categories as shown in Fig. 1. Most of them are port authorities from Italy and Croatia, including the port authorities of Venice, Rijeka, Sibenik and Rovinj.

The ranking results are provided in Table 1. The technologies are ranked by importance I, which is the mean of the stakeholders' judgements based on the five-step scale. In addition, the assessment of deployment difficulty/easiness D is reported along with the standard deviations σ. The colour scale improves the table readability: cells' colour ranges from red to green corresponding to scale values 1 and 5 respectively. The results have also been plotted on a scatter diagram (Fig. 2), providing a more effective graphical representation. It is worth to notice that all the technologies are located in the upper area of the diagram corresponding to high-relevance innovations. This confirms the effectiveness of the selection process carried out during desk research phase. In Fig. 3 a more detailed view is provided of the upper part of the scatter diagram. Numbers in Fig. 3 refer to the ranking (Table 1).

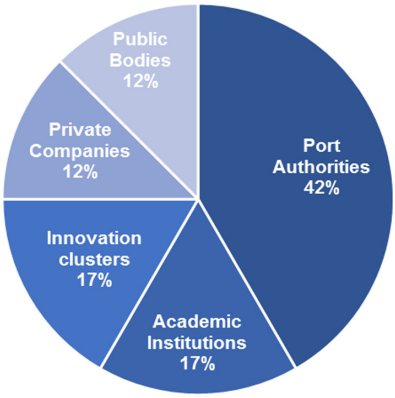

Fig. 1. Stakeholders involved in technologies ranking.

Table 1. Global Rank of innovations

Rank	Innovation	I	σ_I	D	σ_D
1	Maritime transport chain	4.35	0.65	2.70	0.95
2	ETA	4.32	0.76	3.74	0.99
3	Automatic digital identification of passengers	4.21	0.61	2.74	0.85
4	Deliverables Planning	4.21	0.69	3.50	0.90
5	Electrified Lift Solution	4.12	0.83	2.76	0.81
6	Autonomous Trucks/Busses	4.05	0.79	2.43	0.90
7	Automatic container carriers/truck handling systems	4.00	0.69	2.76	0.94
8	Automated Lighting and air-conditioning systems	4.00	0.79	3.44	1.06
9	Smart Connected Lift Trucks	3.93	0.85	3.19	0.88
10	Fully Automated Container Terminal	3.90	0.97	1.95	1.00
11	Unmanned warehouse	3.75	1.04	2.70	0.95
12	Autonomous vessels for coastal navigation	3.68	1.13	2.37	0.81
13	ASC	3.53	0.78	2.65	0.84
14	Unmanned bulk cargo terminal	3.50	0.96	2.18	0.78
15	Unmanned ships/autonomous vessel	3.45	1.20	2.30	0.78
16	Unmanned services	3.41	1.03	2.50	1.17
17	High Bay Storage Systems (BOXBAY)	3.38	0.86	2.94	0.97
18	Autonomous vehicles in port area	3.33	0.94	2.72	0.87
19	WMS with voice integration	3.32	0.86	3.11	1.12
20	Drones for WMS	3.30	1.00	2.70	0.90
21	Remote Cranes	3.26	0.87	3.24	1.03
22	RPAS drones to check ship emissions	3.22	1.23	2.82	0.86
23	Autonomous tugboats	3.19	1.14	1.71	0.76
24	ALP	3.19	0.81	2.80	0.65
25	Automated mooring technologies	3.16	1.18	2.11	0.72
26	Event data certification	2.90	0.92	3.14	0.89

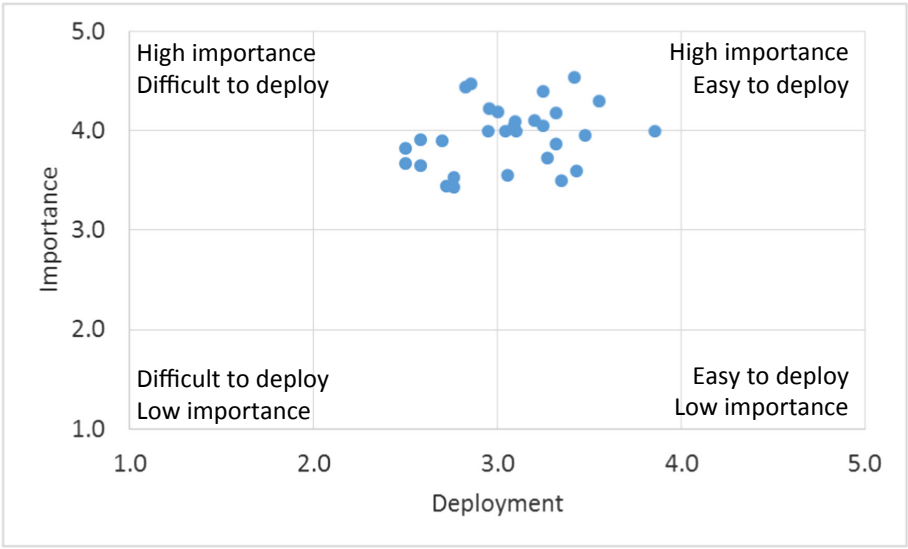

Fig. 2. Importance vs deployment easiness/difficulty

It can be concluded that no clear correlation exists between importance and deployment's easiness/difficulty, since a trend in the scatter diagram does not emerge. Remarkably, groups of innovations having comparable importance can be identified. However, some differences among stakeholders' opinions have led to quite high values of standard deviations related to innovations' importance, thus, partially reducing the significance of the ranking.

According to stakeholders, the most interesting innovations are *Maritime transport chain*, *ETA*, *Automatic digital identification of passengers* and *Deliverables Planning*. It can be noted that all these innovations deal with the automation of the logistics chain in both freight and passenger sectors. Thus, in general, stakeholders from the Adriatic region are strongly interested in such a topic, rather than autonomous vehicles or other automated devices (cranes, lifts, drones, etc.). The inference is confirmed by the group including the least innovations by importance, which are: *RPAS drones to check ship emissions*, *Autonomous tugboats*, *ALP*, *Automated mooring technologies* and, with a quite large gap, *Event data certification*, whose impacts are considered very limited compared to the other options related to transport chain automation.

The results related to innovations' deployment difficulty in the Adriatic Region present a wider spectrum compared to relevance-related ones, while an almost equal level of standard deviations is observed. Hence, deployment easiness/difficulty presents a lower uncertainty on overall stakeholders' preferences. The most easy-to-implement innovation is *ETA*, which largely outdistances the next ones: *Deliverables Planning* and *Automated Lighting and air-conditioning systems*. Hence, *ETA* and *Deliverables Planning* can be considered the most promising innovations among the selected ones in the region, since both show high importance and easy deployment, according to stakeholders.

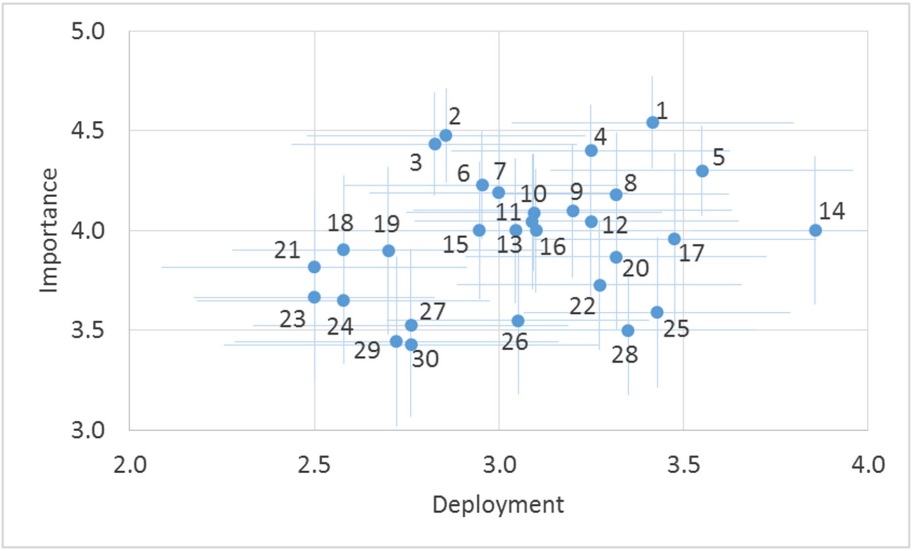

Fig. 3. Detail of importance vs deployment easiness/difficulty; numbers refer to ranking (Table 1); bars refer to a 95% confidence interval

On the other hand, the most difficult-to-deploy technologies are *Fully Automated Container Terminal* and *Autonomous tugboats*, which both require a strong effort to develop dedicated algorithms related to the implementation scenario.

4 Impact Analyses

In the present section, the impact analyses are reported focusing on three of the most important innovations selected for the Adriatic region according to the stakeholders' opinion. As previously stated, the impacts of automation on both technical operations and the labour market are here considered in the freight sector, which has been generally considered by regional stakeholders more relevant than passenger transport.

4.1 Maritime Transport Chain

Global logistics still relies on a huge amount of paperwork. For their operations, the information in such documents has strong influence on the execution speed, the efficiency and the operations planning capability in the transport chain. Anything that can be done to improve the present condition can have a heavy impact on the whole industry. Document digitalization, electronic data exchange, integration of smart sensors, data standardization, visibility and cargo traceability through real-time services like blockchain and other technologies can strongly improve the services in the maritime transport chain. All these technologies have their own benefits, but they can even multiply, if combined in innovative ways, for instance by adopting machine learning

and AI-based algorithms on data coming from IoT devices, shared through blockchains with different organisations. Together, they open new opportunities for management, cost reduction and other areas. Innovations for the maritime transport chain does not include just one or single technology, but rather the combination of new services that complement and in some situations supplement existing systems and services. As a consequence, processes will change, having repercussions on both the technical environment and the required human engagement. The main benefits will be lower resources demand, more effective planning, errors reduction and improved transparency. These changes do not necessarily require large modification of existing information systems. This is an advantage since often very large and revolutionary projects would be too expensive and too disruptive for the normal operations, resulting in a difficult integration in the existing logistic chain. Hence, the introduction of innovative technologies in steps should be preferred, e.g. introduce additional services or interfaces capable to speed up, optimize or eliminate time and resource-consuming tasks (in many cases, innovation can replace some part of the process or a legacy technology).

Necessary modifications to implement proposed innovations and new technologies depend on many factors and can range from a relatively small addition to existing management systems in one particular organization to a relatively big shift in management approach. It depends on the maturity and the structure of the existing technical solution and its flexibility in accommodating new data and process modifications. Considering present systems, the biggest issue will be in particular their relatively fixed scope and inability to support a modified process. This should be carefully evaluated when planning the introduction of a new service or solution to better integrate into the maritime transport chain.

Innovative technologies can bring new beneficial opportunities to the maritime transport chain, but also several risks. First, it shall be noted that smaller initiatives and projects might not outlive their pilot stage and become a widespread solution. Most experts agree that innovative technologies (for instance, blockchain) will be successful only with a comprehensive and widespread application [20]. In order to succeed they have to be accepted by all stakeholders involved in the process: shipping lines, terminal operators, manufacturers, banks, insurers, brokers and port authorities. In such a case, the prospects are very promising: documents could be processed in minutes rather than hours or even days. Another open issue is related to the existence of a single or multiple maritime transport networks handling cargo transportation routes. Not all stakeholders might deploy the same technology solutions and platforms. They might adopt different messaging or networks, rising questions about interoperability and/or standardization. Related to this concern is also the choice of closed rather than open chains. Until now, the success of logistics chain solutions was fostered by “permissionless” chains with no central authority granting or prohibiting the access to publicly accessible data. In the maritime industry, this may be a challenge which will have to be addressed. There is also a variety of different languages, laws and organizations involved in moving cargoes, which might lead to a standardisation processes’ slowdown.

From a labour market viewpoint, the maritime transportation chain automation will trigger changes in the needs of human resources for supporting modified and new processes. Digitalization of the documents and electronic data exchange will reduce the

need for simple manual entry of data and staff necessary to handle these processes. At the same time, innovations in the transport chain will create new job positions with different skill sets. For instance, high demand for skilled people is expected capable to perform advanced resources planning using modern planning tools and to handle intelligent smart devices (e.g. IoT sensors). It is very possible, that the new process will require a reorganization of the work to better exploit its opportunities.

Concerning the risks associated with employees and the labour market, they again depend on the type of innovation applied. Generally, a new skill set will be needed, including specific knowledge of both transportation best practices and particular technology use, representing a challenge for new employments. Another risk is the ability of the organization to re-train the existing personnel in order to utilize the innovative solution regularly and in the proper way. A wrong approach to the change can result in dislike and ultimately the rejection of the new procedures by employees [21]. This issue should be assessed with care during a specific project planning in order to define the appropriate steps and to engage the existing personnel in the change process.

4.2 Vessel ETA

Introduction of advanced estimation of vessel departure and arrival times can improve the port capability of planning berth utilization and optimize all supporting logistic processes, which depend on presence vessels in port. At the same time, the new technology and process will have a beneficial impact on transport resources utilization, including lower waiting time for berthing, cargo loading and unloading. The goal of ETA is to achieve "right on time" management regarding the planning of arrivals, departures and connected services. These estimates are useful for all actors within the port community and transportation chain, being the base for planning their own operations, better exploit available resources and decrease waiting time.

Technology for better estimation of arrival and departure times can be based on metering the progress of transport (arrival) and cargo loading/unloading (departure) processes and comparing the remaining transportation journey or manipulation of cargo towards previously executed (metered) operations. In this way, the estimations can be performed more often and reflect the factors that may change previously calculated estimates. Thus, applying machine learning algorithms, the estimated arrival and departure times will become more accurate and similar to actual times. This approach requires measuring and calculating new estimates, which are then forwarded over common messaging systems to interested parties. On the receiving end, the planning solutions shall be able to process estimates updates, giving to the operators more accurate data for decision and operations' approval. It is preferred that the communication of ETA is compliant to the existing standards, initiatives and project in the maritime sector, like communication and messaging platform MCP (Maritime Connectivity Platform) and IEC 61174:2015 Maritime navigation and radiocommunication equipment and systems. This compliancy can ease the deployment of the ETA and its adoption by a wider number of organisation, which is essential to spread the benefits towards the whole port community.

The main risk for the preparation of estimated arrivals and departures of vessels lays in data accuracy, on which the estimates are based. If the metered data is not reliable, the estimates cannot be accurate and trustworthy. The solution has to be calibrated and monitored to gain adequate accuracy. At the same time, another risk is the overreliance on the estimated arrival and departure times than will be calculated with ETA solution. In case the estimates for any reasons cannot be available or are missing, an alternative source of estimates and verification should be in place to avoid that processes relying on these data are not misled in wrong activities (example: resources reserved and then not used,). Moreover, the methods and standards for estimates calculation might be different from solution to solution, port to port, thus, not immediately comparable. Methods standardization for data collection data and estimation at least in a regional context would be beneficial to mitigate this risk.

Considering the labour market, advanced technologies for the estimation of arrival and departure times are not expected to have strong repercussions on the labour market. Nevertheless, provided that the ETA is reliable and not subject to frequent radical changes, it can improve human resource allocation. Operators will be able to better plan the resources, their utilization and react to external factors that affect changes in departure and arrival times. Finally, as for each technology innovation, the deployment of ETA is expected to increase the demand for specialised personnel capable to maintain and monitor the new systems.

4.3 Deliverables Planning

Deliverables planning solutions can have a strong impact on the efficiency of supply and transport chain enhancing the resources utilization considering the changing conditions during the transportation of the goods. Deliverables planning, providing automatic suggestion or selection of travel routes before the trip and even during the trip, can save costs, decrease the transport time and achieve a smaller environmental impact on the communities affected by the transportation of goods. The proposed solutions can be easily linked to the existing port and maritime information systems, both as sources and targets. The existing operation management solutions can be relatively easy to integrate with new decision planning system, enhancing the data exchange among different organisations within the port community.

The quality of the data provided by a deliverable planning solution depends on the frequency and the reliability of data sources. These may include publicly available data, like traffic conditions, weather data, available transport capacity as well as data available in the transportation management solution, like estimated times of arrivals, number and types of cargo, transportation vehicles. To assemble a successful deliverables planning solution, all this data must be collected, normalized and forwarded to the decision process. This includes developing interfaces for the acquisition of the data from existing sources (e.g. ETA, PCS systems, cargo manifests, etc.) as well as new sources and sensors (location data, transport/stowage capacity monitoring, etc.). Compared to the planning solutions adopted nowadays, innovative deliverables planning can change the suggestions more frequently than today's business practice. Transportation providers will be required to respond to changing requests and adapt their processes. The possibility of frequent delivery changes will have to be verified in

the existing operations management systems and processes, in order to assure their response capability to the new requests and still fulfil their service in the supply chain process. New metrics will have to be defined and aligned among interested parties to maximize the potential of changing plans.

The success of Delivery Planning can be achieved only if all the conditions for its usage are met. On the sources side, some routes to a particular port might not be able to provide the required data. This could limit the effectiveness of the whole planning process. Moreover, some legal issues regarding the long-term availability of data could also arise, since a large part of useful data for deliverables planning comes from commercial and closed (not-public) systems. Hence, a solid contractual base is essential to assure the constant availability and quality of data. In addition, too many disruptions in this area can have a significant effect on the results coming from a deliverables planning system. In fact, the new planning tool might not be aligned with the real deadlines/latest time for changes in delivery methods and, thus, might disrupt the whole process. To mitigate such a critical issue, a gradual approach towards desired goals can verify that the newly developed methodology is reliable and has a positive effect. Finally, flexibility (contractual and technical) might also limit the deliverables planning system usability. Transportation providers shall be able to adapt and change plans as results of the system outputs.

Regarding the labour market, the main consequence of the deliverables planning development would be the sensible reduction in the number of people needed to manage the journeys of a fleet of containers and/or semitrailers, but the fewer operative staff that remain employed shall be more skilled and trained. If implemented on a full scale with a real-time traffic information system and an integrated rail/ferry multimodal booking platform, organizations would become more efficient. A full-scale system would allow a single operator to give more than a hundred orders per minute, managing at the same time an exponentially higher number of communications to suppliers and customers than it would have been possible to handle with a traditional email/phone calls method. For this reason, operators will be required to become more managerial and skilful in order to intervene only in out-of-order situations and to monitor the progress of the day-to-day schedule.

Hence, a radical change to the organisation structure is required, including a fully integrated vertical system, allowing the operational base of the organization e.g. drivers, warehouse staff, terminal staff etc. to directly receive real-time instructions from the system controller, while the system controller would need to receive a full set of key monitoring variables in order to be able to tackle potential anomalies and to check the daily progress of the operations.

The main risk for the labour market would be a distorted use of deliverables planning systems by organizations. In particular, these platforms are meant to help operational staff to take decisions on a day-to-day planning and re-routing activity while some organizations may take advantage of the automated process in order to simply reduce staff, to cut internal costs and to make jobs less repetitive. In an extreme scenario, it is even possible to evaluate an AI system running the deliverables planning system alone, without any help or support by human staff. This kind of risk already came out in big companies, where the use of algorithms could become the best solution available on the market for high volumes of traffic. However, for intermodal traffic,

considering the high level of involvement of human operators at all stages of the value chain, the regulatory scheme should intervene in order to avoid human-free, AI-run deliverables planning systems, in favour of mixed human + AI ones.

5 Conclusions

In the present study, the most promising technologies regarding automation in the port and maritime industry with regards to the Adriatic region have been identified. The assessment of their relevance and importance showed a clear interest of regional organisations for the innovations in the freight sector, aiming to a more automated maritime transport and logistics chain. In particular, the enhancement of the data collection and exchange systems among the involved parties is identified as a priority, as confirmed by the technologies deemed most relevant: *Maritime transport chain*, *ETA*, and *Deliverables Planning*. These technologies are not considered very difficult to be deployed according to the inquired stakeholders, but require the agreement of a large number of different parties in order to assure the success of an automation project. Hence, future efforts are required in order to build a broader port community committed to the exploitation of new transport chain automation technologies. On the other hand, the infrastructure/vehicle automation in port facilities is neither considered an easy task to be implemented in the Adriatic area nor - according to the stakeholders ranking by relevance - a priority.

The impact analyses carried out on the most promising innovations dealing with maritime logistic chains show the benefits for organizations after their deployment, while providing an assessment of risks and related mitigation measures. In particular, as for automation, the main common risk is related to the reduction in the number of non-specialised jobs. At the same time, the demand for skilled personnel with specific competencies will grow. Hence, it is essential to properly plan re-training activities during the introduction of new technologies to assure their acceptance among the employees.

Our results can be valuable for organisations which are planning automation projects in the selected geographical area. However, more detailed analyses are still required to assure a successful implementation. For instance, Strengths Weaknesses Opportunities and Threats (SWOT) analyses can be the next recommended step to be carried out on the most promising innovations. Moreover, further research aiming to the definition of regional roadmaps to increase port automation is still required and new technologies adoption could be fostered by carrying out pilot projects testing the most promising solutions in a limited environment. In conclusion, the proposed methodology has been here applied in the Adriatic region and it can be easily adopted and replicated in other geographical areas and in other technological contexts to foster the innovation among the local stakeholders and align their priorities.

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