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# The impact of autonomous ships on the containerised shipping interface of global supply chains- and networks: a literature examination of selected stakeholder perspectives

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# THE IMPACT OF AUTONOMOUS SHIPS ON THE CONTAINERISED SHIPPING INTERFACE OF GLOBAL SUPPLY CHAINS- AND NETWORKS

A literature examination of selected stakeholder perspectives

By

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# Declaration

I certify that all the materials in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): 

(Date): 18 September 2018

Supervised by: Prof G. Theocharidis

Supervisor's affiliation: SML

# Acknowledgements

To my Family. You are the reason that I am.

To my WMU Professors. You are the reason that I know more and thirst for more.

To my friends, classmates, and countrymen. You are the reason that I want to make a difference in our world.

# Abstract

Title of Dissertation: **The Impact of Autonomous Ships on the Containerised Shipping Interface of Global Supply Chains- and Networks: A Literature Examination of Selected Stakeholder Perspectives**

Degree: **Master of Science**

This dissertation is a theory orientated research project, investigating selected perspectives of the various major stakeholders in the containerised shipping related component of global supply chains and networks, both on the up- and downstream sides, as well as nodal-adjacent in the case of networks, on the potential impact of cargo carrying autonomous ships.

Due to time and access constraints the study is limited to a literature based examination of key perspectives of trade and economics in relation to the technological innovation presented by autonomous ships. The various stakeholders' viewpoints were identified and studied through literature based theory. These perspectives of trade and economics were investigated under the key points of Supply Chains and Networks, Value Chains, Containerised Shipping in Global Supply Chains and Networks, Performance Measurement, Technological Innovation, Industrial Internet of Things, Artificial Intelligence, Risk and Security and finally regulation. A critical analysis is given from the focal point of autonomous ships as a disruptive technology to containerised trade supply chains- and networks.

Recommendations are made on how the stakeholders may apply the identified perspectives to better collaborate, connect and ultimately stay competitive in the face of the possible disruptive technology presented by autonomous ships.

**KEYWORDS:** Technological Innovation, Maritime Autonomous Surface Ships, Global Supply Chains, Supply Networks, Logistics Management, Industry Performance Indicators, Containerised Trade

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# List of Abbreviations

| | |
|---|---|
| 3PL | Third Party Logistics Providers |
| 4PL | Fourth Party Logistics Providers |
| ET | Enabling Trade report |
| GDB | Global Doing Business report |
| GSCNs | Global Supply Chains- and Networks |
| IoT | Internet of Things |
| IIoT | Industrial Internet of Things |
| ILO | International Labour Organization |
| IMO | International Maritime Organization |
| LPI | Logistics Performance Index |
| MASS | Maritime Autonomous Surface Ships |
| NVOC | Non Vessel Operating Carrier |
| NVOCC | Non Vessel Operating Common Carrier |
| SWOT | Strength, Weakness, Opportunity, Threat analysis |
| UNCTAD | United Nations Conference on Trade and Development |
| UAV | Unmanned Aerial Vehicle |
| UUV | Unmanned Underwater Vehicle |
| WMU | World Maritime University |

# Chapter 1

# Introduction

> The one with many strategic factors in his favour wins, the one with few strategic factors in his favour loses – how much the more so for the one with no strategic factors in his favour. Observing the matter in this way, I can see who will win and who will lose.
>
> -Sun Tzu, *The Art of War*

## 1.1. Background

An often quoted statistic in the maritime world is that approximately 90% of all world trade, by volume, is transported by ships as world seaborne trade, totalling 10.3 billion tonnes of cargo in 2016 (United Nations Conference on Trade and Development, 2017). International trade and transport are inescapably linked, as trade cannot take place without transport, leading to the deduction that changes in transport will influence (and be influenced by) changes in international trade (Pavlović & Radoš, 2016). This trade related resultant demand, often also called derived demand characteristic of maritime transport illustrates the important role it plays in global prosperity.

It further also puts into perspective the importance of the role shipping plays in the global supply chains utilised for trade and industry. As a link in a bigger supply chain system however, the Shipping Industry and its direct stakeholders must keep itself informed of and react to, if not pre-empt, changes that could effect that supply chain, whether it be local, regional or global.

Branch (2007, p.401) predicted that international distribution networks will become ever increasingly integrated over the next decades, with multi-modalism playing a significant part in this process. The efficiency of this integration plays a decisive part in scale and market penetration businesses can aim for. Notably he stressed that technology plays a major part in the continued expansion and multi-modal networks, and that the expansion itself is a major facilitator for world trade development. This implies that a strong understanding of the potential impact of new technologies could lead to competitively advantageous strategies for the Stakeholders is these distribution networks that first understand and embrace it.

Many new technologies abound in an ever- and fast changing consumer driven global market place. Terms like Industry 4.0, Internet of Things (IoT), Big Data and Digitalisation are used, but the impact is often not fully understood, nor can it be, as the changes it brings about are often revolutionary and without previous examples.

In order to better understand the changes, and to exploit potentials or mitigate risks that it may pose to the industries and stakeholders affected, research is needed on nature of these technological developments (answering the what, where, when, and how of the changes that will occur).

This paper specifically focuses on investigating the impact autonomous ships will have on the Shipping Interface of larger, global, supply chains- and networks, looked at from the perspective of the current direct stakeholders of the containerised Shipping Interface; in other words, those in the "shipping-link" of the chain, and of those directly "linked" to it, both on the supply and demand side.

## 1.2. Problem Identification

Wijnolst and Wergeland (2009, p.425) note that, although innovation can be an objective in itself, it is more usually started due to competitive forces in the business environment. Innovation is thus tied to changes in the competitive environment. Little

is currently know about the impact that the technological innovation of autonomous ships will have on the shipping as a link within a larger supply chain, and hence also of the impact on the Shipping Industry that that relies on the supply chain. In order to better prepare all stakeholders and assist with informed decision making, further research in this field is needed.

The most important factor to be determined for each stakeholder possibly affected by Autonomous Ships is whether it will solve any problems, leading to a competitive edge. Typical questions that might come to mind for different stakeholders include: Will it make trade easier? Will it lower costs? Will it reduce environmental impact? Will it assist with easing sovereignty control challenges? Will it enable better safety of life at sea? In short, how would Autonomous Ships influence the competitive environment? In order to begin answering these questions, it is necessary to identify key performance measurements, the importance of which must hold true across industries and stakeholders involved in the supply chain, and or supply network.

Currently there is also little substantial literature regarding the effect autonomous shipping will have on the adjacent links of the Shipping Interface. Obtaining quantitative data for comparison is also a challenge, as the Shipping Interface (and the current Shipping Industry that forms the majority of it) is very different from other industries where autonomous vehicles are involved, especially in terms of physical location, legislation and risks, making it difficult to apply comparative data.

What can be compared through literature theory is the way the changes impacted the industry in the past, the performance indicators of supply chains- and networks and relevant industries as well as how comparative technological advances have impacted supply chains- and networks. Past experience in for example the Information Technology (I.T.) and Package Delivery (last mile services) industries have shown that due to the speed and revolutionary characteristics of technological changes, it allows outside actors to enter competitively into industries previously held in monopolistic

ways by a handful of specialised actors, and for them to completely disrupt the set ways of the industry.

It could be deduced that this will also hold true for the Shipping Interface, and that especially Autonomous Ships could have a major long-term impact on the way business is conducted within the industries it affects. This deduction must be investigated. It could also potentially allow new actors, especially in the Developing World, to enter into this industry in new and unconventional ways. Furthermore, decision guides are also needed for government spending plans, especially in terms of infrastructure development required to meet the challenges by the changes in the Shipping Interface.

# 1.3. Research Objective

### 1.3.1. Aims and Objective of the Study

Research is needed in this field in order to allow actors currently within the various industries to prepare for and place themselves strategically for the impact that Autonomous Shipping could have on the industry, and the industries are adjacent to it.

It is necessary to determine:

- The place autonomous ships will have in future supply chains- and networks.
- How those supply chains- and networks will be impacted.
- What are the necessary competitive factors driving autonomous ships.
- How can the above factors be exploited, or alternatively what risks to they represent.
- Action plan recommendations for stakeholders in terms of the above.

The focal point of this study is to determine the perceived impact of Autonomous Ships on the supply chain (and networks) in general, but also specifically on the current shipping industry and its main stakeholders. In order to achieve this, it is necessary

to investigate the key perspectives of trade and economics in relation to the technological innovation presented by autonomous ships. The various stakeholders involved in GSCNs' viewpoints were identified and studied through literature based theory from the perspective of trade and economics under the headings of value chain, security, risk and regulation.

The aim is to lay a foundation for future research to allow more concrete and route specific strategies to be devised for specific stakeholders, such as Developing Countries that are interested in ensuring the correct infrastructure is put in place, and that the correct local industries are developed.

### 1.3.2. Research Question

The problem statement of the study is to investigate the expected impact of Autonomous Ships on the supply chain (and networks) specifically on the current containerised shipping industry and its main stakeholders.

The problem statement is investigated by answering various research questions, namely:

- What are the factors that will drive the further development of autonomous ships.
- What will be the place and role of shipping in future supply chains- and networks.
- What are the risks and opportunities that autonomous ships will represent.
- How may these risks and opportunities be respectively mitigated and exploited by both private industry as well as national, regional and international governing authorities.

## 1.4. Scope of the Study

The objectives of this study are focussed on autonomous container ships, and will not include other forms of shipping (such as crude oil, dry bulk, general cargo or other

grouping types, as defined by UNCTAD, 2017). Although there are many more perspectives, this study is limited to only the trade and economic perspectives of the shipping interface value chain, security, risk and relevant regulation as pertaining to the Containerised Shipping Industry. The research is conducted through a theory and literature based analysis only, with performance indicators of the above perspectives being identified and then prioritised through a Strength, Weakness, Opportunity, Threat (SWOT) analysis, and recommendations made based thereon.

## 1.5. Dissertation Structure

The dissertation is organised into five chapters. Chapter 1 introduces the topic of autonomous ships in supply chains and networks, and gives insight into the problem being addressed through the research. This is used as the basis for the development of the research objective, and for defining the scope of the research.

Chapter 2 provides an overview and explanation of the Research Methodology followed, including the design of the research, an introduction to the qualitative approach followed and the subsequent analysis tactic applied. It also defines the limitations that the specific methodology followed imposes on the research.

In Chapter 3 the key topics involved in the analysis are defined and investigated through a literature based qualitative approach, with critical analysis on their expected respective roles in the effect of autonomous containerised ships. The topics that are dealt with are maritime related supply chains- and networks; value chain theory; containerised shipping in GSCNs; performance management theory; an overview of enabling technologies for automation from a ship point of view; an introduction to risk and security theory and finally regulation as it pertains to international containerised shipping.

Technological innovation as applied to autonomous ships is also investigated and discussed. Firstly technological innovation theory is explored, laying the foundation to be followed by a theoretical definition and classification of autonomous ships.

Chapter 4 provides the recommendations and conclusion of the study, as well as the limitations identified during the study. Through critical reflection recommendations on future work required as identified during the study is also provided in this section.

Chapter 5 contains the reference list and bibliography.

# Chapter 2

# Research Methodology

## 2.1. Introduction and Bibliographic Scoping

This chapter provides a detailed description of the research methodology approach followed in the research, and the reasoning for its use. As a conclusion the limitations to the research is also given.

The research was carried out in a qualitative manner, as there is currently very little statistically significant quantitative data available on commercial autonomous shipping in general, and more so for its application in the containerised shipping industry.

For introductory scoping a bibliographic overview study was conducted on the material listed in the Bibliography. Because it is not discussed in depth, but did lead to the approach followed in the methodology, a short overview of it is given here:

> In the past three years a number of talks have been held at TED Talk conventions regarding changes in the shipping industry, the impact of autonomous vehicles and especially on the legislative and legal aspects of the aforementioned. Various articles by people involved in the various industries have also been posted on these topics on quasi-credible websites such as Quora.com, where industry specialists can voice their opinions and be critiqued by peers. A number of industry-driven presentations were also reviewed. During the introductory overview study. This included material from companies and organisations such

as Rolls Royce, DARPA, CNH Industrial, Tesla, Hitachi Automotive America, Transport Evolved, Yara and Kongsberg.

From the above it emerged that there are various factors being considered as important and relevant to the discussion of commercial Autonomous Vehicles, and specifically also to Autonomous Ships. The application of autonomous vehicles are being considered, developed and in some cases already applied in various industries.

The identified stakeholders are:

- The Shipping Industry, including ports, vessel owners and operators, cargo owners and sailors;
- The Last Mile Delivery Industry, including associated warehousing and final customers;
- The Sovereign States and International Organisations involved in the environments that the supply chain and networks operate in;
- And the feeding industries that deliver containerised cargo to ports.
- Additionally alternative transport industries such as rail, cargo and air are also included as stakeholders, but not investigated in depth.

These stakeholders were identified according to the network interfaces of international seaborne containerised transport. Song and Panayides (2015, p.111) described the components of intermodal transport as collection, trunk line and distribution using standardised containers. The containers are is done via different networks and two or more changing transport modes. Their example of a intermodal transport system by sea, road and another mode was, for the sake of this study, simplified to three main cargo-related viewpoints, namely of

- everything up to but excluding the port,
- from port to port,
- and everything from exiting the port to final destination.

The research questions were applied for different main stakeholders according to the main viewpoints named above, by investigating the key perspectives of trade and economics in relation to the technological innovation presented by autonomous ships. Due to the shared and/or linked interests encountered, these stakeholder viewpoints are investigated and critically commented on from the perspective of trade and economics under the sub headings of value chain, security, risk and regulation, in a manner similar to a limited PESTEL analysis.

## 2.2. Research Design

The aim of this research is to determine the expected impact of autonomous ships on the containerised shipping interface of global supply chains- and networks (GSCNs).

The research was done in a qualitative approach of desk research, as defined by Verschuren and Doorewaard (2010). They characterise desk research as follows:

- Using of existant material, and reflecting upon it,
- Having an absence of direct contact with the research object,
- Material is used from a different perspective than at the time it was produced.

Most of the material that is reviewed was written from industry perspectives, but not with autonomous ships in mind, making this approach applicable.

## 2.3. Qualitative Study

The Qualitative Study literature review is centred on a concept-analysis, the concepts of which were chosen according to an approximated PESTEL-related model, and after discussion of each point critically reviewed in terms of globally-applicable possible impact of autonomous ships on GSCNs.

The primary literature sources that deal with the effect that autonomous ships could have on the Shipping Interface on supply chains are limited. In order to obtain an approximate gauge of the current direction of academic and industry thinking on the proposed topic, various secondary and tertiary sources were utilised as background study, focussing on the following, PESTEL-related, concepts:

- supply chains and networks,
- value chains,
- containerised shipping in supply chains,
- Performance Management,
- Technological Innovation
- Enabling technologies for Autonomous Ships
- Risk and Security and
- Regulation

Dominant theories pertaining to each of these theories are reviewed and critically discussed. A normal full PESTEL analysis was not conducted, but rather a tailored approach, as some of the factors expected to have a major impact on the broader Containerised Transport Industry, and hence also the more specific Containerised Shipping Industry, are not explicitly contained in the PESTELE analyses approaches normally found in literature.

Secondary relevant sources, such as official National and International Regulations, peer reviewed journals, articles, textbooks, research papers and proceedings from seminars and conferences were reviewed and critiqued in order to conduct the research, grouped according to the concepts named above.

## 2.4. Analysis Approach

A deductive analysis approach is followed, as described by Saunders, Lewis and Thornhill (2012, p. 548), wherein theoretical prepositions of the concepts discussed are analysed.

Following the literature review of dominant theories pertaining to the concepts identified, as listed in the Qualitative Study section of this chapter, an analysis is conducted according to those concepts, and their subjectively perceived impacts on GSCNs by autonomous ships.

## 2.5. Methodology Limitations

As noted by Saunders *et al* (2012, p2 548), quoting previous research, a possible impact of following a deductive reasoning approach to analysis is that some key issues to be investigated might have been ignored. This may be addressed in future research by following a Delphi study method in an inductive study approach, still as Qualitative Research.

There is possible bias by the author due to the research approach.

As this is a Qualitative study based on desk research it might be taken less seriously by the audience it seeks to address, namely the stakeholders of global supply chains and networks, including related industries and governments. Further quantitative studies are needed as more data becomes available.

# Chapter 3

# Concept Analysis and Discussion

> The rules of the military are five: measurement, assessment, calculation, comparison, and victory. The ground gives rise to measurements, measurements give rise to assessments, assessments give rise to calculations, calculations give rise to comparisons, comparisons give rise to victories.
>
> -Sun Tzu, *The Art of War*

## 3.1. Supply Chains- and Networks

Branch (2009, p. 5) defines the Supply Chain as "…the sequence of events is a goods flow, which adds value to the value of the specific good. These events may include conversion, assembling and/or disassembling and movements and placements. The Global Supply Chain crosses international boundaries." The implication is that supply chains link the manufacturing or producing entities to the end consumer or next distributor through a dedicated service. He goes on to name Supply Chain Management as one of four key service areas that global logistics operators focus on, alongside Delivery and Customs Clearance, Distribution Management and Import Logistics and Outbound Distribution.

The stakeholder involved in global supply chains are under pressure to ensure their economic sustainability through generic growth, revenue growth, long term trade agreements and operational optimisation. In order to stay competitive, companies traditionally have one of three strategies to pursue: product or service differentiation, cost leadership and product or service focus, the last named done through the

outsourcing of non-core competencies. As companies increased outsourcing, the complexities of the supply chain also increased.

The containerised shipping industry is a vital link in global supply chains, but often taken for granted by end-consumers due to the invisibility of it from their perspectives. It none the less represents an important component in the linking of local and foreign economies through trade, the need of which exists due to the demands of end consumers. The demands of the end consumers also reverberate up the supply chain, such as transparency and visibility of cargo tracking, costs and time from order to delivery.

In order to ensure optimisation of these global supply chains, it is necessary to ensure integration of all aspects of the chain, especially the information management. The less integrated the chain is, the more risk is introduced, the more complex the system becomes and the more prone to instability. Through trends like third and fourth party logistics (3 PL and 4PL respectively), some of these elements of distribution and fulfilment services are addressed by outside companies focussed on supply chain integration. In this regard containerised shipping still has a long way to go, as cargo transparency is almost universally lacking across the industry.

## 3.2. Value Chains

In 1985 Porter suggested a value chain systematic approach for breaking down organisations and systems into strategically important activities according to key categories of activities based on their value creating logic.

Although this model was initially meant for a single industry firm, the basic principle can also be applied for overall industries and industry networks when the innovation driving value system change is common across the industry or networks.

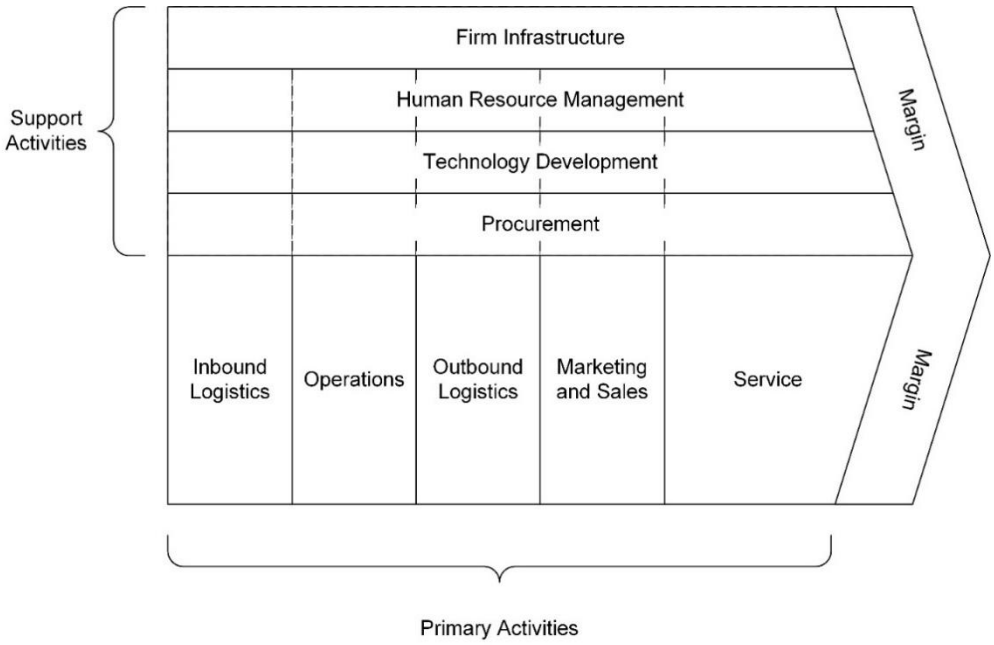


**Figure 1: Generic Value Chain (Porter, 1985)**

These primary and support activities, as shown in Figure 1 above, differ from organisation to organisation within GSCNs, depending on where they are situated within the larger system value chains. As Wijnolst and Wergeland (2009, p. 434) advised, gaining and sustaining competitive advantage by means of innovation is not a matter only of managing innovation, but principally of understanding the organisation's value chain and where it fits into the larger value system.

This could mean that organisations will have to reinvestigate how they approach business process outsourcing concepts of some of these primary and support activities, with concept such as 3PL and 4PL being commonplace, as discussed by Button, Vega and Nijkamp (2010, p. 163). Especially organisations that rely on the 4PL concept, with its emphasis on information management, might have to be revisit how it is managed in the value chain. With an autonomous ship information and communication becomes almost synonymous with physical control of the vessel, and so also with control of the trading ability of the ship.

It is not within the scope of this study to individually identify, investigate or make recommendations on the potential impact of autonomous ships on every aspect of the primary and supporting activities for every stakeholder of GSCNs.

The primary and support activities, as identified according to Porter, for GSCN stakeholders' organisations will all be strategically differently impacted by the technological innovation of autonomous ships, and so it is vitally important for every stakeholder to do an in-depth analysis of the impact on each, and to put appropriate management plans into place to ensure that the value created by the organisation for customers still exceeds the overall costs of doing so.

## 3.3. Containerised Shipping in Global Supply Chains- and Networks

Over the past few decades Globalisation has radically influenced and changed the scope and nature of containerised shipping, not just in the shipping industry, but also on the up and downstream sides of the supply chains and networks it operates within. As world economies became increasingly interweaved through trade and industry, with the constant need to improve manufacturing and service efficiency, global trade surged through the resultant outsourcing. Friedman (2007) theorised that there are ten forces that act as globalisers, or "Forces that flattened the world". Flattener no. 5 he gave as Outsourcing, 6 as Offshoring and 7 as Supply Chaining.

Although all the forces Friedman theorised on influences world trade, and hence as a derived demand so also the shipping industries, these three forces most directly influence the volumes and methods of transport management of containerised trade. His theory is however reliant on the continued global pursuit of free-trade, with less trade barriers and continued growth of multinational operations across industries.

The sovereign states between which trade takes place, and the regulatory requirements they put in place has a major impact on the role and management of containerised transport within GSCNs. As explained by Song and Panayides (2015, p. 16), countries require the tracking of containers coming into, and within their borders, manifests must be made available for customs checking, in addition to physical inspections, risk assessments must be compiled and acted upon by government bodies. Although there are many more requirements, the point is illustrated that containerised trade generates vast amounts of data, and requires time and generates costs. In addition to this, the agreement between buyer and seller as to the terms of payment and risk transfer, commonly done according to INCOTERMs further complicate responsible parties that government bodies must interact with to obtain required information. All of the above contributes to possible delays and cost additions that maritime containerised transport imposes on GSCNs, and so must be optimised for efficient trade and transport.

Ports also play and important role in the facilitation of maritime-based trade. Commenting on the works of others, Song and Panayides (2015, p. 13) note that there are four indicators for trade facilitation: port efficiency; customs environment; regulatory environment; and service sector infrastructure. Song and Panayides (2015, p.291) describes the current driving forces of changes in container port sector's competitive boundaries and industry composition as new economic and institutional environments. These forces are characterised by globalisation, the processes of integration and trade development (driven to a large extent by the World Bank), as well as port reform in developing countries. Terminal operators have in recent years increasing become multinational container shipping industry-related companies, vying for competitive advantage by cargo prioritisation through terminal control.

World trade is however never static. New manufacturing and service trends driven by policies introduced by countries playing major roles in the world economy are starting to give rise to in-sourcing rather than outsourcing, especially in defence-related industries. In particular, the Russian Federation, the Republic of India, the European

Union, the United States of America and the Peoples Republic of China are all starting to or are already actively pursuing changing policies of focussing more on locally developed and built defence equipment and related technologies. As a historically large driver of technological innovation, this gradual change in defence related trade will also influence global commercial trade, as well as influence the policies driving it.

These changes will affect GSCNs, and also then containerised trade. Because the driving force behind this defence-industry change is sovereign nations, and those same sovereign nations define the regulations of international bodies that guide and manage world trade, such as the IMO, WTO, ILO and most notably the UN, it is inevitable that the agreements influencing world trade will also change as a result. The extent and nature of these changes, and their resultant impact must however still be investigated. It is noteworthy that many of these sovereign nations are returning to the core belief that having a state influenced- or controlled merchant marine, both in terms of vessels and crew, is important not just from a trade perspective, but also from a strategic defence perspective.

## 3.4. Performance Measurement

Song and Panayides (2015, p.431) notes that further research into the bottlenecks of containerised shipping and its related operations could provide insight into formal trade barrier measurements. Furthermore gap measurement of pairs of trading countries (the maritime trading network) could provide more insight into trading patterns and costs. They suggest that the gap analysis should be conducted based on the performance measures laid out in respectively the Logistics Performance Index (LPI), compiled by the World Bank; Global Doing Business Report (GDB), compiled by the World Bank & the International Finance Corporation; and the Enabling Trade (ET) report, compiled by the World Economic Forum.

A brief overview of these performance measures, as given by Song and Panayides (2015, p. 23):

- ET report. A report that measures barriers to international trade from a supply chain perspective based on four indices, which in turn are made up a total of 7 sub factors:
    1. Market Access
        - Domestic Market Access
        - Foreign Market Access
    2. Border Administration
        - Efficiency and transparency of border administration
    3. Infrastructure
        - Availability and quality of transport infrastructure
        - Availability and quality of transport services
        - Availability and use of information and communications technology
    4. Operating Environment
        - Operating environment

  The data used for the analysis of the 7 sub-factors are gathered through 56 indicators from datasets of the World Bank, the United Nations Conference on Trade and Development, the World Trade Organisation, the International Trade Centre and other project partners.

  Although this seems to make the report encompassing of all major factors impacting international trade supply chains, it does not take into account the long term agendas of the sovereign states between which the trade takes place.

- GDB report. The report studies and benchmarks regulation that affect private companies in 189 countries. Countries are ranked according to their benchmarked score on eleven specific areas of business:
    1. Starting a business,

2. Construction permit management,
3. Getting access to electricity,
4. Registering property,
5. Obtaining credit,
6. Protection of investors,
7. Payment of taxes,
8. Cross border trading,
9. Contract enforcement,
10. Resolving of insolvency, and
11. Worker employment.

The report gives a good indication of the ease of doing business, as well as the ease with which new players may enter the market from a regulatory point of view.

As with the ET report, a criticism of this report is that it does not take into account the susceptibility and motivation of the governments of countries to enable easier trade from a long term strategic point of view, especially if they have isolationist tendencies.

- LPI report. The LPI is meant as an overall global measurement of trade logistics, based on surveys conducted by express carriers and freight forwarders across 160 countries. The components of measurement in the LPI report are:
    1. Frequency of shipments meeting time schedules to consignees,
    2. The ability of tracking and tracing consignments,
    3. The ease of making competitively priced shipments,
    4. The competence and quality of logistics services,
    5. The quality of transport and trade infrastructure,
    6. The efficiency of customs and border clearance.

Broadly the report measures the input (the last three components) and output (the first three components) of logistics performance.

The report does give a good indication of the logistics performance, but is subject to the perception and individual motivation of the survey respondents, which could lead to an industry bias.

The implication of these performance measurements is that bottlenecks within containerised shipping, and hence the measurement thereof, could also translate to performance measurements of related operations, namely the up- and downstream supply chains- and networks. Hence, to ensure Autonomous Ships add value to containerised shipping operations, they should improve key elements of these performance measurements. The envisaged effect of autonomous ships on these elements could thus be used as a measurement of the driving force, or even momentum force, on the need and adoption of autonomous ships in trade networks.

## 3.5. Industrial Internet of Things

In a TED Talk entitled "Welcome to the age of the industrial internet" Marco Annunziata, (2013) the chief economist of company General Electric Notes that the growing number of internet-connected sensors now being able to be put on machines are allowing new ways of measuring the input to and from machinery, further allowing the collection of vast amounts of operational data. This data, when married to increasingly sophisticated analytics that can scrutinise it, allows deep insight into operations, and also gives guidance into increasing efficiency and effectiveness, as well as allowing the operating of machines and networks of machines in entirely new ways. Phrased differently, it allows both asset and system optimisation. These technologies are also making their way onto ships, and the data being collection is being shared in real time via satellite data links to land-based data collection centres.

The factors allowing the exponential growth of machinery operational data collection are:

- the sharp declines in cost the cost of storing, accessing and analysing data in the cloud,
- The decline in cost and increase in availability of sensors

By analysing the data gathered, predictive, reactive and social machines are becoming possible, and have been proven in applications such as medical science, where Pattern Analytics have been used to ensure doctors, machines and patients can be married together efficiently.

Similarly, it has been proven in the Renewable Energy Industry, specifically on wind turbines, that turbines can be equipped with remote monitoring and diagnostics, allowing predictive maintenance and minimising downtime as well as spare part inventory. Forbes Magazine (Marr, 2018) reported that it is projected that 200 billion smart internet of things (IoT) devices will be connected by 2020. According to Annunziata, up to 80% of all data created on the internet are created by industrial sensors.

According to Annunziata, a further implication of advanced analytics is that specialist help can be streamed as required, allowing basic maintenance to be carried out by less skilled personnel. The implication of the change in industrial data analytics is that the way humans work will change, and focus more on creative aspects, with optimisations being taken over by algorithms feeding on machine and system created data. This could lead to new high skill jobs, but also new low skill jobs, more focussed on intuitive interface based work.

Jobs are built up of tasks, and the tasks need to be done will change as these new technologies enter the marketplace. Software defined machine infrastructure is now becoming a reality, wherein decoupling machine software from hardware is becoming

possible, allowing the remote monitoring, management and upgrade of machines. The applications are however still in their infancy, and have not yet been applied in any meaningful way in the shipping industry. It is however being applied in the last-mile package delivery industry.

All of the above allows a shift towards predictive, condition based maintenance, in turn allowing a movement towards zero unplanned downtime. There are however a number of barriers that must be overcome to make this a reality. Organisations and organisational practices must adapt, robust cyber security is needed to address risks of safeguarding critical data, information and infrastructure. New educational systems are also required to be investigated and developed to equip students with right technical skills.

As can be seen from the above discussion, the application of technologies emerging from the Industrial Internet of Things is a strong enabler for autonomous ships.

## 3.6. Artificial Intelligence

Kelley (2016) made the statement that Cognification is a more descriptive term for Artificial Intelligence (AI). He notes that an understanding of AI requires an understanding of three main concepts:

1. The understanding of what intelligence is – there is no one type of intelligence, but rather multidimensional, consisting of up to a 100 identified types of intelligence, for example deductive reasoning, emotional intelligence, spatial awareness, arithmetic, long term memory etc. Type of AI "smartness" can be achieved by combinations of different types of cognitation depending on the application required.
2. AI can be used to start and maintain a second industrial revolution. In the first industrial revolution new forces of energy conversion was applied to machinery – man made powered ploughs. During the second industrial

revolution, combination of cognitation, or AI, can be applied to machinery, - man can make smart powered ploughs.

3. The implication of the first two concept is that A.I. will becomes a commodity. He notes that the most popular A.I. application in 20years has not yet been invented and made the statement "Thinking different is the engine of wealth".

Defining the types of cognitation needed for the safe and efficient operation of autonomous ships should be a priority for international regulatory bodies such as the IMO. The IMO has recently added the definition of terms for Maritime Autonomous Surface Ships (MASS) to its agenda, and should to pursue the technical definitions needed as a matter of urgency.

## 3.7. Risk and Security

Tying in with Porter's Value Chain approach discussed earlier, based on prior research, Koc and Bozdag (2017) suggested that degree of novelty plays an important role in the risk avoidance and sound innovation processes of organisational policy management, as well as in the supporting knowledge-foundation that must be laid through academic work. The earlier the degree of novelty of innovation can be determined, the easier decision makers in organisations can evaluate innovation based proposals, prepare the organisation and design appropriate management strategies.

Dess, Lumpkin, Eisner and McNamara (2014, p. 55) noted that the internet and digital technologies are significantly affecting the five competitive forces of Porter (Porter's five-forces model of industry competition as shown in Figure 2 below). In GSCNs, because of easier access to information for customers up and down stream; lower barriers to entry (for example NVOCCs); and the fact that substitute services are easy to access and compare, industry competition becomes extremely rigorous. Any competitive advantage must be exploited as quickly and efficiently as possible, but without approaching it as a zero-sum-game, as it would negate the positive influence of constructive relationships that GSCNs are reliant upon. This presents a challenge

to organisations' decision makers that must be prepared for in the face of innovative technologies such as autonomous ships.

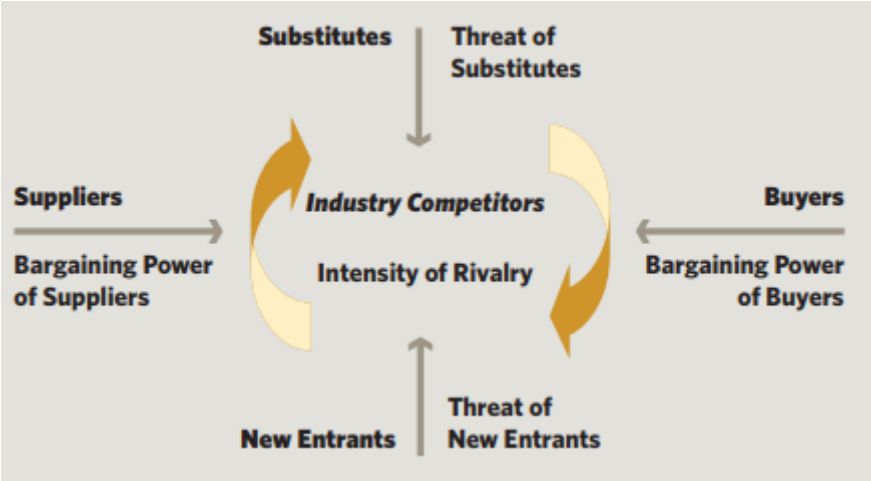


**Figure 2: Porter's Five Forces Model of Industry Competition (adapted from Rice, 2010)**

Adler (2002, p. 188) raised the point that the degree of uncertainty avoidance was found to be largely cultural based, meaning that managers and decision makers from different cultures will approach untried alternatives, for example new innovations, differently according to their risk aversion largely based on their specific cultural approach. For organisations involved in integrated systems like GSCNs it is thus important that, when technological innovations such as autonomous ships are introduced, that the cultural approach to risk across the globally diverse system be kept in mind by the decision makers, and that a common set of ethics be developed, understood by all, and implemented.

## 3.8. Regulation

Stopford (2009, p. 692) identified three regulatory regimes that influence the shipping component of GSCNs, namely classification societies, flag states and coastal states. Traditionally the shipping industry is to a large extent internally regulated through classification societies. They play the role of ensuring vessels are up to specification

through regular surveys during the service life of the vessels. Autonomous Ships entering the shipping industry would require that classification systems and survey procedures be developed and implemented. At the same time liability scenarios will have to be investigated in order to determine how insurance should be applied for the vessels.

Flag states, which are responsible for the laws governing civil and commercial activities of trading vessels, will have to develop laws on issues such as ship design, collision avoidance, certificates of competency and communication & control security for autonomous ships. In order to ensure that a uniform framework of international law exists on these issues, international bodies such as the IMO and ILO will have to start identifying and developing areas of law that will be necessary to ensure safe and efficient trading with autonomous ships. Developing these instruments to ensure compliance will require comprehensive compliance strategies, as discussed by Chayes and Chayes (1998, p. 271). For autonomous ships this will be especially vital, as there will probably not be a human element onboard to make decisions and accept responsibility when things start going wrong.

## 3.9. Technological Innovation Introduction

When defining technological innovation, a good start might be an analysis of the Latin origins of innovation. Innovation stems from the word 'innovare', meaning 'to make something new'. This could then be implied to mean various things, but generally could be broken up to be one of three main concepts, namely Invention – through technical, scientific knowledge creating, producing or conceiving of a new solution, Realisation – Developing a solution into something that can be produced viably, and Implementation – To take an entity and use it to solve a perceived or real need in practice.

Furthering on these concepts, Henderson and Clark (1990) defined the types of innovation as follows:

- Radical – Innovation that puts a dominant design in place, with the associated design concepts.
- Incremental – Innovation that incrementally extends and refines some established design. Underlying design concepts and their associations however stay the same.
- Modular – Innovation that, although the core concept is changed, the underlying architecture and primary function of the product stays the same.
- Architectural – Innovation that reconfigures existing system links, putting components together in different ways.

Broadly similar, Marquis (1969) defined three types of innovation:

- Incremental – Innovation stemming from small changes that improve processes, products and services.
- Radical – Innovations that cause, or have an impact, on significant changes in an entire industry.

System – Innovations that require significant time and various resources to accomplish (such as the Internet and Satellite systems)

## 3.10. Autonomous Ships as Technological Innovation

Are Autonomous Ships a form of Technological Innovation, and should it be managed as such? From the definition given in the Technological Innovation Introduction section of this chapter, it leads to the deduction that **Innovation = Invention + Exploitation.** The definitions, when adapted for the technological innovation of Autonomous Ships specifically, would suggest that autonomous ships could be resorted under various of the types, depending on the arguments followed by the observer. Importantly however is to realise that, as a possible technological innovation, autonomous ships must not just be a realisation to a need (as an invention), but must also be a realisable and producible (Realisation, as a first component of

Exploitation), and be able to be introduced and operate successfully and competitively (Implementation, as a second component of Exploitation).

Because autonomous ships are already invented and are being produced, for example the vessels operated by Wilhelmsen and Kongsberg (Kongsberg, 2018), the Invention component of the equation has already been answered, as well as the Realisation component of Exploitation. The Implementation component of Exploitation is not as straight forward for the Shipping interface of GSCNs though, as every major stakeholder has a different requirement for implementation. An overarching concept that will have a definite impact on its implementation, regardless of the stakeholders, if whether it is beneficial for the global trade it supports, and which remains to be investigated. Autonomous Ships can thus be considered as a form of technological innovation, and should be managed in a commensurate way.

# Chapter 4

# Recommendations and Conclusion

> If generals do not know how to adapt advantageously, even if they know the lay of the land they cannot take advantage of it.
>
> -Sun Tzu, *The Art of War*

## 4.1. Introduction

In the introduction to the collaborative book, A Dictionary of Transport Analysis (Button, Vega and Nijkamp, 2010), the editors state that "Transport Analysis is an area of study rather than an academic discipline such as physics, linguistics or economics". This study has proven that to be especially true, as the factors influencing the transport based movement of goods through GSCNs are not confined to any one discipline, necessitating a much broader investigation when an technological innovation such as Autonomous Ships enters the field.

The research resulted in the following:

- It identified the factors, based on literature, which are expected to drive the further development of autonomous ships. It was determined that Autonomous ships are a form of technological innovation, and that they should be managed accordingly. By utilising guiding principles such as Porter's value chain models and sound innovation management strategies, such as those presented by Wijnolst and Wergeland (2009) stakeholders in the GSCNs may plan and prepare their organisations for the innovations surrounding autonomous ships.

- A reasonable prediction of the place and role of autonomous ships in future GSCNs can be made. It is expected that Autonomous Ships will not play a large part in GSCNs in the immediate future, as they are not expected to contribute to a competitive advantage in the value chains of Stakeholders, and in fact present additional risk to important stakeholders such as Sovereign States. Sovereign States and International Organisations want to ensure that lines of trade stay open and free from foreign interference, which could potential be more exposed with autonomous ships being vulnerable to cyber attacks.

- Risks and opportunities were identified that autonomous ships will represent to the future of the Shipping Interface of GSCNs. The risks are mostly based on ensuring control over information as well as communication to autonomous ships, and will have to be mitigated by advances in communication technology, encryption, artificial intelligence and control system technology. Each of these risks also convert to opportunities for the entities that manage to bring those mitigating technologies to market first.

- Proposals for methods that risks and opportunities may be respectively mitigated and exploited by both private industry as well as national, regional and international governing authorities were identified and given. Besides those mentioned in the previous paragraph, international organisations such as the IMO, P&I clubs, as well as the maritime administrations of sovereign states, should begin investigating and compiling legislation proposals to ensure that when autonomous ships do become a viable trading reality in GSCNs, they can be implemented smoothly and that risk and liabilities issues are addressed for all stakeholders.

## 4.2. Study Limitations

The scope of the research was limited to the following:

- The research was conducted primarily from a Supply Chain point of view.
- The research only focussed on containerised cargo transport.
- The scope of the research covered only Autonomous Ships applief in the containerised shipping industry.
- The research was conducted qualitatively using theory from literature.
- Only the Autonomous Ship impact perspective of trade and economics under the sub headings of value chain, security, risk and regulation were considered. There are numerous other perspectives that must also be identified and investigated in to order to form a more comprehensive impact evaluation.

## 4.3. Recommendations for Future Work

It is recommended that every entity that recognise themselves as stakeholders, such as those identified in this study, to do an in-depth analysis of the role they currently play in GSCNs, and to develop contingency strategies based upon changes in the economic – trade balance that autonomous ships could cause in GSCNs.

For future work there are number of recommendations. Primary sources of data should be gathered through a Delphic Study of structured questionnaires sent to, obtained and redistributed for comment to various expert stakeholders within the Shipping Industry (representing the current Shipping Interface), including private industry from various companies as well as National and International Regulatory Bodies. This will allow convergent opinions to be identified and conclusions to be drawn by future researchers, until such time as more quantifiable data is available.

A more in depth impact study is needed, per Key Performance Indicator of the various stakeholders. Other perspectives than those addressed in this paper must also be identified and investigated in to order to form a more comprehensive impact evaluation of Autonomous Ships.

Studies are also required from legislative points of view, especially to investigate liability implications.

Governance legislation for sovereign states as well as for international organisations such as the IMO must be developed and evolved as a matter of urgency to avoid the catch-up situation that the aviation industry is currently struggling with (with the various types, sizes and classes of autonomous aerial vehicles being introduced around the world).

# Chapter 5

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