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The impact of innovation on dock labour: evidence from European ports

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Abstract

The market environment of ports and terminals is continuously pushing terminal operators to achieve higher levels of dock labour performance. This paper proposes an original conceptual framework to identify, classify and evaluate innovative initiatives of terminal operators addressed to enhance dock labour performance. We link the innovation concept to a market-driven perspective on the organization of dock work in light of changing market requirements. The conceptual approach not only considers technological innovations, but also organisational and regulatory innovations. The framework is used to analyse a set of innovative initiatives of terminal operators in European seaports. The findings reveal that innovative initiatives can have very different characteristics and ramifications when looking at the type of innovation, the boundaries of innovation, the nature of the actors involved, the (expected) magnitude of impact and the impact of labour performance.

Keywords: Innovation, Port labour, Competitiveness.

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1. Introduction

Structural changes in maritime and logistics market have deeply reshaped port industry and consequently labour requirements (Notteboom, 2018). Existing studies on port labour are primarily focused on the social implications related to port labour (see e.g., Ircha and Garey, 1992; Turnbull and Wass, 2007) whereas economic and managerial approaches are generally neglected. On the contrary, port labour performance strongly affects the supply profile of ports and terminals, in terms of both efficiency and quality of services (e.g. service reliability, speed of vessel turnaround and berth availability). Regarding this aspect, Trujillo and Nombela (1999) and Turnbull and Wass (2000) have demonstrated the existence of a correlation between managerial inefficiencies, unreliable services and modest operational performance of ports on the one hand, and labour regimes and human resources management on the other hand. Satta et al. (2019) argue dock labour has a huge impact on port reputation and its market profile (see, e.g. negative implications of strikes organised by dockworkers trade unions on port reliability and reputation). Port labour is a key production factor in the port and terminal environment, and can be placed side by side to the other production factors, i.e. land and capital (e.g. cranes, yard equipment and terminal management hardware and software system) (Notteboom, 2018). Specific efforts and investments by terminal operators are required (e.g. new hires, training courses, improvement of working conditions, etc.) in order to meet dockworker needs and enhance port productivity.

In this perspective, a poor labour organization can negatively affect port competitiveness. Strict working conditions, especially in the container stevedoring industry, reduce terminal productivity and reliability. Satta et al. (2019) claim working arrangements may undermine the ability of terminal operators to deal with the optimal allocation of human resources in different job positions. Considering the highly variable demand for stevedoring services, labour flexibility contributes significantly to port competitiveness, by avoiding overstaffing or understaffing periods (Notteboom 2010). Labour contracts should be flexible enough to prevent excessive costs (in case of surplus of workers) and operational efficiency (in case of dockworkers shortages). However, many terminal operators have to deal with strict labour regulations, which differ from one country to another and/or from one port to another. This limits their flexibility in daily management as well as their competitive position in the market. Legal requirements, such as employment levels, payments and remuneration schemes, do not comprehensively cover all the aspects related to effective management of port labour, as a part of past literature sustains (Ircha and Garey 1992; Turnbull and Wass 2000). Job qualification, career development, team organization, education and training programs, health and safety conditions are considered as critical elements of labour contracts which deeply affect dockworker performance (e.g. working time, shifts, mental and physical stress, rate of accidents, etc.) (Turnbull and Wass 2007; World Bank 2007; Mitroussi and Notteboom 2015).

Notably, the labour market increasingly requires more skilled workers, especially after the advent of digital technologies embedded in the paradigm of Industry 4.0. In this regard, Schröder-Hinrichs et al. (2018) claim that highly skilled and educated

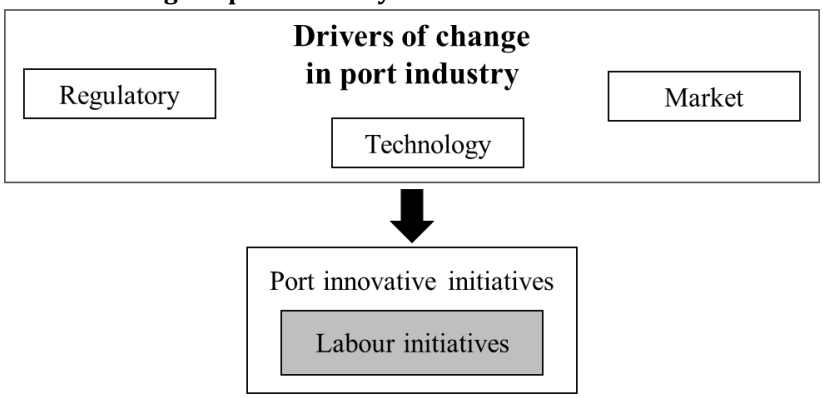
workers are more inclined to employ new technologies to perform their tasks. As a consequence, the demand for such workers has been rising in recent decades along with the introduction and diffusion of new equipment and digital technologies (e.g. Acemoglu and Autor, 2011). Arntz et al. (2016) estimate 14% of existing jobs in 21 OECD countries are at risk of becoming automated. The majority of the industries, indeed, rely on middle-aged workers and this represents an incentive to invest in automation and digitalisation. When it comes to the port industry, Frey and Osborne (2017) argue 27% of dock work is already automated and nearly 85% of their tasks will be automated by 2040. Therefore, dockworkers are challenged to acquire specific technicalities in order to meet current and future labour market requirements. In this perspective, terminal operators could design ad hoc training systems and introduce an innovative labour organisation, since huge investments in terminal equipment and infrastructure may not be sufficient to guarantee an improvement in overall port performance

Given the critical role of the workforce for port and terminal competitiveness and the lack in academic literature of comprehensive studies concerning port labour implications related to structural changes in maritime and logistics market, the paper proposes an original conceptual framework to identify, classify and evaluate innovative initiatives of terminal operators addressed to enhance port labour performance and meet new market requirements. In particular, the paper is structured as follows. Section 2 examines the main drivers (i.e. market, regulatory and technological drivers) which are shaping the port industry and the role of innovation for port competitiveness. Section 3 addresses the methodological issues to evaluate innovative initiatives in the port domain. In section 4, we apply the conceptual framework to five examples of innovative initiatives in the European port industry. Finally, section 5 summarises the conclusions and main implications of the research.

2. Drivers of change and innovation in the port industry

Several scholars have proposed various frameworks to identify the main factors of change in the port industry and to evaluate their implications on port labour. Nonetheless, the focus of these academic contributions predominately is on one single aspect, such as port reform (Brooks 2004), health, safety and security regulation (Naniopoulos 2000), automation (Yeo et al. 2008) and market changes (Notteboom 2010; 2012), leaving room for more inclusive studies. Therefore, the present study grounds on a wider comprehensive framework which identifies three main drivers of change in the port domain (Figure 1), as follows: (i) regulatory (institutional and normative) drivers; (ii) market drivers and (iii) technology drivers. These drivers represent the cornerstone for understanding terminal operators' strategic decisions to face the new competitive environment. In this perspective, innovation is a critical factor since innovative initiatives can significantly contribute to meet the increasing market needs and improve terminal performance, especially regarding the workforce.

Figure 1. Drivers of change in port industry and innovative labour initiatives



Source: authors' own elaboration

2.1. Regulatory drivers

The port and maritime industry is regularly confronted with changes in the regulatory and legal framework (Notteboom and Winkelmans, 2001). Since the 1990s, the deregulation trends in the port industry have been focused on promoting the entry of private terminal operators in the industry in order to boost port competitiveness as well as the financial transparency of public managing bodies and private port-related companies (European Commission 2004; Brooks 2004; Verhoeven 2009; Pallis et al. 2010). The privatization process has led to a wider adoption of the landlord port model by the majority of EU ports (Cariou et al. 2014). This model consists of a well-balanced division of liabilities between public and private actors, in which the latter oversee commercial activities (Comtois and Slack 2003). The corporatisation and privatization processes in the European ports in quite a few cases have deeply affected port labour since management and organization of operations fully or partially passed from public entities to private companies. The port reforms have also impacted dock labour employment systems in Europe. Many countries have abolished (full) labour pool systems (Notteboom, 2018), considering the high number of labour-related inefficiencies (e.g., excessive pools, rigid work rules, etc.) (Turnbull and Wass 2007; Van der Lugt et al. 2013). Therefore, an increasing number of private terminal operators can directly hire dockers for their business on the basis of their needs and, thus, they have higher control on the recruitment processes (Satta et al., 2019). However, the new reform schemes have revealed some weaknesses related to the emergence of social conflicts triggered by the worsening of dockworkers' conditions and wage reductions (Turnbull and Wass 2007). Health, safety and security issues represent traditionally hot topics in this industry since ports are considered one of the most dangerous work environments. Consequently, trade unions are particularly active and put a lot of pressure on public managing bodies aiming at drawing the attention to the numerous risks that stevedores are exposed to (Turnbull and Wass 2000). At the same time, accidents at work degrade the level of terminal efficiency due to work suspensions and a serious

stretching in the operating time. In this perspective, terminal operators have implemented quality management systems and innovative control systems for the identification of potential hazards (Alderton and Saieva, 2013). Furthermore, they have invested in new ergonomic equipment to prevent injuries and diseases (Yeo et al. 2008) and to raise the overall operational efficiency.

Despite the abovementioned positive improvements and the recent document realised by the European Commission aiming at defining standards and more protective rules for dockworkers in the European ports (European Commission, 2013), port privatization has led to the emergence of precarious employment, part-time and temporary job positions (Satta et al., 2019). These categories of workers are generally less skilled and experienced which can increase the risk of accidents and injuries. Furthermore, a downsizing of the number of dock workers can result in higher pressure on the remaining pool of workers (Notteboom 2010). Turnbull and Wass (2007) have demonstrated workers in such a case suffer from higher physical and mental stress, which deteriorates labour conditions and increases the risks at the workplace.

In conclusion, performance at work is likely to be negatively affected in case dockworkers are not sufficiently protected by an appropriate regulatory framework.

2.2. Market drivers

Over the past few decades, the reduction of trade barriers and the delocalization of production activities towards developing countries have supported the strong growth in maritime transport demand, especially before the global financial crisis (Notteboom and Rodrigue 2005). The intensification of trade has put a lot of pressure on ports due to cost and time efficiency and reliability requirements imposed by bigger ships and larger cargo volumes. Consequently, terminal operators have been called to heavily invest in new equipment and embrace new approaches to labour organisation and human resources management (Baird 2002). Notably, the deployment of mega-vessels and the rise of transhipment operations are challenging terminal operators to further improve the performance of ship-to-shore activities, including port labour productivity. For example, the introduction of innovative cranes and equipment involves specific professional competences which require ad hoc training courses and more skilled dockworkers (Satta et al. 2019).

Another important characteristic of maritime traffic is the significant level of volatility and seasonality in the cargo volumes to be handled at seaport terminals (Stopford 2009). Consequently, terminal operators are inclined to keep a core workforce and hire additional (temporary) dockworkers to deal with peaks in the market (Naniopoulos 2000). Additional workforce is provided by job agencies or official labour pools directly managed by the port itself, according to current regulation on labour port schemes (Satta et al. 2019). Furthermore, the high variation of transport demand determines a rearrangement of working practices for achieving further flexibility and operational efficiency. In this regard, Notteboom (2010) proposes an innovative organisational model based on new working procedures (e.g.

variable shift lengths, additional shifts, flexible starting times, etc.) to increase terminal operators' flexibility and boost their competitiveness. Moreover, Turnbull and Wass (2007) suggest terminal operators to invest in ad hoc courses for training multi-skilled dockworkers who can be able to cover diverse jobs and perform various tasks.

As regards the impact of changing market needs, Notteboom (2018) underlines the crucial role of shipping companies, third-party logistics service providers and shippers in reshaping logistics requirements on ports and terminals, including higher port labour performance. Notably, terminal operators are called to meet market requirements if they want to attract cargo and defend their competitive position. Therefore, they are expected to analyse demand needs and adjust or implement the array of services provided. Several authors have dealt with specific shipping lines' requirements (see e.g., Lam and Dai, 2012). Notteboom (2009) proposes an original framework to investigate the main relevant groups of factors affecting shipping lines' demand, which encompasses dock labour as a part of the supply profile of ports and terminals. The author demonstrates dockworker relationships and productivity affect decisively terminal operators' performance such as container handling rates, speed of vessel turnaround, berth availability as well as its market reputation (e.g. service reliability).

Conversely, fewer academic contributions address port and terminal-related requirements of third-party logistics service providers and shippers. In this regard, Nir et al. (2003) point to factors such as the price of port services, reliability of services, low transit time for goods, cargo security and damage prevention and ICT platforms to support the interaction between customer and supplier and facilitate information flows (e.g. track and tracing services).

2.3. Technology drivers

New technologies are considered one of the key drivers of change in the port domain (Notteboom, 2012; 2018; Satta et al. 2019). Technological solutions, indeed, are expected to create new opportunities for terminal operators as well as to shape the future port labour environment, affecting the work of both white-collar and blue-collar employees. Turnbull and Wass (2007) demonstrated automated systems lead to a considerable cost reduction related to the workforce in container terminals and a rise in labour productivity. As reported in the previous section (market drivers), new generation cutting-edge equipment for cargo handling can heavily affect the overall efficiency of ship-to-shore operations, supporting terminal operators to meet shipping companies' requirements, especially concerning the accommodation of bigger ships. In this perspective, automatic crane control (ACC), automated guided vehicles (AGV) and automated stacking cranes (ASC) represent the most diffused technological innovations to handle cargo from ship to shore and from the quay to the stacking area (Naniopoulos 2000). Additionally, digital technologies and ICT systems can boost operational flexibility of terminal operations as well as enhance service differentiation (Agrifoglio et al. 2017). However, all the above-mentioned

technologies require massive investments, which lower the flexibility of terminal operators' cost structure, and might require a (partial) reorganization of port labour. Large cargo volumes and a low volatility in traffic flows represent some of the essential conditions to guarantee enough revenues for justifying investments in innovative equipment technology (Satta et al. 2019).

The introduction of technological solutions can generate several relevant benefits for dockworkers in terms of job safety and working conditions. Still, new terminal technology also triggers discussions on some critical issues. Satta et al. (2019) underline that different limits exist related to the adoption of new technological equipment because of possible inertia of dockworkers in terms of attending training courses or making changes to their work routines (i.e. methods and procedures). Hence, terminal operators are called to develop more sophisticated and advanced training programs as well as to change the internal communication strategy and social dialogue processes for enhancing the motivation and productivity of their employees (Ircha and Garey 1992; Notteboom et al. 2010).

As regards working conditions, the introduction of automated systems causes an intensification of stress for stevedores due to higher responsibilities and more complex tasks (Notteboom 2010). Moreover, Hakam and Solvang (2009) argue new technological solutions and tools are going to reduce the dimension of the labour force in terms of the number of employees, especially for those tasks which still require manual work. In particular, the downsizing of the workforce concerns both personnel employed in the quay area and in warehousing activities (Ircha and Garey 1992).

2.4. Port innovative initiatives in a port environment driven by change

According to Schumpeter's theory (1939), innovation is "doing things differently in the realm of economic life". It represents a linear path which determines irreversible mutations in the competitive conditions of the market and affects the long-run growth of any firms, independently of the market they are involved in. This concept has been further investigated in subsequent economic studies, especially regarding the conditions and implications of the introduction and diffusion of innovative initiatives. In particular, Rogers (1962) describes the innovation path as a dynamic and complex process made by the combination of a plurality of factors, including resources and knowledge, which pave the way to the success and the uptake of a specific innovation. Although academic literature is full of different definitions of innovation, Vanelslander et al. (2019) draw attention to two main similarities: first, innovation drives change, and second, there are different kinds of innovation (i.e. new products or new quality of a products, new production models, new markets, new sources of supply of raw materials and intermediate goods, and new managerial and organisational models). In this perspective, the Guidelines for Collecting and Interpreting Innovation Data (Manual, 2005identifies four groups of innovations: product innovations, process innovations, marketing innovations (aiming at regulating internal/external relations) and organisational innovations, including

workplace and workforce organisation. When it comes to the rate of adoption and diffusion of innovation in a specific industry, Powell and Grodal (2005) emphasise the importance of communication and collaboration among the actors of the same competitive environment (e.g. port industry) as well as the relationship between managers and employees of the same firm. The development of a given innovation, indeed, grounds the process of interactive learning and the exchange of knowledge.

Given the above definition of innovation, this study focuses on the academic literature related to the port industry and, specifically, to port innovative initiatives. In the previous paragraphs, the paper examined the recent significant changes occurring in the maritime-logistics environment. In order to face this profound period of transformation, ports have made considerable progress in various areas, aiming at enhancing their performance and the quality of services provided (Slack and Frémont, 2005). Innovation plays an important role in supporting and advancing the development and management of port activities (Vanelslander et al. 2019). Several authors assert innovation contributes significantly to ports' competitiveness and it appears essential for maintaining and enhancing the competitive advantage of the whole supply chain they are involved in (Jenssen 2003; Flint et al. 2005). However, terminal operators have not fully undertaken innovation processes yet, despite innovation is widely considered as a strategic factor for seaports (Acciaro et al., 2018). One of the main constraints concerns their attitude towards co-operation, which slows down the diffusion and the adoption of new technological and organisational innovations. This issue has also been observed by the International Transport Forum (2010) that registers less pro-activity of transport and logistics firms to introduce innovative solutions in their business in comparison with other industries. In addition, Acciaro et al. (2018) underline port innovation initiatives are often derived from incidental success, which denotes a partial misalignment between the strategic objectives of maritime-logistics companies and their rate of success.

As regards academic studies in the transportation field, they are mainly focused on the assessment of investments addressed to improve the economic and social impact of transport infrastructure, including port facilities (e.g. cost-benefit analysis) rather than to evaluate innovative processes and managerial implications (Zheng and Negenborn 2017). Despite this, some scholars (see e.g., Aronietis et al. 2009) have recently investigated how innovation can advance general performance of transport firms, going beyond the economic perspective. The presence of a collaborative environment and the dynamic interaction among private and public actors in the port domain appear as key elements for the development of innovation paths (De Martino et al., 2013). In this regard, private firms often assume the role of innovation leader and, thus, coordinate the efforts of cluster members aiming at supporting innovation processes. Conversely, processes without a (private) firm leader seem to be less effective in achieving success (Acciaro et al., 2018). Another important aspect is the concept of co-innovation. In this vein, Vanelslander et al. (2019) draw the attention to collaborative innovation among supply chain stakeholders, which can widely affect port-related activities and pave the way for future maritime and port-related innovation development. Given the heavy role of public institutions in the port industry, academics agree that the design of a clear system of rules may create a fairer

competitive environment and stimulate port stakeholders to avoid opportunistic and conservative behaviours (Acciaro et al. 2018). Consequently, policy and regulation can support co-operation within the maritime cluster and promote port innovation development. Public authorities should increase the awareness of port stakeholders regarding the importance of innovation for port competitiveness and the opportunities to exploit agglomeration scale economies through wider synergies among maritime and port actors.

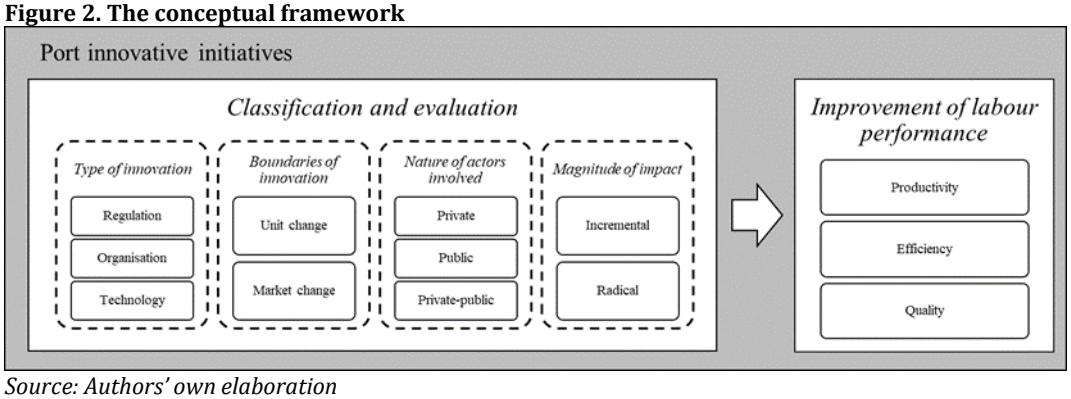
In summary, co-operation behaviour of port stakeholders and supporting regulation may speed up innovation processes and generate greater benefits for all the participants involved in the process, including dockworkers that represent one of the main stakeholders of the port industry.

3. Methodological approach

3.1. Conceptual framework on port labour innovative initiatives

Previous academic studies (see, e.g. Trujillo and Nombela, 1999; Turnbull and Wass, 2000; Notteboom, 2018) have demonstrated port labour performance deeply affects port and terminal competitiveness. However, economic and managerial approaches to the evaluation of labour measures are generally neglected in the port domain. Therefore, the paper proposes an original conceptual framework to classify and evaluate innovative initiatives addressed to port labour (Figure 2). The framework intends to define how ports and terminal operators face the changes in the port competitive environment by performing innovative initiatives aiming at improving port labour performance. Our approach grounds on the wide concept of innovation (see paragraph 2.4) and its critical role in the growth strategy of port and terminal operators.

Figure 2. The conceptual framework



Source: Authors' own elaboration

To this aim, the framework reports a two-steps methodological approach. First, it classifies and evaluates port innovative initiatives according to four dimensions (i.e. type of innovation, boundaries of innovation, nature of actors involved, and

magnitude of impact). Second, it scrutinises the impact of these actions on port labour performance, considering three different dimensions, as follows: labour productivity, labour cost efficiency and quality of labourThe following paragraph explains in detail each of the building blocks of the conceptual framework.

3.2. Methodological building blocks

While port labour can relate to any port-related employment, in this paper we narrow down the focus to dock work only, i.e. labourers involved in the unloading and loading of cargo at seaport terminals. The framework is used to investigate examples of an array of innovative initiatives of terminal operators going beyond the traditional area of equipment innovation and automation (see section 4). The manuscript intends to broaden the boundaries of innovation studies in the port domain by focusing on those innovations directed to improve labour performance (e.g. new organizational solutions for dock labour).

Therefore, after the explanation of the methodological approach for the evaluation of port labour innovative initiatives, the paper proposes some empirical examples to test the proposed conceptual framework (see section 4).

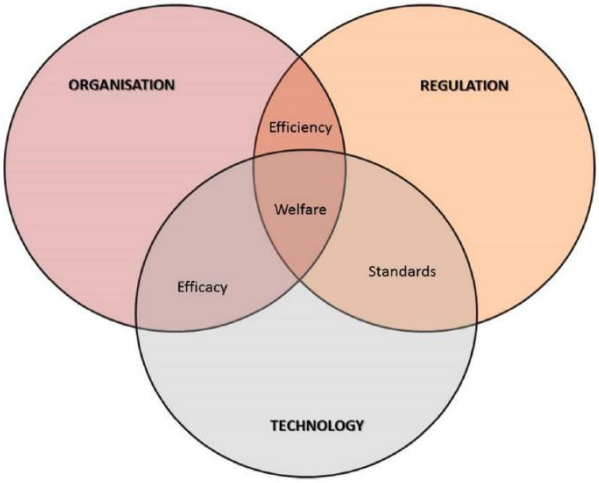
3.2.1. Classification and evaluation of innovative initiatives in the port domain

The first building block of the proposed methodological approach (i.e. classification and evaluation of innovative initiatives in the port domain) grounds on the work of Vanelslander et al. (2019) that examines innovations in the port domain, by using five dimensions: (i) the background of the innovation, (ii) the openness of the innovation, (iii) the actors involved, (iv) the source of innovation, and (v) the magnitude of the impact.

The first dimension (background of innovation) concerns the targeted goals of the innovative initiatives. Vanelslander et al. (2019) design a scheme with three innovation spheres (Figure 3): regulatory (institutional, policy or similar innovation types), organisational (management, system or similar innovations) and technological (product or process innovations). The originality consists of the mutual influence which triggers and fosters the innovation processes (e.g. the interrelation among “organisation” and “technology” explains how management, operational and cultural aspects deal with the introduction of new technological innovations). The second dimension (openness of innovation) outlines the presence of an “information sharing environment”. In particular, “closed innovation” refers to the attitude to keep the results of innovation activities within the firm; conversely, knowledge related to an “open innovation” is shared with the other member of the cluster (e.g., maritime cluster). While co-operation is a critical factor for the adoption and diffusion of innovative initiatives (see section 2), port-related initiatives are mostly “closed innovations” due to the tendency of maritime firms to hide the outcomes of their successful initiatives and, thus, preserve their competitive position in the market. The

third dimension (actors) grounds on the boundaries of the initiative. The authors make a distinction between "(Business) Unit Change" and "Market Change" to outline when a change occurs at a specific location (or involves one specific operator) and when it refers to the entire market. In particular, business or unit changes prevail over market changes in the port industry and, thus, the majority of innovative actions are confined to a single maritime terminal due to the complexity of aligning multiple actors' interests.

Figure 3. Background of innovation: targeted goals of the initiatives



Source: based on Vanelslander et al. (2019)

When it comes to the fourth dimension (source of innovation) there are two possible alternatives: private commercial innovation, addressed to improve a firm's performance, and public innovation, aiming at increasing socio-economic welfare. As concerns the maritime and port industry, the sources of innovation also include public-private initiatives, even though most of port innovations are private. This aspect further explains why most of innovative initiatives are "closed". The last dimension (i.e. the magnitude of impact), describes the size of the impact of new innovative initiatives on the market/business. This dimension distinguishes "incremental innovations" (i.e. marginal improvements/implications), and "radical innovations", which are associated with drastic changes in the market/business but are less diffused in the port industry.

For the aim of the present study, we use four criteria (i.e., type of innovation, boundaries of innovation, nature of actors involved, and magnitude of impact) to classify and evaluate innovative initiatives in the port domain (Figure 2). The "type of innovation" defines the background and the objectives of the action. We use three labels to classify the type of innovation, as follows: "regulation", which involves every change in the policy that can affect dockworkers and related tasks; "organisation", that is related to new organisational and managerial approaches to manage the port labour force (e.g., pool composition, shifts, assignment of tasks, etc.); "new

technology", which regards the employment of new terminal equipment, ICT systems or digital technologies by terminal operators. The second criterion (i.e., "boundaries of innovation") examines if the innovation is confined to a single terminal (i.e., "unit change") or encompasses the whole port, or even multiple ports (i.e., "market change"). The "nature of actors involved" identifies the private, public or private-public nature of the innovators. This distinction is particularly relevant to have a better understanding of the objectives pursued by the innovation process. Finally, the fourth dimension (i.e., "magnitude of impact") outlines the (expected) impact of the innovative initiatives on the terminal/port. The conceptual framework makes a distinction between incremental and radical innovation.

3.2.2. Port labour performance

Innovative initiatives have proven to be critical for the growth strategies of terminal operators (De Martino et al., 2013). In particular, academics and practitioners tend to consider port labour initiatives essential to improve terminal performance since dockworkers productivity is strictly interrelated with port competitiveness (Trujillo and Nombela, 1999; Turnbull and Wass, 2000). Therefore, the second building block of our original conceptual framework (Figure 2) describes how to evaluate the improvement of port labour performance as a result of specific innovative initiatives of terminal operators (classified and evaluated in the previous step). In particular, the methodological approach involves the use of three indicators, as follows: (i) labour productivity, (ii) labour cost efficiency and (iii) qualitative aspects of labour.

According to the economic definition, labour productivity represents the value delivered to the firm by human capital and it is calculated as total output divided by labour inputs. In the port domain, labour inputs are typically expressed in number of working hours per employee or in the size of stevedoring pools deployed to handle cargo. Output refers to cargo volume handled per time unit (i.e., an hour, shift, week, month or year) or value added created by dockers. Notably, input and output quantity can be formulated in alternative ways (e.g. using the output per man/hour or tons per gang/shift). The productivity of dockworkers employed at the quay (calculated as the tonnage loaded and discharged per dockworker/shift) relies on the number and size of the gangs as well as the number and type of cranes and other equipment deployed to handle the vessel including their level of automation.

The second indicator of labour performance is cost efficiency. According to Notteboom (2010), dock labour represents between 40% and 75% of total operating costs of general cargo terminals and 15% to 20% of dry bulk terminals in northwest European ports. While port terminals are increasingly automated and the industry is becoming more capital-intensive, dockworkers still cover a pivotal role in operational activities, absorbing a big portion of terminal operators' total expenditure (especially in container and general cargo terminals). Therefore, labour cost efficiency is a critical goal for terminals operators since it significantly affects their capability to generate margins. In this perspective, terminal operators have to strike a balance between

operating costs and labour performance: a reduction of salaries or a decrease in the number of workers does not always guarantee higher margins as these actions can result in a shortage of workers, strikes or other organisational and operational inefficiencies, which reduce the overall labour performance (Notteboom, 2018).

The last indicator deals with qualitative aspects of port labour that deeply affect terminal operators' logistics services. It is widely believed, a low service reliability, dependability or flexibility of dockworkers deteriorates the capability of terminal operators to meet cost recovery targets and reduces the overall productivity and competitiveness (Notteboom, 2018). In particular, service reliability is undermined by different factors related to the labour organisation and the management of the workforce. For example, the shortage of gangs (or dockworkers) can cause substantial delays in vessel loading and discharging operations, generating a higher cost for shipping companies and lowering the quality of the service provided by the terminal operator. Moreover, a high number of accidents at work may reveal a lack of training or a low commitment to the job of dockworker. Another element to consider are strikes that considerably reduce labour productivity and generate additional costs for all the members of the maritime cluster. Strikes typically emerge from disputes between terminal operators and dockworkers who require better employment contracts and working conditions.

In conclusion, terminal operators are challenged to design innovative initiatives that maximise dockworker performance in terms of productivity, cost efficiency and quality of the service provided.

4. Empirical examples of dock labour-focused innovation in the port industry

This section discusses some anecdotal evidences on innovative initiatives of terminal operators in order to test the original conceptual framework. We include recent examples of technological innovation in terminal equipment and automation, but also innovation in terms of organization and regulation. Notably, we select five innovative initiatives carried out in North European ports throughout the last decade, based on existing academic literature specialised in port management. Most of the examples are inspired by the array of current issues in dock labour systems as presented in Notteboom (2018) which includes relevant information about terminal operators' innovative initiatives. We focus on North European seaports since they are widely considered cutting-edge innovators by academics and practitioners of the industry (see e.g., Deloitte, 2017). More in particular, Tables 1 to 5 provide a structured analysis of the following innovations affecting dock labour in the port industry:

- The introduction of automated container terminals involving remotely-controlled quay cranes and automated yard and quay-to-yard equipment (Table 1);
- Change in the (legal) status of the dock worker (Table 2);

- The move towards more open and autonomous labour pool systems (Table 3);
- A push for continuous work (Table 4);
- Changes in dock labour hiring systems (Table 5).

Using the framework presented in Figure 2, the analysis provides insight in the type of innovation, the boundaries of innovation, the nature of the actors involved, the (expected) magnitude of impact and, finally, the (expected) implication on labour performance in terms of labour productivity, cost efficiency and quality of labour.

Table 1. The introduction of automated container terminals involving remotely-controlled quay cranes and automated yard and quay-to-yard equipment

Anecdotal evidence	New APM Terminals container terminal at Maasvlakte 2 in Rotterdam (the Netherlands)
Type of innovation	**Technology:** with large ramifications on labour organisation
Boundaries of innovation	**Market change:** While full terminal automation is not widespread yet (only 3% of container terminals around the world have been automated – figures Drewry), there is a clear move to automation particularly in larger ports (e.g. Rotterdam, Hamburg).
Nature of actors involved	**Private:** Driven by global terminal operators such as APM Terminals, HutchisonPorts, PSA, DP World, TIL, Terminal Link
Magnitude of impact	**Radical:** Strong decrease in number of required dock workers + change in profile of quay crane operators (i.e. a shift from 'on-quay' labour to 'control room' labour). In this specific case, the new APM Terminals terminal development in Rotterdam faced strong opposition from local labour unions as they feared possible loss of jobs and lower wages given the shift from classical crane drivers to remote operators of automated cranes.
Labour performance (LP: labour productivity, CE: cost efficiency labour, QL: quality of labour)	**LP:** Dramatic increase due to strong increase in the ratio capital/labour-intensity of terminal operations **CE:** Relation between technology and cost efficiency depends on the benefit/cost ratio of investments in new terminal technology and the related reduction in labour costs. **QL:** depending on reliability of technology; labour flexibility is function of equipment operations; the lower number of dock workers does not exclude strikes and disruptions but implies fewer workers can have a large impact on operations.

Source: Authors' own elaboration

Table 2. Change in the (legal) status of the dock worker

Anecdotal evidence	In many ports, only registered dock workers can perform dock work in the port (for example the Act Major in Belgian ports, see Notteboom 2010). This obligation can be imposed by national or regional legislation or might also be the outcome of collective bargaining agreements between port employers and trade unions. In some cases, like in the Belgian case, only one official dock worker pool in each port delivers recognized dock workers. The use of registered dockers through the pool is mandatory. Labour reform processes, pushed by European Commission rules, might aim to introduce competition among providers of registered dock work services.
Type of innovation	**Regulation:** with large ramifications on labour organisation.
Boundaries of innovation	**Market change:** The discussion on the legal status of the dock worker is European-wide and in many countries has already led to a more liberal approach to who can perform dock work. For example, the National Dock

	Labour Board (NDLB) in the United Kingdom was abolished in 1989. Most stevedoring companies now employ a core workforce and run their own recruitment agencies to satisfy peaks in labour demand (Turnbull and Weston 1993). Belgium and Spain are among the countries where only recognized dock workers employed through dock labour schemes can perform dock work in the port.
Nature of actors involved	**Private or public:** Dock workers can be civil servants in state-owned service ports, workers directly employed by a private terminal operating company or workers employed through dock labour schemes. This implies the actors involved can be private or public.
Magnitude of impact	**Radical:** The UK case demonstrates that major changes in the legal status of the dock worker can have wide impacts on the organisation and operations of dock work. It is generally believed that the combination of privatization, increased capital investments and a plentiful supply of labour has contributed to the revitalisation of UK ports. In case a terminal operator is not happy with the current arrangements in terms of dock worker status in a port, he can push/lobby for regulatory change, opt for technological innovation to reduce labour dependency or move activities to a (neighbouring) port with more favourable labour conditions.
Labour performance (LP: labour productivity, CE: cost efficiency labour, QL: quality of labour)	**LP and CE:** While the productivity of port workers in UK ports has generally increased, Turnbull and Weston (1993) argue that UK ports are now 'locked in a vicious spiral of cost-cutting, based predominantly on reducing labour costs. In other cases, it is less clear how a change in dock worker status might affect LP and CE. Mitroussi and Notteboom (2015) point in this respect to the role of motivation in securing LP, next to the overall legal organisation of dock work and dock worker status. **QL:** it is believed that less strict rules on the dock worker status might pave the way to a higher labour flexibility (combined with lower labour union power). At the same time, the European Transport Workers' Federation and individual labour unions consider cargo handling operations as highly dangerous operations that can only be done by trained and experienced workers. Relaxing rules on the dock worker status might therefore negatively impact safety.

Source: Authors' own elaboration

Table 3. The move towards more open and autonomous labour pool systems

Anecdotal evidence	Dock work in many European ports is guided by a dock labour scheme using a centrally managed pool of registered dock workers. These dock labour schemes are based on systems of registered dock workers who are not permanently employed at particular stevedoring enterprises but hired through a central pool or hiring hall. In case there is not enough work available during a particular day or period, the registered dockworkers can rely on minimum pay guarantees or unemployment benefits. Employers and employees jointly determine the size of the docker workforce based on current and future needs. Many of the dock labour schemes in European ports have undergone small or significant changes to labour pool arrangements (see Notteboom, 2018 for a detailed analysis). In some cases, such as in Germany and the Netherlands, employers can hire permanent company employees directly from an external labour market, but any additional (casual) labour must be hired from a regulated labour pool. Overall, there is a general trend towards open and autonomous pool systems with back-up of temporary employment agencies. In some countries, such as Belgium and Spain, this

	process is much slower or even not taking place despite investigations and (legal) actions of the European Commission.
Type of innovation	Regulation and organisation
Boundaries of innovation	**Market change:** The move towards open and autonomous pool systems is European-wide, although the speed of progress differs between countries.
Nature of actors involved	**Private and public:** National governments typically are responsible for designing and implementing the general legal framework of the (national) port labour scheme. However, supranational (i.e. EU) guidelines and regulations/directives also have a key role to play. Processes of social dialogue between employers' organizations and labour unions not only provide input for the government's regulatory work, but also outlines the more practical implementation of such schemes in the ports. Also, port authorities might (informally) influence the reform processes of dock labour systems and regulations.
Magnitude of impact	**Radical:** Major changes in the dock labour employment schemes generally have wide impacts on the organisation and operations of dock work. In case a terminal operator is not happy with the current dock labour scheme he can push/lobby for regulatory change, opt for technological innovation to reduce labour dependency or move activities to a (neighbouring) port with more favourable labour conditions.
Labour performance (LP: labour productivity, CE: cost efficiency labour, QL: quality of labour)	**LP and CE:** No studies are available that analyse the impact of a move towards an open and autonomous pool system on labour productivity. Anecdotal evidence demonstrates that some ports with a closed dock labour pool (such as the port of Antwerp) are known for their high labour productivity (measured in terms of tons/TEU handled per dock worker per shift). **QL:** One of the main incentives behind the establishment of dock labour pools is to guarantee flexibility in labour quantity to cope with possible high volatility in port activity. A move towards more open and autonomous pool systems can only be successful if solutions are found (for example through temporary labour offices) to deal with peaks and troughs in terminal activity in a cost-efficient way.

Source: Authors' own elaboration

Table 4. A push for continuous work

Anecdotal evidence	Terminal operators are pushing for continuous work to meet the service availability (24h/7d) and reliability requirements of shipping lines. As a result, terminal operators in many European ports implement or try to implement operational changes such as individual rather than collective breaks, flexible start times and variable shift lengths. In some cases, such changes are blocked or made difficult by regulatory or operational barriers. For example, half shifts or continuous hiring (starting a shift at a preferred moment in time) are not possible in Antwerp. Another trend is the implementation of the so-called 'hot seat' change or the seamless transition from one shift to another which results in continuous work on a ship thereby reducing idle time of the handling equipment. Dock labour schemes show various ways in dealing with overtime, night shifts and weekend work. For example, in some ports weekend work is considered as a normal shift, while dockers in other ports have the freedom to accept weekend shifts (voluntary basis) with provisions in place for overtime money in case they do.
Type of innovation	Organisation, if needed, supported by regulatory changes
Boundaries of innovation	**Market change:** European-wide phenomenon, although the speed of progress and the intensity of implementation differs between ports.

Nature of actors involved	**Private (but public action often required):** Terminal operators are the main drivers behind the push for continuous work. However, in some cases, regulatory changes are needed requiring action from national or regional governments, for example when existing (sector-wide) labour regulations put heavy restrictions on night shifts and weekend work.
Magnitude of impact	**Incremental to radical:** The impact of the push for continuous work is very much dependent on the local circumstances in the port under consideration. When a terminal operator is dealing with a port that historically has very favourable operational and regulatory conditions in place to allow more continuous work then the impact will be incremental. In other cases, the implementation of continuous working processes at terminals requires a radical rethinking of the existing operational and regulatory environment.
Labour performance (LP: labour productivity, CE: cost efficiency labour, QL: quality of labour)	**LP and CE:** More continuous work can increase LP, particularly when (paid) non-productive time is turned into productive time (e.g. hot seat change). The most important benefit of continuous work is that expensive capital assets (such as cranes) end up having far less idle time which improves the cost efficiency of these assets. **QL:** A move towards more continuous work does not necessarily improve the quality of labour. Some labour unions warn that it leads to increased pressure on the workers and stimulates fatigue (which can increase the accident risk). Therefore, when implementing continuous work practices, terminal operators are challenged to develop a range of additional measures to guarantee work motivation and to avoid any safety issues.

Source: Authors' own elaboration

Table 5. Changes in dock labour hiring systems

Anecdotal evidence	Dock labour schemes in ports often go hand in hand with very specific hiring methods, particularly in case a pool of registered dock workers exists. Notteboom (2010) describes how hiring systems in European ports can differ in terms of (a) the hiring moment (e.g. hiring at fixed moments per week day or on a continuous basis), (b) the persons involved in the hiring process (e.g. foreman, company officials); (c) the characteristics and governance of the supervisory system; (d) the interaction between docker and hiring person/entity (e.g. physical in a hiring hall or via electronic systems); (e) the control given to the docker (e.g. matching on a voluntary basis or controlled externally with or without taking into account the preferences of dockers). Technological advances in mobile communication have facilitated the modernization of job assignment systems towards electronic dispatching of dock workers in ports or terminals. The use of physical hiring halls is therefore becoming very rare.
Type of innovation	**Organisation**, if needed, supported by regulatory changes and technology (e.g. electronic hiring)
Boundaries of innovation	**Market change:** European-wide phenomenon, although the speed of progress and the intensity of implementation differs between ports.
Nature of actors involved	**Private (but public action might be required):** Employers' organisations and labour unions are the actors involved in proposing and implementing changes in the hiring systems. However, in some cases, regulatory changes are needed requiring action from national or regional governments.
Magnitude of impact	**Incremental:** In most cases, a change in hiring system does not fundamentally alter the overall dock labour conditions and systems in the port. However, it can have an impact on more social dimensions of the life of a dock worker. For example, casual dock workers in the port of Antwerp

	used to be hired during four daily sessions at a central hiring hall near the city (note that about two thirds of all casual dockers in Antwerp are effectively quasi-permanent or semi-regular, working for the same employer on a regular basis via a 'repeat hiring' by a regular employer). A few years ago, the hiring hall was replaced by a system of electronic hiring. This new hiring method brings a more efficient matching of supply and demand and avoids dock workers having to commute to the hiring hall. However, it also made an end to the centuries-old function of the hiring hall as a place of social exchanges among dockers and employers.
Labour performance (LP: labour productivity, CE: cost efficiency labour, QL: quality of labour)	**LP and CE:** impact expected to be limited. **QL:** impact expected to be limited.

Source: Authors' own elaboration

5. Conclusions

The market environment of ports and terminals is continuously pushing terminal operators to achieve higher levels of dock labour performance. This pressure has direct implications on the requirements for dock labour arrangements and employment systems and has intensified the search for technological, organisational and regulatory innovative solutions. This paper proposed an original conceptual framework to identify, classify and evaluate innovative initiatives of terminal operators addressed to enhance port labour performance and meet the ever more stringent market requirements. This paper contributes to existing dock labour literature by linking the innovation concept to a market-driven perspective on the organization of dock work in light of changing market requirements. By focusing on those innovations directed to improve labour performance, this study also broadens the boundaries of innovation studies in the port domain. We did not only consider technological innovations, but also incorporated organisational and regulatory innovation in the presented conceptual approach and their potential impact on port labour performance.

The methodological framework was used to analyse a set of innovative initiatives of terminal operators: the introduction of automated container terminals; a change in the (legal) status of the dock worker; the move towards more open and autonomous labour pool systems; a push for continuous work, and; changes in dock labour hiring systems.

The results show that innovative initiatives can have very different characteristics and ramifications when looking at the type of innovation, the boundaries of innovation, the nature of the actors involved, the (expected) magnitude of impact and the impact of labour performance in terms of labour productivity, cost efficiency and quality of labour. The study also underlines that organisational and regulatory innovation, next to technology, has a key role to play in achieving a higher labour performance.

Port actors should also acknowledge the strong interdependency among the types of innovation. Organisational innovation often requires supporting actions in the field

of regulation and new technological solutions. In this perspective, the relation between the three types of innovation is not univocal. For example, an inefficient and costly dock labour system in a port might give impetus to terminal operators to opt for terminal automation. However, the benefits of automation partly depend on whether or not the technological innovation enables the terminal operator to reduce the workforce and achieve significant savings in labour costs. The existing organisational and regulatory arrangements in terms of dock labour might undermine the operator's opportunity to fully reap such benefits of automation. Thus, terminal automation often requires some regulatory and operational innovations as well.

Another finding is that the majority of the discussed innovations relate to radical market changes, not an incremental unit change. This implies that the transformations the port industry is going through are widespread across ports and generate fundamental impacts that potentially change the face of the port/terminal scene.

Finally, the analysis also demonstrated that the impact of the discussed innovations on labour performance (in terms of labour productivity, cost efficiency labour and quality of labour) is difficult to measure and complex in nature, particularly when focusing on the quality of labour dimension. Organisational changes can lead to increased pressure on the workers, and higher risks of accidents and fatigue. Terminal operators are challenged to develop a range of additional measures to guarantee work motivation and to avoid any safety issues. This supports the idea that terminal operators cannot only focus on hard economic aspects of innovation when trying to improve labour performance, but also should incorporate softer social aspects in innovation processes such as dock worker motivation, commitment, social interaction and the need for social dialogue. In addition, terminal operators are expected to invest in *ad-hoc* courses for training multi-skilled dockworkers who can be able to cover diverse jobs and perform various tasks. Through this way, they can also meet the recent demand for high skilled and educated workers triggered by the introduction and diffusion of new equipment and digital technologies embedded in the paradigm of Industry 4.0.

This study contains several limitations and opens avenues for future research. First, while the conceptual framework in principle can be applied to ports around the world, the external validity of the empirical application is limited. Each port region has specific characteristics in terms of market environment, governance structure, level of inter-port competition and port labour organisation and associated regulatory framework. These differences may require some specific adjustments to evaluate the implications on workers involved in the industry. Second, the empirical analysis included an application of the conceptual framework of five different innovative initiatives related to dock labour. While these selected initiatives brought forward some interesting findings on how innovation affects dock labour, there are obviously also other innovations in the port industry which affect dock labour. For example, advances in data mining techniques helped global terminal operators to develop an increased focus on performance measurement and benchmarking among the terminals within their network. Future research can focus on how innovations at

terminal level are shared in such global terminal networks and on how these innovations and benchmarking practices affect dock labour performance targets and arrangements at the local level. Third, the conceptual framework was empirically supported by evidence on dock labour in European ports. However, the relationships have not been empirically quantified. We believe there is room for such a quantification, but this assumes that difficulties in obtaining non-publicly available data on dock labour performance can be overcome. Next, there is room for extending the port sample to other regions around the world, so that a more global view can be developed on the relations (and potential regional differences) between innovation and dock labour performance.

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