Big Data Opportunities for the Port and Maritime Transport Sector in the Adriatic Region

Marco Mazzarino[1], Luca Braidotti[2,3], Maurizio Cociancich[3]

[1]*Department of Architecture and Arts, University of Venice I (Università I UAV di Venezia), Italy*

[2]*Department of Engineering, University of Trieste, Italy*

[3] *TeDIS Program, Sustainable Logistics Unit, Venice International University, Italy*

Abstract

Big data technologies offer new opportunities for the port and maritime industry in both freight and passenger transport. In order to ensure the success of a new big data project in a specific environment, it is essential to assess the benefits and the efforts required by its implementation. The present work addresses this topic for a specific area: the Adriatic region. Several relevant stakeholders from the selected area have been contacted to assess the relevance and deployment difficulties for a set of promising big data technologies. The study provides a picture of the current state and the future outlook for the Adriatic region, being useful for local operators and a valuable example to be replicated in other contexts.

Introduction

Recently the port and the maritime industry have been experiencing a radical change due to the introduction and application of several disruptive innovations leading to rapid digitalisation processes. These innovations, starting from being costly solutions which serve a niche, perform the so-called "disruption of the market" when they reach the mainstream market as a mass-produced product (Christensen, 1997). In the maritime sector, characterised by a large number of actors, early detection and development of the most promising technologies is essential to be more competitive in the market.

Among other such technologies, opportunities for the transport sector derived from big-data technologies have been studied in recent years (Grover & Kar, 2017). In fact, big data can provide positive effects in terms of economics and safety & security on port operations and maritime logistics (Mirović et al., 2018) as well as in the whole transport chain within the shipping industry (Zaman et al., 2017). The application of these technologies is foreseen also in the Adriatic region. In this specific context, a selection of the most promising innovations is underway (Mazzarino et al. 2019), to prepare the regional stakeholders to face future challenges.

The aim of the present work is to assess the relevance of the new opportunities related to big data in the Adriatic region. It is also essential to identify the issues which might hinder their deployment. The data here presented can help regional stakeholders in planning and managing their digitalisation process, fostering the introduction of big data technologies in the Adriatic region. Moreover, this case study might be of interest also in other similar contexts which are facing the same innovation processes.

Big data technologies tested

The technologies concerning big data for the transport sector have been selected according to Mazzarino et al., 2019 and are reported in Table 1. They refer to both passenger and freight transport and are briefly depicted hereinafter.

Data standardization and data management are essential when dealing with big-data projects. Usually, each private company defines its proprietary standards, but this can hinder the integration among different actors in the transport chain, thereby reducing the data collection capability. This is why some of the world's largest carriers are working on common standards within the Digital Container Shipping Association (DCSA). At the same time, port authorities, terminal operators and shipping companies are already leveraging data to intelligently plan

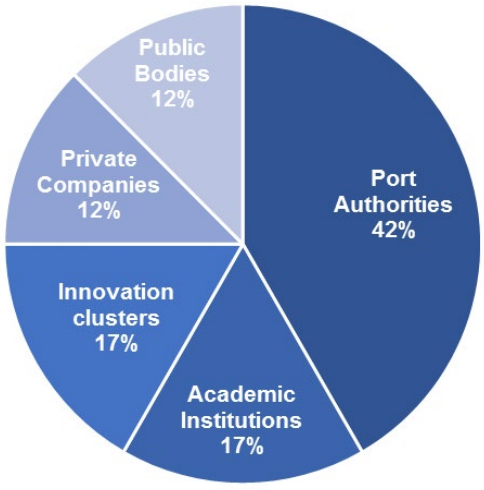

Fig. 1: Stakeholders involved in technologies ranking.

Technology	Sector	Description
Automatic detection of logistics' level of service	F	Forecast the performances for a consequent decision support and to improve the logistic efficiency based on data detection and management technologies.
Loading/unloading optimisation	F	More efficient loading /unloading procedures and planning of resources based on real-time Data and AI algorithms.
Big Data Analytics	P/F	Consolidated methods and techniques to collect and analyse "big data" in general.
Big data/data management	P/F	Make readily available to all the harbour operators accurate and reliable information, in order to improve every processes.
Data standardization	P/F	Definition of common standards for data collection and storing among different stakeholders.
Digital twin	P/F	A model capable to reproduce the state of an asset and its behaviour in reaction to external operating context.
Machine Learning	P/F	Algorithms to explicit historical data to make predictions or categorisation in current situation.
Anomalies detection & predictive maintenance	P/F	Identification of anomalies or failures on a specific machinery, equipment or system, and aid to maintenance programming
Georeferenced data	P/F	Assess the impact of events or scenarios and can save time, effort, and resources before implementing the actual project.
Port traffic management	P/F	Increase port safety and security based on data collected by a network of sensors.
Energy Efficiency	P	Energy efficiency improvement of complex systems.
Passengers flow analysis	P	Timestamping of passages position at strategic locations for findings gaps for process improvements.
Sectors: P: Passenger; F: Freight		

Table 1. Big data technologies tested in the survey.

their operations. In fact, Big-data Analytics technologies can be used to collect and analyse data that is employed to predict individual ship movements and cargo flows. Machine learning provides the algorithms to classify and analyse flows and situations based on previous experience (Mitchell, 1997). For instance, the correlation of logistics data to detect anomalies and / or errors can be used to assess and to predict bottlenecks based on recognizable patterns. A second innovative application of big-data technologies consists of the digital twin: a model capable of reproducing the state of an asset and its behaviour in reaction to external operating context in close to real-time. Machine learning and big-data analytics improve the knowledge extraction capability of software that deals with large and heterogeneous output collected by sensors, enabling the improved performance of a digital twin (Erikstad, 2017). A third application of big-data analysis provides considerable benefits to energy efficiency. Energy Management Systems (EnMS) can substantially increase the efficiency of navigation of complex passenger ships (Gualeni et al., 2016) and port facilities (Lee Lam et al., 2017). In this context, big data analysis offers a very powerful instrument for EnMS configuration (Perera & Mo, 2016). Moreover, bigdata can also be exploited in passenger terminals to study and optimise passenger flows and embarkment procedures.

Finally, in the freight sector, loading/unloading operations can be optimized. Specifically, resources can be planned based on real-time data and artificial intelligence (AI). The automatic detection of logistics' level of service can be performed through systems based on data detection and management technologies such as radio frequency identification (RFID). Moreover, before the implementation of a new project, georeferenced data can be exploited to analyse scenarios and future events in order to reduce the implementation time and required resources. Finally, big data can improve port safety and security by monitoring and managing vessel traffic management based on real-time information coming from sensors.

Ranking results

By applying the methodology provided in Mazzarino et al., 2019 the relevance and ease of implementation of the selected technologies have been defined according to the opinion of relevant stakeholders from the Adriatic Region. Five-step scales have been applied for the importance in the area (1. not at all relevant; 2. not very relevant; 3. no opinion; 4. relevant; 5. extremely relevant) and the efforts required for its deployment (1. very difficult to implement; 2. somehow difficult to implement; 3. no opinion; 4. somehow easy to implement; 5. very easy to implement). Responses have been collected from 24 organizations, divided into different categories as shown in Figure 1. Most of them are port authorities from Italy and Croatia, including the port authorities of Venice, Rijeka, Sibenik and Rovinj.

Rank	Technology	I	σ_I	D	σ_D
1	Bigdata/data management	4.60	0.58	3.20	0.81
2	Data standardization	4.36	0.64	2.86	1.14
3	Big Data Analytics	4.30	0.64	3.00	0.77
4	Port traffic management	4.09	0.67	3.05	1.02
5	Loading/unloading optimisation	3.95	0.80	3.30	1.05
6	Automatic detection of logistics' level of service	3.89	0.81	2.68	0.80
7	Energy Efficiency	3.88	0.76	2.69	0.92
8	Anomalies detection & predictive maintenance	3.86	0.77	2.81	0.73
9	Machine Learning	3.75	0.62	2.60	0.92
10	Passengers flow analysis	3.70	0.71	2.95	0.86
11	Digital twin	3.52	0.91	2.35	0.91
12	Georeferenced data	3.48	1.10	2.85	0.85

Table 2. Ranking of big data technologies.

The big-data technologies, ranked by importance I are shown in Table 2, along with their deployment difficulty/easiness D and the related standard deviations σ. Figure 2 provides a graphical representation of the results on a scatter diagram. It is worth noticing that all the technologies are located in a restricted area in the upper part of the diagram. Figure 3 provides a more detailed view of the scatter diagram. Numbers shown in Figure 3 refer to the ranking reported in Table 2. It can be concluded that no clear correlation exists between importance and deployment's relative ease or difficulty, since a clear trend in the scatter diagram does not emerge. However, the quite high value of standard deviations related to innovations' importance reduces the significance of the ranking. At the same time, a group of more interesting innovations can be identified from the diagram, including Big data/data management, Data standardization and Big Data Analytics meaning that the organizations involved assign a clear preference for data storing (database design/data management) and data standardization issues globally as a prerequisite for the efficient application of any kind of data analytics.

The least important innovations are Digital twin and Georeferenced data. The first is not considered very significant for improving the logistics chain, despite the fact that the digital twin is considered a very powerful simulation tool according to stakeholders. Regarding Georeferenced data, they are judged useful – but not essential - for optimization purposes, since similar results could be easily obtained with the adoption of other technologies. A wider spread can be observed on the innovations' implementation difficulty in the Adriatic region as well as larger standard deviations, leading to greater uncertainty. Innovations which are considered to be easily deployed are Loading/unloading optimization and Big data/data management, since well-established procedures and applications are already available on the market for both of them. On the other hand, the innovation most difficult to be deployed is Digital twin, since it requires considerable efforts in terms of system integration, collection of historical data, and the development of processing algorithms.

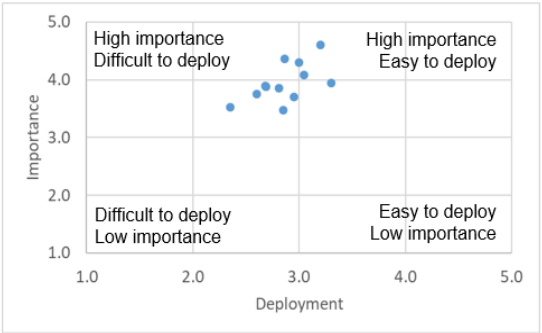

Fig. 2: Innovation Importance vs Deployment Easiness/ Difficulty

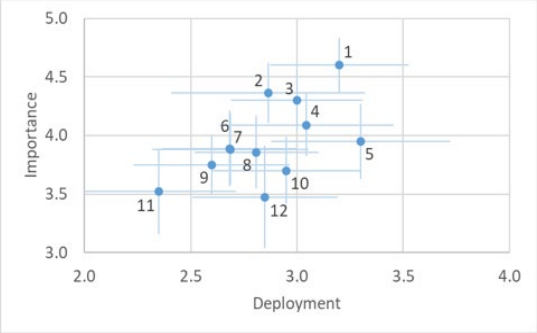

Fig. 3: Detail of Importance vs Deployment Easiness/Difficulty; bars refer to a 95% confidence interval

Conclusion

Overall results show that all the innovations considered in the study are located in a restricted area in the upper part

of the scatter diagram. Clearly, then, involved stakeholders assign a medium/high importance to all the selected innovations, thus, confirming the quality of the selection process carried out during the preliminary study.

By analyzing stakeholders' preferences, a ranking of innovations by importance is defined in the Adriatic region. However, the quite high value of standard deviations related to innovations' importance reduces its applicability. Nevertheless, a group of more promising innovations is clearly detected, including Big Data/data management, Data standardization and Big Data Analytics - which all are at the basis of every big-data project. Results then suggest that in the Adriatic area, where a strong interest in the development of the infrastructures required for their exploitation is in place, the application of big-data technologies is just at its starting phase. In conclusion, the whole "big data issue" does represent a significant focus in the area by relevant stakeholders. In particular, major opportunities are reported, ranging from data management to analytics and data standardization.

Acknowledgements

This work was entirely financed by "DigLogs - Digitalising Logistics Process" Interreg Italy-Croatia 2014-2020 project.

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Keywords

Big data, maritime transport networks, Adriatic region