ALTERNATIVE SCENARIOS OF LABOR FLEXIBILITY FOR DOCK WORKERS IN TRANSHIPMENT CONTAINER TERMINALS

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ABSTRACT

In the competitive environment of Transhipment Container Terminals (TCTs), it is essential to reduce unproductive costs and offer efficient services to shipping companies. One of the most important factors for TCTs efficiency is to plan human resources allocation optimally. However, in some TCTs, strict work regulations and insufficient labor flexibility can prevent an optimal use of available resources and produce an increase in terminal operating costs.
This study analyzes work regulations in Mediterranean North-West Coast TCTs and proposes several change scenarios on labor flexibility. The aim of this study is to show the effects of a greater labor flexibility in terminal operations in terms of a more efficient use of available resources and a reduction in operating costs. To address this problem, regulations on Italian dock labor are analyzed and a scenario corresponding to the current work organization is built. This scenario is compared to five alternative scenarios constructed by increasing the share of daily working flexibility and introducing a new type of labor flexibility, called mini-flexibility. The use of a state-of-the-art Integer Linear Programming Model for the daily assignment of human resources in a TCT has allowed to simulate the effects of each scenario in terms of operating costs and workers under-manning. Results show that an increased labor flexibility can lead to significant reduction in TCT operating costs related to workforce management.

Keywords: Labor Flexibility, Manpower Management, Maritime Container Terminal.

INTRODUCTION

In the competitive sector of transhipment container terminals, it is essential to reduce unproductive costs and offer efficient services to shipping companies. In fact, a crucial problem in terminal management is to optimize the balance between shipping operators who request fast service on their vessels and port operators who request economic use of their resources (Stahlbock and Voss, 2008). An optimal service level should be considered by the operating costs of port system and vessels turnaround time costs.

In port activities, time efficiency and costs are deeply related and low-speed handling or unproductive hours on the dock should be avoided as much as possible (Emeghara and Ndikom, 2012). Fast handling operations have a positive impact not only in reducing the vessel turnaround time, but also in the number of trips that can be performed by vessels (Chin-Yuan e Wen-Chin 2001). In fact, a greater use of a container vessel can only be achieved reducing the time spent in port and increasing the time spent in navigation, only in this way fixed costs can be spread over a greater number of trips. Terminal efficiency is increasingly linked to the ability to ensure rapid processing of the vessels and ever more often shipping companies choose terminals that provide the best time efficiency. In other words, when a shipping operator chooses a terminal it not only evaluates the possibility to reach the terminal in time but also the possibility to leave it in a short time (Konig, 2002).

In not automated container terminals, where activities are mainly based on the labor of operators ("blue collars"), a key factor for terminals efficiency is to plan human resources allocation effectively. In these terminals, labor cost is on average between 40% and 75% of the total operating cost (Castalia Report, 2012). Furthermore, even in capital-intensive container handling terminals, it frequently happens that labor cost reaches 50% of the total operating cost (Notteboom, 2010). Therefore, an optimal manpower management is a priority in pursuing a policy of reducing operating costs and minimizing the total vessel turnaround time, the latter closely related to the actual workforce availability and its performances. When in a working shift, the available workforce is less than the quantity of staff that would be needed to complete all operations scheduled for the shift, it is said that in this shift there is a manpower shortage. The manpower shortage in a shift makes that part of the work planned for that shift cannot be completed. The completion of the unfilled work is postponed to the following shifts with inevitable lengthening of vessels turnaround times. In fact, a vessel cannot restart his journey until loading/unloading operations on it will not be completed.

The occurrence of manpower shortages can have significant impacts in terms of additional costs for both the container terminal and the vessel, moreover, in the long term, it can have undesirable implications on terminal reputation. The optimal management of human resources is therefore a key element in port management and it is not a coincidence if many terminal operators underline the need for analytical tools to support decision making process. However, even an optimal resources management implemented through an effective analytical tool, may not be sufficient to ensure at the terminal a competitive position in a market characterized by competitors operating under more permissive regulations and working with lower labor costs.

An example in this regard is represented by the case of pure transhipment container terminals (Cagliari, Taranto, Gioia Tauro, Algeciras, Malta, Port Said East) located in the Mediterranean Sea. Their competitiveness is mainly due to the high proximity to the ideal route (Suez Canal - Strait of Gibraltar) which allows large container vessels to save several days of sailing. Currently, the competition between them is distorted by economic-regulatory inhomogeneities which place the ports located in Mediterranean North-West Coast (MNWC) in a significant disadvantage with respect to African competitors (Eurispes Report, 2011). In fact, MNWC terminals are characterized not only by a greater taxation of transhipment activities and higher infrastructure and energy costs with respect to their nearby competitors but also by more restrictive labor regulation and higher labor cost[1] that put them in a significant disadvantage.

Although in the medium/long term, the balance between supply and demand for port services and the increase in rates practicable from ports situated on the Mediterranean South Coast should

[1] An example: the average hourly cost of labor in Egyptian and Moroccan ports is much lower than in Italian ports: 22,1€/h in Italian ports, 3,1 €/h in Moroccan ports and 1,9 €/h in Egyptian ports (Eurispes, 2011).

encourage the competitive repositioning of MNWC ports, in the short term it is essential to implement intervention strategies to reduce the competitive gap of MNWC ports with respect to other competitors (PRIN, 2011).

In this respect, several change scenarios on labor flexibility for MNWC terminals are proposed in this study in the attempt to show how a greater labor flexibility could result in lower manpower shortages, reduced operating costs and greater port competitiveness. The proposed scenarios are constructed by increasing the share of daily working flexibility, than is currently allowed in MNWC terminals, and introducing a new type of labor flexibility, called mini-flexibility. Only as an example of this process, Italian work rules are considered in this paper but the analysis can be extended to other National labor legislation.

To evaluate the economic effects of labor flexibility in reducing manpower shortages and vessel operation delays a cost model is also proposed. The cost model illustrates the relationship between manpower shortages and costs related to extra-time spent by vessels in port to complete loading operations.

The simulation of the effects produced by each scenario, in terms of operator shortages and additional related costs, is performed through the use of a state-of-the-art mathematical programming model for the optimal daily allocation of operators in a transhipment container terminal.

The aim of this study is to show the importance of labor flexibility in the port area in order to stimulate a discussion on the need/opportunity to implement changes on MNWC port labor regulation, today too restrictive and in fact very limiting for terminals.

It is important to note that greater flexibility can help reduce the competitive gap of MNWC terminals in relation to other competitors working under more lax labor regulations. The greatest risk is that, in the absence of interventions in the short term, the loss of competitiveness that MNWC transhipment ports have demonstrated in recent years will result in a reduction of activity with its negative economic effects.

The paper is organized as follows. Section 1 presents a brief summary of Italian regulations concerning port labor. Also, this section presents a description of the organization structure for manpower management currently used in Italian container terminals. This is followed by Section 2 which presents a brief literature review on human resources port management. Section 3 describes our methodology and presents a cost model associated with manpower shortages. In Section 4 several scenarios of change in port labor flexibility for terminals are presented and tested. Finally, concluding remarks are presented in Section 5.

THE FRAMEWORK LEGISLATION: THE ITALIAN CASE

The handling activity in a container terminal is closely related to the availability of vessels in dock, and then to the arrival times of vessels in port. However, the arrival time of a vessel is a parameter affected by significant uncertainty. The level of precision in its evaluation becomes acceptable only when the actual arrival of the ship in port is approaching. In fact, although a vessel periodically sends to the terminal expected arrival time through ETA (Estimated Time of Arrival) from as early as the weeks before its actual arrival, only ETAs sent 48/24 hours before the arrival show an acceptable level of reliability.

However, due to union and work rules, working shifts must typically be planned a number of months before their implementation, when the demand data on vessels that must be handled in the day is still highly uncertain. A shifts scheduling that does not take into account demand data and is

performed only on the basis of labor agreements and trade unions, has clear limits of efficiency and avoids a good match between the work demand and the work supply available in the planned day.
A synthesis framework concerning port labor regulation in Italian ports is provided below.
The Italian legislative framework consists of:

- The Legislative Decree 66/2003;
- The National Collective Bargaining Agreement[2] for dock workers (NCBA);
- The Law 84/1994[3];
- Second-level Agreements (specific for each port).

The Legislative Decree 66/2003 is in Italy the general norm for the labor organization in all employment sectors, it defines the following key points:

- The regular working time is established in 40 hours per week;
- The average duration of working time (regular and overtime) may not exceed 48 hours per week, in reference to a maximum period of 4 months;
- The minimum daily rest period is fixed in 11 consecutive hours every 24 hours;
- The maximum amount of overtime work is fixed in 250 hours per year.

Recognizing the special nature of port labor, the Legislative Decree confers on Collective Agreements, against objective technical or organizational reasons, the possibility of establishing the maximum weekly commitment of each worker and defining additional organizational flexibility by extending up to 52 weeks the reference period for calculating the average duration of working time (daily and weekly).
The NCBA in place in Italy is the *NCBA for dock workers 01/01/2009 - 31/12/2012*. It regulates labor relations among terminal operators, port authorities, port companies and dock workers (as defined by the Law 84/94 and its amendments). The NCBA sets out a series of instructions for the specific activity of organizations operating 24h/7d, such as container terminals.
The duration of the standard weekly working time is fixed in 36 hours for 24h-shift-workers and for the staff of external firms authorized to provide temporary port labor. The weekly working time can be distributed on 5 or 6 days a week (the decision is referred to second-level agreements). In the attempt to provide an answer to the uncertain nature of terminal activities, the NCBA introduces the contractual institute of flexible service, allowing a maximum of six flexible services per month for each operator. The contractual institute of flexible service is studied for organizations, such as container terminals, which organize their work on the basis of a multi-period programming (usually annual or monthly) of working shifts. Because of the uncertainty of work demand the multi-period programming assigns, for each day, workers in “fixed” service and workers in “flexible” one. A worker in fixed service in a given day is already assigned to a specific shift on that day while a worker in flexible service knows he will have to work on that day but his working shift will be

[2] A Collective Agreement is a legally contract, specifying terms and conditions of employment, between an employers’ association and trade unions representing workers in the area.
[3] Law 28/01/1994, n. 84: Reorganization of port legislation.

provided only later, with a reasonable notice time. The definition of the notice time is referred to second-level agreements of each port, in most cases the notice time is fixed at 24 hours.

On the basis of regulations concerning port labor, Italian transhipment container terminals have organized the workforce management according to two different planning levels:

- Long-term plan. It consists of a sequence of working and rest-days for each terminal worker ("internal worker") and is typically performed once a year, according to work rules and contractual clauses only.
  Internal workers in a day may be in fixed or flexible service. Workers in fixed service ("fixed workers") are already allocated to a specific shift in that day while workers in flexible service ("flexible workers") are not yet assigned to a specific shift in that day. Since the real work demand is not yet known, tasks (quay crane, yard crane, truck trails, etc.) and activities (vessel or housekeeping) of workers cannot be planned in this phase. Figure I shows an example of long-term assignment for an internal worker in Italian container terminals. Each line represents a months of the year while each column represents a day of the month. The single box shows the daily assignment of the worker. Worker in a day may be in fixed service (the box-code is the working shift), in flexible service (the box-code is *FLX*) or in day-off (the box-code is *RPI* or *RIC*).

- Short-term (24/48 h) plan. It determines shifts, tasks and activities in the next work day for each worker. This plan is a refinement of the long-term one and it is typically performed 24 hours in advance of the planned work day, when the work demand data is more precisely known. The operational plan is required to inherit workers in fixed service from the long-term plan and determine the shifts of workers in flexible service. Moreover, to face work demand peak, a limited number of "external workers" coming from outside the dock workers pool, can be employed for performing some tasks when internal workers are not sufficient.

2011	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
01	RIC	FLX•	II	III	RPI	RIC	RIC	II	FLX•	III	RPI	I	RIC	FLX	II	RIC*	RPI	I	RIC	II	FLX	III	RPI*	RIC	RIC	FLX	II	III	RPI	I*	RIC
02	II	FLX	III	RPI	I	RIC*	FLX	II	III	RPI	I	RIC	II*	FLX	III	RPI	I	RIC	FLX	II*	III	RPI	I	RIC	II	FLX	III*	RPI			
03	I	RIC	FLX	II	III	RPI*	I	RIC	II	FLX	III	RPI	I*	RIC	FLX	II	III	RPI	I	RIC*	II	FLX	III	RPI	I	RIC	FLX•	II	III	RPI	I
04	RIC	II	FLX•	III	RPI	I	RIC	FLX	II	III*	RPI	I	RIC	II	FLX	III	RPI*	I	RIC	FLX	II	III	RPI	I*	RIC	II	FLX	III	RPI	I	
05	RIC*	FLX	II	III	RPI	I	RIC	RIC*	FLX	III	RPI	I	RIC	FLX	II*	III	RPI	I	RIC	II	FLX	III*	RPI	I	RIC	FLX	II	III	RPI*	I	RIC
06	II	FLX	III	RPI	I*	RIC	FLX	II	III	RPI	I	RIC*	II	FLX	III	RPI	I	RIC	FLX•	II	III	RPI	I	RIC	II	FLX•	III	RPI	I	RIC	
07	FLX	II	RIC*	RPI	I	RIC	II	FLX	III	RPI*	I	RIC	FLX	II	III	RPI	I*	RIC	II	FLX	III	RPI	I	RIC*	FLX	II	III	RPI	I	RIC	RIC*
08	FLX	III	RPI	I	RIC	FLX	II*	III	RPI	I	RIC	II	FLX	III*	RPI	I	RIC	FLX	II	III	RPI*	I	RIC	II	FLX	III	RPI	RIC*	RIC	FLX	II
09	III	RPI	I	RIC*	II	FLX	III	RPI	I	RIC	FLX•	II	III	RPI	I	RIC	II	FLX•	III	RPI	I	RIC	FLX	II	RIC*	RPI	I	RIC	II	FLX	
10	III	RPI*	I	RIC	FLX	II	III	RPI	I*	RIC	II	FLX	III	RPI	I	RIC*	FLX	II	III	RPI	I	RIC	RIC*	FLX	III	RPI	I	RIC	FLX	II*	III
11	RPI	I	RIC	II	FLX	III*	RPI	I	RIC	FLX	II	III	RPI*	I	RIC	II	FLX	III	RPI	I*	RIC	FLX	II	III	RPI	I	RIC*	II	FLX	III	
12	RPI	I	RIC	FLX•	II	III	RPI	I	RIC	II	FLX•	III	RPI	I	RIC	FLX	II	RIC*	RPI	I	RIC	II	FLX	III	RPI*	I	RIC	FLX	II	III	RPI

Figure 1 – Example of a long-term assignment of an internal worker.

STATE OF THE ART ON HUMAN RESOURCES PORT MANAGEMENT

The handling activity in a container terminal is closely related to the arrival times of vessels in port. The level of precision in the evaluation of vessels arrival times becomes acceptable only when the actual arrival of the ship in port is approaching. Moreover, recently, new forecasting tools applicable in the short term (24-48h) for predicting vessels arrival times are being developed and contribute to making sufficiently accurate the work demand data relative to 24 hours (Fancello et al., 2011).

However, due to labor rules, working shifts must be planned a number of months before their implementation, when the demand data is still highly uncertain. As a consequence, one of the main risk factors in the daily management of human resources is the lack of workers to meet the demand of the day and the resulting delays in vessel operations (Notteboom, 2010). Manpower shortages can derive from unexpected reductions in the number of available workers (due to strike, sick leave, etc.) or, more frequently, from unforeseen demand peaks. Whatever the cause, manpower shortages produce a slowdown in port activities and a lengthening of vessels turnaround times with related additional costs. Recently, Park and Dragovic (2009) have analyzed the problems originating from vessels waiting to complete operations in Busan terminals, stating that waiting costs are as important as operating costs.

Manpower shortages result from an unsatisfactory matching between the work demand of the day and the work supply available in the same day. In fact, the complexity of the relationship between work demand and work supply would require a high labor flexibility, not always achievable.

Labor flexibility may be realized in several forms (Notteboom, 2010):

- Flexibility in working hours, which gives, within certain limits, a lot of initiative to the employee.
- Flexibility in tasks, which allows that port workers can be used for different types of tasks (multi-skilling or multi-tasking) according to their qualifications.
- Flexibility in the size of working teams.
- Flexibility in labor quantity, which refers to the possibility to adapt the size of the workforce to the amount of work that needs to be done.

Flexibility in labor quantity is probably the most important form of flexibility for a good business operation in container terminals, where demand peaks not included in the long-term plan can often occur when daily workforce management is being performed.

Literature provides many studies on workforce management, a wide framework is given by Ernst et al. (2004), however few of these studies are devoted to the specific context of container terminals. Among the most significant contributions on the manpower management problem in container terminals there are: Kim et al. (2004) who investigates the scheduling of workers to handling equipment, Lim et al. (2004) who formulates a manpower allocation model for the movements of workers at Singapore port, Hartmann (2004) who presents a general model for the scheduling of jobs and operators in container terminals, Legato and Monaco (2004) and Monaco et al. (2009) who propose two different models for the long-term and the short-term plan of workforce management.

However, none of these studies considers manpower shortages and their impact in terminal activities. Fancello et al. (2011) is, to our knowledge, the only study in which manpower shortages are for the first time treated as decision variables of the human resources allocation problem.

Their model is used in this study to simulate the effects of changes in labor flexibility in Italian terminals in terms of workers shortages and related cost.

METHODOLOGY: THE COST MODEL

In maritime container transport, shipping companies choose terminals evaluating benefits of each of them in terms of cost/efficiency and time savings. The optimal service level should be considered by the operating costs of the terminal system and vessels turnaround time costs. The higher service level, the shorter service time and waiting time for vessels and the lower operational costs.
A lengthening of working times on vessel produces operation delays and additional costs for both the shipping company and the terminal. In manpower management, minimizing the total service cost is equivalent to minimizing a cost function that takes into account budgeted working hours and additional hours that may be necessary to complete operations.
From the terminal point of view, costs related to longer operation times can be divided into two major categories: *direct costs* and *hidden* ones.
Direct costs are mainly related to financial penalties contracted with shipping companies for non-compliance with agreed working times. Hidden costs are more difficult to estimate than direct ones and may include different cost factors:

- Costs related to a sub-optimal use of berths, arriving vessels are forced to wait in the harbor an available mooring;
- Social costs related to a greater risk factor for workers due to an increased workload;
- Environmental costs caused by pollution on both the seaside (vessels in the harbor) and the landside (waiting trucks);
- Slowdown of terminal activities and loss of terminal efficiency.

Also from the vessel operator point of view, costs related to longer operation times can be divided into *direct costs* and *hidden ones*.
Direct costs take into account costs borne by vessels during the time spent in port (calculated as a proportion of their fixed cost) and increased mooring costs, if any. Hidden costs are more difficult to estimate than direct ones and may include:

- Costs related to backlogs and delays in delivery of goods;
- Increased fuel consumption in the attempt to reduce the delay in reaching the next port;
- Economic penalties for delays at the next port.

A complete evaluation of the costs related to the lengthening on vessel operation is rather complicated. Terminal operators are traditionally reticent in spreading sensitive information related to their business and moreover, many of the cost parameters involved are difficult to estimate in monetary terms.
Anyway, to better understand the extent of the problem addressed, an exemplification of these costs is here provided, supposing that they depend only on costs related to extra-times spent by vessels in ports to complete operations, hidden costs are neglected.

The extra cost incurred by vessels due to the lengthening of handling times can be calculated as a proportion of its fixed costs. In fact, time that vessel spends in port is a time that does not produce any profit.
Traditionally, fixed costs of a vessel are divided into three major cost categories (US DTMA, 2011):

- voyage costs (fuel and port charges);
- capital costs (principal and interest);
- operating costs.

Taking no notice of voyage costs, the extra-cost can be calculated as a proportion of capital and operating costs. In fact, voyage costs include fuel costs and port charges, the first are mainly related to the time that vessel spends sailing while port charges are in most cases independent of mooring times (within reasonable limits).
Capital costs take into account purchase cost of the vessel and depreciation during its useful life.
Table I shows Capital Cost shares for three classes of container vessels, selected according to their capacity in TEU (Twenty-foot Equivalent Unit). Capital Cost shares are derived from average purchase costs of vessels (UNCTAD, 2011). Capital Cost shares are calculated assuming a thirty-year useful life.

Table I - Capital Costs shares.

Vessel Type	Capacity (TEUs)	Average Purchase Cost* ($)	Capital Cost Shares ($)			
			Annual share	Daily share	6-hour shift share	Hour share
Panamax	4.000	46.000.000	1.533.333	4.201	1.050	175
Post Panamax	6.000	75.000.000	2.500.000	6.849	1.712	285
Post Panamax Plus	10.000	107.000.000	3.566.667	9.772	2.443	407

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Operating costs are costs associated with the day-to-day running of the ship. The maritime industry typically defines operating costs to include crew, stores and lubes, maintenance and repair, insurance costs, and overhead costs.
Table II shows Operating Cost shares for the three classes of container vessels already reported in Table I. Values shown are derived from the operating costs data provided by shipping agencies.

Table II - Operating Costs shares.

Vessel Type	Capacity (TEUs)	Operating Cost Shares ($)			
		Annual share	Daily share*	6-hour shift share	Hour share
Panamax	4.000	9.307.500	25.500	6.375	1.063
Post Panamax	6.000	12.045.000	33.000	8.250	1.375
Post Panamax Plus	10.000	14.600.000	40.000	10.000	1.667

**Drewry Shipping Consultants.*

Table III shows the Total Cost shares for the three classes of container vessels. Total Cost shares are calculated as the sum of Capital and Operating Cost shares described in Tables I and II.

Table III - Total Costs shares .*

Vessel Type	Capacity (TEUs)	Total daily Cost ($)	Total 6-hour Cost ($)	Total hour Cost ($)
Panamax	4.000	29.701	7.425	1.238
Post Panamax	6.000	39.849	9.962	1.660
Post Panamax Plus	10.000	49.772	12.443	2.074

**Our elaboration on the basis of previously mentioned data.*

Any delay in handling operation produces a lengthening in the vessel turnaround time. As previously said, in a traditional container terminal (mainly based on human labor), manpower shortage is one of the main causes of operation times lengthening.
To evaluate how the lack of an operator affects vessel operation delays, a vessel gang made up of 1 quay craner, 2 yard craners and 3 truck trailer drivers is here considered. Many terminal operators keep statistics on labor productivity that are used for internal purposes but also in relation to customers. Average productivities for each task, estimated from historical data of a Mediterranean transhipment container terminal, are reported in Table IV.

Table IV - Average Productivities .*

Task	TEUs/h	TEUs/6-hour shift
Quay craner	22	132
Yard craner	11	66
Truck trailer driver	7,3	44

**Our elaboration on the basis of private container terminal data.*

For example, a quay craner handles 22 TEUs per hour, i.e. 132 TEUs per 6-hour shift.
Table V shows the effects of operator shortages in a six-hour shift for all possible tasks of a vessel gang. The second column indicates how many containers are not handled, due to the lack of 1 quay craner, 1 yard craner and 1 truck trailer driver respectively. For example, when 1 truck trailer driver misses in a shift, 44 TEUs are not handled, according to the estimated values of productivity given in Table IV. The third column indicates the related operation delay, i.e. how long a vessel gang should work to handle containers not yet handled. The remaining columns indicate the related Operation Delay Cost for each type of vessel. For example, an operation delay of 2 hours generated by 1 missing truck trailer driver results in an Operation Delay Cost amounting to $ 3.321 for a Post Panamax vessel, according to Table III.

Table V - Operation Delay Costs.

Task in shortage in a six-hour shift	TEUs not handled in a 6-hour shift	Operation Delay (h)	Operation Delay Cost * ($)		
			Panamax	***Post-Panamax***	***Post-Panamax Plus***
1 Quay Craner	132	6	7.425	9.962	12.443
1 Yard Craner	66	3	3.712	4.981	6.221
1 Truck Trailer Driver	44	2	2.475	3.321	4.148

**Our elaboration on the basis of previously mentioned data.*

THE APPLICATION: NEW SCENARIOS OF LABOR FLEXIBILITY

The scheduling of workers according to the two planning levels (long-term and short-term) presents several problems related to the fact that the long-term plan, binding to the next level (short-term), is performed when the effective work demand of the day is almost unknown.

The consequences of the long-term plan rigidity can be summarized in three typical situations shown below. Each situation is followed by a description of its resulting effects according to the current Italian port work regulation.

1. On the planned day, a number of workers greater than that actually needed to meet the demand of the day is assigned;

   The container terminal is operating below its potential: workforce supply is oversized compared to the actual need of the day. The effects of the manpower oversizing vary according to the type of worker in surplus:

   - If the worker in surplus is in flexible service, his working day is transformed into a rest day. The rest day may compensate overtime hours performed by the worker in the quarter of reference;

   - If the worker in surplus is in fixed service, he will have to be paid for a normal working day, regardless of the fact that he has worked or not, at least theoretically.

2. On the planned day, a number of workers lower than that actually needed to meet the demand of the day is available;

   The workforce supply is undersized compared to the actual need of the day. The manpower office assigns all internal available workers and, when possible, external ones. The purpose is fulfill at least activities with highest priority. Part of the activities scheduled for the day cannot be performed. There are two possibilities of intervention:

   - To fulfill part of activities through overtime work but at a cost per hour higher than the standard;

   - To postpone backlogs to later shifts with inevitable operation delays for vessels at berth.

3. On the planned day, the allocation of workers on shifts, inherited from the long-term plan, does not allow the optimal match between demand and supply, although the total amount of available workers would be sufficient to cover the actual demand of the day;

   In other words, in some shifts workers assigned are more than needed while in other shifts workers are not sufficient. The little flexibility of the long-term plan does not allow the optimal use of the available workers in the planned day.

As seen, the little flexibility of the long-term plan involves, in the three situations described, different effects. These effects are all characterized by a reduction in terminal efficiency and an increase in port operating costs.
In this section, through the use of a state-of-the-art Integer Linear Programming Model for the daily allocation of human resources in a transhipment container terminal (Fancello et al., 2011), the effects in the short period of changes in labor flexibility introduced in the long-term plan are simulated.
The allocation model used in this experimentation is able to produce the optimal daily assignment of internal and external workers to shifts, tasks and activities highlighting manpower shortages,

where these occur. In order to detect possible manpower surpluses, original constraints inherent balancing between supply and demand in each shift have been relaxed.
The scenario corresponding to the current work organization in Italian transhipment container terminals is compared to five alternative scenarios constructed by increasing the labor flexibility allowed from the long term plan.
Changes in labor flexibility introduced in the long term plan may concern:

- *An increase in the share of traditional monthly flexibility for each worker.*
  Scenarios are constructed increasing the number of available workers in flexible service, while maintaining the same amount of available workers.

- *The introduction of a new type of flexibility, called mini-flexibility, ensuring a greater room for maneuver in the short term manpower management.*
  With the introduction of the contractual institute of the mini-flexibility a worker that in a given day results in mini-flexible service from the long-term plan (monthly/annual) does not yet know his exact working shift but he knows for sure whether it will be a night-shift (19-01, 01-07) or a day-shift (07-13; 13-19). The partitioning of 4 shifts in the two typologies (night and day) allows to take into account the differences perceived by workers in relation to a greater or lesser attractiveness of a shift and, at the same time, allows to consider the different hourly cost characterizing the 4 shifts: night shifts cost an average 30% more than day shifts.
  Mini-flexibility allows to reduce the discomfort of workers compared to traditional flexibility. In fact, a worker in mini-flexible service in a given day has the possibility to know already from the long-term plan what will be his likely working shift. Moreover, mini-flexibility allows a wider leeway to planners who making the manpower allocation in the short term, allowing shift by shift a better match between demand and supply.
  Scenarios are constructed assuming a share of workers in mini-flexibility among internal workers available in the planned day.

- *The simultaneous use of a quota of traditional flexibility and a quota of mini-flexibility.*
  Scenarios are constructed assuming a share of workers in mini-flexibility and a share of workers in traditional flexibility among internal workers available in the planned day.

The experimentation has been performed considering a normal working day of a Mediterranean container terminal. The working day is divided into four shifts of six hour each. The work demand is expressed in terms of number of gangs needed in each shift to perform vessel and housekeeping activities. The standard vessel gang is made up of 1 quay craner (qc), 2 yard craners (yc) and 3 truck trailer drivers (tt) while the typical housekeeping gang has 2 yard craners (yc) and 3 truck trailer drivers (tt). It is important to note that configurations considered are among the most common but not the only ones possible.
To illustrate work demand data we refer to Table VI and Table VII.
In Table VI each column represents a shift, the first line represents the required number of vessel gangs (*V*) while the second line shows the required number of housekeeping gangs (*Hk*) in each shift.

Table VI – Work demand of the day.

	Shift 1	***Shift 2***	***Shift 3***	***Shift 4***
Vessel gangs (V)	4	4	2	6
Housekeeping gangs (Hk)	0	1	0	1

Table VII shows the same amount of work demand but in terms of operators needed for each task in each shift. For instance at shift 2, 8 yc are required to serve vessels and 2 for housekeeping. Since qc are not involved in housekeeping work, their demand is denoted by "-". The last row shows the total number of workers required in each shift and in the whole day.

Table VII - Work demand of the day, in terms of number of workers required.

	Shift 1		**Shift 2**		**Shift 3**		**Shift 4**		**Day**
	V	*Hk*	*V*	*Hk*	*V*	*Hk*	*V*	*Hk*	
Quay Craner (qc)	4	-	4	-	2	-	6	-	16
Yard Craner (yc)	8	0	8	2	4	0	12	2	36
Truck Trailer Driver (tt)	12	0	12	3	6	0	18	3	54
Total workers required	24		29		12		41		**106**

The available workforce in the day is described by Table VIII. The first column shows the number of available internal workers, split between fixed and flexible, the second column shows the number of external workers while the third column shows the total amount of available workers in the day.

Table VIII – Available workforce in the day – Scenario 0.

Internal Workers		**External workers**	**Total workers at hand**
Fix	**Flex**		
80	8	12	100

Data in Table VIII are used to generate the first scenario, which is denoted as Scenario 0. The Scenario 0 corresponds to the current work organization where flexible workers in a day are about the 10%.

Looking at the supply and demand data of the day we note that the number of available workers (100 operators) is undersized compared to the actual work demand (106 operators).

The previously mentioned state-of-the-art model (Fancello et al., 2011) for the optimal daily allocation of human resources in container terminal is here used to determine the optimal assignment of workers. Results of the allocation relative to Scenario 0 are presented in Table IX. What would be expected from the manpower allocation problem implemented through the optimization model is the assignment of the 100 available workers and the report of 6 shortages. However, results in Table IX show something different.

Table IX shows for each shift the number of internal workers assigned, the number of external workers allocated, the number of shortages in each task (qc, yc and tt) split between vessel and housekeeping gangs and the number of manpower surpluses, if any. The surplus is defined as the number of workers in excess in a shift with respect to the actual work demand of the shift.

For instance, 20 internal workers are assigned at shift 3. Since the total work demand at shift 3 was 12 a surplus of 8 workers occurs.

Table IX – Assignment Results – Scenario 0.

	Type of worker		**Shift 1**	**Shift 2**	**Shift 3**	**Shift 4**	**Total**
Scenario 0	- INTERNAL		20	24	20	24	**88**
	- EXTERNAL		2	-	-	10	**12**
	- SHORTAGES	- *Vessel Gangs*	2 yc	-	-	2yc	**4yc**
		- *Housekeeping Gangs*	-	2yc+3tt	-	2yc+3tt	**4yc+6tt**
	- SURPLUS		-	-	8	-	**8**

The last column of Table IX shows the overall work balance of the day. Despite being assigned 88 internal workers and 12 external ones, identified shortages are not 6 but 14 (4 yc in vessel gangs and 4 yc plus 6 tt in housekeeping gangs). As it happens, 8 workers in fixed service at shift 3 cannot be assigned to other shifts, as rigidly assigned by the long-term plan to shift 3 in which, however, are not required. As a consequence, the terminal have to face a shortage of 14 workers despite a surplus of 8 workers at the third shift.
At this stage, the goal becomes to verify how this assignment would change if, while maintaining the same amount of available workers, a greater labor flexibility within the pool of internal workers available in the day was allowed. For this purpose five change scenarios in labor flexibility regulation are produced. The proposed scenarios are described by Table X.

Table X – Five Scenarios of change in labor flexibility.

ID Scenario	Internal Workers				External workers	Total workers at hand
	Fix	Flex	Mini-flex	Total		
Scenario 1	72	16	0	88	12	100
Scenario 2	64	24	0	88	12	100
Scenario 3	60	0	28	88	12	100
Scenario 4	60	8	20	88	12	100
Scenario 5	50	8	30	88	12	100

For each scenario, Table X shows:

- in the second column, the number of available internal workers divided into fixed, flexible and mini-flexible;

- in the third column, the maximum number of available external workers;

- in the fourth column, the total number of available workers (internal workers plus external ones) in the planned day.

The total number of available workers as well as the number of external workers remains unchanged in all scenarios. In fact, scenarios are constructed varying only the amount of traditional flexibility or introducing a quota of mini-flexibility within the basin of the 88 available internal workers. The total amount of workers is the same as Scenario 0. The 5 scenarios introduced are so characterized:

- Scenario 1. The share of workers in traditional flexibility is doubled compared to Scenario 0, that is, of the 88 available internal workers 72 are in fixed service while 16 are in flexible service. Scenario 1 does not provide workers in mini-flexible service.

- Scenario 2. The share of workers in traditional flexibility is tripled compared to Scenario 0, that is, of the 88 available internal workers 64 are in fixed service while 24 are in flexible service. Scenario 2 does not provide workers in mini-flexible service.

- Scenario 3. Compared to Scenario 0 there are no workers in traditional flexibility. Scenario 3 introduces the mini-flexible service: of the 88 internal workers 28 are in mini-flexibility while the remaining 60 are in fixed service.

- Scenario 4. It provides a combination of workers in traditional flexible service and workers in mini-flexibility. The 88 internal workers are as follows: 60 are in fixed service, 8 are in traditional flexible service and 20 are in mini-flexible service.

- Scenario 5. Compared to scenario 4 it provides a greater share of workers in mini-flexible service. The 88 internal workers are as follows: 50 are in fixed service, 8 are in traditional flexible service and 30 are in mini-flexible service.

The results

Results of the assignment performed through the optimization model for the 5 scenarios are shown in Table XI. Table XI is organized as Table IX.

Table XI - Assignment Results – Scenarios 1, 2, 3, 4 and 5.

Scenario ID	Type of worker		Shift 1	Shift 2	Shift 3	Shift 4	Total
Scenario 1	- INTERNAL		18	23	18	29	**88**
	- EXTERNAL		5	1	-	6	**12**
	- SHORTAGES:	- *Vessel Gangs*	1yc	-	-	4tt	**1yc+4tt**
		- *Housekeeping Gangs*	-	2yc+3tt	-	2yc	**4yc+3tt**
	- SURPLUS		-	-	6	-	**6**
Scenario 2	- INTERNAL		19	22	16	31	**88**
	- EXTERNAL		5	5	-	2	**12**
	- SHORTAGES	- *Vessel Gangs*	-	-	-	3tt	**3tt**
		- *Housekeeping Gangs*	-	2yc	-	2yc+3tt	**4yc+3tt**
	- SURPLUS		-	-	4	-	**4**
Scenario 3	- INTERNAL		15	29	15	29	**88**
	- EXTERNAL		6	-	-	6	**12**
	- SHORTAGES	- *Vessel Gangs*	3yc	-	-	1tt	**3yc+1tt**
		- *Housekeeping Gangs*	-	-	-	3yc+2tt	**3yc+2tt**
	- SURPLUS		-	-	3	-	**3**
Scenario 4	- INTERNAL		16	25	15	32	**88**
	- EXTERNAL		6	2	-	4	**12**
	- SHORTAGES	- *Vessel Gangs*	2yc	-	-	-	**2yc**
		- *Housekeeping Gangs*	-	1yc+1tt	-	2yc+3tt	**3yc+4tt**
	- SURPLUS		-	-	3	-	**3**
Scenario 5	- INTERNAL		16	28	12	32	**88**
	- EXTERNAL		6	-	-	6	**12**
	- SHORTAGES	- *Vessel Gangs*	2yc	-	-	1tt	**2yc+1tt**
		- *Housekeeping Gangs*	-	1tt	-	2yc	**2yc+1tt**
	- SURPLUS		-	-	-	-	**-**

Table XII shows the effects of the assignment produced by each scenario in terms of operation delays and related costs due to the lengthening of vessels turnaround times. Operation delay costs are calculated for all tree types of container vessels considered in the *Cost Model* section. Effects of each scenario are calculated as a function of manpower shortages detected in the planned day. The operation delay is the time that a vessel gang takes to handle containers not yet handled due to manpower shortages. The estimate of this additional time required to complete operations and costs related is made on the basis of considerations given in Table IV and V. Since this is an estimate of the extra time required to complete operations on vessels, manpower shortages in housekeeping gangs are here neglected.
For instance, looking at Table XII, 3 truck trailer drivers are in shortage in Scenario 2. This manpower shortage corresponds to 132 containers not handled and an operation delay of six

hours, i. e. a vessel gang needs six more hours to complete operations on vessel. This operation delay results in a cost of $ 7.425 for a Panamax vessel, $ 9.962 for a Post Panamax vessel and $ 12.443 for a Post Panamax Plus, according to Table V.

Table XII – Operation Delays and related Costs for Scenarios 0, 1, 2, 3, 4 and 5.

Scenario ID	Manpower shortages	Containers not handled (TEUs)	Operation Delay (h)	Operation Delay - Daily Cost ($)		
				Panamax	Post Panamax	Post Panamax Plus
Scenario 0	4yc	264	12	14.850	19.924	24.886
Scenario 1	1yc+4tt	242	11	13.618	18.260	22.814
Scenario 2	3tt	132	6	7.425	9.962	12.443
Scenario 3	3yc+1tt	242	11	13.618	18.260	22.814
Scenario 4	2yc	132	6	7.425	9.962	12.443
Scenario 5	2yc+1tt	176	8	9.904	13.280	16.592

In addition, an estimate of the cost related to manpower surpluses in the planned day is provided in Table XIII. As seen before, the surplus in a shift of a worker in fixed service produces additional cost for the terminal. In fact, at least theoretically, that worker should be paid even if he does not work in that shift. The estimate of the cost associated to the manpower surplus in the planned day has been done considering an average hourly labor cost of 29 $/h per worker. For instance, 6 workers are in surplus in Scenario 1, the corresponding Manpower Surplus Cost for the terminal amounts to $ 1.044.

Table XIII – Cost related to manpower surpluses for Scenarios 0, 1, 2, 3, 4 and 5.

Scenario ID	Number of workers in surplus	Manpower Surplus - Daily Cost ($)
Scenario 0	8	1.392
Scenario 1	6	1.044
Scenario 2	4	696
Scenario 3	3	522
Scenario 4	3	522
Scenario 5	-	0

Looking at the data shown in Tables XII and XIII is observed that, compared to Scenario 0, the increase in the share of traditional flexibility or the introduction of mini-flexibility produce lower manpower shortages, lower additional costs and a better use of available workers in all tested scenarios. The more efficient use of available resources is confirmed by a reduction in the number of workers in surplus and lower manpower shortages in the planned day.
The increased labor flexibility allowed from the long-term plan allows a more efficient allocation of manpower in the short-term with positive economic effects for both the terminal operator and the shipping company. Cost values reported in Tables XII and XIII prove the key role of labor flexibility in terminal management.
It is important to note that the analysis performed in this study is referred to a single day of terminal activity. Cost values involved will assume a more relevant weight if compared to what may occur in a whole year of activity of the terminal.

CONCLUSIONS

Time spent in port has always been an important determinant of port attractiveness to shipping companies. In maritime industry time and costs are highly related and mainly depend on the terminals efficiency. In traditional container terminal, where activities are mainly based on the labor of workers (“blue collars”), a key factor for terminal efficiency is to plan human resources allocation effectively. An optimal workforce management is essential to ensure an efficient work and the respect of working times agreed with shipping companies.

However, in some container terminals, strict work regulations and insufficient labor flexibility can prevent an optimal use of available resources. Consequences are a reduction in terminal efficiency, an increase in operating costs and a loss of competitiveness in respect of port competitors operating with more permissive regulations.

In fact, labor flexibility plays a crucial role in terminal management, where uncertainty on vessels arrival times may result in unexpected work demand peak (or decrease) with consequences in manpower shortages (or surpluses) and additional costs for both terminal operators and shipping companies.

This study focused on Mediterranean North-West Coast (MNWC) transhipment ports and analyzed their labor regulations. Several change scenarios on labor flexibility for terminals were proposed with the aim to illustrate how a greater flexibility in terminal labor may produce a more efficient use of available resources and a decrease in operating costs.

The scenario corresponding to the current labor regulation in MNWC ports was compared to five alternative scenarios constructed by increasing the share of daily working flexibility and introducing a new type of labor flexibility, called mini-flexibility. To evaluate the economic effects of labor flexibility in reducing manpower shortages and vessel operation delays a cost model illustrating the relationship between manpower shortages and costs related to extra-time spent by vessels in port to complete loading operations was proposed.

The use of a state-of-the-art Integer Linear Programming Model for the daily assignment of human resources in a transhipment container terminal has allowed to simulate the effects of each scenario in terms of operating costs and workers under-manning generated by each of them.

Results showed that an increased labor flexibility can produce a better use of human resources and a significant reduction in operating costs related to workforce management. In fact, lower manpower shortages and shorter service times on vessels occur when a greater labor flexibility is used.

The findings of this work may serve as input for discussions on the importance of labor organization and flexibility in terminal containers. It is important to note that greater flexibility can help reduce the competitive gap of MNWC terminals in relation to other competitors working under more lax labor regulations. The greatest risk is that, in the absence of interventions in the short term, the loss of competitiveness that MNWC ports have demonstrated in recent years will result in a reduction of activity with its negative economic effects.

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