UNIVERSITY OF WISCONSIN, PLATTEVILLE

UNITED STATES OF AMERICA

The attached educational project, by Samuel Irvine, entitled “Global Climate Change Impacts, Opportunities, and Threats to Supply Chain Logistics”, when completed, is to be submitted to the Graduate Faculty of the University of Wisconsin- Platteville in partial fulfillment of the requirements for the (MASTER OF SCIENCE IN INTEGRATED SUPPLY CHAIN MANAGEMENT) degree.

Approved: Mary Bartling Date: 5/11/20

Project Advisor

Professor Mary R. Bartling

Suggested content descriptor keywords:

Arctic Supply Chain Network, Trans-Arctic Sea Route, Transpolar Distribution Networks, Developing Logistics Routes

A Paper

Submitted to the Graduate Faculty of

the

University of Wisconsin, Platteville By

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MASTER OF SCIENCE IN INTEGRATED SUPPLY CHAIN MANAGEMENT

Year of Graduation: Spring 2020

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Abstract

Purpose of the Study: The primary purpose of this research paper is to bring awareness to developing climate change impacts to global supply chains to include exploring new Trans-Arctic sea route opportunities as they become feasible to transit. Twenty-first century importers and exporters must understand how their external environment may affect internal operational success to include adapting to new trade routes and identifying their logistics system strengths, weaknesses, opportunities, and threats. This research paper compiles and summarizes all environmental changes impacting traditional global logistics operations and adding newly formed opportunities to improve supply chain network efficiency through new logistics prospects. Also, this paper raises important issues logistics planners must factor so they can adapt to new external operating environment, which altered by rising sea levels affecting ports, higher temperatures creating new sea passageways, and more frequent storms impacting historical trade routes. New opportunities emerging through continually developing Arctic landscape alterations outline multiple potential shipping routes due to climate change melting the polar ice caps, opening gaps in the frozen region. Logistics network impacts to these new routes include reducing transit time and costs to move goods through the region in comparison to traditional Trans-Atlantic or Trans-Pacific sea routes. The Arctic waterway routes also will reduce total transit distance, time, and more economically link Asian, European, and North American continents markets and ports. Maritime shipping route exploration offers importers and exporters the ability to reach continents in less time correlating to reduced logistics costs and time associated to move goods throughout the world. Many challenges remain to develop and explore these routes as well as resolve potential geopolitical struggles between competing nations to gain sea control and access over the regions the Arctic sea routes transit.

Introduction

Significance and Implications: This research highlights external changes to the environment which will directly impact global trade infrastructure, sources of supply, and ability to transport product to market. These new challenges pose opportunity for firms to adapt from traditional routes, storage locations, and develop superior strategies to prepare for a different operating environment. Compiling prior articles and research conducted enables logistics firms to quickly understand the forecasted problems based on current climate change models in the Arctic region. Knowledge of potential external impacts assists firms to better direct their resources and supply chain design. This research paper highlights the impending new shipping routes through the Trans-Arctic region created by the effects of rising global climate temperatures. There are many new opportunities and challenges with opening sea lanes including possibility for geopolitical conflict over sea control and regional access. These prospective new distribution routes enable shippers to more swiftly reach their destination at less overhead cost in comparison to the competition utilizing Trans-Atlantic or Trans-Pacific routes. Control and access over this lucrative regional transportation route could result in a global conflict started over supply chain networks to gain greater economic market share and expand distribution networks.

Methodology: The primary approach this project utilized consisted of reviewing previously published scholarly research articles and studies as well as relevant climate change data collection to solidify research and develop findings. Geographic mapping of climate data and future sea routes visually depicted the situation and demonstrated the future potential for navigate the polar routes. There are many published research articles detailing great economic potential of the polar regional climate change enabling ships to safely pass through the region,

while also outlining the existing issues with establishing new distribution networks in unchartered territory.

Assumptions: Empirical evidence demonstrates the polar glacial caps continue to deteriorate and the Arctic landscape is indefinitely changing. Assuming meteorologist researchers polar forecasts are accurate in predicting consistent declining ice masses, the expanding maritime area will create new navigational sea routes feasible to transit. This region is in a developmental and exploratory transition phase, so exact locations of sea routes or viability for commercial ships to transit year-round is unknown. Research and scientific data collection predict the polar region will change significantly in structure and composition, which in theory would enable potential for greater commercial activity. This research paper assumes Arctic global warming transformation projection models are correct and the region continues to change in a way to support navigable sea routes.

Research Limitations: This project applied currently available data, climate change forecast models, and previously conducted research on the global sea trade routes to highlight the upcoming issues, threats, and opportunities presented to logistics focused importers and exporters. A changing global environment is fluid to record, so new data gathered could impact timelines associated with implementing the sea routes by mid-twenty-first century.

Statement of the Problem

Climate change global effect to trade is an escalating phenomenon creating greater frequency of storms causing damage to infrastructure and facilities, increasing global temperatures are melting polar glacial region, which impact and pose potential opportunities to global supply chain networks. Throughout the Arctic region potential geopolitical issues initiated by resource scarcity, aspirational sea lane control, and distribution restructuring will

inspire disruptions to global free trade connecting networks. However, there are potential opportunities in a changing environment to condense ocean shipping routes through the Trans-Arctic region, create more formidable and resilient transportation and warehousing infrastructure, and improve the logistics network flexibility. The external environmental impacts threaten the traditional supply chain network distribution strategies and open new opportunities to redirect shipments as well as reallocate priorities to reduce risk.

Evolving environmental change will greatly impact global supply chain networks. Firms positioned to embrace changing climate, temperature, and oceanic conditions will be able to seize developing logistics opportunities, while others operating under a traditional strategy will face more adversity to compete against the early adopters. The climate change problem is relevant to all supply chain professionals planning future organizational operations and strategy.

Humpert and Rapotnik (2012) state seaborne trade currently accounts for ninety percent of world trade and primarily consists of transportation of raw materials, tanker trade, and other dry cargo including containerized loads. Increased shipping traffic between Europe, North America, and Asia correlates to more ships traversing the same Atlantic, Indian, and Pacific Ocean routes, which raises risk at choke points i.e. Suez Canal of ship collusions or geopolitical events halting global trade through sea control. A Trans-Arctic shipping route will not replace existing shipping routes between continents but rather supplement and provide additional capacity and flexibility for increasing global seaborne vessels transporting greater volume of cargo.

Air travel and freight flights routed over the Arctic region curtailed flight time and distance between Europe, North America, and Asia revealing the potential for a more cost-effective transit option reducing fuel, hourly crew costs, maintenance, and delivery time required

(Humpert & Rapotnik, 2012). The end of the Cold War enabled previously restricted air space and routes over the former Soviet Union territories to open to global commerce to Western commerce without geopolitical instability or fear. Polar air route exploration between continents allowed for air carriers to reach their destination quicker, newly instituted regulations assisted in safeguarding and monitoring air travel through the region, and overall, the route demonstrated numerous benefits of transporting goods through a new Arctic passageway.

According to Smith and Stephenson (2013) satellite images dating back to 1979 displayed a trend of reduced late-summer sea ice in the Arctic region. Since 2006, ice melted in the Arctic region at a seasonal exponential level and in upcoming decades forecasts predict the region to develop into pockets of ice-free sea passageways. Climate models are not definite forecasts and often have shown to conflict with the feasibility over whether the routes are traversable without excessive risk to life, vessels, or cargo transported. The authors describe three additional Northern sea routes that could open to enable container ships to move large volume of cargo between Europe, North America, and Asia. Continual environmental trend observations enable refined climate model projections, which is generating logistics industry and governmental interest in probable new geographically shorter sea shipping routes connecting the Atlantic and Pacific Oceans through a Northern Sea Route, Transpolar Sea Route, Arctic Bridge Route, and Northwest Passage. The Northern Sea Route connects Northwestern Europe (Germany, Norway, and United Kingdom) to Northern Asia (Japan, Korean Peninsula, and China) by travelling near and through Russian territorial control. The Transpolar Sea Route would connect between Iceland, Northern Russia, and Northern Asia flowing through the center of the polar region. The Northwest Passage flows between Greenland and Canada towards Alaska and Eastern Russia to connect North America and Asia. Finally, the Arctic Bridge Route

connects Canada to Iceland and flows regionally through to Northern Russia, Norway, and Finland.

Literature Review

Burnson (2016) describes in "Climate Change Adds to Supply Chain Complexity" the challenges a changing environment poses for supply chain networks and pressure to enhance sustainability. The author describes how enhanced building material technology aides to withstand increasing global temperature. Additional maintenance and investments are necessary to prevent frequent flooding from damaging import and export logistics infrastructure including bridges, ports, and storage facilities. The higher heat temperatures will make transportation vessels less fuel-efficient costing import and exporters more to ship goods, while also enhancing safety measures to avoid high storm prone routes. Stakeholders of firms engaging in global trade expect transparency in their operational performance metrics regarding sustainability, safety, and risk.

Christodoulou, Christidis, and Demirel (2019) bring awareness in "Sea-Level Rise in Ports: A Wider Focus on Impacts" to the risks climate change poses to supply chain networks exposed to greater environmental instability. The authors outline a few different climate change scenarios and effects they will have to existing infrastructure, transportation vessels, and facilities in the path of more frequent storms causing prolonged flooding and damage to the logistics system. Currently, many ports are susceptible to experience significant issues without more investment into protective measures, which poses a significant cost to industry and national infrastructure spending. Another possibility could be to redirect supply chain networks to ports better prepared to withstand storms or flooding caused by polar ice melting or outside of ocean

storm pathways i.e. Rotterdam, Netherlands modern port design in response to climate change threats.

Dasaklis and Pappis (2013) provide a general overview in “Supply Chain Management in View of Climate Change: An Overview of Possible Impacts and the Road Ahead” of the impending impacts to strategic and operational level supply chain planning. The authors found supply chain networks are susceptible to physical, operational, and reputable risks caused by climate change. Enhanced regulations, market forces, and stakeholder pressure are driving future decarbonization of global supply chain networks. Research literature advises supply chain managers to pay attention to climate change and its strategic and operational challenges it poses to their firm networks.

Hilburn (2008) outlines in “Trans-Arctic Shipping?” the difference in professional opinion on whether the utilization of the Trans-Arctic region as a new passageway between Europe and Asia. The author states many firms are interested in natural resources found within the Arctic region, but some are unconvinced that the route will be feasible to enable container ships to transit through. The main issues raised are the current Arctic navigational seasons are short, the temperatures can be severe, storms appear on short notice, and ice is always a present danger for ships. Another natural phenomenon effecting transit is the Northern Lights which can disable electronic systems ships rely on to safely navigate around ice. Ways to mitigate the harsh Arctic conditions include strengthening ships hulls, adding ice breaking capability to the stern of a ship to navigate through rough areas to mitigate risk, and azimuth technological devices used to detect hidden sub-surface icebergs. The author further describes the geopolitical risks in transiting the areas through Russian territory, fees associated, and potential for global conflict.

Halldórsson and Kovács (2010) outline in "The Sustainable Agenda and Energy Efficiency Logistics Solutions and Supply Chains in Times of Climate Change" means to solve supply chain problems connected to climate change. One solution the authors focus on is energy efficiency in the logistics network to reduce transportation costs. They argue energy efficiency has been a neglected topic in supply chain management studies, so they examine operational and conceptual level considerations to improve transportation systems. Forecasted energy costs are increasing due to climate change impacts, which initiates firms to retool their traditional supply chain designs to mitigate environmental impacts to global operations.

Humpert and Raspotnik (2012) elaborate in "The Future of Arctic Shipping Along the Transpolar Sea Route" how the Arctic ice is melting rapidly and could within the next decade transform from an ice land mass to a waterway wide enough for container ships to traverse. The author further examines the Transpolar Sea Route economic, legal, climate, and geopolitical implications to a developing waterway. This sea route is unique because it is the only Northern waterway route outside of current geopolitical control and is attracting a lot of attention from nations i.e. China. Other countries such as Iceland would benefit greatly from the route and could become a significant shipping distribution hub due to its proximity along the lane. This paper outlines the range of key challenges facing the future Transpolar Sea Route as well as geo-political sphere of influence shift to the Arctic.

Lasserre (2011) illustrates in "Arctic Shipping Routes: From the Panama Myth to Reality" the issue of control over the receding polar ice regions. Evidence of the melting is creating speculation among major nations in Asia, North America, and Europe over which nation will legally or militarily control the sea lane. The Arctic Shipping Route is considerably less distance when crossing between through the Americas between Europe and Asia. If transit

speeds remain constant across the Arctic Sea Route shipping companies could reduce shipping timelines correlating to lower overhead transportation costs. Importers and exporters share these savings enabling more efficient supply chain networks. The Arctic Sea Route is not with obstacles and is only an option during warmer seasons, while still posing a significant risk to navigate.

Ng, Wang, Yang, Li, and Jiang (2018) examine in "How is Business Adapting to Climate Change Impacts Appropriately? Insight from the Commercial Port Sector" the climate change impacts to business ethics and customer livelihood. This article focuses in on commercial ports affected by climate change and their role in global supply chains for importers and exporters. Port planning and operations must adapt to a changing environment to mitigate risk and develop potentially other options for future port development. The authors propose a new approach to enable port planners and stakeholders such as importers and exporters to conduct port adaptation planning and good practices. The Arctic Sea Route creates the need for new intermediary ports between Europe and Asia in countries such as Iceland or Greenland to provide relief from hazardous weather events and extreme prolonged flooding.

Østreng, Eger, Fløistad, Jørgensen-Dahl, Lothe, Mejlænder-Larsen, and Wergeland (2013) detail in their book Shipping in Arctic Waters: A comparison of the Northeast, Northwest and Trans Polar Passages the future feasibility for shippers to utilize Arctic region to bridge a shorter route between Europe, the Americas, and Asia. This book is organized into seven sections independent of one another including transportation passages through the Arctic Ocean, geopolitics in the Arctic, shipping economic trends and alternative transportation means, environmental challenges in the shipping industry, Arctic infrastructure and training required to navigate, ocean and coastal law, and a comparison of Northeast, Northwest, and Transpolar

passages. One strength this book offers are the detailed geographic maps and images which aid in displaying the issues with the Transpolar region and changes to the environment. Additionally, this book is an excellent comprehensive resource for Arctic shipping operations, describes the last frontier of unutilized sea control, and unexplored resources.

Rothwell (2012) writes in "International Straits and Trans-Arctic Navigation" about the history of international trade routes and key regional junctures in global trade. The author focuses in on the importance and Arctic route would provide to shippers providing another link between the Atlantic and Pacific Oceans. From the Arctic route there will be a few pivotal straits branching off from the region to include the Bering Strait, Nares Strait, Davis Strait, Fram Strait, and Denmark Strait. These routes will provide different key points of access to the polar region and could cause geo-political issues over sea control and access. Chokepoints along the Arctic region create navigational rights and freedom of movement problems between the Atlantic and Pacific Oceans, which are all governed by different nations and international law. Without internationally accepted regulations and freedom of movement throughout the region geopolitical control problems could hinder international trade through the Trans-Arctic region.

Smith and Stephenson (2013) detail in "New Trans-Arctic Shipping Routes Navigable by Midcentury" the recent observed reduction in Arctic sea ice levels and future projections for greater waterways created in the once frozen land mass. The changing region has fueled speculation about potential sea lane creation linking the Atlantic and Pacific Oceans enabling shippers to cut the sea travel distance between Europe and Asia. However, the authors point out the lack of projected geophysical data for change in sea ice prevents accurate assessments over feasibility of ship navigation through the region. The authors focus on the lack of evidence to draw assumptions and formulate their own assessment based on seven different climate change

models and ice level projections. They found by mid-twenty-first century the Arctic sea lanes will have melted enough ice to allow for ships to traverse the region and link both Atlantic and Pacific Oceans with a new sea route. There are three primary routes with a Northern route passing through Russian territorial area, a second Northern route going through the North Pole, and other routes moving through Northwest passageway.

Smith (2013) describes in "Climate Change: Corporate Sustainability in the Supply Chain" the direct impacts of company waste as well as emissions created by facilities and transportation vessels in complex global supply chains delivering value-added products to consumers. To reduce the environmental impact and costs associated firms must redesign their supply chain networks with upstream suppliers to become more sustainable. One method to reduce climate change impacts is to shorten the supply chain distance to cut costs related to transportation and labor. The Transpolar route could help firms shipping finished goods by sea to lessen their environmental impact and avoid severe weather-related storms and destruction.

Evolution of Trade Routes

Maritime trade routes historically facilitated international trade for centuries, spanning continents, kingdoms, and connecting people and things to one another. Early international trade route maps, referenced in the Chinese Selden Map, vividly show different cultures connected through early nautical sea paths (Batchelor, 2013). These routes take creative liberties to detail ancient kingdoms connection and influence on one another, providing historians an insight into European and Asian culture early interactions. Routes on the Selden Map pictorially show direct lines between major goods offered and traded at each kingdom. One key takeaway from this map and others of the period is the guiding principle of international maritime trade has always simply remained the same, for groups of people have desired to obtain scarce resources,

products, and technology goods from other environments or regions through bartered trade and exchange.

Modern maritime trade has seen many changes in routes and strategy to efficiently and effectively transport increased containerized cargo loads between ports. Throughout recorded trade history potential for piracy, terrorism, and geopolitical conflict threatened sea routes especially when passing through unstable choke point areas. Some international shippers prioritize flexibility and decided to mitigate risk of ship loss by rerouting cargo through indirect safer routes at greater overhead cost as well as transportation time. Diverted ships seek to avoid modern high-risk areas such as Suez Canal, Gulf of Aden, and Bab-al-Mandeb entirely. The shippers additional overhead costs associated with rerouting around conflict are surprisingly much lower than the higher risk probability cost correlated to ship hijacking, seizure, or lost due to regional conflict (Chang, Xu, & Song, 2015). An example of time and cost required to redirect ships due to external threats as described by Ansari, Modarress, and Thies (2012), “it takes about twenty days to reach Rotterdam and thirty one days to reach Louisiana Offshore Oil Port if Saudi tankers transit through the Strait of Hormuz to the Arabian Sea, Gulf of Aden, and Bab el Mandeb through the Suez Canal. Rerouting the voyage from the Strait of Hormuz to the Indian Ocean to avoid the Gulf of Aden will add approximately 4,750 nautical miles to the voyage, which converts into twelve to fourteen more days to reach Rotterdam from the Persian Gulf at 14.5 knots per hour. This alternate route will also add about 2,700 nautical miles, or seven to nine more days, to reach Louisiana Offshore Oil Port from Saudi Arabia”. Significant delays such as this example demonstrate weaknesses related to the current route flexibility options, for more incurred time and costs contribute to the less direct and dangerous route. Also, this equates to fewer number of trips shippers can complete in the same time period.

Additionally, emerging market countries bordering the contentious sea lanes dependent on maritime transportation are likely to see negative economic repercussions due to rerouted shipping avoiding their ports and regions (Martinez-Zarzoso, 2013).

Environmental changes in the Arctic regions have opened new possibilities for shipping routes between Asia, the Americas, and Europe (Smith, & Stephenson, 2013). By mid-twenty first century the navigable Arctic Sea Routes will increase, thus expanding potential for more direct access between these continents. In addition, ships will be able to transit through these waters during colder seasons, for ice traditionally blocking routes during winter months will not be present due to environmental changes. The Northern Sea Route increases the number of trips shippers can make in a year through the Arctic region, for the route navigates away from the Russian territorial coast and takes a more direct route breaching through once solid Arctic area. Human influenced environmental changes negatively attributed to industry and consumption, but will have some positive economic impacts, for expansion of global trade routes through the Arctic will reduce transportation costs and increase transportation productivity. However, one great concern in this region is the emerging conflicting multinational naval patrols and sea lane territory claim over this valuable trade route (Blunden, 2012). Countries such as the United States of America, Russia, and China will increasingly compete for access and control over the Northern Sea Route, seeking to increase their position of power and influence throughout the region.

At the end of the twentieth century the introduction of polar air travel and freight flights between North America and Asia reduced overall transit distance and overhead costs (Humpert & Rapotnik, 2012). Priority for commercialization enabled previously restricted routes to emerge throughout Europe and Asia. Polar route exploration between continents created the

future probability for an Arctic commercial passageway. This pair of authors describe three additional sea routes that could open to enable container ships to enable increased flexibility to move greater cargo volumes between European, North American, and Asian continents. Climate model projections continually fuel discussions about potential new geographically shorter sea shipping routes connecting the Northern hemisphere continents through a Northern Sea Route, Transpolar Sea Route, Arctic Bridge Route, or Northwest Passage.

Arctic Supply Chain Network Strengths, Weaknesses, Opportunities, and Threats

The first decade of the twenty-first century witnessed continually depleted summer sea-ice levels in the Arctic and data models show continual trend towards accelerated seasonal gaps in the polar region (Lasserre 2011). Previous climatologists forecasted the Arctic would possibly be ice-free by year 2100, but recent climate models have drastically reduced these projections by nearly seventy years to 2030. Recent shorter period climate regression models further demonstrate acceleration in ice melting during summer months at a greater rate than historically measured over the same measurement period in the last century. These models demonstrate quicker potential of receding ice during summer months throughout the Arctic which could hasten the pace of open sea exploration and charting commercial passageway routes.

Receding ice in the Arctic opens navigational channels between Europe, Asia, and North America, which previously through this region was unavailable to commercial shippers. Importers and exporters desire a shorter route traversing the Trans-Arctic region to save time and resources, while improving the supply chain network flexibility. The distance between Rotterdam, Netherlands and Yokohama, Japan, two major shipping ports in Europe and Asia respectively, is separated by 23,470 kilometers when transiting the Panama Canal, 21,170 kilometers through the Suez Canal and only 13,950 kilometers through a Trans-Arctic Northwest

Passageway (Lasserre, 2011). The drastic reduction in distance travelled would translate to less fuel costs, time in transit, and reduced labor overhead to complete the same trip between Europe and Asia.

Additionally, the Transpolar Passage location within international waters and outside jurisdiction of any one nation enables importers and exporters to operate freely without interference from Canada, Russian or any nearby nation's direct control, influence, or taxation (Østreng, Eger, Fløistad, Jørgensen-Dahl, Lothe, Mejlænder-Larsen, and Wergeland, 2013). The High Seas laws govern this region and specific route but should transform from broad guidelines into binding abided rules to ensure corporate governance, sustainability, and accountability over actions in the area without geopolitical influence or control over shipping companies transiting the waterway.

One contemporary difficulty transiting the emergent Arctic seaways is the limited summer timeframe to navigate without risk of striking glacial ice mass (Lasserre, 2011). Even though Arctic ice surface is melting at an exponential rate year-over-year, the colder winter season refreezes the ice masses throughout the routes. This disruption to year-round Arctic shipping lanes will impact importers and exporters relying on the shorter Arctic sea lanes to consistently provide route flexibility. Relatively recent environmental changes to the Arctic region have not yet enabled these routes to supplement transcontinental commercial routes passing through Atlantic or Pacific Oceans. The contemporary Arctic sea routes are still developing due to climate change, while only suitable as potential seasonal supplemental route during Northern Hemisphere summer months. The precise polar ice freezing dates is difficult to pinpoint year-to-year due to seasonality and climate variance, so importers and exporters at this

time cannot depend on an exact start and finish date to utilize the route, so they will need to formulate adaptable and flexible cargo shipment schedule planning.

Another weakness the Arctic sea routes pose is the safety requirement dictating slower container ship transit speeds through the passageways in comparison to ships operating in open waters. In comparison to historical transcontinental routes the Arctic sea lanes are geographically significantly shorter distance between continents, but ships will be unable to move at the same speed as the open Atlantic or Pacific Oceans during spring or fall months when ice will be present throughout the region. As recent as 2007 a commercial cruise ship MS Explorer sank in Antarctica after hitting a small ice growler submerged below the visible surface. The risk levels during the spring and fall seasons will be higher than the summer and to mitigate risk ships exercise caution by transiting at slower speeds to avoid catastrophic loss.

Rothwell (2012) reveals the hurdles still ahead for regional commercial success transiting through the once inhospitable polar region. Projections vary of when the area will have longer duration ice-free days and some experts believe this could occur by mid-twenty-first century extending the season from thirty to over one-hundred twenty days. Some routes i.e. Northern Sea Route are already receiving commercial investment to develop port infrastructure in preparation for shipping operations. However, the Arctic routes are not entirely international waterway protected areas in which shippers can move freely without neighboring nations disrupting access or implementing sea lane control. If importers and exporters could begin Trans-Arctic shipping operations today, they expose themselves to geopolitical risk interfering with their ships through foreign military-government interception, harassment, or charged escort taxation to move between international and nationally controlled territories.

The greatest opportunity presented by the Trans-Arctic sea routes are the potential logistics cost savings gained from reducing geographic distance resulting in a shorter transit time, reduced fuel consumption costs, lower labor costs, and enhanced customer delivery experience. Air travel greatly improved by flying over the shorter Arctic continent region, which enabled air logistics to become more efficient and effective operationally, while reducing expensive overhead costs. Supply chains operating throughout the Northern Hemisphere will economically benefit from polar route usage and can position themselves to become more competitive in delivering goods quicker and at a lower cost to the customer.

Østreng, Eger, Fløistad, Jørgensen-Dahl, Lothe, Mejlænder-Larsen, and Wergeland (2013) list the tangible and monetary benefits transiting a polar route in comparison to routes transiting traditional routes originating in Rotterdam, Netherlands passing through the Middle East or between the Americas to link to Yokohama, Japan. The authors increased polar route insurance to reflect greater risk and even increased fuel costs per day to reflect slower inefficient polar region transit speeds and variations, yet the savings were still at least $710,000 per trip in comparison to the longer traditional routes. Additionally, the total sailing time decreases from thirty-four down to twenty-two days, which enables shippers to increase yearly shipping capacity and number of trips per ship. Increased transportation efficiencies lower logistics costs incurred and enables the downstream customer to ultimately attain a lower delivery price.

Time saved using a shorter polar route also benefits upstream supplier and exporter, for they can more quickly turn over product shipment lots from inventory, delivered downstream, and revenues returned into working capital. Greater frequency of inventory turnover enables a firm to expand faster and fulfill greater number of orders. It is important for high manufacturing cost goods to turn over their products quickly, so greater liquidity enables a firm to decrease

excess inventory in distribution channels allowing for long-term capital investments or growth. An intangible value gained from quicker deliveries is the advantage of delivering product to market faster than competition utilizing historical transcontinental shipping routes. Importers and exporters directly benefit from moving goods quickly and efficiently to market while reducing logistics overhead costs to provide enhanced value for their customers.

An additional opportunity the Trans-Arctic sea routes create is greater sustainability and environmentally friendly logistics system reducing overhead fuel usage attributed to rising global greenhouse gas expenditures. A changing environment influenced through human industry ideally motivates firms to utilize fuel-efficient transportation routes to alleviate future damages to the climate, while also providing greater value to their customers. According to Østreng, Eger, Fløistad, Jørgensen-Dahl, Lothe, Mejlænder-Larsen, and Wergeland (2013) environmental impact from business activities is becoming a greater corporate stakeholder mandate, so to meet expectations set by customers and shareholders firms need to explore new trade route opportunities to reduce distribution overhead cost related carbon outputs.

Hilburn (2008) describe the dangers of the Trans-Arctic sea routes pose to shipping companies due to submerged ice, frequent storms, poor weather, and increased ship maintenance required to withstand frigid temperatures. Each threatens the system differently for submerged ice if not mitigated against with ice breaker ships, container ship modifications, or convoy operations could easily sink a ship in a highly desolate location. Currently, there is greater risk to life and property to transit the polar regions due to lack of required sea rescue forces prepositioned to respond in case of ship distress or any significant infrastructure to support ships requiring assistance. Also, the high storm frequency and bad weather will slow ships avoiding these hazardous risks, which would cause ripple effects in the supply chain resulting in shipment

delays. Increased ship maintenance will occur due to the extreme cold temperatures ships will experience transiting through and potentially increased frequency of crossings through the region. Additionally, increased maintenance costs threaten profit margins for the whole supply chain network and if significant could reduce feasibility to utilize these routes. Greater regularity of preventative and corrective maintenance will become progressively more costly to endure the freezing Arctic climate.

Smith and Stephenson (2012) illustrate the geopolitical threats facing Arctic sea routes due to Russia, Canada, America, and Northern European countries all bordering and occupying various portions of the sea routes. Countries could potentially annex international polar regions to exercise sea control forcing shippers to pay escort fees or tariffs to transit through their territory. Tariffs and sea control could lead to geopolitical conflict in the polar region due to no current legal standards over commerce and shipping regulations to transit through the entire polar region. Lack of internationally mandated polar law and order could lead to countries disputing sea control and disrupting global trade.

Østreng, Eger, Fløistad, Jørgensen-Dahl, Lothe, Mejlænder-Larsen, and Wergeland (2013) list the potential crew training issues as a threat to operating in this remote and unforgiving environment. Crews will require additional specialized training to survive and operate as a team when transiting through dangerous and relatively narrow sea routes. Also, consistently mapping the navigational routes will be a persistent issue and threat to ensure the tracking of latest environmental shifts to prevent ships from colliding with submerged ice shelves.

Discussion

The results of this study suggest commercial Arctic distribution utilization remains in an exploratory stage and widespread regional navigation is not yet a viable option. However, the research hypothesis proves some of the Arctic sea routes demonstrate navigational potential through Northern Hemisphere summer months when solid ice masses are at the lowest seasonal levels. Arctic land mass reduction studies demonstrate the economic sustainability of new sea routes which shorten transcontinental distance between ports traversing through the polar region as opposed to crossing Atlantic or Pacific Oceans. These new sea routes are environmentally developing and over the next decade near the point of commercial utilization. With commercialization nations will likely increase their military presence throughout the region to protect economic interests. Beyond the ecological challenges to traverse the Arctic region the greatest threat discovered through this research is heightened probability of geopolitical territory and sea lane annexation over these economically strategic routes and resources. The Arctic region will be a key sea navigational highway connecting continents and sea control over this area could develop from territory annexation disputes into global conflict. Nations motivated by domestic economic incentive are already intermittently positioning naval forces in the region strategically to secure territory and resources. Further research into international governing agencies interdiction to enable free trade and negotiate terms of Arctic sea way usage will provide enhanced understanding of whether this paper's hypothesis remains economically sustainable to pursue. Limitations of this research primarily reflect the present available planetary meteorological forecasts, scientific and commercial exploration of the region, and current and consistently developing geopolitical affairs. As up-to-date studies, forecasts, national and military strategy, commercial infrastructure development, and geopolitical

negotiations occur the future feasibility of utilizing Arctic waterways could dynamically accelerate or remain limited to further scientific research, commercial exploration, and military exercises. Although, temperature and glacial mass reduction forecasts have accurately predicted the current waterway expansion the region may experience changes in land mass formations which alter or hinder transcontinental navigation. Further, if climate models underestimate the rate of glacial melt the land mass region could significantly forever change enabling greater commercial transcontinental navigation. Consistent scientific, commercial, and geopolitical affairs observation over the polar region enables enhanced research opportunities to build up the previous decades exploring economic interests in the Arctic.

Conclusion

A Trans-Arctic sea route creates a unique opportunity for import and export logistics to significantly reduce the transit distance, shipping timeline, and costs associated to distribute cargo between Asia, Europe, and North America. Currently, the Arctic region is demonstrating rapid change to the volume of ice throughout the summer months enabling meteorological forecasts to demonstrate potential of Trans-Arctic shipping lanes linking the Northern Hemisphere continents within the next couple of decades. If forecasts prove to be reality it could disrupt historical logistics transcontinental sea networks to gain greater speed, efficiency, and logistics value. However, there are many maritime legal, container ship capability, port and maintenance infrastructure development, crew training, consistent accurate Arctic regional mapping, and outstanding geopolitical issues impacting future polar transit feasibility. As climate forecast models develop it enables supply chain planners to determine if the Trans-Arctic sea route is a new shorter bridge to a better seaborne logistics network or too great a risk to develop. Further research gathered through new developments of the Arctic sea lanes and

commercial development supports better industry understanding of the potential additional regional economic opportunities and new threats to diminish.

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