How the Coronavirus May Influence Our Lives Via our Maritime Supply Chains, International Trade, Economies and Livelihoods: The Risks, Impacts, Adaptation and Opportunities, 23 March 2020

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Introduction

With over 300,000 cases, exceeding148 nations and 12,000 deaths reported, the coronavirus offers the potential to be among the most disruptive pandemics since the cholera outbreak after World War 2 and second only to the 1919 Great Spanish Flu epidemic. This havoc-wreaking virus originated in Wuhan's illegal exotic wildlife and live seafood market in China, reputedly from the highly threatened pangolin species. It was first diagnosed around 7th January and subsequently been among the most tumultuous of evens to affect the developed world and more industrial nations directly far more than many emerging nations and small island developing states. This provides a reversal to events such as most climate change, natural and human related disasters or socioeconomic crises. Across the world has been marked by empty shelves; mass hoarding and speculation; stock market crashes, border closures, flight cancellations, travel bans… restrictions… Yet what do these actually mean? How will the coronavirus or COVID 19 truly influence our lives? This article provides certain aspects of the risks, potential impact costs, adaptation strategies and even prospective opportunities for maritime supply chains and international trade, our economies and our livelihoods as a basis to comprehend the implications; and ultimately prepare to minimise disruption… Although no vaccine has proven successful as yet, estimates range from 3 to 12-18 months as the expected direct impact. However, the death rate globally hovers only around 3-5%, disproportionately spread by travel and contact with the infected, either directly or indirectly. SARS had a 9.6% case fatality rate and MERS had a 34.4% rate.

Risks

Risks are amplified via air borne virus dispersal thorough individual behaviour touching uncertain surfaces, physical contact and poor sanitation/hygiene/heath. Just in time production and globalisation potentially accelerates risks. Stakeholder remain uncertain as to how other supply chain stakeholders are predicted to influence them or how they should react which entails greater inaction and opportunity costs. Symptoms include fever, acute respiratory conditions in breathing, coughing and pneumonia along with an infection to disease period around 7 days on average.

Impacts:

As choices become restricted and COVID 19 disseminates it will present significant direct, indirect and other unquantifiable impact costs. Smaller shipping, logistics, retail and other supply chain operators are more vulnerable given all the restrictions such as labour quarantines, uncertainty of demand, supply, credit and congested ports. Operating costs remain higher. Over $1.7 billion in lost revenue has been estimated for the larger firms. Qantas cancelled overseas flights by 90%. In Australia and New Zealand entry was restricted to citizens only. These may ultimately threaten food security and livelihoods along with the cultures, values and options of many. Increased additional security may be needed in countries such as the UK and Australia to guard grocery stores and rationing may even be needed to curb the mass onslaught of panic. Social distancing and a new form of etiquette are becoming normalized. Mass sports events and social gatherings are restricted. People cannot even attend the funerals of their beloved and cherished deceased.

Australia

Australian states have resorted to quarantines, mass travel and gathering bans. Businesses, especially airlines and smaller scale enterprises are receiving six month repayment holidays up to October 2020, worth AUD $100 billion. Passengers and cargo will face unprecedented restrictions or delays. For example, Rex airline in Burnie Tasmania cancelled flights by 50%. Even marine tourism on Sydney's Bondi beach has been prohibited. Travel is effectively banned with even those symptomless and travelling on essential business expected to restrict themselves. Churches, casinos, clubs, cinemas and sport have all faced bans, whilst cafes and restaurants can only mostly offer takeaway offers.

UK

The UK has banned schools and mass gatherings. The elderly may have to be confined up to 3 months, despite the need for frequent medical visits and exercise/company. Mass hoarding and speculations empty supermarket shelves with a surge in demand for online delivery retailers. Parliament has shrunken to 15 people. Public transport such as London's Tube Underground are heavily restricted. In parts of Europe fines up to 400-500 euros exist for anyone who does not have an absolutely essential reason for venturing outside. Mass tourist attractions are closed. Businesses are compelling people to work from home as much as possible, many jobs being suspended or asked to take reduced salaries. Supermarkets are reducing product variety and reconfiguring supply chains to adapt to areas of the greatest demand. Just in time production means that they are focusing on quantity for a few options over quality and a variety.

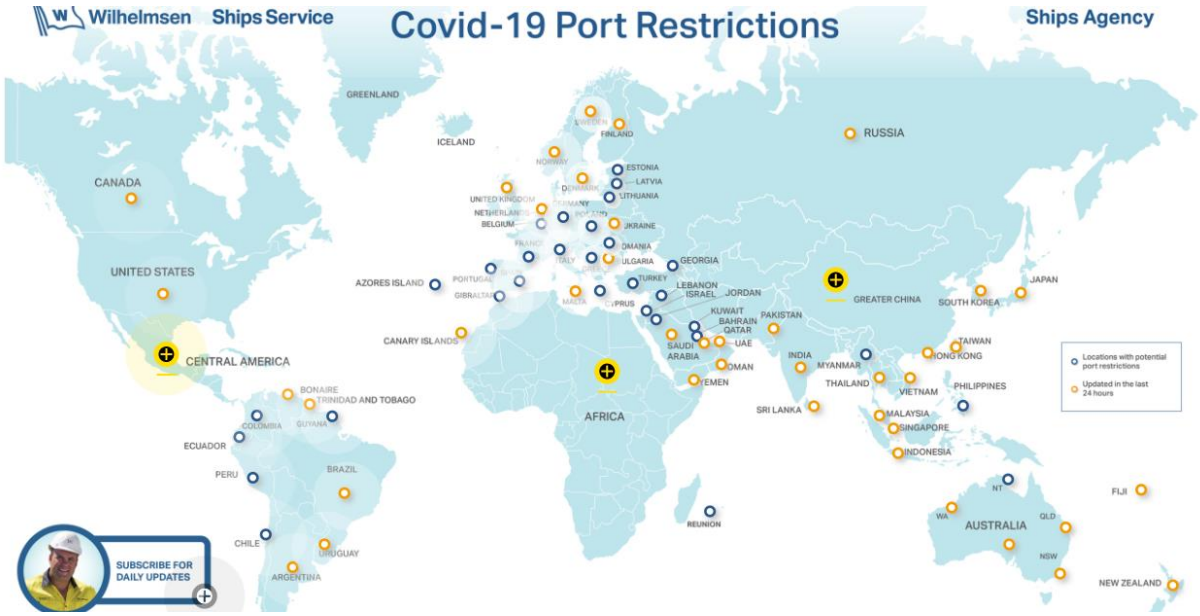
South Africa

South Africa has international travel to high risk nations such as Iran, Italy and South Korea, prohibited. Libraries are closed, the mass Easter and other church events cancelled along with swimming in the sea as

lifeguards reputedly fear to perform resuscitation/mouth to mouth. Taxi ranks are being mass sterilized. Many land border posts are being closed with resources consolidated. Restaurants cannot have more than 50 people including staff and are scrambling to adapt by offering takeaways and high sanitary practices. Sanitizers may be absent from government offices and shelves but along with trolley wipes are appearing in more supermarkets.

Sources such as Intermodal forecast over 400 billion euros of trade as potential impact costs from the coronavirus. A Dun and Bradstreet report estimated impacts for at least 938 for the top Fortune 1000 companies, via exposure directly and indirectly to China. At least 87 vessels on the Asia-US route and 66 on the Asia-Europe route were cancelled from Chinese vessels during the Lunar New Year period. Ports accelerated efforts after the Diamond Princess cruise ship sailing from Japan to Australia faced over 700 cases. Nations have added further health inspection centres such as Turkey with 33. Certain companies are suspending production placing additional pressures on shipping as Chinese demand or supply fewer raw materials and containerised commodities. However, certain routes are highly benefitting from enhanced freight rates presenting greater opportunities. For example, in March over 20% increases in freight rates between the UK and India have risen to $1,100 per TEU and $1,500 per FEU. Italy increased from $425 to $550 per TEU and $650 to %850 per FEU. India to New York increased 25% up to $2,000 and $2,400 respectively. Higher bankruptcy rates are likely to create even higher freight rates and costs for existing operators; although aided by record low fuel prices. Port restrictions are summarised in Figure I.

Figure I: Global Coronavirus Port Restrictions.



Source: Wilhelmsen Ships Services 2019.

Implications for ports and maritime supply chains are especially concerning. Los Angeles port cancelled over 50 vessels from China in high risk areas in February. China lost 17% in exports in January and February as the virus emerged initially. Chaos is already ensuring given over 100,000 global seafarers need to change every month which is no longer feasible given myriad restrictions. Other projected impact costs can be determined based on a similar distortion effect to climate change. Examples are summarised in Table I. Potential risks and connected, economic impact costs are enhanced by global corporations, which outsource

production, labour and resource inputs. Risk event changes will change agriculture and aquaculture economic yields, associated cargo throughput and production, As Table I summarises, increased risk exposure may influence supply chain, production processes through reduced labour and operation productivity. It increases damage, delay and congestion impacts to infrastructure, equipment and technology. These may create higher associated maintenance, repair and adaptation, impact costs. Production output capacity, performance, speed, composition, quality and quantity may also be affected through disruption risks to cargo throughput. For interlinked beneficiation supply chain stages, these create higher associated transport, storage, insurance and opportunity impact cost and lost profit consequences. Specific impacts are summarised for a commodity supply chain in Table 2.

Table I. Coronavirus Long Term Impacts for International Trade and Maritime Supply Chains

All Risks	Impacts on Port	Impacts on Shipping	Impacts for MSCs
	-Reduced port and surrounding economic hinterland/supply chain physical land area and access. -Physical damage and weakened resilience for port infrastructure, equipment and services.-This creates increased repair, maintenance and replacement costs		-Physical damage, delay, congestion, financial and opportunity costs to individuals, cargo, property, equipment and port functions to all supply chain stakeholders for all risk events **Changes in** -Inputs/Resources, -Labour -Processes -Production Outputs -Outsourcing -Distribution/Sales -Access to Financial Capital -Profits and Costs -Customs processes -Legislation
	-Increased duration may create flooding and increased surface runoff creating temporary/permanent physical damage, delay and other port disruption costs. -Increased damage to exposed physical commodities and port equipment This creates increased port and related supply chain performance delay and impact costs	-Increased precipitation may discourage strategic vessel callers. -Increased physical vessel fatigue, commodity damage and reduced navigation –increased vessel delay/slow steaming, insurance, costs	
	-Weaker structural infrastructure resilience and possible physical damage oxidation and corrosion increasing over time. -Potential health/safety risk to port labour, equipment, management and technology decreasing port performance	-Potential physical commodity damage and increase in energy consumption of reefer/containerised cargo throughput	
	-Risk to cargo handling labour, container stacking crane gantries, equipment	-Risk to physical vessel docking, pilotage, tugs turning basin movement	
	-This disturbs port ecosystems and physical risk exposure; maritime resources and habitats affecting related commodity yields.	-Alters water flow, complicates vessel navigation, higher tug mooring and pilotage costs. Increased hull cleaning, maintenance and repair costs.	

Table 2.2: Coronavirus and Other Pandemic Impact Costs on a Commodity Supply Chain

Producers	Retail/Wholesalers/Intermodal Transport	Consumers/Customers
Physical damage, delay, congestion, financial and opportunity costs to individuals, cargo, property, equipment and port functions to all supply chain stakeholders		
Inputs/Resources, Labour	Transport, storage and other costs	Demand/Supply
Processes	Insurance costs	Price
Production Outputs	Reputation risk	Life/Heath
Outsourcing	Opportunity costs	Availability
Distribution/Sales	Trade diversion/creation	Employment/Consumption
Access to Financial Capital	Access to Financial Capital	Access to Consumer Credit

Profits and Costs	Profits	Changing Consumer Preferences/Behaviour

Source: Author

General impact costs for customers/consumers include a possible decrease in economic demand and activity from a substantially lower population; lower employment, price increases and reductions in resource availability. The virus as with other epidemics is expected to affect resources supplied and change markets from trade creation/diversion. This provides economic benefits for flexible firms to adapt. It offers significant opportunity and other costs to those not so prepared. Not just producers, retailers and logistics distributors but consumer preferences and habits may also be influenced to become more sustainable, invest in the circular economy and greater sufficiency, automation, online services including delivery, less retail space and other changes including product range. This creates a further increasing supply and decreasing demand, impact risk for each dependent supply chain stage. If prolonged over the next 3-4 months for direct impacts and indirect impacts under an antivirus vaccine is developed and implemented over 12-18 months; it is likely to influence supplier decisions of sourcing material cost, type, quality and quantity including factors such as geographical location, port and transport restrictions; distance (if ocean or large land-based), size, environment and risk negotiating, buying/pricing, strategic demand and supply. Customer demand and producer supply expectations or requirements may continue to shift in adapting. This affects pricing, sales, distribution, order management, fulfilment and distribution along with the degree of customisation port users might require, as they may become potentially more or less flexible in response to this and future epidemics. The speed at which a stakeholder can satisfy demand, provide services, alter schedules and requirements involves being responsive, adjusting the price and quality/quantity of services. This response rate is considered to depend upon the extent to which they prioritise adaptation and resilience.

The economic impact consequences of disrupting any commodity include increased customs, cargo handling, storage and distribution, port authority and transport delay, time, opportunity and reputation costs. Financial impacts threaten profits and port revenue from possible port congestion. This creates risk and uncertainty for all dependent stakeholders adversely influenced by the loss, damage or suspension of trade. Additional indirect impact costs to port authorities and other stakeholders include climate change risks to agriculture, aquaculture, forestry, transport, infrastructure, cargo, equipment and the overall economy. Examples include lost wages, business delays and interruptions, increase in operation, risk management, training and capital expenditure associated with port recovery, adaptation, repair, maintenance and cleaning costs. This further reduces overall MSC performance and associated economic activity. This research identifies subsequent impact costs for which it is difficult to obtain precise, quantitative cost estimates. These include reduced quality of life, environmental damage, loss of cultural heritage, essential infrastructure and services including labour productivity (even experience and skills from loss of life or damage). It may extend to customer reputation, loyalty costs from key port users, reduced inter-port competitiveness and other opportunity costs. Higher psychological impacts also include a productivity loss for ports and supply chains due to a reduction in spirit/morale from an event aftermath. It also however includes the will and capacity to acclimatise, enhance resilience or respond. The actual impact costs, risks and extent of adaptation required is conditioned by previous and current disaster experience, information resources and preparation. Comparatively few have been affected by the Zika, Asian avian and swine flu and others; in living memory since the cholera epidemics of the 1950's or the Great Spanish Flu of 1919.

Overall supply chain, performance cost losses may expand significantly from idle capacity, poor maintained, damaged or destroyed facilities, equipment and cargo and from reduced physical access. This is identified through the following indicators of port productivity and activity. Indicator examples include vessel waiting time for berths, average cargo dwell/clearing time, average customs clearance and processing time along

with vessel, road and rail turnaround time. Average berth occupancy rates for existing vessels physically exposed to risk events' aftermath is expected to increase temporarily from supply chain congestion. It is expected to contract for the number of new vessels entering a port. Gross crane moves per hour, number of container moves per ship working hour, tonnage of cargo carried per running metre of quay and per unit of cargo employed/worker may decrease significantly from increased wind velocity and storm damage. Many operators being risk averse, historically based on factors such as limited profit margins and high sunk capital costs adapt through reduced output and minimising exposure to potential risks and costs.

Average cargo capacity utilisation may become lower for many commodities for which demand will be less, aside from certain opportunity sectors detailed later such as groceries and pharmaceuticals. This creates greater downtime for port labour reducing productivity, port and cargo dues and user willingness to pay for facilities. This can affect agriculture and other economy production variations in demand and supply through reducing cargo throughput and revenue. Further impacts include reputational loss and subsequent possible trade diversion/loss to other less vulnerable forms of transport e.g. shipping/air from road/rail, affecting port trade flows. Alternatively, trade may divert to ports providing greater flexibility, fiscal resources and commitment in prioritising adaptation solutions. Therefore, ports and dependent MSC stakeholders are expected to experience significantly higher total costs per year. This arises from physical commodity and facility, damage, time delay, reputation loss, congestion and other impact costs from decreased port activity creating further delay, reputation and opportunity costs to cargo throughput from this increased pressure and complexity in adapting. Significantly expensive, regulatory compliance costs of additional legislation will exist from travel, trade and port restrictions for nations, port authorities and local shipping companies with limited fiscal, labour, legal and governance institutional capacity already having to prioritise other adaptation measures. A failure of shipping stakeholders to adapt to climate change risks threatens profits further from reduced economies of scale, specialisation, efficiency and correspondingly lower freight rates from reduced cargo throughput. Increased research, information and communication cooperation and sharing of more epidemic-sensitive port and cargo handling equipment, technology and transport adaptation solutions are suggested for industry

The most significant impact costs to ports and shipping are considered here as those to life and property (Table 3). These establish a potential economic loss from disruptions to production, consumption, management and labour force (particularly for primary commodities), reducing supply capacity for cargo throughput. This reduces port revenue and physical capacity to undertake port functions with significant, adverse implications via contractions in supply chain trade/economic activity. The extent of damage combined with the probability of risk exposure, may reduce business confidence in utilising a port. The more immediate the event, the higher the associated impact cost/p commodity damage; the greater the reputation, opportunity cost. Inadequate COVID 19 responses can decrease a port's reputation. Another sudden impact cost involves a physical threat to providing port bunkerage, water supply and other services causing minor delays to activities. Other port impact costs include increased customs, cargo handling, storage and distribution, port authority and transport delay, time, opportunity and reputational costs. Further costs add lost commercial profits and port revenue from possible congestion, risk and uncertainty which affect shipping and overall MSCs.

Table 3: Short Term Impacts/Extreme Coronavirus Risk Events for MSCs

	Impact Costs on Port	**Impact Costs on Shipping**	**Impact Costs for MSCs**
All Risks	Increased threat to communications, information and early warning systems.	Physical vessel/port/ commodity damage.	Increased frequency, duration and intensity of long-term impact costs as

		Physical danger to vessel navigation.	short term, sudden cost changes summarised in Tables 2.2 and 2.3 Risk Changes In Species Migration/ Biodiversity Changing Rate of Innovation and Technology Global economic activity Changes in Seaborne trade Changes in access to maritime finance Changes in global and regional social-political/commercial/ environmental instability. Increase in insurance premium costs Changes in economic demand, supply and associated changes in economic activity, employment, production, consumption, exports and imports, inflation and exchange rates affecting possible purchasing power and trade competitiveness.
	Physical damage to port infrastructure from fewer workers and revenue, vessels, equipment, cargo and related utilities, creating increased construction, repair, maintenance and replacement costs. Possible physical commodity damage decreasing a port's reputation, loss risk/creating increased insurance costs from reduced business confidence. Psychological costs, threat to life and property, creating a loss of economic potential, commercial profits, tax and port revenue. Higher Port Costs.	Higher insurance premium, repair, maintenance, labour, voyage, charter and other costs, Reduced port access, increased congestion, Physical navigation risk Threats to vessel navigation, safety, delays and congestion.	
	Physical threat to agricultural and fishery productivity reducing potential cargo throughput. Lower water depths may limit channel/port navigation and related vessels Physical threat to providing port bunkerage, fuel and other services.	Changes in demand, supply, port profitability and pricing Changes in routes, markets, trade diversion and reduction,	
	Physical threat to port productivity – health and safety of affected workers/ operators creating idle capacity and other delay costs Direct threat to physical fatigue of infrastructure, equipment and operations delaying port activity Damage to information/ communication systems	Production variations in demand and supply reducing cargo throughput and revenue Physical legal/technical regulatory compliance costs, increased insurance liability costs Production variations in demand and supply, reducing cargo throughput and revenue	
	Operational/financial and reputational cost loss	Operational/financial and reputational cost loss	Changes in port pricing, taxes, subsidies to recover costs and finance adaptation.

Source: Author

A health and safety impact cost could occur. Health and safety disruption costs to workers and equipment threaten overall supply chain performance from increased temperatures and increased downtime, in creating idle capacity and other delay costs. Increased congestion and public health costs potentially delay cargo further. Safety risks include an indirect threat to physical fatigue of supply chain infrastructure, equipment and operations, delaying berthing, mooring, cargo handling and other activities. Currently, asymmetrical information and lack of coordination amidst global supply chain stakeholders is present, challenging formulating effective awareness and early warning, disaster risk management responses. As summarised in Table 3, this research identifies further vulnerabilities to specific, Pacific port operations but also to the wider maritime economic hinterland from increasing congestion, reducing capacity and performance and from fewer vessels navigating the port safely. Many emerging and even developed nations whether in the Caribbean, the South Pacific, the UK, Middle East or Japan are not self-sufficient and depend upon the cargo

and mobility of people to operate successfully. This significantly increases opportunity costs of disruption, for those failing to prepare. Shipping firms will therefore experience increases in maintenance, repair and related insurance premium costs decreasing profitability on a route such as the Pacific. A further impact study limitation is noted for MSCs, they ignore impacts on vessel availability due to restricted port access and cargo supply availability.

A pandemic such as the coronavirus influences decisions to visit a port of containerised, dry and wet bulk cargo, fishing, and other strategic vessel callers including tramp steamers, repair, military and cruise vessels. Fewer companies will wish to trade with China, Iran, Italy, South Korea, the USA, Spain, United Kingdom and Portugal. Fewer cruise vessels and airlines will survive and be able to easily trade. Potential impacts are present; not just for creating supply uncertainty but also threatening economic demand, production and consumption for supply chains. Vessels may have to adjust trade routes, markets, commodities and shipping schedules to adapt. Other short-term impacts for shipping in Table 3 consider the cargo type, value, quality and volume may also change from these risks, requiring replacement costs to avert or mitigate potential customer reputational costs from delays. This presents an opportunity cost to future business. This article anticipates increased daily fixed capital and operating costs per TEU, time in port per ship and total shipping cost, increasing reputational loss and financial risks, discouraging customers further. This review advocates cargo load sizes and subsequent vessel, cargo capacity utilisation may decrease. Shipping companies reduce profits further from increased stores, fuel consumption and bunkerage costs; crew wages required (including possible health and safety risk premiums from perceived and actual greater risk exposure), voyage and time charter costs. Costs include related administration, information and communication incurred in response to or adapting to disruption event consequences. This threatens a commercially profitable future for shipping. Continuous disruption risks also threaten locational and technical, economies of scale where shipping provides conventionally the lowest cost per unit of containerised cargo between road, rail, air and sea, which existing solutions fail to address.

Average vessel sizes are expanding to exploit economies of scale for global trade. Coronavirus impacts on local and regional shipping may require contingency re-routing or adapting to smaller vessels to reduce direct costs, although benefitting from lower fuel costs and reduced emissions. Other factors may also encourage adapting to smaller vessels with lower cargo carrying capacity given enhanced damage risks and reduced survival prospects of commercial markets, port infrastructure, populations and land areas for many Small Island Developing States and other emerging nations. Risk events present increased uncertainty for tramp steamers and time/voyage charters. These base profits on avoiding ballast voyages with no/minimal cargo, adjusting to seasonal fluctuations in bulk commodities and irregular demand. However, some marginal callers may benefit from temporary trade diversion opportunities from idle liner vessels. It may also increase reputational, trade and transport costs to Pacific liner companies. These companies may have to increase corresponding freight rates but also depend upon greater price stability, a fixed, regular sailing schedule and diverse cargoes, often of high value. These requirements are increasingly threatened by greater congestion and associated delays to required functions; predicted as direct consequences.

This review's significance identifies that coronavirus disruption risks and associated impacts also influence not just ports and shipping firms, but other supply chain stages of producers, transport and distribution. These include road, rail and air intermodal connections, retail and consumers. It influences stages via lost operational, opportunity and business delay impact costs summarised in Table 3. Each disruption/delay increases associated transport, storage, insurance, labour, port and customs duty, administrative, marketing, information, cargo management, security, insurance and communication impact costs to overall stakeholders. For example, for a fuel supply chain from local supply and import, refinery production, to wholesale bulk fuel terminal storage, transport and distribution, to retail company owned, franchise and

independent sites. Upstream influences include domestic and international exploring, production, refining, imports than sale and distribution to retailers. An epidemic can therefore cause significant impact costs for stakeholders not just to a supply chain but across the local economic hinterland. Long term changes might include economic demand, supply and associated changes in economic activity, employment, production, consumption, exports and imports, inflation and exchange rates. This affects possible purchasing power and trade competitiveness. It influences access to maritime finance, insurance premium costs, in global and regional social-political, commercial, environmental instability, along with the changing rate of innovation and technology.

Fewer callers and reduced cargo throughput will create reduced tax revenue for government stakeholders. It reduces potential public budget expenditures and creates indirect opportunity costs to other supply chain stages and levels of economic activity. Potential shipping disruption may cause further threats to shipping operations, markets, cargo, sourcing of labour and related productivity. Risks include changes in global and regional, Pacific, social-political, commercial or environmental instability. Communities and stakeholders may become so desperate for survival; they provide a physical health and safety risk to ports, intermodal transport, vessels and crews, in seeking to escape from direct climate change risk impacts. Additional increases in adaptation strategy costs, including those proposed below are further anticipated to reduce commercial viability and sustainability for shipping operations and stakeholders directly.

Examples include increased staff overtime from not changing crew, disaster response and risk assessment training expenses and improved vessel resilience. It involves updated research, communication and information measures, adapting market and shipping operations to minimise costs from Pacific climate change. This article suggests operators may have to focus on developing an adaptive cycle for sudden shocks, involving adapting shipping schedules with fewer and smaller vessels, exploiting economies of scale. This could be applied to the Pacific. It points out how shipping companies may have to diversify into new routes or markets, new consumer demand and supplies, diversifying into multimodal transport opportunities, to exploit trade diversion from those failing to adapt and to enhance financial and shipping market resilience. Labour productivity may further decrease from being infected or fear perceptions of being so. It presents higher public health and safety impact costs. These may reduce available labour, creating idle capacity from increased employee absenteeism, diminished port performance and other delay costs. Potential adaptation solutions include hygiene, incentive pays, social distancing, improved training and adopting flexible working hours such as nocturnal shifts and weekend overtime, midday breaks, protective clothing, equipment and shelter to prevent fatigue. Drones, robotics, videoconferencing and logistics automation for supply chains to reduce risk consequences. However, equipment is and less flexible in adapting. This also imposes additional cost constraints and increases local unemployment and related economic activity.

Seaborne trade given the larger time period involved to reduce COVID 19 risks via trade through MSCs offers many economies of scale, weight, volume, time, flexibility, and other advantages compared to alternative road/rail/air transportation. Alternatives are impossible for sovereign nations surrounded by ocean. An existing gap in current insurance and risk management literature comprises increased insurance premium costs, from perceived or actual, risk exposure, liability and vulnerability. This affects carriage of goods by sea, based on risk aversion and asymmetrical information. It touches shipping companies through increased reputational damage costs, unless insurance adapts. This area has yet to receive an official policy or guidelines from global maritime law associations and Admiralty Courts as a potential research area. An additional short-term impact may affect or be influenced by changing technology and innovation. This complicates the decision of which solutions, how, when and where to adapt, that shipping and other MSC stakeholders facing significant constraints should endorse to prioritise climate change mitigation or adaptation. These risks and short-term impacts may be only partially reduced by increased information,

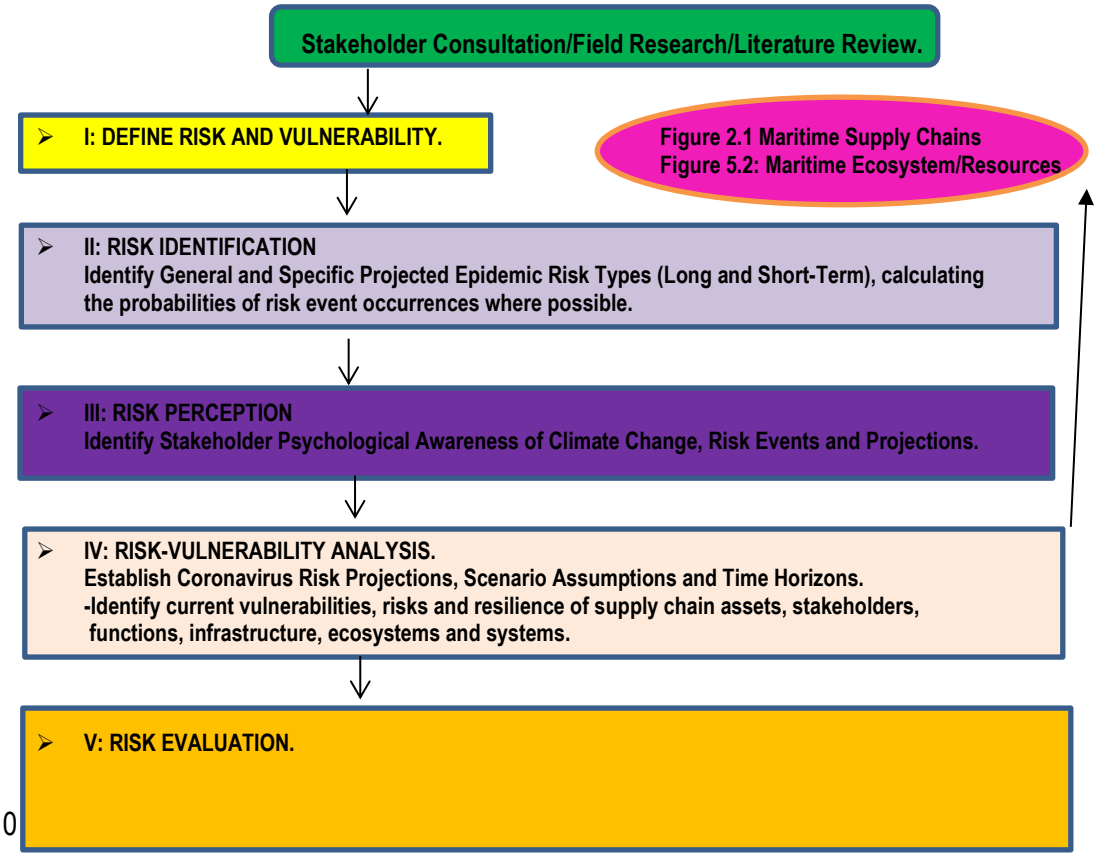
communications, risk management training and investing; supporting research and technology development plus other proposed solutions summarised in this article.

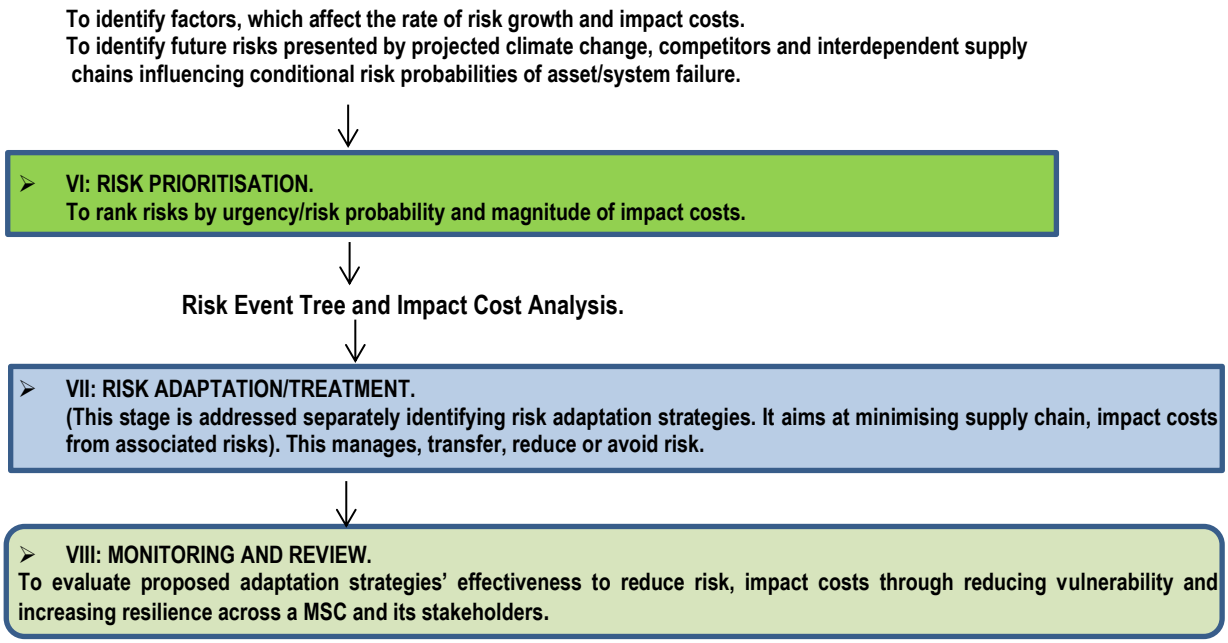
Finally; this review advocates the most significant MSC stage affected by risk events and associated impacts includes access to financing and capital investment sectors for climate change adaptation. New production, consumption and investments will be constrained by increasing reluctance by the risk-averse global financial sector to invest in affected countries with port restrictions based on increased uncertainty, asymmetrical information over potential disruption risks, and sacrificed or delayed profits. This will deny commercial and investment opportunities not only for producers, but shipping companies and other transport distributors, retailers and access to consumer credit for customers. Climate change also threatens insurance companies and financial sector solvency e.g. banking (who may underwrite voyages, cargo, products or other loans to consumers). This influences the capacity for other supply chain stages to transact and perform. This further confounds resilience adaptation strategies. These have previously not been implemented across an entire supply chain, to extend beyond just individual ports and shipping to face a global implemented scale for a public health epidemic such as COVID 19.

A Method to Diagnose Risks

In response this article proposes modifying existing risk assessment methods to specifically consider how maritime supply chain stakeholders, people, organisations, businesses and communities can more effectively identify the extent to which risks will affect them. To enable MSC stakeholders to prioritise a proactive risk-vulnerability, anticipation integrated method rather than reactive event approach; this article reduces potential asymmetrical information and uncertainty. Figure 2 adapts a climate change risk event methodology for a coronavirus or other sudden related risk pandemic. Figure 3 provides potential criteria to assess potential adaptation solutions.

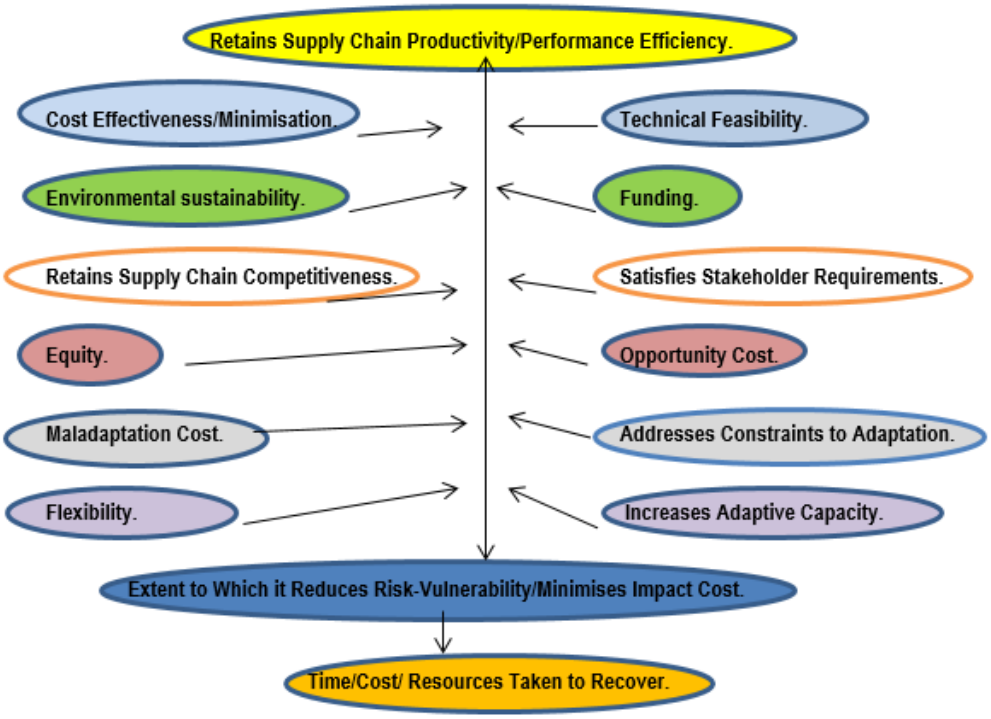
Figure 2: Proposed Vulnerability-Risk, Analysis Stages For A MSC.





Source: Author.

Figure 3: Adaptation Solution/Strategy Evaluation Criteria.



Source: Author.

A comprehensive method would further consider a combined method conceptual framework through a joint risk and impact event tree. It summarises key MSC stages, sudden and long-term risks, factors affecting the probability of a risk occurrence, factors which influence supply chain vulnerability/resilience. These factors connect to risks, direct and indirect impact costs across the supply chain. These are not specifically investigated from limited data but present a hypothetical, future research area. Coronavirus and other epidemic risk event occurrence and vulnerability are conditional upon drivers in Figure 3.2 e.g. population/economic growth, infection rates; extent of quarantine, medical facilities, testing kits, economic self-sufficiency; time horizons, technological progress, production and consumption. However, this tree and conceptual framework's advantage includes flexibility to consider additional dimensions as information becomes increasingly available. This reduces uncertainty over projected impacts. This thesis also outlines factors which influence the extent of risk for a MSC commodity, supply chain, asset vulnerability and economic, impact cost sizes via Figure 2. These are ignored by formal safety assessment and other risk methods. Factors include projected design, material (labour, capital, technology, equipment and infrastructure), life expectancy, location, financial reserves, and distance to event risks/pollution. Others for indirect asset impacts include asset condition, past risk exposure, degree of climateproofing and the extent to which effective repairs and maintenance are conducted.

Existing Risk Management Theory, Conceptual Framework Challenges

Existing risk management theory (section 3.2), provides significant flaws for coronavirus implications affecting MSCs. Risk management methods and theory assume risk probabilities are essentially static and one dimensional over a specific timeframe/scenario, without considering inter-dependencies or linking to other factors, which influence the probability of that risk occurring. It ignores accumulated risk, survival and resilience. It marginalises how risk can be measured in relation to performance, recovery time, cost and other indicators. To calculate future probabilities, the following risk factors can be incorporated into conventional risk management: the type and nature of risk, records, infection rate, event timing, duration, intensity and frequency. Other factors combine degree of natural resilience, reserves, automation, labour access, training, experience, technical standards or service life and asset resilience or shock absorption capacity (Factors include the extent and condition of natural resources needed for a commodity in all production and processing stages. Current research challenges include locating and establishing the information necessary to calculate risk probabilities for events and conditional probabilities for asset failures, given specific risks/events. considers risk event probabilities can be amplified through globalisations' just-in-time production, contract obligations, accumulated risk, stakeholder complacency, moral hazard and system interdependency. Factors which contribute to vulnerability, increase the probability of a risk event and conditional probability of a maritime asset failure. Redundant capacity in assets, systems and resources can minimise risk exposure. Factors enhancing resilience and adaptive capacity can minimise the conditional probability of failure and should be subtracted. This method approach provides guidelines for stakeholders to replicate and utilise.

This method aims to overcome existing literature gaps across an entire MSC by proposing an asset, system, resource, ecosystem and stakeholder inventory. This prioritises the most significant supply chain risks in risk exposure and adaptation cost. It considers risk exposure to assess each asset's importance to maintaining supply chain performance, stakeholder requirements, operations and institutional capacity. Risks may also affect existing and future port assets' and systems' ability and capacity to be upgraded. Existing methods also have not considered how ports and other stakeholders' interdependencies of complicate identifying specific risks and impact costs for a single commodity or impact. Public health crises such as COVID 19 events present impact costs to assets, ecosystems, operations, production, asset procurement, demand, supply, price, customer order fulfilment and reputation. This method highlights direct and indirect costs. Conventional risk management fails to prepare stakeholders to survive simultaneous, disruption risks. These

methods ignore how to facilitate trade, supply chain performance; security and eco/commercial sustainability continuously along with public health risks.

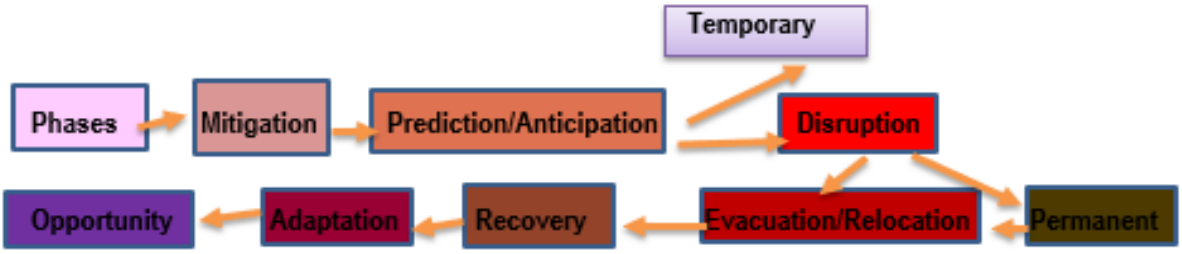
This method and Figure 2 propose a risk-vulnerability evaluation process during a MSC disruption for stakeholders, standardised across scenarios, growth rate and time horizons. This is capable of identifying risks autonomously of stakeholder, supply chain and company type, size, location, resources and number. It evaluates systematic and individual implications of a projected increase in the frequency, duration and intensity of events on supply chain risk. It aims at effective adaptation. It targets achieving stakeholder requirements. It considers vulnerability, resilience and adaptive capacity. This method aims to aid stakeholders to adjust to uncertainty conditions among projected risks. This creates a dynamic method framework and criteria; allowing information, risks, time, demographics, infection rates, adaptive capacity, resilience, vulnerability and ecosystems to change. With empirical, impact cost estimates, this method emphasises the significant, direct and personal cost, consequences of ignoring climate change. Unlike others, it enables environmental sustainability; improved technical efficiency, training and maximised opportunities across MSCs. This aims for a world that retains functioning, cost-competitive supply chains and the physical survival of maritime economies with highly vulnerable, coastal communities.

To identify risks for stakeholders across Pacific MSC stages (KRQA), the proposed risk-vulnerability analysis method includes 7 stages in Figure 2. This article emphasises creating a new risk perception stage (III). This ascertains stakeholder awareness of risks, when compared to actual data; to evaluate their psychological capacity to accurately determine, value and understand risks sufficiently. Given risk perception bias, this stage is proposed to consider the extent to which stakeholder awareness is measured accurately. This minimises risk omission, under and overestimation. It advises stakeholder identification of past risk frequency, duration and intensity/impact costs. This can be combined with asset failure against existing risk events, to provide objective, risk identification criteria. Once risks are identified and combined with projected impact costs and calculated through the proposed impact cost analysis, stakeholders may more effectively establish stage VI (risk adaptation and treatment). An effective risk assessment framework would integrate various adaptation strategies proposed and those already implemented by various stakeholders. Stage VII advocates prioritising risks with potentially more urgent or significant impact costs. This sequence also recommends a final monitoring and evaluation stage VIII. Virtually no post-impact adaptation, feasibility studies exist for public health related epidemics for maritime supply chains such as COVID 19 to assess the extent of successful intervention or risk management including supply chain stages. This stage needs repeating to prepare stakeholders to continuously identify emergent risks, over future time horizons, as risks fluctuate in duration, intensity, frequency and impact costs. It is also necessary to assess each adaptation strategy's value through the extent to which it resolves key risks and associated impact costs, whilst preserving stakeholder requirements. This is ignored by the overwhelming majority of existing risk models.

Empirical data enables stakeholders to test hypotheses and monitor the effectiveness of existing strategies, aiding risk-based decision analysis and effective resource/risk management. It considers what magnitude of impact cost is sufficient for stakeholders to react or encourage adaptation. Its advantage specifically concentrates on why certain stakeholders succeed or fail, and how much adaptation is truly necessary to reduce projected impacts, ensuring recovery, resilience and opportunity. Figure 4 proposes that future impact cost analysis could distinguish between impacts at different phases. Considering standardised data collection approaches to manage current and future risk impacts aims to optimise adaptation strategies, to minimise disruption and preserve stakeholder requirements. A lack of historic impact cost data is overcome by directly assessing stakeholders/secondary data/other techniques to ensure sufficient information is provided. This aims to rectify promptly disruption or impact costs to minimise loss and damage, including shadow/nonmarket cost approximations where market values cannot be obtained. Limiting time horizons provided to 1, 5 and 10

years overcomes the problem of year-by-year data when data format can be event specific and limited.

Figure 4: Risk Event Disruption, Impact Cost Phases for a Maritime Supply Chain (MSC)



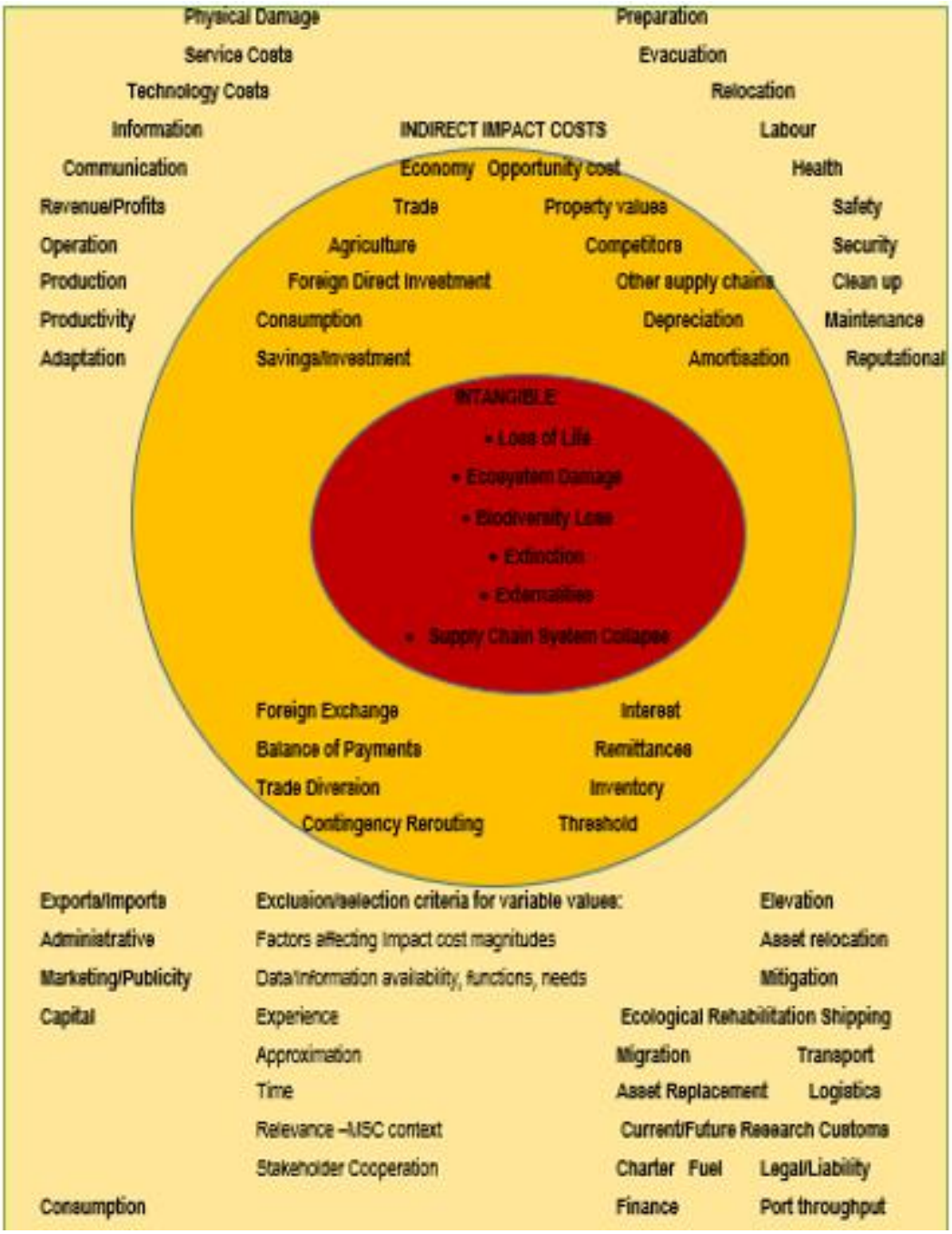
Source: Author.

Figure 5 presents cost types associated with a potential epidemic impact on MSCs such as the coronavirus. It provides objective criteria to ascertain historic, present and future impact costs in order to estimate competitors, supply chain partners and personal costs. This influences intervention timing, location and which impact/threshold costs are highest, most critical or pertinent. Impact cost magnitudes emphasise why it is necessary to react. Costs are only estimated to increase over time by numerous sources. It can aid in reducing issues of moral hazard, asymmetrical information, ignorance, herding, risk aversion and information cascading, which superfluously magnify impact costs. Given states frequently ignore and underestimate private sector impacts, stakeholders learn to anticipate disruption/certain impact costs, reducing uncertainty. This minimises inaction, opportunity and maladaptation costs. A bottom-up approach assists in pinpointing how many costs are risk event specific; (whether from this pandemic specifically or other disruptions including bankruptcy), affecting estimates. This assists in managing multiple objectives simultaneously and assessing whether existing operations, investment and resources/reserves are sufficient to minimise disruption, given limited information. Adopting this approach for further events can provide a continuously evolving forecast model. As future impact cost data becomes recorded, available and prioritised, cost estimations improve for media, state and aid agencies. By identifying true risk exposure; it avoids litigation risk, evaluating essential versus nonessential capacity to increase awareness of supply chain consequences.

This article's approach considers lifecycle cost, ecological resource security, sustainability, future existence/utilisation and stakeholder personal responsibility beyond just the direct public health and socioeconomic impact consequences. It aims to overcome problems of relying on skewed media/aid agencies for unverified information estimates. Costs are often not indexed or consistent, making baseline comparisons even more challenging. A standardised approach minimises result issues of assessing impact costs from specific risk events, using multiple sources with divergent criteria. It is flexible in considering psychological reactions. This includes how average individual projected impact costs can be adjusted daily. It enables the resolution of which impact costs are generic and which are stakeholder/event/location specific. Publicly available impact cost estimates are limited, reducing the capacity for post impact-cost assessments as a key current method proposed stage. This method advocates using inflation adjusted market/current values for recent events including single versus joint/successive accumulating risk events. This allows 1, 5 and 10 year business cycles to ascertain accumulating impact cost for multiple events. The approach considers the time gap problem for information, before the actual risk event manifestation. It accommodates issues of double counting impact costs for stakeholders, given asset/system interdependency and selective recall of past impact cost, event exposure, seldom recorded accurately. The approach provides advantages of considering which supply chain, stakeholder or product characteristics magnify disruption. Which uncertain disruption costs cannot be forecast or estimated given method, data and resource limit constraints/research

restrictions? A challenge exists in considering which knowledge is necessary, sufficient and feasible to estimate economic impacts. Variables can only be recorded for which information exists.

Figure 5: Direct, Indirect and Intangible Coronavirus Costs for a Maritime Supply Chain



Source: Author

The evaluation of impact costs improves risk awareness to survive, minimise failure and avoid maladaptation/opportunity costs. Stakeholders are thoroughly motivated by events to transform and secure a business-as-usual future. Results consider the benefits of coordinated data collection, with standardised

impact cost variables, rather than haphazard, sporadic variables more complicated to analyse over time. Results/equations can be flexibly altered to consider shadow cost appraisals valuing performance, quality, ecosystem/resource/environment, public service and economy functions and productivity as accurate indicators of effectiveness of climateproofing adaptation and mitigation. This bottom-up approach defines spatial-temporal-geographic parameters and input variables. This reduces challenges of ascertaining impact costs for mobile assets and monetarising values, where possible. These results consider service costs multiplied by projected event average duration/possible asset value, depending on risk. However, the results are limited via the extent to which impact cost data can be estimated and variables included, especially for intangible costs including loss of life, life quality and extent of damage. It can be uncertain if costs are from general inefficiency or other disruption risks/forms of loss. There is limited sense to weighting certain impact costs as more significant over others; given data bias, subjective stakeholder perceptions (human, event or system specific) and challenges to independently replicate aggregate, impact cost estimation methods.

Impact costs need to be measured and analysed to reduce vulnerability, increase resilience and minimise disruption/externality costs. They help stakeholders to identify and exploit opportunities and avoid worse fates. It aids to ascertain the liability or responsibility for risk event impact costs. Measuring costs also determines where costs develop and multiply, to avoid greater risk exposure. Future research could analyse consequences for development, economic growth, externality costs, supply chain performance, productivity, stakeholder requirements, survival, reputation, ecosystem, key objectives and critical cost thresholds. Survey and interview participants consistently referred to cost, time, vulnerability, resilience; Asset Design/Service life, Stakeholder Expectations, Will/Inaction and Asset/System Interdependence as key disruption factors affecting impact costs. Cost magnitudes were further influenced by geographical location, contact, infection rate risk type, size, duration and intensity. Content analysis clarified the following factors influenced how persistent costs were for epidemics such as COVID 19 and whether stakeholders can recover.

Factors to Ascertain Extent of Impact Costs

- Complacency/inaction/ risk ignorance.
- Conditional probability of an asset failure.
- Existing priority on government not aiding private sector awareness, resilience, recovery, survival.
- Failures to resolve other challenges/environmental pressures.
- Insurance type.
- Just-in-time production, global source procurement.
- Lack of foreign supply chain stakeholder interest/willingness/action.
- Location – vulnerability, resilience.
- Accessibility and distance.
- Presuming business as usual, lack of reserves, ignoring research, delayed decision costs.
- Relationship including mistrust or a lack of coordination.
- Reliance, initiative.

Factors Affecting Stakeholder Successful Survival/Recovery Content Analysis

- Adaptation.
- Adapting to opportunity not business as usual recovery.
- Competitors versus collaboration –impact costs of competitors versus own.
- Ecosystem protection.
- Extent of aid/reserves/support/flexibility.

- Extent of organisational loss, reputation, relocation costs.
- Extent to which businesses/stakeholders have experience, overcome past-existing impacts.
- Event specific impacts/location.
- Insurance.
- Local autonomy/initiative rather than international centralised control.
- Local sourcing, rerouting/contingency plans; collaboration and joint resource pooling.
- Observing events, sharing information.
- Price, volume, cost, quality, demand, supply, local and foreign market conditions, affected supply chain stages.
- Product substitutability/necessity.
- Supply chain partner and network responses.

Solutions

Various stakeholders including the World Health Organisation, International Maritime Health Association, IBIA, International Chamber of Shipping and the IMO have published website advice relating to addressing the COVID 19 catastrophe since it was first diagnosed in Wuhan on 7th January. These focus on port screening, sanitation and health awareness/quarantine, outbreak management plan and public health information processes. It incorporates advice on Hygiene Measures for Seafarers on Ships, Managing High Risk Exposure, Case Handling, Isolation and Cleaning, Disinfection and Waste Management. The International Chamber of Shipping also includes posters which can be printed out and placed onboard ships as well as a Sample Pre-Boarding Passenger Locator Form and a WHO COVID-19 Support and Logistics Supplies List. The International Maritime Health Association also advised against resupplying of fresh seafood, meat and groceries from China since the 14th January. A 14 day quarantine period at many global ports places unprecedented impact costs across maritime supply chains, especially for more time sensitive cargo. Crew cannot be replaced and mandatory port health screening is intensified. Singapore, Kuwait and Indonesia have restricted crew, passenger and vessel arrivals from China, France, Germany, Iran, Italy, South Korea, Thailand and Spain in the past fortnight. Other countries such as Portugal have exemptions for local citizens. 40 South Africans were quarantined onboard an MSC vessel calling into Durban port. The MSC Orchestra only managed to sail and return when it changed its intended Pomene Mozambique port destination to 5 days at sea. Malta have had crew from infected countries as restrictions since 24th February.

Since the 15th March, the entire Philippines, Netherlands, France, Spain and Italy have all been under quarantine. Argentina extended the ban to the US, Japan, UK and European Union. Israel, India, Taiwan and other nations have banned those entering from China. Australia, South Africa and other nations are restricting entry to those undertaking 14 days quarantine. Bangladesh has banned those from the European Union and China. Bulgaria, Cyprus and Cameroun favour quarantine. The Dominican Republic have banned cruise vessels and flights for a month from high risk areas. Gabon has restrictions for 24 high risk countries. Aside from essential services, Iraq has imposed a curfew on people's movements since 17th March. Malaysia imposes the need for sanitizers, gloves, face masks and other equipment for companies still operating. Panama has suspended air travel from Europe and Asia. Papua New Guinea have suspended crew changes. Saudi Arabia only allow voyages and air travel related to cargo, trade and evacuation of citizens. Yemen has closed borders, except for humanitarian and aid but is far from self-sufficient.

Chinese coronavirus stimulus measures include 156 billion euros in direct support along with customs and trade exemptions for core US imports such as agriculture equipment, food and medicine. Potential suggested solutions include minimising risks to various impacts such as human labour; transport routes, customer

demand; supply; information; needing proactive risk management and emergency operations centres/coordinated focal points with designated responsibilities throughout a supply chain. It includes identifying risks to ach supply chain stakeholder. The need for reserves, redundancy and back up plans or strategies remains essential for COVID 19. The need for more local supplies is recommended to be available. Stakeholders will experience increased need for automation and technology; less physical access to staff as many move home and restrictions for ports and intermodal logistics, curtailing flexibility and efficiency. Greater transparency over supply chain processes and information sharing may be needed to stop speculative buyers from impulsively hoarding. In extreme cases such as Australia and the United Kingdom, nations may even have to introduce rationing. The National Health Service has shops in England opening an hour early just so emergency workers can in fact get access to the basics. Many legal contracts also have to keep being reformulated given uncertainty of the coronavirus for the force majeure clause.

In response nations such as the UK are offering a 350 billion pound direct financial support, loan extensions and a 12 month tax holidays for the airline, hospitality and other industries, especially small businesses although uncertainty exists as to eligibility and access criteria among myriad stakeholders. UK solutions include a small and medium enterprise sick pay package and business grant funding for rate or rural rate relief. It includes grant funding of £25,000 for retail, hospitality and leisure businesses with property with a rateable value between £15,000 and £51,000. It extends to the Coronavirus Business Interruption Loan Scheme to support long-term viable businesses who may need to respond to cash-flow pressures by seeking additional finance along with the HMRC Time To Pay Scheme to help with tax. In Australia citizens will be able to access their superannuation or pension funds without penalty at an early age and the Prime Minister Scott Morrison announced a $17.6 billion stimulus package. Government bonds are receiving higher support and demand, given global Reserve Banks are heavily penalising depositors. The Australian government have prompted the banks to offer $ 8 billion in support to small businesses.

From experience in sudden-climate related natural disasters and climate change as low probability, high impact or Black Swan events, this article considers several core adaptation strategies can assist to reduce the potential impacts. These can be divided into five response strategy themes of mitigation, adaption, retreat, migration or opportunities along with individual measures identified in Table 4 and this article. Supply chains concerned with possible consequences could undertake these responses to minimise associated risks and connected impact costs to resources, economies, coasts, infrastructure and populations, as key factors affecting maritime supply chain (MSC) performance.

Table 4: Coronavirus and Other Pandemic Risks, Impacts and Specific Adaptation Measures for Ports and Shipping

Risk Events	Long- and Short-Term Impacts	Proposed Adaptation Measures for Ports	Proposed Adaptation Measures for Shipping
Long Term Risks	Table 2	- Early warning systems. -Changes in technology, infrastructure design, technical standards, research and development.	Changes in routes, markets vessel design and technology, vessel pricing, marketing, research and development
Short Term, Sudden Risks	Table 3 -Physical vessel/port/commodity damage. -Higher insurance premium, repair, maintenance, labour, voyage, charter and other costs,	-Observatories and early warning systems -Acquire new/upgraded port equipment -Natural Engineering	-Increased risk awareness assessment, monitoring, stakeholder education and training -Redundancy Circular Economy Automation, Drones, Robotics

	-Reduced port access, increased congestion, physical navigation risk -Threats to vessel navigation, safety, delays and congestion. -Changes in demand, supply, port profitability and pricing -Changes in routes, markets, trade diversion and reduction, -Reputational loss impact -Physical legal and technical regulatory compliance costs, increased insurance liability costs -Operational/financial cost loss -Planning, preparation or adaptation cost in devising solutions	-Sanitising infrastructure, drainage Facility relocation, elevation, strategic retreat and land reclamation.	Sensors, Cloud Computing
		-Critical port functions can face relocation, elevation or retreat inland -Physical Engineering levees, dykes, storm retention basins -Increased coastal vegetation zones and legal foreshore protection to reduce surface moisture/coastal erosion. -Redesigned water storage, drainage and infrastructure for greater protection. -Increased rainwater storage/improved drainage to reduce port area runoff Revised engineering designs, standards and technological adaptation -Port Pricing Changes -Excess precipitation storage/ attenuation systems and water conservation and diversion plus efficiency measures e.g. education and conservation policy legislation, training -Increased monitoring/information sharing -Provide greater worker and equipment protection, improved training, flexible working hours and nocturnal shifts to prevent supply chain disruption costs. -Improve cargo throughput protection by reducing exposure, enhancing facility insulation and protection. -Greater information and communications updated periodically to reassure stakeholders. Provide emergency planning response training and equipment - -Ensure sufficient waste locations and design standards are in place.	- Early warning systems plus coordinated port stakeholder information, communication and training -Flexible working hours, shade, adjusted training, protective clothing/improved facility insulation and new equipment. -Improved cargo insulation, Renewable, sustainable energy powering emergency reefer points -Wind breaks, -Physical engineering research and redesign standards, -- Facility relocation. -Mangroves/afforestation for natural protection -Adjust training, -Increased current monitoring systems -Short term intermodal transport shift. -Not applicable –except as landside cargo, infrastructure and cargo are affected in higher delay/opportunity, fiscal costs.

Source: Author.

These adaptation measures have time and fiscal advantages for SIDS and emerging nations with significant technical, skilled labour, port equipment, financial and other constraints. They can adjust solutions to current and future supply chain infrastructure, equipment, training and cargo to minimise potential disruption risk costs from risk events. Other adaptation measures that apply to ports, shipping and overall MSCs include increased risk awareness assessment. Joint risk adaptation solutions are increasingly favoured Examples include improved early warning systems to anticipate disruption risks and prepare with as much time and information as possible. Investing in stakeholder education and training allows time and flexibility to adjust to risks. This provides pre-emptive adaptation strategies. This research's contribution to existing literature gaps

will be to identify, adapt and evaluate these measures to address systematic risk. It establishes specific adaptation strategies for supply chain stakeholders and stages. These are summarised in Table 5 for previously identified risks and associated impact costs. Increased global supply chain, stakeholder cooperation and coordination in information gathering, early warning systems, communication, research and planning are recommended. Examples of cooperation advantages include economies of scale, avoiding wasteful duplication of unnecessary resources, increased efficiency and supply chain performance. Potential congestion, reputational, business delay, economic, environmental and other opportunity costs are lowered. This article provides adaptation strategies considering the limited labour, technology, budget, land, infrastructure and institutional governance capacity, constraints of many nations. Whether COVID 19 and other epidemics will permit a sustainable future for affected stakeholders depends on the extent to which they prioritise strategies summarised in Table 5 and elsewhere in this article.

Table 5: Summary of Hypothetical Epidemic Risks, Impact Costs and Adaptation Strategies for MSCs

General Risks	Coronavirus Disruption Impacts for Supply Chains	Proposed Adaptation Strategies
Long Tern Risks Table 2	Reduced emissions	Pre-emptive via mitigation, circular economy, redundancy, retreat/surrender, migration, Reactive –sanitation and waste,
Long Term Climate Change Risks/ Associated Impact Costs Short Term and Sudden Risks/ Associated Impact Costs Table 2.3	Physical or indirect vessel/port/commodity and infrastructure damage.	-Increasing vessel, equipment, infrastructure and operational resilience/training to minimise disruption threat costs. -A short term transport intermodal shift from road/rail to less affected shipping/air for vital cargo may occur Physical engineering Natural engineering
	Higher insurance premium, repair, maintenance, labour, voyage, charter and other costs, reduced port access, increased congestion, physical navigation risk	-Adapting through increased disaster risk response, information gathering and early warning systems -Improved training, disaster emergency contingency planning and vulnerability risk management adaptation, physical adaptation of vessels
	Threats to vessel navigation, safety, delays and congestion.	Greater coastal reserves, adjusted courses, modified legislation, slow steaming
	Changes in demand, supply, port profitability and pricing, commodities and input sourcing	-Increasing market flexibility to favour smaller vessels/lobby for reduced port rates during disasters based on remote Pacific locations/increasing other inter-port competitiveness. -Consumers and producers may alter preferences
	Changes in routes, markets, trade diversion and reduction,	Flexible marketing, delivery arrangements and adaptation with smaller/fewer vessels, short term intermodal transport shift to less physically exposed alternatives
	Reputational loss	Improved and coordinated information/ communication, increased security and resilience training/disaster management -Prioritise mitigation/environmental adaptation solutions

	Physical legal and technical regulatory compliance costs, increased insurance liability costs	Increased access to political-legal information and participation through offering stakeholder advice/lobbying, to minimise uncertainty
	Operational/financial cost loss	Improved and coordinated information/communication to prioritise climate change awareness and risk management
	Planning, preparation or adaptation cost in devising solutions	Increasing support for research and technology endorsing solutions

Source: Author

Numerous research sources ignore or underestimate the disruption impacts climate change initiates on MSC stakeholders with limited resources, in proposing expensive climate-proofing solutions, especially those of the Pacific. Developed World sources have yet to truly quantify and consider many of the specific and generic risks, impact costs, constraints and solutions of COVID 19 and the public health/other socioeconomic risks for international trade, communities and economies. They propose resource, capital, technology, skilled labour, education and wealth intensive solutions, e.g. hard and coastal engineering approaches, as common resilience strategies. Conversely, this research points out just how few existing sample surveys have been done for stakeholder awareness and adaptation to this and other pandemics. Yet research gaps occur from ignoring the significant costs of paralysing economic activity globally from MSC failures. Mutual cooperation in risk education, information, existing technology and policies alone could simultaneously reduce over $2 trillion worth of economic disruption costs to global supply chains. This enhances resilience of global ecosystems and MSCs simultaneously. Directly or indirectly, CIVUD 19 offers potential to disrupt affect every port, commodity, MSC, connecting economic hinterland and dependent stakeholder, to varying extents. Unlike climate change and natural disasters, satellite high resolution imagery, drones and direct observation cannot simply convey its total extent.

There are risks from asymmetrical information to the principle agent problem to moral hazard and the free-rider risk problem many will face in persuading others to join this network. Certain stakeholders desire others to finance adaptation instead. It further endorses a cooperative approach, so ports can enact climate risk evaluation, mitigation and adaptation strategies without losing their inter-port competitive advantage status. It once more primarily focuses on sanitation measures by health workers. This ignores other significant contributing factors towards disruption and the need for greater diversification away from depending on China, favouring domestic import substitution where practical and the transition towards a zero waste, circular economy. It means considering just how many meetings and travels are necessary to reduce emissions and congestion. It also strengthens the arguments against the trade in pangolins and other exotic yet highly vulnerable and rare livelihoods. This research favours the need to minimise disruption costs via the alternative of active stakeholder adaptation. The weakness of many adaption scenarios is that most contingency planning efforts are isolated not coordinated. They exclude core stakeholders from direct formation and participation. This presents significant risks in response value. It misdirects priorities and wastes scarce resources, given constraints of many nations.

This review advocates effective adaptation strategies consist not only of minimising adverse consequences but exploiting any potential benefits such as additional commercial opportunities that COVID 19 and other epidemics may necessitate for Pacific and global MSCs as below. Opportunities include trade diversion from less climate resilient MSC stages. It incorporates outlasting competitors failing to adjust. Despite this heightened risk exposure, that other sources and this article seeks to affirm, people seem reluctant to truly prioritise climate change emissions reduction, a circular economy, ban the wildlife trade and be proactive in

responding to the pandemic via temporary restrictions and to pay the initial sacrificial cost. Adaptation strategies provide an anticipation and behavioural adaptation to psychologically and physically acclimatise over time to long- and short-term risk events, pressures, impact costs, constraints, challenge, and consequences. This entails higher anticipated adjustment costs to be effective; rather than just a reaction approach to events. Without considering mitigation, retreat, financial support and adaptation strategies as potential responses, risks appear increasingly unavoidable. In conclusion, an effective risk assessment framework for Pacific MSCs would integrate mitigation, adaptation, retreat/surrender, relocation, governance and policy issues and ecological rehabilitation, as illustrated in Figure 2 where the risks and adaptation measures would be as summarised in Tables.4 and 5. Stakeholders need to find a way to overcome existing psychological and other constraints. Examples include a lack of credible information, stakeholder coordination and cooperation, risk management; financial reserves, technology, economic, social, environmental, legal, administrative, equipment/resources, training, leadership and others. Potential adaptation strategies include these along with sharing experiences and support; quarantines, sanitation and waste management; marketing and PR, income source diversification, increasing flexibility and others.

MSC Psychological Constraints to Rectify

- Apathy/Indifference
- Asymmetrical Information/Uncertainty
- Character assassination –rather than evidence-based critique
- Despair/Haplessness
- Faith in others/Technology
- Fear of ostracism/Powerlessness
- Lethargy/Inaction
- Moral hazard
- Pedantry
- Present moment orientated –Short Term Immediacy Syndrome
- Risk aversion –the status quo
- Self-advantage/gain
- Self-interest

Investment Horizons of Opportunities

Interest rates have been slashed to 0.15% -the lowest in over 300 years of Bank of England History, mirrored by fairly low rates across the US Federal Reserve, Australia and South Africa. This will further penalize savers at a time when additional income sources are denied to them and the stock markets are reaching levels not experienced since the 2008 global Financial Crisis or even the 1987 crash. The rationale is to encourage spending but with businesses closing, staff being curbed in movement and customers unable to browse; priorities are favouring survival items over material fripperies of consumerism and affluence in a highly misguided global approach. Most banks are on fixed term rates for mortgages and loans -just use it to encourage abandoning the banking system entirely as it becomes worthless.

Yet business activities continue to exist as opportunities. For example, supermarkets have seldom been busier for toilet paper, sanitary items and groceries. Many of them have been hiring additional staff. Most of South Africa's face masks supplies were shipped off to China. In the UK toilet rolls increased from 1 pound 80 pence for 4 to over 18 pounds for 1 in just 2 weeks It shipped 2.6 million masks and 10,000 bottles of hand sanitizer in 24 hours alone for 150 hospitals. Over 1400 companies are converting production lines to

ventilators. Test kits are also thriving. Other investment opportunities have shown a steady increase in pharmaceuticals, Internet streaming entertainment and delivery services such as Netflix and Amazon. Video conferencing and Skype are thriving as are news providers. Textile industries are generating higher profits with possible conversions to producing face masks, gloves and protective clothing. Initially private jets and yachts as a means of escape were also popular. With enough sanitation, domestic tourism such as remote chalets, parks and Air BNB may prove popular as people seek alternatives to international destinations being restricted. Food takeaways may see a surge in popularity until being banned to compensate for social distancing norms being imposed in restaurants. The fuel price record low of $27 per barrel and stock market crash having not been lower for a decade indicates the markets are almost at unprecedentedly low levels enabling options for further investment for those with idle cash to speculate upon.

Government bonds are reaching yield rates exceeding 10% in countries such as South Africa. China also raised over $4 billion on COVID bonds. Other entities may benefit from greater credit access and reduced restrictions. Chinese banks were instructed to lend up to $49.7 billion to small and medium enterprises at reduced interest rates. Reduced social security contributions and rental payments can also free up cashflow more. This epidemic should also present a market for tools, DIY supplies, solar panels, batteries and other essential equipment. Future potential is expected to emerge from technology investments such as the NASDAQ, especially the development of apps, online delivery services, robotics, automation and other creations minimising disruption to the real economy. Others include import substitution and the pressure towards a more eco conscious, circular economy with fewer emissions, reducing the need for air and shipping cargo to places such as Asia, the US or the European Union externally.

In conclusion, if there is one thing to derive from this is the unexpected implications of how disturbingly disruptive an unexpected pandemic can be to many of the systems and processes. SARS cost over $40 billion globally but this has potential for even greater cost consequences of this Black Swan risk event. It truly tests the need for greater anti-fragility in supply chains locally and globally. Climate change emissions have radically decreased from the reduced flights, shipping, road and rail. Water, air quality, sound and scent have dramatically improved. Fish are now present in the Venetian canals where there weren't any before. More people have apparently shown empathy and aided those confined to minimise risks to public health. One factor highlighted by the coronavirus is how anti-fragile or lacking in resilience many supply chains are -but others are able to adapt if they can sense the opportunities as investment horizons. Ultimately without being dominated by China, EU and US exports and trade dumping; domestic companies across the world may assist in the need for greater anti-globalization and domestic economic autarchy, facilitating substitutions in local investment, consumption, demand and employment. Certain supply chains may benefit with shipping companies that are prepared to face the significant range of cargo restrictions and ports; whilst ports and companies that are more resilient or able to adapt swiftly, can profit from trade expansion and diversion.