Strategic Investment of Emerging Technologies in the Shipping Industry at the Port of Virginia: Machine Learning Models as Applied to Ports
(Technical Paper)

The Sociopolitical Implications of Emerging Port Technologies
(STS Paper)

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Introduction

The United States and Europe once had many of the world's most trafficked ports, however, today the top 10 most trafficked global ports are in Asia and the Middle East (*World Shipping Council - Partners in Trade 2020*). A large part of this shift is due to worldwide economic and demographic trends but another significant portion is due to technological changes in the shipping industry (*Global Port Trends 2030 2020*). According to consulting giant Deloitte, as technologies such as the internet of things, 5G, machine learning and block chain become more available, they will enhance the shipping industry in the realms of efficiency, security and automation with new abilities to ship and track more cargo containers in less time (*Global Port Trends 2030 2020*).

This thesis will examine the implications of new technologies entering the shipping and port markets and how those technologies will impact global shipping trends, economic statuses, and the shipping industry. This thesis will also examine the political and social implications of these technologies through the actor network theory and the technological determinism STS frameworks. The STS research paper will include a focus on the economic impact of automation in ports on various stakeholders. The technical project inspiring this thesis involves the research and simulation of different data integration techniques and emerging technologies for tracking port and ship assets. The technical project described in this proposal will study industry leaders which have already implemented various technologies in their ports to determine which technologies will be the best investments for the Port of Virginia. The technical project will also include a section on different shipping and data models as applied to the Port of Virginia.

Technical Topic

The technical project will focus on strategic investment of innovative technologies allowing for superior automation at the Port of Virginia, using case studies from cutting-edge ports around the world, patents, and global research. The ultimate goal of this project is to create a framework for the Port of Virginia's future that incorporates innovative port technologies from global leaders. The focus of the technical project will be on investigating the use of augmented intelligence, Internet of Things, and blockchain to assist in the integration of automation into the port, building towards becoming a smart port. The need to innovate towards automation is driven by three main drivers of the industry: Operational Excellence, Migrating Activities, and New Business Opportunities. This project will focus on operational excellence. Operational excellence means providing value on both the supply and the demand side. On the supply side there is a drive to increase capacity, efficiency, reliability, and support while keeping costs low. On the demand side, this means improving the service provided to stakeholders such as reducing time in the port, improving security, and allowing for traceability of cargo. These technologies are necessary because of the many challenges with automation itself. A McKinsey

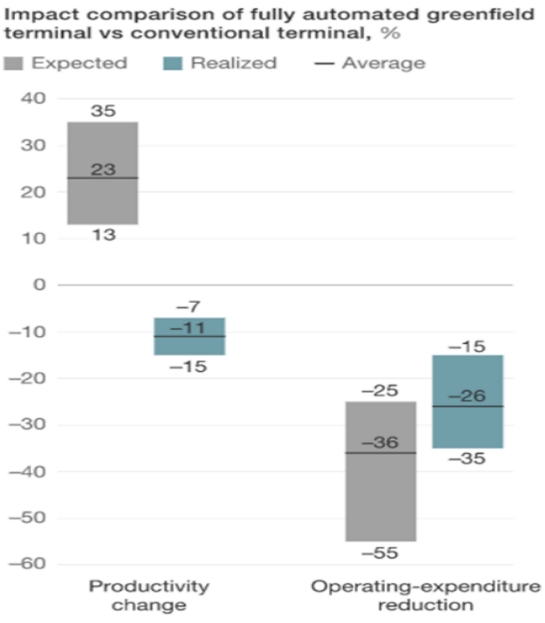

Figure 1

study shows that automated ports improve safety, decrease human-related disruptions, and improve predictability of performance, but do not necessarily improve productivity as seen in Figure 1 above. Return on invested capital of assets at some automated ports fell short by up to one percentage point from the industry norm of about 8%. Operating expenses fell by 15-35% versus the expected 25-50%, and productivity actually fell by 7-15%. What this report shows, is a need for proper integration of data driven technologies to aid in successful automation. (*Chu 2018*) The technical project will also include a section on a machine learning model which will be applied to a set of container data that enters the port to determine which cargo containers customs will likely want to open. This machine learning model will be used to identify what criteria customs uses to pull containers for inspection. With the primary goal of the Port of Virginia to move containers swiftly and facilitate commerce, the use of this information will be for the Port of Virginia to more efficiently stack containers in a way that less time is lost on customs inspections because less containers must be moved to access containers of interest.

Technical topic: method, Sources

The first stage of research will focus on case studies of the ports of Antwerp, Rotterdam, Hamburg, and Shanghai. Each of these ports have employed a specific technology that the study will focus on.

Antwerp uses a service called NxtPort, a data utility platform that facilitates data-sharing practices between users at the Port of Antwerp. One of the key groups of data NxtPort focuses on is data from terminal operators, ensuring everyone gets the right information at the right time. In June 2018, Antwerp also began a pilot project to use blockchain to ensure secure

exchange of phytosanitary certificates. The 2018 project from Antwerp is specific, but the technology can be generalized to any kind of data being made available more quickly (*Carlan 2018*).

The Port of Rotterdam has employed a similar data integration platform called NextLogic. NextLogic's focus is on more efficiently handling inland container shipping by providing a platform where the entire chain of container shipping by barge can work together. Its applicability is in integrated planning, information exchange, a performance dashboard, and providing a general information platform (*Carlan 2018*).

The Port of Hamburg introduced an IoT framework with the smartPORT initiative that "includes modernizing its IT infrastructure to coordinate all aspects of port operations by installing sensors to coordinate ship–road traffic and monitor infrastructure performance *(Carlan 2018)*. To realize the full potential benefits of this project, logistics operators are improving their information systems capabilities to receive and use the notifications sent by the port to truck drivers on available parking spaces and bridge closures. This allows drivers to optimize route planning and reduce travel time (*Carlan 2018*).

Finally, the Port of Shanghai introduced China's first fully automated container terminal, and the largest intelligent container terminal in Asia. Although the Port of Virginia has no interest in full automation, our study will look at how this was successfully implemented to examine which pieces of automation the Port of Virginia will want to apply themselves. The Shanghai example will also help the Port of Virginia identify which automation technologies are too costly to consider.

The final phase of the project will look at the Port of Virginia and how they can invest in these emerging technologies using a scenario analysis. The scenario analysis takes in stakeholder perspectives, criteria, potential investment initiatives, and emergent conditions grouped into potential scenarios. A Criteria-Initiative assessment table is produced, giving one of 3 levels of influence of each initiative on each criterion. A graph as seen in Figure 2 is then produced. For each initiative, the black marker shows its current ranking of importance. The blue line shows how far this ranking may move up given the potential emergent conditions, while the red bar shows how the ranking may move down. Figure 2 provides insight into the importance of potential initiatives that the port may invest in.

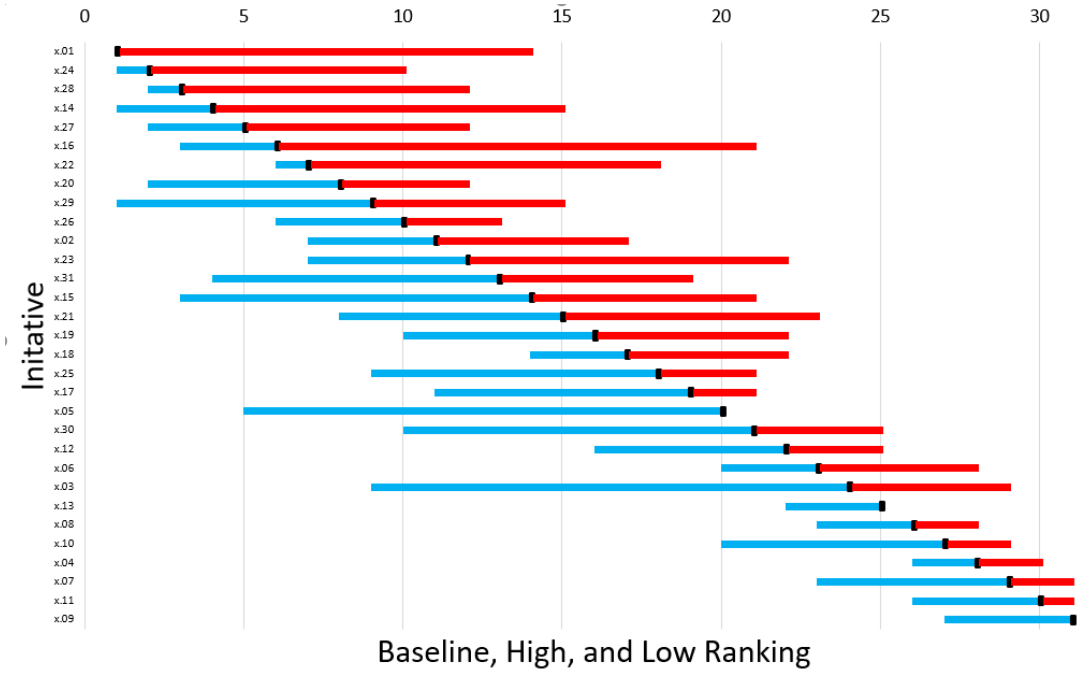

Figure 2

STS Topic

The United states has had a continuous import/export deficit for over 40 years. Economists in the US have varying arguments as to whether or not the trade deficit is a negative for the country overall, but can agree that ports are the major place to address this subject.

Arguments against trade deficits include the reliance on foreign nations (most notably China, OPEC, and parts of Africa) for goods including medicines, personal protective equipment, energy, and rare earth minerals such as cobalt (*The United States Is Dependent on Other Nations for Critical and Strategic Minerals 2019*). As the port industry has moved rapidly into automation, ports have not responded as positively as comparable industries. With low productivity and profitability returns in exchange for extensive automation investments, the shipping industry faces a unique challenge going into the next decades. The STS topic of this paper will be about the impact of emerging technologies on maritime commerce and the social and political impacts of these technologies. As ports automate certain processes, they may experience revenue gains, but at the cost of longshoremen and the benefit of almost all other parties discussed as ports are a crucial part of economic activity in the US. The stakeholders examined will include ports, shippers, government, consumers, suppliers, and criminal enterprises. Tools for automation represent the main physical artifact and government and business policy around maritime trade can both be viewed as the main non-physical artifacts that will be examined as impactful on the stakeholders above.

The STS theories and frameworks used in this thesis will include Actor-Network theory and Technological Determinism. The Actor-Network framework is a systematic way to organize humans, technology, and the natural world in a web of relationships to describe the roles of different entities in connection to one another. This theory emerged in the 1980's from authors John Law, Bruno Latour, and Michel Callon *(Cressman 2009)*. Critics of ANT cite its abandonment of assumptions as a negative for contextualizing the web of relationships, however this thesis will discuss the motivations (both financial and other) of nodes and connections to combat this criticism. Technological Determinism is an STS framework that views technological

advances alone as driving societal change and outcomes. Critics of Technological Determinism claim that the theory does not consider that social factors drive technological advances or that there is a synergy between technology and society in leading to outcomes *(Smith 1994)*. This thesis will combat the criticism that social factors are ignored by examining the economic benefits and costs of comparable technologies to favor the view that the most profitable or advantageous technologies will consistently be chosen by a majority of consumers/decision makers.

This Research is important because it examines the relationships between technology, government, and the economy in the port industry. As automation and the technologies discussed become increasingly prevalent in the port industry it is valuable to understand and anticipate the social and political impacts that advanced maritime commerce will produce.

Methodologies

Research Question: How will emerging technologies and automation in the port industry affect the US economy, government, and the laborers of the port industry?

To answer my research question, I will use the Actor-Network Theory and Technological Determinism approaches. The thesis will begin by giving a background on maritime trade in the US economy and an overview of the varying degrees of port automation that exist in different areas around the globe. The information on the maritime trade in the US economy will be from a mixture of online economic journals and statistics from government records. The varying degrees of automation will be researched during the technical project as strategic investments are evaluated and this research will come mainly from academic papers and funded studies by global ports. I will introduce Actor-Network Theory as a web to describe the relationships between stakeholders, technology, and policy in maritime commerce. ANT will provide the

information about the key relationships between stakeholders that I will examine. I will also use the Technological Determinism approach as I discuss the technologies evolving in the port industry and make predictions about their effects based on similar technologies of the past *(Cressman 2009)*. Research on Actor-Network theory in relation to ports and laborers will come from news articles around automation and the impact on longshoremen jobs. Automation will be examined in comparable industries and the effect automation has had on worker's salaries and the availability of work. I will establish the connection between technology replacing workers while simultaneously creating new jobs as seen in the industrial revolution of the early 1900's. Case studies about automation replacing workers while also increasing GDP will be discussed to advocate for the use of more technology in ports. Throughout the paper I will discuss US government policies around international trade including deals such as NAFTA, tariffs, and embargos (*The United States Is Dependent on Other Nations for Critical and Strategic Minerals 2019*). These STS frameworks and research approaches will formulate the answer to my research question as I am mainly discussing the impact of technology on the economy with technological determinism and historical information in automation and shipping.

Conclusion

The technical project in this proposal introduces research on emerging technologies and automation to be applied to the Port of Virginia and the simulation of those technologies for the Port of Virginia as well as an application of a machine learning model to port manifests for security. The purpose of this project will be to provide insight to the Port of Virginia on which technologies the POV should invest in and to facilitate the efficient stacking of containers to be compliant with Customs and Border Patrol. The team will produce simulation results and the machine learning model with the goal of maximizing port profitability and efficiency.

The second proposed project is the STS research paper which will be about the technological impacts on the economy of the US as emerging technologies are applied to ports. This research will identify which stakeholders will be most affected by new technologies and will give predictions to government on the best ways to respond to maritime trade automation. This research will help businesses and politicians to make educated investments and policy decisions regarding maritime commerce.

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