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Title	Managing port-related supply chain disruptions : a conceptual paper
Author(s)	Loh, Hui Shan; Thai, Vinh Van
Citation	Loh, H. S., & Thai, V. V. (2014). Managing Port-Related Supply Chain Disruptions: A Conceptual Paper. The Asian Journal of Shipping and Logistics, 30(1), 97-116.
Date	2014
URL	http://hdl.handle.net/10220/20000
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Managing Port-Related Supply Chain Disruptions: A Conceptual Paper*



Hui Shan LOH** · Vinh Van THAI***

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Abstract

The increased importance of ports makes them a vulnerable node as a port-related disruption can generate domino effect on a network of supply chains. The vulnerability of ports thus needs to be addressed to ensure the functionality of ports and enhance supply chain resilience.

This paper synthesizes the current literature into a management model that seeks to target operational deficiencies at ports. The management model is operationalized in three tiers, from the top management level to the front-line employees, with characteristics from risk management, business continuity management and quality management theories. The proposed model serves as a universal guide in assisting port management in managing port-related disruptions and seeks to reduce the occurrences of port-related supply chain disruption threats.

Key Words : Risk Management, Disruption Management, Port Resilience, Management Model

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* This paper is a revised version of two earlier papers presented at International Association of Maritime Economists Conference held in Marseille, 3-5 July, 2013 and International Forum on Shipping, Ports and Airports held in Hong Kong, 27-30 May, 2012.

** Ph.D Candidate, Nanyang Technological University, Singapore, Email : hslol1@e.ntu.edu.sg

*** Assistant Professor, Nanyang Technological University, Singapore, Email : vvthai@ntu.edu.sg

I. Introduction

In recent years, supply chain disruption has become a major area of research, gaining increasing popularity. Among the numerous nodes in global supply chains, seaports play a critical role in maintaining the continuous flow of cargo between supply chain entities. Seaports have transformed its role from a traditional regional gateway to one where important value adding and complex logistics-related activities take place. The more mature phases of ports are well-developed ports acting as important players in cargo distribution. This increased integration of ports into supply chain management creates a higher level of uncertainties for downstream planning, product movement and information exchange. For that reason, risks occurring in everyday port processes are operational deficiencies which are capable of developing into augmented unsought effects in supply chains. Together with supply chain trends and practices, the likelihood of a supply chain disruption is increased as the effects of a disruption that originate from ports are easily exacerbated in today's business environment.¹⁾ The potentiality of ports to administer seamless services, operations and transfer of cargo is thus very much sought after. In other words, it is important to identify measures which the port management can implement to minimize the impact of port-related supply chain disruptions (PSCD) and reduce the occurrences of PSCD threats. PSCD threats are defined as operational risks inherent in port processes that are capable of disrupting the continuity of upstream and/or downstream supply chains. Hence, natural disasters and weather conditions that also result in disruptions are not in the scope of this study.

This paper seeks to address the above issue by way of a management model that reflects a holistic management approach for port management to implement. While there have been several studies exploring risks in port operations, there has been no studies addressing a full set of operational risks from a holistic perspective, especially in connection with supply chain disruptions. Since the introduction of containerization, the focus of research within the maritime industry revolved around improving internal operational efficiencies which does not reflect the actuality of port's integration with its peripherals. Elaborative research on general supply

chain disruption strategies emerged only in recent years, while studies on port disruption strategies concentrate on discrete disruption causes. These collectively epitomize the paucity of a port-wide holistic approach towards the management of port-related supply chain disruptions. The main objective of this research is therefore to identify the actions which the port should initiate to minimize port-related supply chain disruptions. The remaining of this paper is organized as follows. First, studies examining port-related disruption management will be reviewed. This forms the conceptual foundation of the management model. Next, specific actions within the management model will be presented. Industry's views and implications of the proposed management model will be discussed. The paper then concludes with future research directions.

II. Literature Review

1. The Importance of Ports in Supply Chains

Much work has been done on studying the changing role of ports in supply chains. The transformations that ports undergone have redefined their significance in supply chain networks. Comparing these changes since transformation from the traditional ports, investigation of the evolutionary developments in port functions through three generations have been presented.²⁾ Ports once provided the convenience of cargo storage but eventually services such as cargo distribution, packing and processing became important port functions for conventional and bulk cargo in ports of the second generation. The third generation ports saw emerging concepts of cooperation and information sharing with ports acting as the facilitators, and with technology playing a key role in information exchanges between the different stakeholders. Changes in port ownership, port development strategy and scope of port activities are apparent throughout the three generations.³⁾

1) Kleindorfer and Saad(2005); Handfield et al.(2007)

2) UNESCAP(2002)

3) UNESCAP(2002)

Consequently, the objectives of ports have deviated much; from being a region's gateway to a system that provides value-adding and facilitation services.⁴⁾ Ports have been defined as critical links which deliver and capture value in value-driven chain systems, thereby changing their positions in business environments.⁵⁾ It is precisely because of the port's capacity in administering the connection of logistics functions throughout the supply chains that renders its influence on cargo flow along supply chains. Especially due to the new context of being increasingly integrated, ports are suggested to take on the role that links up interacting parties or become hub centers where values are generated by offering a whole range of activities in a bid to retain their clients.⁶⁾ On top of that, ports can continue the transformation into a knowledge-based global supply chain management center.⁷⁾ However, challenges arise when these changes of context are introduced.⁸⁾ The challenges faced by ports in a higher integrated supply chain have been empirically examined through studying the behavior of supply chain actors.⁹⁾ These challenges are worth noting as it helps define the business settings in which the ports are embedded in.

As ports are encouraged to adopt agility in their current processes to create better value,¹⁰⁾ the features of agile ports have been defined and steps towards an agile approach for ports to undertake have been recommended.¹¹⁾ Similarly, research has been done on studying port strategies from supply chain perspectives, emphasizing on responsiveness, agility and efficiency.¹²⁾ The need for ports to be more agile is compelled by repercussions of port inefficiencies, which include unnecessary additional operating and transportation costs.

4) Ng(2009)

5) Robinson(2002)

6) Perez-Labajos and Blanco(2004)

7) Wang and Cheng(2010)

8) Carbone and Martino(2003); Wang and Cheng(2010)

9) Carbone and Martino(2003)

10) Paixao and Marlow(2003)

11) Lun et al.(2010), pp.205-218.

12) Zhang et al.(2013)

2. Supply Chain Disruptions from the Port's Perspective

The importance of incorporating resilience in supply chain entities has been emphasized in many studies and the way an organization handles disruptions can greatly affect its image and market share. One classic example is the disruption faced by Ericsson when lightning struck Philip's semiconductor plant in New Mexico.¹³⁾ Ericsson had used a single-source supplier strategy and was unable to respond flexibly to the halt in production of mobile phone chips. Its market share suffered as a result. Strategic mechanisms applied in supply chain disruptions are useful for port management for the same purpose. As ports are increasingly seen as critical nodes of global supply chains, the profile of potential port-related risks which can lead to disruptions in the whole supply chain will become more comprehensive due to the complexity of port operations and management as well as its interaction with other supply chain players.¹⁴⁾

Notable cases of well-managed supply chain disruptions by organizations imply several essential traits in effective management of supply chain disruptions and the traits include responsiveness, flexibility, strong supplier relationships, organization's ability to influence demand, commitment to organization and uniformity in processes and procedures.¹⁵⁾ The ability to identify a disruption and establish continuity plans has also been emphasized in studies.¹⁶⁾ Specifically, researchers have identified characteristics of risk mitigation approaches to take on the following seven forms: (a) increase capacity, (b) acquire redundant suppliers, (c) increase responsiveness, (d) increase inventory, (e) increase flexibility, (f) pool or aggregate demand and (g) increase capability.¹⁷⁾ The effectiveness of these strategies boils down to eliminating root causes of the disruptions, which differ across organizations and industries. This is where a port can contribute as it does not undertake industry-specific strategies to reduce supply chain disruptions. The strategies that ports utilize can be as extensive as to minimize supply chain disruptions that span across a variety of industries.

13) Liu(2009); Tang(2006)

14) Thai and Tran(2011)

15) Liu(2009); Tang(2006); Sheffi and Rice(2005)

16) Handfield et al.(2007)

17) Chopra and Sodhi(2004)

Amid approaching port security threats as a potential source for supply chain disruption from the logistics and supply chain management perspective, one way to increase security standards in the maritime network is to have ports and their stakeholders predict outcomes of detected vulnerabilities across the ports' internal and external systems, in an integrated collaborative effort.¹⁸⁾ It is through a higher level of cooperation that security can be infused and ensured throughout the chain. Otherwise, firms which opt out of security initiatives such as the Customs-Trade Partnership against Terrorism (C-PAT) might end up with slower cargo processing. Specifically, an empirical analysis of the impact of ISPS Code, CSI and 24-hour rule on container terminal operations efficiencies has been carried out.¹⁹⁾ The results show that terminals implementing 24-hour rule generally have lower efficiency than those without the 24-hour rule and the implementation of CSI has experienced a gain in terminal efficiency while terminals without CSI implementation have experienced a loss. On the other hand, as interpretations of the ISPS Code vary across ports, an assessment of productivity gains or losses relating to the implementation of ISPS Code is tricky.²⁰⁾ Nevertheless, the long term effect and benefits may justify the costs of security measures. Ultimately, a well-performing supply chain requires connection and synchronization for the continuous flow of goods between each point to occur. This in turn demands for security measures to be fulfilled at all links in the supply chains.

Arrangements to mitigate disruptive effects of undesirable events require the efforts of internal port management as well as collaboration or involvement from external parties. Otherwise, the scope of actions and the extent of relief to disruptions will be restricted. The application of complex network theory has been proposed in the examination and modeling of shipping networks such that an undesirable event at a port can be simulated to show the global effect it has.²¹⁾ Alternatively, the Disruption Analysis Network (DA_NET) is another quantitative approach which can be used to show propagation of attributes while measuring the

18) Bichou(2004)

19) Bichou(2011)

20) Bichou(2011)

21) Angeloudis et al.(2007), pp.95-106.

impact on the system.²²⁾ It allows its users to better understand the radius of disruptive events in a supply chain. Optimization models can also be used to compare different scenarios and severities of disruptions that caused a redirection of vessels to other ports in a network.²³⁾ These ocean-focused models can be integrated with those that study landside capacities for a more inclusive analysis.²⁴⁾ To mitigate the impacts of collisions within port waters, a multi-level model of collision risk has been proposed by researchers.²⁵⁾ The purpose of this system is to act as a real-time system that allows pilots to carry out countermeasures according to the different severities of dangers worked out by the system. However, a higher level of communication in the form of data sharing is required for the development of an adequately robust vessel restoration model.

In the light of changing role of ports and increasing scope of intermodal transportation services at ports, the concept of using integrated centers for Transshipment, Storage, Collection and Distribution (TSCD) of freight has been suggested to improve cargo handling efficiency within the ports.²⁶⁾ Besides easing threats of port congestion, business accessibility will also be enhanced with the use of TSCD concept as benefits can be derived from the physical proximity. The call for similar “port-centric logistics” approach is apparent in the United Kingdom through several significant partnerships under the pressure of thriving cargo volumes.²⁷⁾ Alternative approaches to prevent port congestions are identifying substitute ports and creating proper forecasts that help generate supply balances while overseeing transiting demand and supply.²⁸⁾ However, the port needs to take into consideration the trends in the industry such as the arrivals of larger vessels as well as the effects from external environment as they play a role in affecting terminal performance and port improvement plans.²⁹⁾

In addition, facilitating any policies and strategies would require effective communication and acceptance within the community which require incorporating knowledge and understanding of the human resource

22) Wu et al.(2007)

23) Paul and Maloni(2010)

24) Paul and Maloni(2010)

25) Chin and Debnath(2009)

26) Konings(1996)

27) Beresford et al.(2011), pp.137-154

28) Blanchard(2007)

29) Verbraeken and Notteboom(2012); Sánchez and Perrotti(2012)

field. Addressing the soft attributes of individuals in the port, it is proposed that maritime education should be enforced and should focus on cultural awareness, seeking to motivate, creating understanding between each other and a sense of belonging.³⁰⁾ Human resource management skills are essential competencies in shipping as expertise in technical knowledge fail to be actualized when precise instructions cannot be accurately given or received.

The review of literature reveals several key findings and limitations. Firstly, ports have increased their importance and integration in supply chains. Secondly, the investigations of disruptions by previous researchers are confined to actions and consequences within the port and not linked well to potential disruption in the supply chains. Thirdly, there are fundamentally three aspects in combating disruptions, namely, preventing the disruption from occurring, mitigating the effects of disruptions and administering concepts which target disruptions. What is absent in prior research is to recognize that disruptions can originate from the port itself and be propagated to supply chain entities despite acknowledging the increasing integration of ports. Very few studies have investigated the management of port disruptions from the supply chain perspective. This is an area of research deserving attention as the users and customers of the ports constitute global supply chains. The closest topic in the current literature is research on port agility. However, research on port agility is scant at this stage and studies on similar topics do not provide a comprehensive framework for implementation at ports. An integration of the relevant theories from the supply chain perspective would be meaningful as it would offer an universal approach to guide port management on the areas which they should focus on to effectively manage disruptions that originate from the port operations. Therefore, this paper shall fill the literature gaps by determining how ports can manage port-related disruptive events, i.e. the *PSCD Threats*, which affect supply chain resilience. This paper aims to integrate disruption strategies in a framework and the application of principles of risk management (RM), business continuity management (BCM) and quality management (QM) is to ensure that the objectives of the framework can be achieved.

30) Horck(2008)

3. Theoretical Cornerstones of the PSCD Management Model

From the above review of literature, it is apparent that the significance of ports in supply chains has been increased and port functions have become much more complex today. These changes affect the ports' ability in minimizing disruptions. With the network proximity between ports and their users, ports are expected to be engaged in a higher level of interaction with the external parties, especially those within the port community. Thus, conducting RM and planning for contingency together with the external parties are deemed to be necessary actions to combat disruptions. The PSCD threats are analyzed in RM process to assess the consequences and probability of the threats. On the other hand, BCM allows the impact of the PSCD threats to be analyzed in order to determine the necessary recovery and mitigation plans that are to be in place. Therefore, RM will identify PSCD threats that affect the core deliverability of the port and assess the suitability of existing and additional controls, while BCM drives the ability to recover from the disruptions.

With this background in mind, the business environment that ports are embedded in has generally become riskier as they are more vulnerable to uncertainties attributed to global inter-connected supply chain entities, which in turn are more reliant on the ports in ensuring the delivery of their customers' requirements. Therefore, the application of RM theories and the presence of business continuity plans are critical. RM approach is essential to identify, analyze and manage PSCD risks and is useful in raising risk awareness within the port. On the other hand, the development of business continuity plans will enable the port management to maintain port operations in the event of a disruption. RM together with BCM will reduce the likelihood of disruption causes and also ensure the continuity of port operations during adversity. In other words, an application of both approaches provides a more holistic protection and view for port management in disruptions.

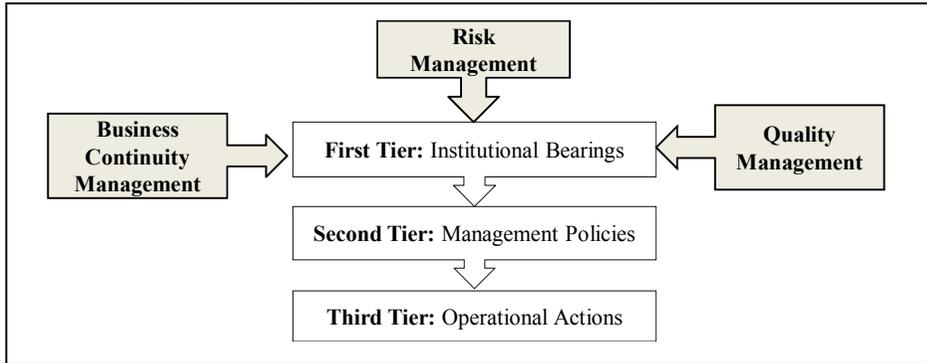
Global challenges need to be addressed so that the port management is able to adjust to increasing changes. Among the changes and trends in the industry, there arise opportunities which the management can make use of to address the challenges and boundaries faced. The ever-changing market environment which the port is situated in also leads to the need to examine

the criteria of working towards minimization of its disruptive potential. Thus, the relevancy of any proposed changes at the port must be ensured and this is the reason for regular monitoring and review of practices and policies at the port. The complexities of different organization vary in extent. Similarly, in the port industry, not every port is at an identical stage of maturity and establishment. This emphasizes the importance of identifying the requirements which the ports should work on internally to ensure the deliverability of action plans. In essence, it is similar to the theories of QM and a holistic approach adopted by the leadership will facilitate changes in operations, cultures or practices at the port.

III. Components of the Proposed Management Model

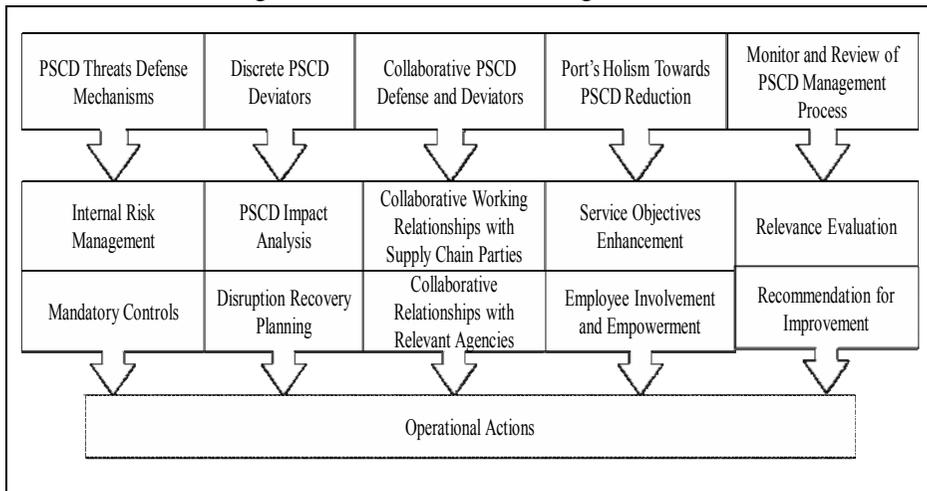
The management model is presented in three tiers for the directives to be operationalized. The first tier starts at the top management and is referred to as Institutional Bearings in the management model as the focus is on the level at which decision making takes place and these strategic directions will go on to affect the course of actions to be taken by the port to work towards the objectives. There are five Institutional Bearings and each of them constitutes the first tier of the management model. These five Institutional Bearings address the external challenges through a committed internal support throughout the port, with theories of RM, BCM and QM being applied. Extending from the first tier, management policies will then be formed at the second tier and front-line actions will be implemented at the third tier. Consequently, the second and third tiers of the management model are named Management Policies and Operational Actions respectively as shown in Figure 1. The arrows in Figure 1 demonstrate the direction in which the Institutional Bearings will be enforced to manage the disruptive potential at the port and the application of RM, BCM and QM principles to the management model.

<Figure 1> Application of theories to the management model



Each institutional bearing is responsible for taking the port towards a certain directive. As can be seen in Figure 2, beneath each Institutional Bearing are two related Management Policies which in turn expand into Operational Actions in order to address the corresponding management policies with the objective of steering the port towards that particular direction stipulated by the Institutional Bearing.

< Figure 2> Overview of the management model



The first Institutional Bearing, PSCD Threats Defense Mechanisms, relates mainly to managing PSCD threats within the port and is addressed by Internal Risk Management and Mandatory Controls. Applying the principles of RM and BCM, the third tier translates Internal Risk Management into actions that ensure the employees acquire and share the

necessary RM knowledge internally and carry out the fundamental risk procedures diligently, such as conducting risk assessment and ensuring that risk levels are monitored. These enhance the ability to identify and prevent the occurrence of PSCD threats. On the same note, Mandatory Controls specifies that buffers and alternatives should be created in port equipment, systems and transportation solutions; port should ensure that it is sufficiently insured against damages and losses; and mitigation strategies should be well-documented, closely adhered to and catered for different types of risks. By doing these, the port prepares itself for expected and unanticipated incidents. Considering the changing market trends and business environment, these strategies are to be regularly evaluated to ensure their relevance and effectiveness. There are also existing mandatory safety and security rules and regulations that the port has to comply with as these initiatives contribute to mitigating risks in ports when effectively implemented.

PSCD Impact Analysis and Disruption Recovery Planning are the Management Policies associated with Discrete PSCD Deviators, whose main aim is to reduce the impact of disruptions caused by PSCD threats. The key processes and operations at a port are dependent on the types of cargo handled. Relating them to a detailed record of incidents which previously resulted in disruptions helps reveal critical business functions where due regard should be given to. Simulating scenarios of these areas and the occurrence of PSCD threats would then expose the extent of disruptions. With that information, port management is suggested to plan for disruption recovery through documenting detailed emergency response plans for each functional department; implementing systems that allow prompt contact with and response from internal management and employees; and conducting emergency drills that mandates the participation of all employees. These Operational Actions reflect the essence of planning ahead for contingency and sustainability. Together with PSCD Threats Defense Mechanisms, Discrete PSCD Deviators allow a more comprehensive protection from PSCD threats as it complements the former with recovery capabilities.

The third Intuitional Bearing, Collaborative PSCD Defense and Deviators, reflects the port's efforts in managing PSCD threats and planning for contingency together with external parties comprising of supply chain parties and relevant agencies. Supply chain parties, who are

port customers and port users, are the ones who feel the immediate impact of disruptions propagated from ports. It is therefore important to handle risks with them and involve them in measures that increase port resilience. Hence, Collaborative Working Relationships with Supply Chain Parties is suggested. Operational Actions corresponding to this Management Policy include information exchange with port users on the status of their cargo and port's berths in an accurate and timely manner; ensuring that contractors' default do not affect port's operations; collaborative risk management; involvement of external parties in port's emergency drills; implementation of communication systems that enable prompt contact with and response from external parties; agreement on labor welfare; and coordinated provision of alternative transportation for port's customers in times of disruptions.

Also placed under the third Intuitional Bearing is another management policy named Collaborative Relationships with Relevant Agencies. The aim of this Management Policy is to tap on influential parties with resources that enable continuous improvement in the process of managing PSCD threats. Operational Actions include having agreements with government agencies, employees and management on employee welfare; collaborating with government agencies in risk and disruption management; adopting relevant guidelines or framework established by local industry professional standards or alike; and conducting research and development with higher education institutions regularly to improve on port operations. The purpose of these actions is to ensure that the capabilities of managing PSCD threats are being updated and continuously improved on and refined.

The above three Institutional Bearings administer the management of PSCD threats by increasing organizational resilience and mitigating consequences through a series of measures that require internal and external cooperation. Naturally, these concerted efforts can materialize when there is approval and support to do so. As the name suggests, Port's Holism Towards Reduction is associated with the port's holistic attitude towards management of PSCD threats. Stemming from this Institutional Bearing are two Management Policies – Service Objectives Enhancement and Employee Involvement and Empowerment. Service Objectives Enhancement can be described as a pro-service attitude that ensures quality of PSCD management through its Operational Actions.

Appropriate actions are ensuring commitment from all functional departments to provide quality port services; upgrading of employees' professional skills; identifying customers' thresholds for delays; understanding customers' current and future needs; soliciting views from customers and users as well as re-evaluating workflow processes to improve efficiency.

Furthermore, it is suggested that leadership should involve and empower the employees so that the employees feel valued and respected. Leadership is recommended to motivate employees to offer constructive feedback on process improvement through giving incentives and have their opinion collected through internal portals. The port management is also advised to delegate authority to front-line employees who can make wise decisions in a timely manner. This shall help prevent and mitigate disruptions. When there are policy changes, the port management is encouraged to communicate issues brought about by the changes through small group meetings with the employees. Therefore, the objective of the fourth Institutional Bearing is to ensure the deliverables of the PSCD management process while business profitability and cooperativeness in corporate culture is not compromised.

Lastly, Monitor and Review of PSCD Management Process seeks to ensure the relevance of the PSCD management process and improvements on it. This is essential due to the dynamism of the industry that is filled with changing business trends. Hence, one action for Relevance Evaluation is to review disruption management strategies regularly. Not forgetting the importance of involvement of external parties, the port is encouraged to communicate regularly with them and other stakeholders on issues pertaining to disruption management as well as conduct post drill evaluation together with its users and customers. The purpose is to identify ways to cooperate and adapt to the changing landscape. Similarly, Recommendations for Improvement is a plan to continuously improve on existing practices in disruption management. It is proposed that this be achieved by conducting thorough post drill and disruption analysis, adopting feedback and suggestions gathered from customers and employees wherever deemed useful and also apply previous lessons learnt. These lessons when shared with other industry players can help prevent same mistakes by another party and hence is also encouraged.

In summary, the management model for port-related supply chain disruptions consists of Institutional Bearings, Management Policies and Operational Actions derived from the theoretical approaches discussed in the previous subsections. The PSCD management model proposes actions which are applicable to all types of ports. The main objective of this management model is to target operational deficiencies at ports such that supply chain continuity can be enhanced through reduced port-related disruptive risks. As ports are now more embedded in supply chains than ever before, it is important to enhance the functionality of ports and the PSCD management model proposed in this paper is the first step to make this happen. As such, this model is of relevant contribution to both theory building and practical management of port-related supply chain disruption.

IV. Industry's View on the Proposed Management Model

It has to be noted that this is a preliminary study that offers conceptual background of the management model. Further work needs to be done to empirically validate the measurement items in the management model. At this stage, seven in-depth interviews were conducted with industry professionals to solicit their views on the proposed PSCD management model. These interviewees hold managerial positions at ports in Australia, Singapore and Vietnam and the interviews were conducted between January 2013 and February 2013. The purpose of the interviews was to ensure the appropriateness and feasibility of the proposed PSCD management model at the preliminary stage.

The interviewees indicated that the items in the proposed management model are important in the management of PSCD threats and that implementation is feasible. Firstly, the growing importance of ports in supply chains was acknowledged by all interviewees. Secondly, it was found that the internal risk management is conducted at all interviewees' ports. However, one interviewee mentioned that a special department in charge of risk affairs has been newly set up and another interviewee indicated that their existing RM procedures were rather theoretical and needed improvement. Thirdly, business continuity planning is conducted at

all ports, but not all the ports involve the participation of supply chain entities. In cases where supply chain entities were invited to participate in such emergency exercises, they were very willing to as it concerns the wellbeing of their operations, according to the interviewees. All interviewees' ports have documented response plans, specifying the administration of each step. However, some interviewees reported that the application of these plans tends to be ad-hoc and haphazard in real life. The job of rectifying an exception is sometimes given to the more experienced employees who have the capacity to resolve those issues. In this sense, knowledge seems not to be acquired and shared throughout the port. This reiterates the importance of involving and empowering employees but shows an absence of a holistic attitude. The importance of quality of employees has been stressed in all the interviews. Lastly, collaborations with external parties are important as they help the ports to plan ahead in avoiding mismatch of infrastructure. Government agencies are possible sources of financial and legislative support to materialize plans. External parties that ports usually work with are labor unions and shipping lines so that the ports understand their profiles and future needs. One interviewee indicated that feedback from customers is solicited in his port, though not through formal channels and is not done on regular basis.

The following are the main observations from the interviews:

- 1) A higher level of external collaboration and internal commitment is observed at ports that are more mature in their development stage. This supports the management model as the main essence of the model is about ensuring internal quality through own effort and collaborative effort with external parties.
- 2) Importance of employees to the port in managing disruptions is emphasized regardless of the types of cargo handled. This is in line with what the management model proposes.
- 3) Costs should not be compromised in managing disruptions and this concern is addressed by components of the management model with the application of QM principles.

The above points are reported and kept generic to ensure the confidentiality guaranteed to interviewees. From the results of the interviews, there is a high level of consensus among the interviewees that the management model is practical and appropriate in achieving its objectives.

V. Conclusion

This paper has proposed a PSCD management model aiming to reduce the supply chain disruptive potential of ports and ensure that supply chain continuity is not affected by their operational deficiencies. The management model is synthesized from the application of RM, BCM and QM theories and is presented in three tiers such that the directives can be operationalized from the top management to the front-line employees. There are five institutional bearings at the top management level and ten management policies at the second tier, which are further expanded into operational actions at the third tier.

The proposed PSCD management model takes into consideration the changing role of ports and requires collaborative working relationships internally within the organization as well as with external parties. Port management have preliminarily endorsed the management model which they can use as a guideline to check how well their ports have performed in each component of the PSCD management model. The presence of such a guideline helps facilitate the functionality of port operations and assists in ensuring supply chain continuity. However, the management model can be improved by formulating more specific actionable plans for ports in different business markets and environments and is subject to further empirical validation.*

* Date of Contribution ; November 11, 2013
Date of Acceptance ; April 1, 2014

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