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FUTURE OF
LOGISTICS
by John Manners-Bell
IDB

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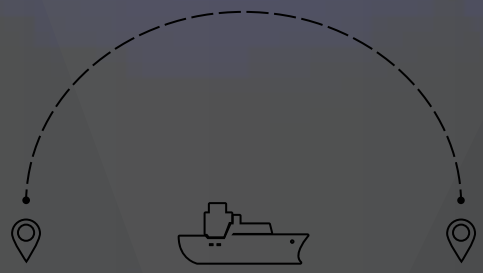
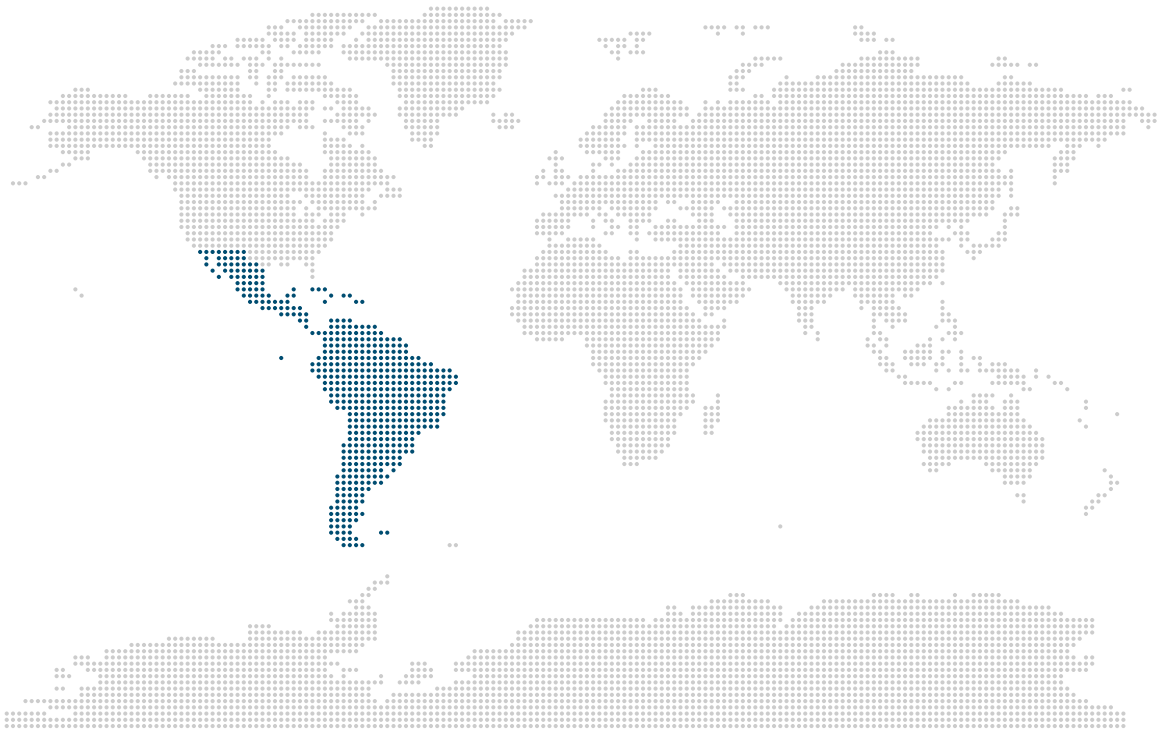


CHAPTER ONE:

INTRODUCTION

01



By 2030, the Fourth Industrial Revolution (4IR) —the term used to describe the full range of technological, societal and business-related innovations— would have led to the transformation of the global economy. In this context, novel technologies would have also changed logistics and supply chains, which ought to be more customer-centric, agile, sustainable and inclusive. Based on an extensive literature review and interviews with international experts, public sector, academia, and business, this paper presents the novel trends that are expected to significantly impact logistics and supply chain management in the next decade. These trends are automation, digitization, sustainability, blockchain, and 3D printing. The paper is organized in five sections, each describing one trend and providing examples of how such a trend is already having a significant impact on the logistics and supply chain industry. Moreover, each section examines the steps required by the private and public sectors if these innovations are to be genuinely transformational; as well as what would delay their adoption, and the benefits and risks to economies, societies and the environment if they are adopted.

This document was prepared as a background paper for the discussions in the context of the Inter-American Development Bank's "Development in the Americas" flagship report, which is to be released in 2020 with a focus on the status and future of infrastructure-related services in Latin America and the Caribbean.

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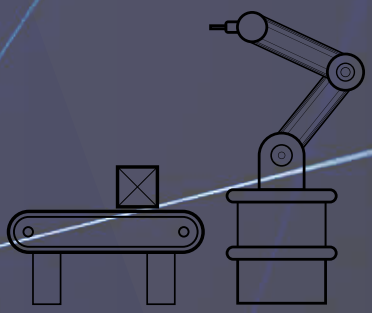


CHAPTER TWO:

AUTOMATION

02

Innovation	Automation
Trends	• Robotics and automation are being rapidly adopted to increase efficiency and reduce costs in the warehouse. E-commerce, with the need for single item picking and high volatility of demand, is driving the initiative. • There is vast investment in autonomous vehicles (AVs), including trucks. Although not yet driverless, 'assistive' technologies and platooning might reduce accidents as well as costs and emissions. • As well as trucks, crewless ships and aerial vehicles (UAVs) or drones are under development.
Proposition	By 2030, robots would have replaced many workers in warehouses and significant levels of automation would be commonplace in trucks throughout the region.
What is needed to achieve the state proposed?	• For warehouse robotics, governments need to encourage investment by retailers, manufacturers and logistics companies in automation technology. • The development of AVs relies on a robust legal framework to allay concerns of safety and security. • Government investment on information and communications technology (ICT) and transport infrastructure is to be required.
What are the risks?	• Unemployment created by the reduction in the need for warehouse workers and truck drivers. • Reduction in wages as employees compete against cheaper robots.
What are the opportunities?	• Increased warehouse efficiency and lower costs. • Reduction in traffic congestion through better infrastructure capacity utilization. • Transport labor cost reduction and lower risk of labor-related disruptions.
What barriers may limit adoption?	• Legislation addressing insurance and liability. • Development of technology such as artificial intelligence. • Broadband bandwidth and mobile technology infrastructure. • Robust cybersecurity environment. • Resistance from labor organizations to automation.
What is the potential for these innovations to be in place in 2030?	• High probability of warehouse automation driven by a strong economic business case. • Lower probability of wide adoption of fully autonomous trucks due to regulatory and technology issues. • Drones might become commonly used but only in specific operating environments.

Automation is a fundamental element of the Fourth Industrial Revolution (4IR). Advances in technology, both physical and digital, have provided opportunities to re-evaluate established supply chain and logistics models. Demand and supply-side trends, such as the driver shortage and e-commerce, are driving the widespread adoption of these technologies, as companies grasp the opportunity to reduce costs while improving efficiency. However, automation has the potential to go much further. It will not only be a substitute for labor, but it can offer a completely new way of organizing logistics and supply chains.

2.1 ROBOTICS AND WAREHOUSE AUTOMATION

Automation in the warehouse through the use of robots is gathering pace. Although robotic systems have been around for some time, a number of demand and supply-side trends are driving their widespread adoption. Not least of these is the e-commerce phenomenon, which has led to many retailers to adopt omnichannel and multichannel marketing and distribution strategies, and transform the characterization of supply chain volumes from unitized and quite predictable to single item and volatile. This might result, according to a report by consultancy Tractica, in the growth in sales of robots rising from US$31 billion in 2016 to US$237.3 billion in 2022 (Tractica, 2017). A further driver is the increasing cost of labor and its shortage. Automation is being seen as a way of boosting efficiencies in the warehouse, reducing the need for human workers and — at the same time— providing more flexibility to fulfill peaks and troughs of demand using modular systems.

Apart from the labor cost element, automation also means lower real estate costs as a human-free environment allows greater density of storage; for example, operating with narrower aisles (or in some cases, no aisles at all). What is more, robot technology is becoming more robust, and the cost per robot is falling, bringing them into the reach of smaller companies. Robotics-as-a-Service solutions are being developed by some suppliers who work on a pay-per-pick basis, therefore taking away the large capital outlay formerly required. Howev-

China's e-commerce giants lead the way

Process and cost-efficiency guide the logistics development of China's e-retailing giant JD.com, spanning 300 warehouses and 65,000 delivery employees. One current innovation is the development of a network of "dark warehouses". One of such unmanned, automated fulfillment centers occupies 40,000 sq mi in Shanghai's Jaiding District. The facility has the capacity to fulfill 200,000 orders per day and is operated by a combination of robotics and other automated technologies, which can self-calculate how to avoid collisions and optimize routes. It has just four human employees. Though such automation comes with restraints; the facility can only handle certain types of goods —uniform in size, shape and weight— as its robotic picking arms cannot lift packages heavier than 3 kg.

Case study: Amazon's use of robots

E-commerce company Amazon has been using robots since 2012 to bring the 'picking face' to the human pickers, rather than have staff walk up the aisles to the right picking location. Amazon now employs 80,000 robots at 25 fulfillment centers worldwide. This automation has allowed Amazon to offer industry-leading service levels at a much lower cost than using a wholly human solution. An estimation shows that it allows workers to pick 2-3 times faster than conventional manual systems. Amazon itself says that the average time it takes to fulfill an order has fallen from 90 to just 15 minutes (Hess, 2017). In the US, this has allowed it to push back two-day delivery cut off times from 3:00 p.m. to midnight, achieving an impressive extension for this service option. The solution still requires human participation; not only pickers but the workers needed to unload trucks, unpack the boxes and place items in racks. These racks are then taken by robots to locations in a caged 'non-human' area to await collection by another robot.

er, automating such a labor-intensive sector as warehousing will have repercussions —these may well be at a macro level, affecting countries due to the impact on employment, or, in a lower level, it would also be felt amongst logistics service providers (LSPs) whose revenues are largely made up by managing or providing outsourced labor forces.

2.2 AUTONOMOUS VEHICLES

With technology giants such as Google and Uber and vehicle manufacturers investing heavily in autonomous vehicles, it is only a matter of time before they are seen on roads around the world. In fact, many assistive technologies (such as adaptive cruise control, lane keep assistant and help with parking) are already on use. Vehicles now are capable of interacting not only with other vehicles around them but also with roads, ports and airport infrastructure. Autonomous vehicles (AVs) contain a vast collection of new and innovative technologies that sit alongside existing hardware and software. These include:

- Onboard sensors, cameras and data processors that collect vast amounts of data and process it in real-time, enabling decision making and ensuring the vehicle operates safely.

- Artificial intelligence (AI), including deep learning and machine learning, that enables the vehicle to adapt to the current situation

and to improve vehicle performance continuously.

- Cloud-connected data processing and management tools that aggregate and analyze real-time telemetric data, like speed and the proximity of objects surrounding the vehicle, and signal the needed actions like braking or lane-switching.
- GPS systems that provide location and route planning.
- Radars that detect objects and determine their distance, angle and speed.
- Lidar which senses brake lights and changing road conditions.
- Connected and 'smart' technologies which allow the vehicles' sensors to communicate with road system markers, traffic lights and lane markers.
- Internet of Things (IoT) connectivity to enable vehicles to learn from one another, and for components to make adjustments for weather changes and shifting road conditions.
- Sonars that can 'see' small objects at higher resolution and close range.
- Inertial measurement unit that contains odometer, gyroscope and compass to give the AV a sense of position, direction and speed when GPS is out of range.
- High Definition digital maps with detail and precise models of a region's most important features.

As such, the development of a fully autonomous vehicle that can complete end-to-end journeys unaided is ultimately dependent on the advancement of a number of overall technologies and individual components that enable the outcome. In this regard, many companies are working on the various hardware and software developments needed — some in an individual sense, like the start-ups trying to develop lidar at costs cheap enough to mass produce, or major chip manufacturers like Nvidia and Intel aiming to make chips powerful and efficient enough to be the processing brains. Future advances in technology would be in Vehicle-to-Vehicle (V2V), vehicle-to-infrastructure (V2I) and infrastructure-to-infrastructure (I2I) initiatives, which would build on the development of technologies already in place, adding in more cameras and sensors.

It is also increasingly possible to "harvest" a considerable amount of data from vehicles, both cars and trucks, which if analyzed in a proper and timely way, might result in efficiencies, mostly related to the avoidance of congestion. These data can be generated either by traffic authorities (such as municipalities or highway agencies); by private companies, which provide information to users on the speed of traffic, or, more recently, mobile applications, which allow individuals to log incidents as they observe them. The latter can theoretically mo-

Trialing of autonomous vehicles at ports and on highways

Significant progress has already been made both on public and private highways with trials taking place in Europe, North America and Asia.

- In Europe several semiautomated platoons of trucks have been driven across Europe, arriving in Rotterdam from Sweden, Denmark, Germany, Belgium and the Netherlands as part of a challenge coordinated by DAF, Daimler, Iveco, MAN, Scania and Volvo. The report on the trial, by the Dutch Ministry of Infrastructure and the Environment, found that truck drivers regarded merging traffic and on/off ramps as the most challenging elements of platooning in practice.
- PSA Corporation and the Ministry of Transport (MOT) Singapore have signed agreements with Scania and Toyota Tsusho to design, develop and test-bed an autonomous truck platooning system for use on the country's public roads.
- In the US, autonomous trucks are operating on the I-10 freeway between Texas and California in a collaboration between Ryder, technology company Embark and white goods manufacturer Frigidaire.
- In China, a self-driving truck start-up, TuSimple, is trialing operations at 10 ports with a full rollout expected in 2020. Progress on public roads has been slower due to regulatory issues.

bilize thousands of drivers who act as monitors of traffic situations in areas which no other organization could reach. By being able to communicate with each other, there is also the possibility of platooning. Trucks (and even eventually cars) would be able to travel in convoys along the motorway, drafting the vehicle in front. According to the US Department of Environment, platooning can create fuel cost savings of between 8-11% (Lammert et al., 2014).

In summary, vehicle manufacturers believe that the efficiencies the technology would deliver might come in the form of:

- Reduced fuel consumption —the computer would drive the vehicle more fuel efficiently.
- Reduced emissions —for the same reason.
- 100% connectivity and location services, which allow for 'perfect' route planning, although V2V, V2I and I2I connectivity would be required for optimization.
- Diagnostic services, which ensure correct maintenance and fewer breakdowns.
- Emergency braking, which would ensure fewer accidents.
- Replanning of routes around known areas of congestion.
- Reduction of accidents caused by human error (through tiredness, for example).
- Shared communications with customers to provide visibility of delivery times, changing in line with the traffic situation.
- Driver shortage solutions.

2.3 AUTONOMOUS SHIPS

As with trucking, many in the shipping industry believe that autonomous ships would eventually totally replace the crewed alternative. There are good commercial arguments for this belief. Benefits would include lower labor costs (due to the removal of the crew); lower fuel costs (due to the removal of accommodation, perhaps by 6%); lower construction costs and more room for paying the freight; and lower insurance for accidents involving humans. According to one survey of Norwegian shipowners, 5% of shipping companies believe that they would be using unmanned ships by 2025 (Think Ocean, 2018). This projection increases to a half by 2050. The initial cost is high as each system incorporates the costs of GPS, lidar, infrared and high-resolution cameras needed to operate this new type of vessel. However, its operating costs are likely to be dramatically lower than a normal container ship. Reports suggest annual operating costs could fall by up to 90%, with no fuel costs or seafarers to pay for (Paris, 2017). According to Mikael Mäkinen, President of Marine Business at Rolls Royce Holdings, "autonomous shipping is the future of the maritime industry. As disruptive as the smartphone, the smart ship will revolutionise the landscape of ship design and operations." Different types of ships have different cost cases for the introduction of automation. For example, labor costs make up a small proportion (around 2%) of ultra large container vessels (those typically working on intercontinental trade routes) whereas these labor costs account for more like 20% of the total costs of bulk ships, general cargo and smaller container vessels (Mandra, 2018). Consequently, the latter categories plus, tugs, barges and rig serving vessels are far more likely to be amongst the earliest adopters. Areas in which development might need to be focused if this is to become a reality are:

- Ship-to-shore ICT networks providing security and reliability.
- Autonomous bridge enabling for planning, sensing and maneuvering the ship.
- Autonomous engine room, which could be one of the biggest challenges to overcome, as equipment should be reliable enough not to need maintenance or repair during a voyage.
- Shore control center, monitoring a fleet of autonomous ships.

2.4 DRONES

Leveraging their ability to move quickly over terrain which may have little or no transport infrastructure, drones are already proving to be well-suited to the transport of urgent ship-

ments in remote locations. Examples of successful trials include:

- DHL drones, delivering medications from the German mainland to the North Sea island of Juist in 2014.
- Zipline's drone-based transportation of medical supplies throughout Rwanda since October 2016.
- Matternet's operational network, serving hospitals throughout Switzerland by transporting blood and pathology samples between hospital facilities on demand.

What makes each of these business models viable is the absence or weakness of road transport infrastructure. The mountainous terrain of Switzerland constitutes one of the few areas in Western Europe where the delivery of medical samples cannot be executed rapidly through conventional channels. Rwanda, as is the case in many parts of the African continent, lacks a reliable road network resilient to climatic disruption. In London, the severe road congestion experienced has prompted one company, Skyports, to build rooftop drone ports on 15 roofs in the central area of the city. By doing this, it is possible to utilize redundant rooftop space and offer users fast and efficient package delivery, of course, the necessary regulatory framework should have been put in place.

Drones are being deployed in a slightly different way in China. They are being used for the delivery of lower value e-commerce packages, albeit in rural areas. Both SF Express and JD.com are deploying drones. Speaking to CNBC, JD.com's CEO Richard Liu said the cost of serving rural areas would "drop down at least 70 percent" with the use of drones as opposed to cars or vans. SF Express won a license from the Chinese authorities in 2018. It intends to implement a three-stage air network involving aircraft, large-scale drones and final-mile drones resulting in a 36-hour delivery capability linking many of China's rural areas and smaller cities. It has also entered into a partnership with a Kenyan company to test its technology for parcel deliveries in Africa.

The conclusions to be taken from the recent activity are clear. Drones used for logistics in Europe and North Africa are likely to provide deliveries in niche, time-critical areas where no other suitable options exist. In other emerging markets, including Latin America, it may be that drone delivery would gain more mainstream use, serving as a leapfrogging technology and allowing the expanding e-commerce industry to overcome substantial infrastructure deficits to reach consumers.

IDB Proposition: By 2030, robots would have replaced many workers in warehouses and significant levels of automation would be commonplace in trucks throughout the region.

2.5 WHAT IS NEEDED TO ACHIEVE THE STATE PROPOSED?

In assessing what is needed to enable the widespread adoption of automation by 2030, it is essential to differentiate between the automation that occurs in private versus public spaces. For example, the use of robots in warehouses would largely depend on technological progress; the investment of international manufacturers, retailers and logistics companies in the sector as well as the underlying economics of the job market. However, when automation involves vehicles in public spaces, the issues become much more complex as public policy, health and safety, security and insurance issues have to be taken into account alongside basic commercial necessities and technological capabilities.

First and foremost, as it is discussed below, governments and intergovernmental organizations (such as the International Maritime Organization) must put in place legal frameworks to provide confidence to manufacturers and technology companies that a market would be allowed to develop. For example, in the trucking sector managing new and evolving relationships between these parties would be essential as the "driver" effectively becomes the "passenger". This framework must balance the needs of industry with public safety and security concerns. Secondly, high bandwidth mobile networks would be required for vehicles to work effectively. Sensors installed in the vehicles provide a certain amount of the data required, but for the full benefits to be exploited, the vehicle has to be able to access the data being generated by other vehicles around

it (V2V) and other roadside units (V2I), which can inform it, for example, of traffic conditions many miles away. Likewise, intelligence transport infrastructure would also be needed to communicate with autonomous vehicles. This infrastructure requires significant investment by governments and information and communications technology (ICT) companies. This information would also include data on weather and road surface.

2.6 WHAT BARRIERS MAY LIMIT ADOPTION?

Legal

The United States is leading the way in the development of a legal framework for autonomous vehicles. As of May 1, 2018, twenty-nine states had enacted legislation allowing for autonomous vehicle testing and operations. At the start of the year, there were just 11. Legislation is required to address the insurance issues involved; for instance, if an autonomous vehicle creates damage while driving itself. Draft legislation proposed in the UK makes the insurance company liable for the costs unless the owner has not updated the vehicle's software. In an environment where human error is responsible for most accidents, legislation addressing liability is essential to encouraging further investment. An alternative would be to regard the failure of an autonomous vehicle as a product liability issue which would push the risk back to the manufacturer. During an interim period when semiautonomous systems assist human drivers there is likely to be even more opacity; for example, identifying whether the driver should be in control of the vehicle or not. Insurance is not the only issue which legislators would need to address. As the role of the truck driver changes so will hours of service regulations (HoS). At present, the number of hours which a driver can work is limited for safety reasons which also limits the utilization of the vehicle. If the driver is not actually driving the vehicle, then the HoS regulation would be redundant and allow much greater efficiency of the asset. However, the regulatory framework required for an interim period, when trucks are only semiautonomous (for instance, self-driving only on main highways), would need to be developed. In this sense, in October 2018 the US Department of Transportation released the report "Preparing for the Future of Transportation: Automated Vehicles 3.0", which indicates that the term "driver" no longer refers to humans only.

AI

Although significant progress has been made and current programming techniques employed in AI are able to provide a computer with the abilities to infer potential actions in 95% of the unfamiliar situations, the likelihood of full autonomy for vehicles is still some way off.

ICT Infrastructure

High speed and low latency connectivity can improve the way AVs interact with each other and with smart infrastructure. Although it does not seem to be a prerequisite, governments would also need to promote 5G deployment and to invest in roadside units in charge of collecting and transmitting data on a real-time basis.

Smart transport infrastructure

The development of smart transport infrastructure can only occur as part of a public-private partnership between governments, infrastructure owners, and engineering and technology companies, all of which have very diverse business cultures. Sensors, mobile and wireless technologies along with wired networks would need to be deployed and maintained over a long period. Not only are high levels of capital investment required but operationally all parties might require an understanding of the commercial risks involved in each project.

Cybersecurity

With an increasing reliance on connectivity over distance, the physical threat of cyberattacks increases significantly. In 2015, hackers exploited a "zero-day" vulnerability (a system vulnerability unknown to the vendor), which allowed them to take full control of a vehicle by connecting to its entertainment system over the internet.

Labor organizations

As examined below, there are significant societal implications of automation related to the impact of unemployment. This is likely to result

in the opposition of labor organizations, mindful of the threat to their membership. Of immediate concern should be the future of those employed in warehouses as robots become ubiquitous. However, eventually, as the need for drivers becomes redundant (much further in the future) many more people could lose their jobs. This might mean that unions would inevitably fight a long and sustained political battle against automation.

2.7 WHAT ARE THE RISKS?

Unemployment

There are considerable concerns that automation might result in large scale unemployment as low-skilled jobs in the warehouse and potentially, driving, are replaced by robots. The US National Bureau of Economic Research estimates that "...one more robot per thousand workers reduces the employment to population ratio by about 0.18-0.34 percentage points and wages by 0.25-0.5 percent" (NBER, 2017).

According to a survey on the impact of robotics in the UK by the RSA, 21% of business leaders believe that a high level of jobs in the logistics industry can become automatable, more than any other sector. Consultancy PriceWaterhouseCoopers has estimated that 56.4% of transportation and storage jobs are at risk in the UK, equating to 950,000 positions (PWC, 2017). In the US, another report by the Oxford Martin School for Citigroup estimates that 2 million workers are employed in the warehouse fulfillment sector alone, with 90% of picking done by hand (Citigroup, 2017). In China, a World Bank report estimates that 77% of jobs are at risk, although it is even higher in Ethiopia (85%) (World Bank, 2016). This situation raises fears that developing countries may miss out on the employment revolution experienced by China, with the jobs taken instead by robots.

Automation may not only have an impact on the numbers of workers but also on pay. Substituting lower cost machines which provide greater levels of productivity might naturally have an impact on supply and demand. Those workers who have not been replaced might find that they are competing with, effectively, low-cost mechanical labor. There are also implications in terms of "de-skilling". Automation can allow some functions, previously highly skilled, to be undertaken by lower-skilled workers in conjunction with robots. For instance, it may be that heavy goods vehicle (HGV) drivers who presently have to undergo rigorous testing are replaced by autonomous systems, with a much lower skilled passenger to act as a truck manager. Even low-skilled jobs can be de-skilled. Training of warehouse operatives, for example, can become unnecessary as machines —for example, augmented reality (AR) glasses— would inform them where to go, how much of an item to pick, where to take the order and in which box to put it. Such AR glasses are being tested at various DHL Supply Chain warehouse locations around the world. Vision picking enables hands-free order picking at a faster pace, along with reduced error rates.

However, it is imperative to recognize the effect of so-called "recycled demand". Automation results in the fall of prices to consumers who are then able to buy more goods or shift their spend to another part of the economy. Presently, indeed, the number of people employed in the warehouse environment is still growing, but their role is already changing. Many of the most highly repetitive jobs are the best suited to be automated. This means that human roles can become more value adding with the benefit that they become more personally fulfilling. For example, human workers, whose role was once to stack containers, a physical and tiring but necessary function, now oversee robots who have taken over this function. Despite this, there are two clouds on the horizon. Firstly, because Amazon and other e-commerce companies have created efficiencies in the warehouse which allow them to outcompete many bricks and mortar retailers, the employees that they take on may be at the cost of employment in traditional retailing as well as their distribution systems. What this means is that there is a migration of jobs to the likes of Amazon rather than a net generation. The logic (although this could be difficult to prove without more data) is that there must be a net loss in employment as many of the jobs which would have been created have been taken by automation. Secondly, robots are getting cheaper which could mean that eventually all segments of industry would be able to use them. Robots, which don't require breaks, health insurance or vacations and can work round the clock at peak times —to

mention just a few benefits—, would be very attractive to many companies. How governments can deal with the social fallout from this and the loss of tax revenue is another problem.

In any case, as the previous technological revolutions show, labor markets tend to regain equilibrium in the medium term, given that technological changes create the need for new job profiles. In this context, the critical question is how to re-skill workers who lost their jobs due to increased automation so that they can take advantage of the opportunities created by the digital economy.

2.8 WHAT ARE THE OPPORTUNITIES?

Warehouse efficiency

One of the foremost reasons for the investment in warehouse automation is the potential increase in operational efficiency that could be achieved. Robots can be utilized around-the-clock without the need to take breaks and without limited working hours. They also do not require light or heat, which are significant costs for warehouse operators. The fact that they do not need on-going training is also a positive factor in ensuring high degrees of utilization. There are benefits to warehouse workers, however. Robots can be deployed to assist humans, meaning that their jobs would become more value adding, less physical or less routine.

Reduction in congestion

With congestion forecast to rise substantially in the near future, there is a need to break the link between economic growth and vehicle movements. German authorities predict that truck transport volume could increase by 39% by 2030 unless steps are taken (Newbold, 2016) and many developing countries don't have the money available to make the sort of investment required in new roads. Therefore, it becomes essential to utilize existing road capacity more efficiently, and new technologies can aid in this goal.

Cost savings of automated vehicles

In many countries, it is estimated that around 45% of total cost for road freight operators is related to the driver (TI, 2018). Eventually removing the driver (although no one is suggesting this is likely for many years) would obviously have an enormous impact on road freight costs, profits and margins, as well as on risk management (due to lower risks of labor-related disruptions). Labor costs are even more significant in the shipping industry. One survey has put them at up to 60% of operating costs, which demonstrates the massive impact that autonomous ships would have on shipping economics (Moore Stephens, 2018).

Another issue is a looming labor shortage crisis. Many people are increasingly unwilling to commit to a career as a driver or a seafarer given the hours away from home, the relatively low pay and the conditions. This would eventually translate into higher costs for customers.

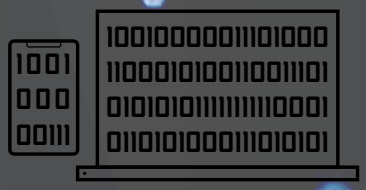
In the trucking sector, taking away much of the stress from driving by leaving most of the important decisions to a computer, working conditions might become more attractive. There may also be the opportunity for the role to become more value-adding, as the driver would have the time and connectivity to undertake better obligations, perhaps in transport management activities. In the shipping sector, it is likely that the only workers left on board ships would be those undertaking maintenance as and when required.

2.9 WHAT IS THE POTENTIAL FOR THESE INNOVATIONS TO BE IN PLACE IN 2030?

Although parts of Latin America are struggling with weak transport and ICT infrastructure, prerequisites if autonomous vehicles and trucks are to become commonplace by 2030, there are good reasons to believe that the region might not be far behind the rest of the world in the adoption of the technology. Many global truck manufacturers have bases throughout the region (for example, Daimler, Volkswagen and Volvo) and these could provide a conduit for their global research and development. Many assistive driving features might soon become available. However, only if governments invest in the necessary infrastructure and put in place legislative programs to develop regulatory frameworks, fully autonomous trucks would become commonplace in this time-

frame. It is easier to envisage high levels of robotics in warehouses, as this depends more on company investment and technological development than government investment and regulation. Not only automation could become much cheaper over the coming years but increasing labor costs might make it much more attractive for warehouse operators to invest in capital goods. However, the role of labor organizations in slowing adoption can be important. Drones, despite massive hype, might only ever fulfill a niche role in the industry. However, in some parts of the region, particularly remote areas subject to extreme weather events and with weak transport infrastructure, they could become vital tools.

- Fully autonomous trucks – low probability
- Semi-autonomous trucks – high probability
- Warehouse automation – high probability
- Drones – low to medium (mass market)
- Drones – medium to high (niche market)



CHAPTER THREE:

Digitization/ Internet enabled innovations

03

Innovation	Digitization/Internet enabled innovations
Trends	• E-commerce is transforming the retail sector with implications for the logistics and supply chain industry. Last mile parcels companies are reacting to consumer demand for greater flexibility and shorter delivery times. • On demand is increasingly important, enabling the instant delivery of a range of products. • Cross-border e-commerce platforms are providing opportunities for micro, small and medium-sized enterprises (MSMEs) to sell their products around the world. • The Internet of Things (IoT), enabled by low-cost sensor technology, is connecting consumers with suppliers and providing companies with a vast amount of big data. Artificial intelligence is being developed to analyze and make sense of the data. • Digital logistics markets are being established to better match freight capacity with demand, and crowd-shipping allows anyone with a smartphone to collect and deliver parcels.
Proposition	Digitization would enable new sources of growth by both increasing firms' participation in e-commerce and improving supply chain productivity and efficiency.
What is needed to achieve the state proposed?	• For cross-border e-commerce to develop, countries must adopt trade facilitation and tax harmonization measures, digitize trade documents and encourage foreign investment by logistics companies. • Investment in ICT infrastructure to stimulate digital innovations. • Encouragement of inclusiveness by promoting greater penetration of banking services.
What are the risks?	• Unethical employment practices in the new gig economy. • An increase in efficiency would bring less congestion. • High street retail disruption and unemployment. • "Disintermediation" of the traditional logistics market.
What are the opportunities?	• Growth of global markets for MSME e-commerce retailers. • Better use of logistics infrastructure capacity. • More efficient customs clearance practices and fewer irregularities.
What barriers may limit adoption?	• Insufficient investment in ICT infrastructure. • Lack of protection of Intellectual Property Rights as well as consumer protection. • Weak skills and training. • Lack of priority for logistics land use in rapidly urbanizing areas.
What is the potential for these innovations to be in place in 2030?	• High probability of e-commerce adoption which is already widespread. • Increasing adoption of IoT, big data and artificial intelligence in supply chains. • Medium-high probability of digital logistics markets, crowd-shipping and on demand deliveries.

Digitization —the process of converting information into a form which can be processed by computers— has had a seismic impact on the supply chain and logistics industry. As discussed below, it has led to new relationships being forged between customers, retailers, manufacturers and logistics companies.

One of the major benefits of digitization has been the potential to increase efficiencies. These include addressing supply chain wastes such as:

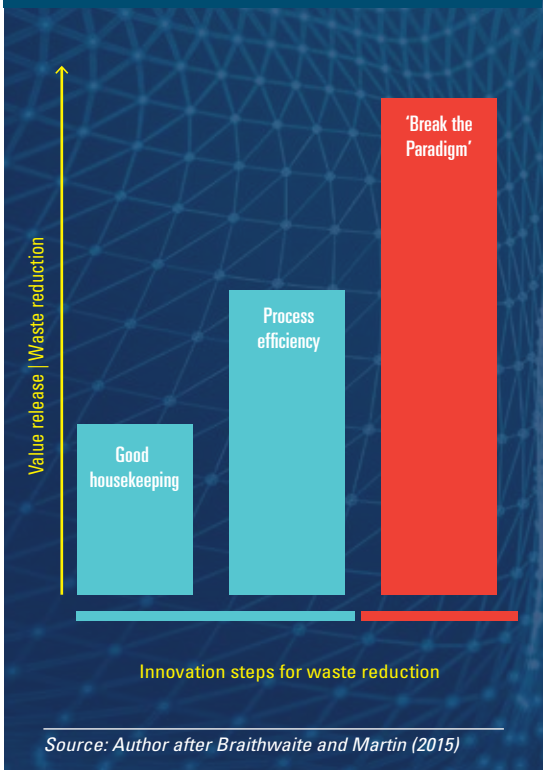
- Excessive inventory
- Imperfect market knowledge
- Space mismanagement (trucks, ships and warehousing)
- Unnecessary processing (for example, rekeying of data)
- Unnecessary transportation.

However, digitization has also created the opportunity to develop entirely new ways of operating. Not all companies have been able to adjust to this new paradigm as existing systems.

Figure 1 shows several companies use digitization, firstly to make existing operations more efficient by better management and planning, and then by improving internal processes. However, the third stage is to use digitization as a catalyst for change and reinvention, which requires an entirelynew perspective on delivering value to customers.

The way in which the democratization of technology has taken place means that it is no longer the preserve of companies with vast internal technology departments and huge budgets. Large companies must find ways to overcome the millstone of legacy systems and a sclerot-

Figure 1. "Breaking the Paradigm"



Source: Author after Braithwaite and Martin (2015)

ic management structure. The result has been an upsurge in MSMEs taking advantage of the lower barriers to market entry, with a major opportunity to enter markets previously controlled by giant multinational retailers. As discussed below, global platforms, such as eBay, allow local manufacturers based anywhere in the world to sell directly to consumers in developed markets, obviating the need for distributors or cutting deals with major retailers.

3.1 E-COMMERCE

Retailing, and the logistics and supply chain industry which supports it, has been transformed over the past two decades by the emergence of the e-commerce phenomenon. Well-known retailers, such as Woolworths, Toys"R"Us, Sears and K-Mart, to mention just a few, have faced restructuring or even bankruptcy, unable to compete in a market which has come to be dominated by the likes of Amazon, Alibaba and eBay. These companies have brought a new business model to the retailing industry —stores open 24/7 via a consumer's laptop or mobile device; the ability to compare products and prices; and prompt, low-cost delivery to the consumer's door or, in some cases, even to the consumer's fridge. The changing retail environment has led to a root-and-branch restructuring of the associated logistics and transport sector. Those companies which have been agile enough to embrace the new distribution channels with a host of new services have prospered. Not least amongst these have been the parcels companies responsible for last mile business-to-consumer (B2C) deliveries. This trend has also created a welcome new revenue stream for the post offices previously struggling to come to terms with the inexorable decline of mail volumes.

The express parcels industry has undergone a critical transformation over this period. At the outset, it was far from certain that many of the major express players, such as UPS, FedEx or DHL, would embrace home delivery due to the high costs involved in the number of undelivered parcels caused by "not-at-home" end-recipients. Today B2C is an important part of the major players' thinking and revenues. Delivery times are getting ever-faster, with the number of same-day and one- or two-hour delivery services rising, which is having a knock-on effect on customer expectations. End-recipients are also demanding greater flexibility as well as more delivery options, fitting in around their lifestyles rather than around the operational demands of parcel delivery companies. Technology is helping to bridge this gap, leading to higher levels of customer service combined with fewer failed deliveries. Alternative delivery solutions are also under development. Lockers, in car, or pick up/drop off networks are growing in popularity and omnichannel retailers have placed emphasis on click & collect offerings, which are not only convenient for customers but prove a useful source of revenue for retailers. Many logistics providers have tailored value-added solutions for transport, fulfillment and returns. They are also playing a role in many retailers' strategies as they support the expansion of services into new international markets.

On demand deliveries are an increasingly important aspect of e-commerce. The term has been defined as "instant delivery services provid[ing] on demand delivery within two hours —by either private individuals, independent contractors, or employees— by connect-

ing consignors, couriers and consignees via a digital platform" (Dablanc et al, 2017). Whether meals, products bought online or fashion items bought at a shop but delivered to buyers' homes, consumers increasingly want immediate access to their purchases. Whether a good thing or not, this is an unalterable part of modern life which suggests that on demand could be with us for many years to come. Moreover, it seems inevitable that the market might continue to grow. Consultants BIA/Kelsey estimate that in the US only 7% of the addressable market is served (Paine, 2017), which suggests that in other, less mature, parts of the world the opportunities are even bigger.

One of the highest areas of opportunity is expected to be in the cross-border segment of the market which is growing much faster than domestic volumes, albeit from a smaller starting point. Globally, consultancy Forrester forecasts cross-border e-commerce growth of 17% between 2017 and 2022, compared with 12% for overall e-commerce (cross-border and domestic) (Forrester, 2017). Cross-border purchases have been forecast at 20% of worldwide e-commerce by 2022, comprising some US$627 billion (Rodriguez, 2018). Another report by DHL says that cross-border e-commerce accounts for 15% of global e-commerce sales. By 2020, that share is expected to rise to approximately 22% (DHL, 2016). Of all markets, the Asia Pacific region is believed to be leading the way, in large part due to China, which is set to become the largest e-commerce cross-border market for both imports and exports. Rising incomes, an expanding middle class and dissatisfaction with domestic products are driving China's e-commerce growth. At the same time, the scope of cross-border e-commerce is also expanding. Fashion and electronics have long been cross-border top sellers, but consumers are now branching out further. Presently underserved product categories include beauty and cosmetics, pet care, food and beverage, and sporting goods.

E-commerce has the potential to link MSMEs throughout the world with global markets, facilitated by the major digital e-retailing platforms. This can bring major economic benefits for those who are able to embrace the opportunity. However, there are many logistical challenges which would have to be overcome if the opportunities are to be spread evenly throughout the world. Failure to address these could result in the global economy becoming further split into the digital haves and have-nots.

3.2 INTERNET OF THINGS, BIG DATA AND ARTIFICIAL INTELLIGENCE

The Internet of Things (IoT) is a term used to encompass the use of sensors, technology and networking to allow buildings, infrastructures, devices and additional "things" to share information without requiring human-to-human or human-to-computer interaction. It can create richer data and deeper intelligence for all parties in a supply network. According to research company IDC, by 2020, this IoT and the technology surrounding it is expected to be an US$1.1 trillion market in 2021, growing at 14.4% per year between 2017 and 2021 (IDC, 2017). IDC further suggests that the installed number of "things" connected would be 212 billion by the end of 2020, including 30.1 billion connected autonomous things. With the lower cost of production, sensors could become more economical for use in a range of supply chain applications. They provide visibility down to item level, a level of granularity that has thus far come at a significant cost. These visibility gains could result in substantial operational and financial benefits, as supply chains become far better at optimizing supply chains in real time and mitigating risks.

The connected consumer

Domestic automation, enabled by the IoT, includes a wide range of functions and appliances in households, many of which are not supply chain related (controlling heating and lighting for instance). However, other appliances can integrate the supply chain, such as a refrigerator. Using sensors and video cameras (monitoring the contents of the fridge), the appliance can be a portal for ordering and re-ordering perishable goods. The software can learn to recognize items, such as milk or tomatoes, and track buying behavior. Eventually, smart packaging should even be able to identify when products are out of date. The same principle applies to other household appliances. For example, washing machines and dishwashers can automatically reorder detergent, perhaps in conjunction with a virtual assistant. Sensors

can also be attached to appliances in order to perform predictive maintenance. This may enable them to perform self-diagnostics, alerting the service company to the fault and which parts are required.

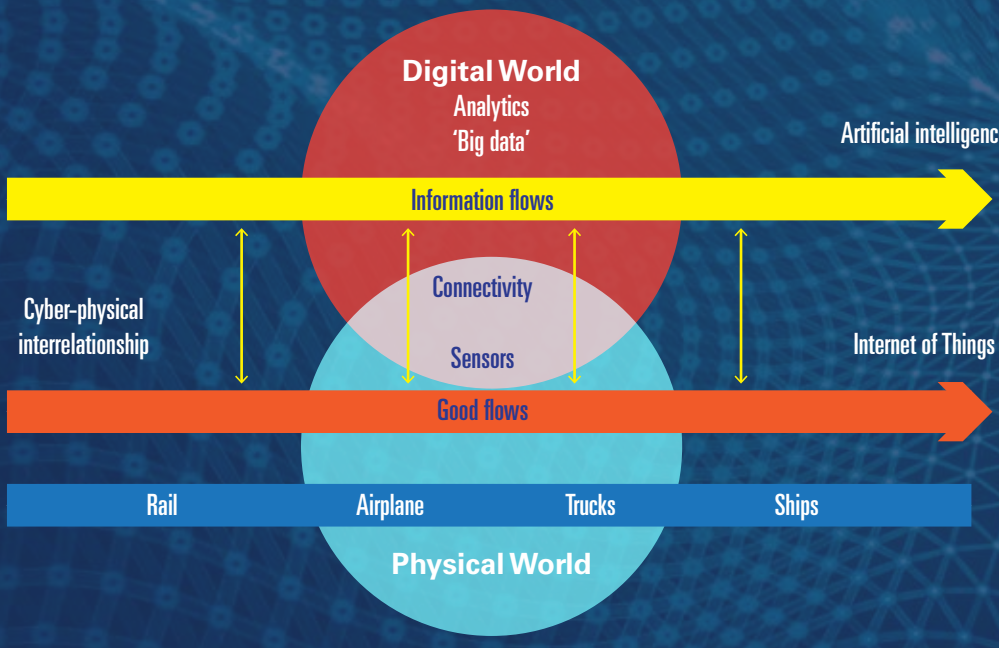
According to a Worldpay report, 44% of shoppers globally are already using connected home technologies, and 46% of those interviewed for the company said that they were happy for the devices to place orders automatically without human intervention (Worldpay, 2018). Other connected innovations could also change buyer behavior. 3D body scanners, for example, could encourage more consumers to buy clothes at home without going to the store to try them on. Although the advent of the connected home is inevitable and to be welcomed, there is also the need to improve cybersecurity. Either manufacturers would need to ensure their products are harder to subvert or users would need to reinforce their domestic infrastructure. This topic is often ignored by both media and manufacturers but could become a significant issue over the next few years.

Supply chain inventory management

Sensor technology would play an important role in making supply chains more efficient. For example, sensors on products can identify when stock is running low in-store (so-called "digital shelving") and enable reordering automatically. Stock levels on the shelves as well as in the stockroom, distribution centers as well as other stores can be linked and viewed, theoretically, on a real-time basis. Shipping containers can be tracked in real-time, providing an alert when a door is opened or if environmental parameters, such as temperature, are exceeded. Furthermore, visibility at the item-level allows retailers to keep much tighter control over shrinkage, which cost an estimated US$46.8 billion in the US in 2017, according to the US National Retail Federation (NRF, 2018).

The ubiquitous nature of low-cost sensors has led to the rise of big data. The trillions of data points which are now being generated mean that the availability of information is no longer

Figure 2. The Cyber-physical relationship in the supply chain



Source: Author

a problem. However, the challenge remains to be able to use such high levels of data to make informed decisions. Cloud-based control towers, which monitor and manage supply chain activity, are a step towards utilizing this data. They can deliver complete visibility from planning, operational performance monitoring, track and trace, event management to statistical analysis of shipment volumes. However, on their own they are insufficient. The potential of big data can only be exploited by removing human involvement from the decision-making process. Humans are just no longer capable of analyzing the overwhelming levels of data which are being generated. This is where artificial intelligence becomes critical.

Figure 2 shows the relationship which exists between the Physical World and the Digital World. Sensors in transport assets and actual products are able to communicate data about their status, location, condition and environment at every stage of the supply chain. The big data generated then requires a real-time analysis if it is to be of any use, allowing decisions to be made and which would create supply chain value such as exception-management, resulting in rerouting or change of delivery time, or intervention, such as precautionary maintenance on a truck or ship. All of this occurs without human interaction, working to a set of algorithms or rules which hard wires efficiency into the supply chain.

What is artificial intelligence (AI)?

AI is a broad concept, traditionally conceived as "the capability of a machine to imitate intelligent human behavior" (Merriam-Webster Dictionary, 2019). AI within the current commercial context is now broadly accepted as a term to convey a machine capable of performing tasks that would formerly require human intelligence, such as visual perception, speech recognition, decision-making, and language translation. For a machine to be artificially intelligent, it may be informed by human reasoning, but it does not necessarily need to function in the same way.

A fundamental component of AI is machine learning, a term which informally is defined as "the field of study that gives computers the ability to learn without being explicitly programmed" (Merriam-Webster Dictionary, 2019). For example, through this process, a computer can "learn" to distinguish a dog from a cat by learning from a data bank of thousands of categorized images and respond to human corrections to build an association between the data.

To leverage the benefits of AI, it is first necessary for the computer in question to have access to vast amounts of data, which is where big data becomes relevant. Moreover, in understanding the analogy of big data as the "fuel" for an AI "engine", it is also important to recognize the significance of the IoT as a means of generating useful data to be analyzed. As these technologies progress and mature, they would be increasingly embedded within a mutually supportive ecosystem, which operates and improves physical and virtual networks, such as supply chains.

The supply chain and logistics applications of AI include the operation of last mile delivery systems, providing end-recipients, for example, with greater levels of flexibility in delivery preferences; the development of the so-called connected consumer (utilizing the data generated by the proliferation of home assistants such as Amazon Echo); and warehouse automation, making decisions on the most efficient placement and picking routes. Predictive shipping is another concept based on analytics. The idea is that the shopping platform would make decisions on when and where to ship and hold product based on prior buying behavior, but before the consumer has even placed the order. This would allow manufacturers to locate inventory in optimal and potentially local storage locations and even, perhaps, to dispatch a product on a truck in readiness for an order.

3.3 DIGITAL LOGISTICS MARKETS

Numerous new technology platforms have entered the logistics market with the fundamental aim of better matching supply with demand. In the trucking sector, in theory, this offers the potential for better utilization of assets for carriers and lower rates for shippers. However, whilst the potential advantages of a digital brokerage service are relatively clear to shippers (lower costs, flexible capacity, assets

on demand), many companies operating in this field have failed to articulate clear benefits to carriers who fear a "race to the bottom" in terms of the rates they can charge.

Digitization is having a significant impact on efficiency levels in freight forwarding. Reliant on email and telephone communications to contact carriers and establish quotations and bookings, customers have perceived many freight forwarders have been perceived as low tech and unresponsive. The advent of cloud-based instant quotation and booking systems, such as Freightos and Cargobase, have resulted in dramatic improvements brought about in booking, quoting and price visibility. In response, many of the largest freight forwarders have developed online systems of their own.

3.4 CROWD-SHIPPING

One of the many benefits of these network connected smartphones is that they provide the means to combine users into virtual communities. Disruptors, such as Uber, have utilized this power to challenge regulated sectors such as personal mobility —but now also freight transportation. "Crowd-shipping" is part of this trend. The leading academic, Professor Alan McKinnon, says crowd-shipping "…effectively turns ordinary citizens into couriers, creating new informal logistics networks for the local distribution of small items ordered online" (McKinnon, 2016). The concept involves ordinary individuals taking parcels with them on an existing journey and stopping to effect the delivery en route. The benefit of this process is that the delivery has low marginal costs both in terms of the financial and environmental implications. It also means that the person carrying out the delivery gets reimbursed for their time and effort, creating value from an essentially non-value adding exercise. As McKinnon has also commented, "the growth of crowd-shipping is an example of people using social networking to behave collaboratively and share services and assets for the greater good of the community."

Although the term crowd-shipping originally referred to the practice as undertaken by ordinary individuals, some of the platforms established, such as Zipments, are used predominantly by professional couriers. Some, such as Deliv, are focused around the delivery of goods purchased in shopping malls. Deliv (part owned by UPS and operating in the US), for example, says it seeks to bridge the gap between multichannel retailers and their customers. DHL was one of the first companies to trial crowd-shipping as an addition to its existing service.

Whether or not crowd-shipping is undertaken by an individual, on their way to work, for example, or by a professional courier, is an important issue. Although it may not matter to the end-recipient, the shipper or, for that matter, the platform, there are implications in terms of road use, congestion and environmental impact. Professional couriers may travel much longer distances to collect and deliver shipments, making dedicated journeys for each consignment. By substituting a low-cost alternative to formal delivery networks traditionally involving the consolidation of parcels in vans, the result may be higher levels of congestion and emissions. Certain popular high-density delivery locations, such as an urban area, may attract large numbers of professional couriers from outside, exacerbating already over-crowded roads. Innovations such as "curbside" collections, where orders are picked by store staff and delivered on demand to the waiting customer outside the shop, could cause localized congestion.

IDB Proposition: Digitization will enable new sources of growth by both increasing firms' participation in e-commerce and improving supply chain productivity and efficiency.

3.5 WHAT IS NEEDED TO ACHIEVE THE STATE PROPOSED?

Although these innovations may seem diverse, at their heart is the democratization of technology. The power of the smartphone has empowered a new generation of entrepreneurs, the so-called "micro-multinationals". This provides an unprecedented opportunity for economies in developing regions to benefit from the access that global platforms provide (such as Amazon, eBay and Alibaba) to nascent exporters.

However, if these opportunities are to be fully embraced, governments should provide a

facilitating framework that allows companies to grow and develop at the same time as consumers are provided with the confidence to buy the services and products on offer. In that matter, they should:

- Ensure compliance with the WTO's Trade Facilitation Agreement and push for further deregulation which would facilitate trade and investment.
- Push for the digitization of regulatory required shipment metadata such as bills of lading or airway bills.
- Encourage greater cooperation between public organizations and private businesses, specifically MSMEs.
- Create a more open environment for international logistics operators to invest in domestic transport markets. This would increase the likelihood that market-leading technologies would be imported.
- Ensure e-commerce, handle tax and duties predictably. Since rules are often complex and differ widely from jurisdiction to jurisdiction, this presents traders and logistics companies with a major headache in compliance.

Of course, for these digital innovations to thrive, ICT infrastructure would require higher investment. Across the region, many countries are in different stages of development. In Uruguay household penetration of fixed broadband stood at 78.9% at the end of 2017 compared with just 43.4% in Brazil and 26.9% in the Dominican Republic (Telegeography, 2018). Mobile technology shows more advancement. According to GSMA, more than 400 million people are already connected to a mobile network, and more than 500 million would be connected by 2025. Operators would invest US$47 billion during the period 2018-2020. On the other hand, 4G, although experiencing a slow start, provides connections to about a 30% of users (GSMA, 2017) with 5G networks expected to reach 8% penetration by 2025. However, as with fixed broadband, there is a large degree of variance across the region. As of December 2017, just 11% of mobiles in Venezuela have 4G connections, compared with 46% in Brazil and a regional average of 30%. As a benchmark, 53% of connections with a smartphone in China are already 4G (GSMA 2017).

Airpay

AirPay's e-wallet operates in Thailand, Vietnam, Indonesia and the Philippines through 178,000 partner-operated services counters serving as "reverse ATMs" by taking cash deposits. The service can be used as an online shopping platform, as well as for making e-payments for everyday products and settling bills, therefore offering a financial inclusion option for the 60-70% of citizens in these countries without a bank account.

Source: World Economic Forum (WEF, 2018)

Higher penetration of banking services would play an important role in ensuring the inclusive nature of MSMEs in the new digital environment. In 2014, worldwide only 62% of adults held bank accounts making it difficult to access or sell services and products via the internet. In Mexico, the proportion of the adult population with an account was just 31% in 2014 although much higher in Brazil (68%) (World Bank, 2015). One of the main reasons behind this is the cost involved in having a bank account. Although one method of increasing so-called "financial literacy" would be to pay governments to pay state workers electronically, an evolving e-payment system may prove to be part of the solution.

Smart infrastructure

It is not just investment in purely digital assets that would be required. In order to facilitate the movement of physical goods, more investment by governments in smart transport infrastructure is necessary where the digital and physical are integrated. This would include the structural integration of sensing systems (for example, wireless or fiber optic) in the construction of new roads, railways, ports and airports. These sensors would generate vast amounts of data that can be analyzed to provide performance data but also to link transport networks with other intelligence networks. For example, sensors monitoring traffic flows working with dynamic road pricing systems and traffic controls to alleviate congestion.

London's approach to open data, a model for adoption

Whilst many organizations and administrations have taken the view that the data generated by the many sensors and cameras deployed must be protected within closed systems, Transport for London (TfL) took a different approach. It opened up all its public data to developers to use in their own software and services. This has led to the proliferation of innovative apps improving efficiency and transport user experience. The categories of open data include:

- Air quality.
- Passenger transport: Tube, Bus, Coach, River (service performance).
- Roads (congestion, live traffic disruptions, camera images, etc.).
- Network Statistics (most congested times on trains or tubes).

Due to TfL's open data policy, it is estimated that there are over 600 apps which are now being used by 42% of Londoners. TfL estimates that this has generated an economic benefit of up to £130 million per year in terms of customer, TfL and citywide value (Deloitte, 2017).

For freight movements, the benefits have largely been seen in time and cost savings as data on road works, congestion and accidents are fed into navigation systems. This also results in emission reductions. TfL also saves by not having to employ developers itself to provide these data —it estimates that 13,000 developers currently benefit from its open data approach. In addition, TfL also gains from access to data which it doesn't collect —such as crowdsourced traffic data.

Making ports smarter is also a priority area for the industry. Pressure on space, the need to improve productivity, cost pressures, environmental considerations and health and safety issues are driving the need to adopt technological innovations. Efforts have been hindered by complex and heterogeneous systems and also the competitive nature of many of the companies within the port community which limits data sharing. However, initiatives such as Nxtport (Antwerp), I Am Port (Amsterdam) and Portbase (Rotterdam) have sought to generate data and share it between shippers, shipping lines, forwarders, port operators and government agencies (Deloitte, 2017a). This can include the deployment of IoT technology, including sensors to monitor weather, bridges, traffic congestion and pollution. Other data services can also be integrated, such as automatic identification systems for ships and trucks, linked to GPS, providing insight into ship and container movements.

Digitization of trade documents and smart customs

One of the provisions of the WTO's Trade Facilitation Agreement is the simplification of trade processes, especially those that involve customs authorities. Signatories are expected to facilitate the acceptance of electronic trade documentation and the payment of duties electronically to ensure the rapid release and clearance of shipments whilst reducing time and cost for traders. This will include Single Window arrangements, meaning a single entry point for traders to submit required import, export or transit documents to multiple agencies (WEF, 2017a). A single window initiative in Senegal reduced preclearance and processing time by 90% from on average two weeks to one day and reduced the cost of border processes by 60%.

3.6 WHAT BARRIERS MAY LIMIT ADOPTION?

CT investment

Investment across the region in ICT infrastructure has not been consistent, which means that even within the same region it would happen what is termed as a "digital divide". The gap would increase even more quickly with developed markets, consigning countries which have not embraced the digital revolution to a future of possible stagnation.

Intellectual property rights

In a digital world, issues such as intellectual property rights would become even more important. Consequently, governments might

need to be in place legislation to protect international investors if they are to attract them.

Trust and consumer protection

Although trust networks are developing due to a range of initiatives undertaken by e-platforms, governments would still need to put in place legislation to protect the rights of the consumer. This is not least essential when dealing with the issue of e-commerce returns. Ideally, these regulations would be standardized across the region.

Skills

In many developing regions, the skills required by workers to compete in this new digital age are not yet developed. This is a fundamental barrier to the adoption of any of the innovations highlighted. The government would play an important role in ensuring that education systems prepare workers for the new environment, and by encouraging investment and allowing new businesses to compete on the world stage.

Urban planning

The growing consumer demand for e-commerce deliveries has resulted in a corresponding demand for warehouses, which can serve local areas in a short time scale. This means that, if the full economic value of on demand, crowd-sourcing and other courier services is to be realized, space needs to be made available in urban areas for distribution facilities. The requirement for inventory to be placed close to the end-user is at odds with the trend for warehouses to be built on cheaper, suburban land outside metro areas. However, new solutions are being developed which could make use of empty retail units as micro-fulfillment centers. For example, Inditex S.A., the parent of Zara, recently announced that it is exploring the use of existing stores as such centers. This strategy allows them to fulfill customer orders from the closest store, in the event the item is not available in a central warehouse (Lyon, 2018). Automated systems could be deployed within months, leveraging empty stores on the high street or in shopping malls, a situation caused not least by consumers' migration to online shopping (Melendez, 2018). Such innovations, however, could be held back by planning restrictions (the transfer of retail space to warehousing) and in this respect policy attitudes would play an important role. In Paris, for example, politicians objected to the market entrance of Amazon Prime Now, Amazon's on demand service, saying that it competed unfairly with local retailers. In Madrid, conversely, it was welcomed as a sign that the city was facilitating innovation.

3.7 WHAT ARE THE RISKS?

Ethical behavior and the gig economy

Volatility in the e-retail logistics market, characterized by frequent peaks and troughs of demand, has meant that the vast majority of last mile delivery companies have adopted an outsourced model. Subcontractors bear not only the cost of investment in transport assets but also carry the risk of revenues by being paid "by the drop" or by the mile. The e-retail market is such that so-called "free shipping" is a major selling point for many companies. Of course, the costs of this marketing device are pushed onto the carrier, resulting in ultralow rates of remuneration. This has raised ethical concerns. The low barriers to market entry and a plentiful supply of people willing to take on a low skilled job have meant that the amount paid by some carriers is barely enough to cover the cost of running a vehicle. There have been allegations that for some carriers their subcontractors are disposable. They can be utilized for a period of time at an unsustainable rate, knowing that they will eventually be forced to give up due to the lack of economic viability. The carrier will then replace the owner-driver from a plentiful pool of new market entrants. There is also the perception that many of these platforms pay low levels of tax.

Congestion and pollution

Although some of the digitalization innovations would make the market more efficient and cut congestion and pollution, this is not necessarily the case. A paper published by the International Transport Forum suggests that "lower transport costs [brought about by digitalization] could reinforce freight traffic growth making it harder to meet emission reduction targets" (ITF, 2018) Research already under-

taken suggests that on demand deliveries already account for 2.5% of all freight delivery trips in urban areas (Dablanc et al., 2017). As of June 2016, the authors estimate that there were 100,000 on demand pickups and 100,000 deliveries a week in Paris, although due to regulations on van use, this is largely carried out by bicycle. In other cities where regulations are not so tight, it can be assumed that on demand small vehicle movements are far greater. The authors conclude: "If this trend [for on demand deliveries] were to continue for the next few years then the results would be of major concern in terms of the impact on the urban street space and kerbside."

Retail market disruption

The e-retail revolution is having a major impact on the traditional retailing sector as both established brands (including such well-known names as Woolworths, Toys"R"Us and, most recently, Sears) and independent high street stores fail. The Center for Retail Research (CRR) estimated that, in the UK, 70,000 shops have closed since 2012; whilst at the same time online sales have grown by almost 88% (CRR, 2018). In the US, since 2001, department stores have reduced their workforce by half a million jobs (Petersen, 2017). Fears over volume stagnation are also driving consolidation in the market. In the UK grocery chains Sainsbury's and Asda, which is part-owned by Walmart, are proposing to merge; and, in France, speculation surrounds a potential tie-up between Carrefour and Casino. The implications for conventional logistics service providers are very significant. Traditional operations face a substantial risk of both rationalization and displacement by e-commerce solution technology companies. Fewer, but larger, conventional retailers would look to consolidate both transport and warehousing, while the demand that shifts into e-commerce would move business to other types of logistics provider. French retailer Casino, for example, is to use Ocado's smart-platform e-retailing package.

Logistics market disruption

The changes in the organization of the retail sector have indirect consequences to the associated logistics markets. Existing last mile delivery companies, such as the major express parcels carriers, have struggled to cope with the additional demands being placed upon them by e-retailers such as Amazon, Alibaba and JD.com. Enormous shipping volumes have at times overwhelmed services which were designed for business-to-business (B2B) rather than business-to-consumer (B2C) customers. Although parcels carrier have been investing heavily in their networks, in markets such as the US, China and Europe, e-retailers have built out their own infrastructure, developing their own logistics operations including warehousing and delivery services. In this way they are able to exert more control over a strategic area of operation, initiating new and flexible services whilst driving down costs. This has resulted in a period of what has been termed "co-opetition" with major express parcels carriers. In some markets and segments, e-retailers might seek to compete for business with logistics players (for example, Amazon's Fulfilled by Amazon product) whereas in others they might work in partnership. Even the CEO of shipping line Maersk has voiced his concerns that Amazon and Alibaba may become competitors if the shipping industry is not able to provide them with the service they need (Whiteman, 2018).

There is also the risk that digitalization could result in the disintermediation of logistics markets. Online market places allow manufacturers and retailers to book direct with asset-owning carriers, undertaking much of the role traditionally fulfilled by freight forwarders. However, although this risk is real, finding a competitive price is just one part of the process, albeit one that would be increasingly automated. As well as identifying the best route, the forwarder would also ensure that each international shipment must conform with a whole host of regulatory requirements from phytosanitary to certificate of origins, air cargo security, duty and tariff declaration obligations, letters of credit, insurance and risk, as well as being responsible for all the documentation. Freight forwarding would play an important role in the international movement of goods for many years to come.

3.8 WHAT ARE THE OPPORTUNITIES?

In the e-commerce sector, digitalization would mean that MSMEs in Latin America have an unprecedented opportunity to gain scale in

global markets and do not have to rely on local markets for their revenues. They are able to very cheaply access technology which originally cost many billions to develop but is now available to them at marginal cost. In many cases, the same product is available to both micro and multinational companies, a situation which would have been unthinkable just a few years ago. In addition, MSMEs have no need to deal with wholesalers. This means that they can provide single item sales at a much higher margin and engage directly with the end customer. These platforms also help them grow by providing them with all the services they need: financial processing, marketing and logistics (for example, by fulfilling the order on the customer's behalf). Previously it would take a very long time and considerable investment to develop this level of operation. Trust can also be developed more rapidly, whether manufacturer, retailer or transport company, by using a digital logistics market. Consumer reviews and oversight by the e-platform gives customers the confidence to place an order with an MSME rather than feeling compelled to use the brand of a much larger company.

Digital logistics markets also reduce congestion and increase efficiency by better matching capacity with demand. This translates to assets being better utilized, which increases profitability within the sector but also reduces environmental impact in terms of carbon emissions and other pollutants.

Where services or infrastructure are undeveloped, these innovations provide the opportunity for markets to leapfrog models employed in developed countries. An example of this is M-Pesa, a mobile phone-based money transfer, financing and microfinancing service, launched in 2007 in Africa. This service took advantage of the lack of financial and ICT infrastructure in the country to provide an innovative new way for customers to pay for goods.

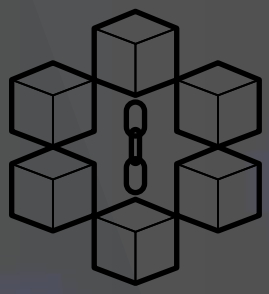
Though raising traditional trade finance from banks is presently difficult, future solutions under development by digital forwarders and other parties would make it much easier.

The digitization of trade documentation including information required for customs clearance should have a major impact on the potential for irregularities at borders. Manual processes allow for intervention which purely digital do not. This would reduce the burden on traders and speed clearance.

3.9 WHAT IS THE POTENTIAL FOR THESE INNOVATIONS TO BE IN PLACE IN 2030?

E-commerce, in many markets throughout Latin America, is already well advanced. However, it can't be said that the full potential has been fully realized. For MSMEs to exploit access to global markets, governments across the region must adopt the provisions of the WTO's Trade Facilitation Agreement and invest in transport infrastructure providing robust and comprehensive international connections. The Internet of Things and artificial intelligence would be steadily integrated within the supply chain and logistics sector, but adoption would be delayed by the ubiquitous nature of low-cost barcodes, their ecosystems (from retailers to manufacturers and the logistics providers in between) and tested reliability. Other digitized innovations will need investment in ICT networks as well as the development of skills. As a largely urbanized region with pressure on resources, there are many reasons why the sharing economy could be embraced to solve logistics challenges. On demand operations might become an important addition to the established hub and spoke networks of the express parcels carriers.

- E-commerce – high probability.
- Internet of Things – medium to high probability.
- Artificial intelligence – medium probability.
- Digital Logistics Markets – medium to high probability.
- Crowdshipping – medium to high probability.
- On demand – high probability.



CHAPTER FOUR:

BLOCKCHAIN

04

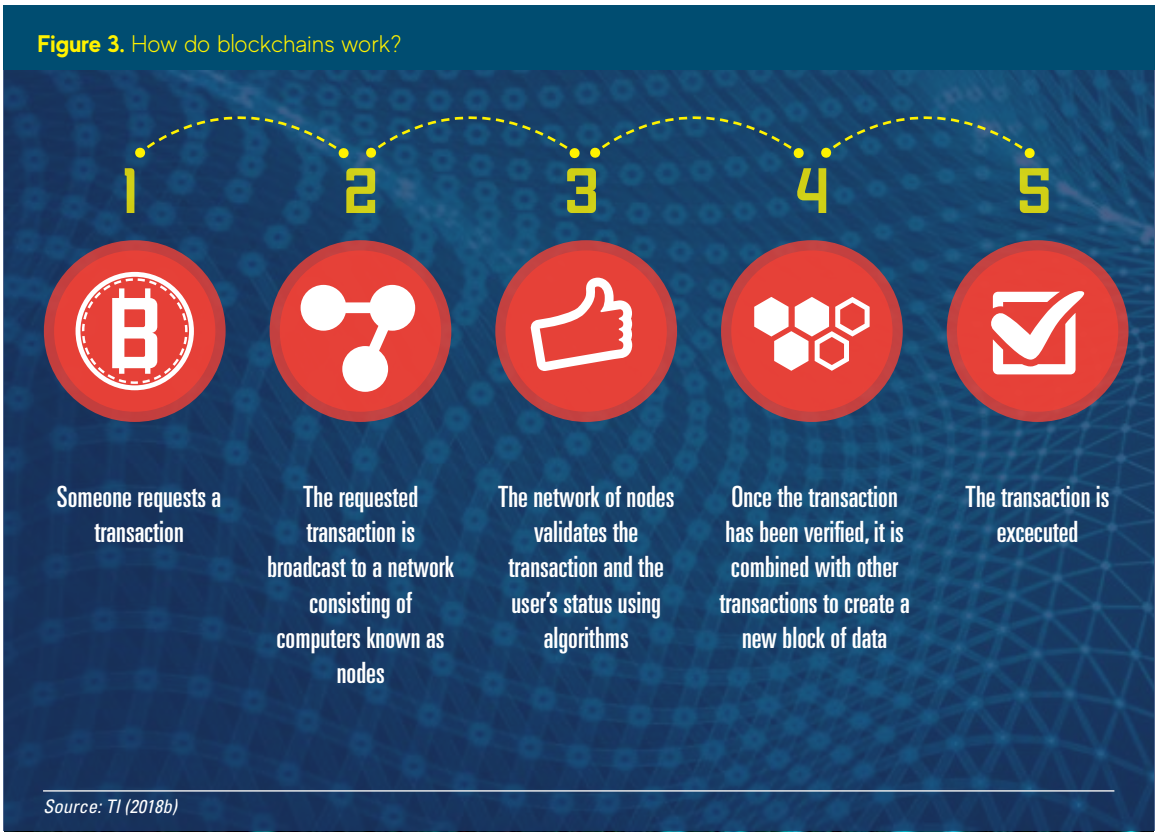
Innovation	Blockchain
Trends	• Blockchain is a permanent record of transactions stored across a decentralized network of computers. • It is increasingly being used as a system for supply chain data due to the high levels of trust and visibility it provides. • Blockchain is being used for smart contracts, which are automatically triggered once an event (such as final delivery) has occurred.
Proposition	Blockchain will become an established supply chain technology reducing costs as well as increasing trust, visibility and security.
What is needed to achieve the state proposed?	• Investment in broadband bandwidth or mobile technology will be required if emerging market traders are to access the Blockchain. • An increase in know-how and technology training will need to be facilitated and encouraged by governments.
What are the risks?	• There is a chance that the technology will not take off as predicted or will be superseded by competing technologies. • Smart contracts may not have legal standing in many jurisdictions. • MSMEs in emerging markets may miss out on the benefits that accrue to much larger shippers.
What are the opportunities?	• Blockchain provides higher levels of trust in the supply chain for all parties due to its immunity to tampering. • It is cheaper than existing systems, encouraging use by smaller shippers. • It provides transparent supply chains, increasingly important for sectors such as food and medicines. • It improves efficiency and removes the possibility of re-keying data, incorrect shipping charges or inaccuracies.
What barriers may limit adoption?	• Vulnerabilities in the presence of cyberattacks. • Anonymity and data privacy. • Lack of standards in place globally. • Lack of regulation as administrators struggle to keep up with the pace of development. • Lack of strategic investment. • The weakness of industry knowledge.
What is the potential for these innovations to be in place in 2030?	• There is a high probability that blockchain will be adopted widely by 2030, although this relies on the development of the underlying technologies and the infrastructures that facilitate it.

Although there is one clear master record, in a public blockchain the computers involved are not owned or controlled by any single party or organization. The network of computers supporting the blockchain confirm, verify and record the transactions independently, providing trust through consensus. This is an alternative approach to the explicit trust that is provided by a third party located between all of the participants, for example, banks or market exchanges, and it guarantees that transactions cannot be modified once confirmed in the blockchain, unless every computer (node) or a majority of them in the network agree to do so at the same time. If the blockchain network involved comprises a random number of machines outside the control of any single party, it becomes impossible to subvert. The implication of this is that public blockchains are likely to be more trusted and implicitly more secure.

In contrast, private blockchains require participants to be registered and conform to rules established by the owner of the blockchain. However, this poses the question of why a private blockchain would be preferred as opposed to a solution built around a centralized database. This is perhaps similar to the situation when the Internet became generally available to all. Many companies used the technologies supporting the Internet to build their own private Intranets. After creating these "walled gardens" (often for perfectly valid reasons) they soon realized that the open (public) Internet provided much more capability. The walled gardens soon opened up and these days, some companies only maintain their private Intranets where industry legislation requires (banks, for example). There are now a number of very large organizations coming together to collaborate around blockchain developments across industries. The Linux foundation's Hyperledger Fabric, R3's Corda and Microsoft's Coco are all examples of these, with Amazon's AWS about to enter the market as well.

Some blockchain exponents think that emerging markets will be amongst the biggest beneficiaries if they are able to adopt the new technology. This is because, unlike in the developed world, there is often an absence of trust in government systems and governance. As is discussed below, blockchain provides an alternative, independent and more effective

Figure 3. How do blockchains work?



Source: TI (2018b)

trust network which could come to underpin supply chains. There are other advantages to emerging markets too. The high transaction costs of doing business in the markets, the lack of incumbents or competing systems and the need for fairly simple solutions make these markets fertile ground for the benefits of blockchains.

Blockchain and smart contracts

Trade finance is one area in which Blockchain and associated smart contracts could significantly improve market access, especially for MSMEs, which have struggled since the 2009 financial crisis due to increased levels of risk assessment and enhanced due diligence (WEF, 2017b). Lawyers Allen and Overy have defined a smart contract as "...a set of promises, agreed between parties and encoded in software, which, when criteria are met, are performed automatically" (Allen & Overy, 2018). They don't exclusively involve trade finance contracts, but due to issues of trust, complexity, time and paper-based inefficiencies, the benefits that smart contracts can deliver to the sector are substantial. As the legal company says, blockchains easily provide an underlying trusted network conveniently and efficiently. By hardwiring the financial transaction process into software code, certain events can be triggered at specified milestones. The most obvious of these is at the point when the goods have been delivered. When the final delivery is made and a scan or electronic proof of delivery is generated, a signal can automatically be sent back up the supply chain, authorizing, for example, the release of funds to the exporter.

All of the above is under the assumption that the smart contract works in the way that both the exporter and importer intended. Whilst they may reduce human error by eliminating human intervention, this is not to say that errors cannot be made in programming the hard code in the first place. How this plays out in legal terms is really yet to be seen. According to lawyers, there is a reversal of the burden of litigation with the exporter having to pursue a claim for damages, as the shipment will have already been delivered and the importer will be in possession of the merchandise. At pres-

Airpay

A.P. Moller-Maersk and IBM entered into a joint venture to provide more efficient and secure methods for conducting global trade using blockchain technology. The new company aims to offer a jointly developed global trade digitization platform built on open standards and designed for use by the entire global shipping ecosystem. A shipping information pipeline would enable all actors involved in managing a supply chain to securely and seamlessly exchange information about shipment events in real time. The other core capability is paperless trade. This would digitize and automate paperwork filings by enabling end-users to securely submit, validate and approve documents across organizational boundaries, ultimately helping to reduce the time and cost for clearance and cargo movement.

Successful blockchain Trial Concludes in Singapore

Following the signing of the MOU in 2017, Pacific International Lines (PIL), terminal operator PSA International (PSA) and IBM worked on a Proof of Concept exercise built on IBM blockchain platform. The exercise tested a blockchain-based supply chain platform to track and trace cargo movement from Chongqing to Singapore. Core objectives of the trial included real-time track and trace, transparent and trustworthy execution of multimodal logistics capacity booking, regulatory-compliant execution of the multimodal logistics capacity booking processes and permission access control for ecosystem participants. The trial has been deemed a success by the operating partners.

ent, it would fall to the importing party to pursue a claim for damages when delivery had not been made under the terms of a contract. In addition, there are legal question marks over what happens when the smart contract becomes impossible to perform, or there is misrepresentation or illegality. In some cases, a smart contract may not be a contract at all, as it is not recognized by certain jurisdictions. However, more positively, the way that blockchain works in creating a single and unalterable record means that documentation duplication and even fraudulent invoice financing will become impossible.

IDB Proposition: Blockchain will become an established supply chain technology reducing costs as well as increasing trust, visibility and security.

4.1 WHAT IS NEEDED TO ACHIEVE THE STATE PROPOSED?

Although emerging markets could stand to be amongst the biggest beneficiaries of blockchain, most of the present investment in the technology is being made in markets in North America, Europe and Asia. Bringing blockchain to markets that struggle to access the internet will be a major challenge (Blockchain Council, 2018). Mobile technology could go some way to solving this problem. Mobile penetration rates are already high in most countries and according to the International Finance Corporation (IFC, 2017): "If Blockchain manages to provide proof of concept for a viable business model in payments for mobile banks and other financial players, it would advance the long-standing developmental goal of financial inclusion." This may provide blockchain with the capability of leapfrogging existing technologies due to the so-called "new market creation rationale". However, at present, smartphones are not able to read entire blockchains, which means that considerable investment and focus on this sector would be required. This may not be forthcoming if the main focus of the technology remains on developed markets.

4.2 WHAT ARE THE RISKS?

Blockchain technology is in its infancy and too much confidence in its successful development may be misplaced, especially in emerging markets such as Latin America. As a technology that is to some extent being funded by companies based in developed markets and by multinational companies with specific requirements, there are risks that MSMEs based in developing countries miss out on the full benefits of the technologies. For instance, will the technology be able to deal as successfully with the movement of multiple cross-border e-commerce parcels as it does with fewer numbers of predictable containers from Shanghai to Rotterdam? There are also risks (discussed below) in the creation of a

distributed ledger, since if it had no legal standing in the case of a dispute it would be useless. Legislation and regulation need to evolve at the same pace as the technology, a challenge even in developed markets (Devex, 2017).

4.3 WHAT ARE THE OPPORTUNITIES?

Trust development. One of the greatest opportunities presented by blockchain in emerging markets is how it can secure the entire process of a transaction, which provides all parties with trust in the system, from the seller, the bank, customs and border agencies through to the buyer. This is particularly important where the provenance of the product is required, for instance, if the Convention on International Trade in Endangered Speciesof Wild Fauna and Flora covers the good or it is part of a fair trade program. In developing countries, trust is a major issue and one that is regarded as a factor in delaying economic development. One economist suggests that traders in the poorest parts of the world do not have access to world markets due to the lack or unreliability of formal records and their unwillingness to provide data on themselves (Gupta and Knight, 2017). The latter point is largely due to the lack of trust in their own governments. Blockchain, however, by being secure and immune to tampering by other parties, may be able to provide traders with the confidence to enter a more formal economy. This means there is far less opportunity for fraud or corruption and gains for the trader become predictable. The efficiency of the technology also means that it becomes cheaper, encouraging more trading and resulting in a virtuous circle, encouraged by government investment, for example, in localized technology centers.

Supply chain integrity. In many markets, food chain and healthcare transparency are considered national priorities and there have been many pilot projects testing the appropriateness of such solutions. Consumers can access this information trail at any time by scanning product bar codes in the supermarket or local store and the information trail is revealed. This access to the data and information generated at each stage in the supply chain process can reduce costs and provide a very rapid response to any issues which develop.

Cost savings. Current industry estimates indicate that 10% of all freight invoices contain inaccurate data, including duplication, wrong freight mode charges and incorrect fees (Tanner, 2018). This leads to disputes as well as many other inefficiencies in the logistics industry. One of the major advantages of the blockchain is that it can power leaner, more automated and error-free processes.

Other benefits of applications in the sector are:

- Asset tracking and visibility across multiple tiers of the supply chain.
- Accountability.
- Process conformance.
- Improved collaboration across the supply chain.

4.4 WHAT BARRIERS MAY LIMIT ADOPTION?

Cybersecurity. Despite statements of being tamper-proof, there are concerns that vulnerabilities exist in blockchain technology. There have been cyberattacks on smart contracts.

Data privacy. Although there are claims that suggest that it would be impossible to access personal data on the blockchain, there are still worries that anonymity may not be totally guaranteed. Any successful hack would undermine the entire system.

Standards. Despite the emergence of platforms such as those mentioned above, no comprehensive supply chain standards are currently in place for blockchain solutions or providers. This means there are no definitive solutions to questions relating to a consensus on blocks and which encryption technology to use. A solid interoperability standard is very likely to emerge as the technology advances. An absence of such standards would add complexities, hindering supply chain applications due to confusing information exchanges.

Regulation. Regulation has failed to keep pace with the development of all new digital technologies and blockchain would be no different. Unless regulations are standardized and facilitatory rather than obstructive, companies will

be deterred from investing financially or operationally.

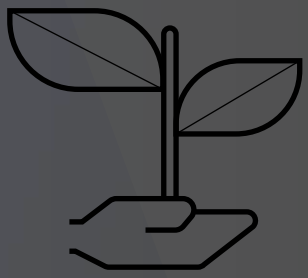
Strategic investment. As the technology is still largely at a nascent stage in development, companies require considerable management engagement to risk the significant investment of time, resources and money. The investment would mostly be undertaken by companies in the developed world, with small and fragmented exporters in emerging markets having little say.

Limited knowledge capital. The numbers of technology professionals with knowledge of blockchain are relatively few even in developed countries. A lack of experts would hinder the adoption of blockchain in Latin America, A situation which should only be addressed through the improvement of the talent pool.

4.5 WHAT IS THE POTENTIAL FOR THESE INNOVATIONS TO BE IN PLACE IN 2030?

Presently it remains to be seen if blockchain is adopted widely in the developed regions let alone emerging markets such as Latin America. Its adoption is reliant on the underlying technologies; the willingness of shippers and logistics providers to embrace the technology and the ICT infrastructures which underpin it.

- Blockchain – high probability of adoption.



CHAPTER FIVE:

SUSTAINABILITY

05

Innovation	Sustainability
Trends	• The circular economy is an alternative to the "take, make and waste" culture. Products are designed to retain some value at the end of their lives enabling them to be reused or repurposed. • The sharing economy is part of this trend. Platforms are under development to allow the better utilization of assets (such as cars) during their lifetime. • Manufacturers are increasingly selling access to products servitization, which gives them a vested interest in ensuring that the product lasts as long as possible. • Regulators are increasingly adopting diesel-bans on the grounds of public health and encouraging investment in clean technologies such as electric, hydrogen and biofuels. • Such technology is still at an early stage of development.
Proposition	Adoption of alternative business models such as the shared economy and clean fuel technologies would increase supply chain sustainability and reduce societal impact.
What is needed to achieve the state proposed?	• A partnership between government, NGOs and business to develop a framework for investment in and facilitation of new sustainable technologies. • Congestion and pollution control zones in cities. • The development of urban logistics centers to transship consignments from diesel to non-polluting trucks.
What are the risks?	• Logistics "sprawl" as land use policies favor residential use in cities, forcing warehouses further away from consumers and increasing emissions. • The impact of climate change on infrastructure from more extreme weather events and rising sea levels. • Misguided and untested public policy decisions which result in unintended consequences and economic harm.
What are the opportunities?	• Better use of materials and resources, leading to fewer carbon emissions and pollutants.
What barriers may limit adoption?	• Competition to alternative fuels from existing and improving diesel technology. • Lack of a comprehensive charging network which would encourage businesses to adopt non-diesel engine vehicles. • Insufficient electricity generation capacity and power distribution network.
What is the potential for these innovations to be in place in 2030?	• Economic imperatives would delay the adoption of sustainable technologies and business models as an increasing standard of living results in more consumer spending. • Alternative fuels might become more widely adopted as vehicle manufacturers import their technologies to emerging markets. • Sharing economy and servitization of manufacturing also would gain wide scale adoption due to commercial benefits.

5.1 THE CIRCULAR AND SHARING ECONOMY

The circular economy is seen as an alternative to existing linear economies where products, materials and components are discarded when their usefulness comes to an end, also known as "take, make, waste". Whilst in the latter model the value of materials reduces to nothing over the lifetime of the product in which they are integral, in the circular economy, design at the outset ensures that these materials retain some of their value, which ensures that it is economically viable to reuse them in one function or another. The concept requires a concerted effort by designers to develop products that can be made of reclaimed materials and also ensure that these materials can themselves be used in other products at their end-of-life. In a traditional manufacturing process, "virgin" materials are typically used, and there is the assumption of cheap and easily accessible energy. External costs of disposal and the wider environmental disbenefits generated throughout the manufacturing process are borne by society and not the producer or the consumer. This approach is looking increasingly outmoded, not least due to the increase of alternative business models being developed as part of the sharing economy.

The circular economy also has the advantage that it encourages manufacturers and retailers to look beyond production and sales to engage more closely with their customers in terms of product use. It also decouples the growth of their company from the sourcing and use of natural resources. In a book by Peter Lacy and Jakob Rutqvist, "Waste to Wealth, The Circular Economy Advantage" (2014), the authors identify five business models which could be adopted by companies to shift their businesses to a "new paradigm":

1. Circular Supply Chain: shift to the use of secondary materials for new products as an alternative to "virgin" resources.

2. Recovery and recycling: recover value at end of life.

3. Prolong product life.

4. Sharing economy, for example, Uber and AirBnB.

5. Shift from the sale of products to selling access to products.

Whilst the first three of these innovations could be related directly to materials, the last two involve the development of new markets and ways of doing business. For example, the authors say that 80% of products kept in the typical home are only used on average once a month. The sharing economy means that new platforms are being developed to better utilize these assets by matching latent supply with demand. The best known examples are Uber and Lyft (relating to the use of cars and time) and AirBnB, relating to the use of spare room space. By using these assets more efficiently, fewer cars or homes/hotels need to be built, meaning that fewer resources are required in the first place. At the same time, consumers and microentrepreneurs are able to save and/or make money, leading to economic growth (decoupled, as mentioned earlier, from resource exploitation).

Effectively, new technologies have enabled transaction costs to be reduced whilst at the same time as matching supply and demand. It works best when consumers have an expensive and under-utilized asset. They are then able to rent out access to this asset with the software application providing a range of transaction-facilitating services such as advertising its availability; letting prospective customers know its location (through GPS); providing social network feedback on the trustworthiness and customer service of the supplier and handling the billing. All these services may have existed in one form or another prior to the onset of the sharing economy. However, they were often too inefficient or expensive to make the exercise worthwhile for customer or supplier. Examples of this model being deployed in the supply chain include on demand warehousing platforms provided by Stowga or Flexe (an AirBnB-like solution for inventory) and truck trailer capacity sharing platforms (such as that provided by Equivvy).

The shift from manufacturing products to "selling access" to them (a process referred to as "servitization" or "product as a service") is a transformational concept increasingly common in some niche sectors. The model involves the leasing of goods by the consumer while the manufacturer takes on responsibility for the total cost of ownership, including maintenance and repair. This would mean that manufacturers take more interest in longevity, reliability and reusability. As Lacy and Rutqvist (2014) say, "Performance trumps volume, durability tops disposability, and companies have an opportunity to build new relationships with consumers." Perhaps as important for the manufacturers, it also means that there is a way of reducing commoditization of products through adding value.

One of the most developed sectors in this respect is the defense and aerospace, which for years has practiced "performance based logistics". It is now being joined by high tech manufacturers, such as those which provide server capacity, and other high tech sectors, such as lighting. Although these sectors are by no means insignificant, the greatest gains will be achieved if the model gains traction in the "big ticket" slow moving consumer goods market. If manufacturers took over the responsibility for maintaining white goods such as ovens, washing machines and fridges, a substantial impact would be made on waste goods.

5.2 ALTERNATIVE FUELS

It is clear from the environmental and public health policies being adopted by most administrators and regulators around the world that diesel-powered vans and trucks would make up a much smaller proportion of the commercial vehicle fleets in the years ahead. It is also clear that, despite a wide range of alternatives, not one single form of fuel or technology would be able to replace diesel across the board. The demands placed on commercial vehicles are very different not least due to the diverse functions which these vehicles undertake, the weight of freight they move, the number of stops they make and the range they require. Light commercial vehicles (vans), for example, are likely to make multiple drops, work within urban areas and carry lighter loads. Heavier goods vehicles, in contrast —

need greater range—, would stop fewer times and obviously carry heavier loads. One of the main advantages of diesel power is its versatility; it performs well in multiple roles. This is certainly not the case for alternative powertrains —at the moment, there is no single technology able to supersede diesel (or for that matter petrol) powered engines. As European Automotive Manufacturers Association (ACEA) Secretary General Erik Jonnaert stated, "Different transport needs require different transport solutions" (ACEA, 2017). Policies must recognize and support this market-based approach while encouraging the use of sustainable energy sources.

Another issue for industry is that without government support or, indeed, environmental regulation, alternative propulsion systems are unlikely to have been developed. The overwhelming operational advantages and the scope for making diesel technology even more efficient would have provided little impetus for investment in suboptimal technologies. This is important because it has led to the trial of a proliferation of technologies, often subsidized, many of which are highlighted below. For a fleet procurement manager, the choices used to be much simpler, based on efficiencies, power and cost with all van/truck manufacturers providing similar products. Now the landscape looks set to become much more complex with not only competing manufacturers but competing technologies against a backdrop of shifting government regulation and subsidy. Although there is no overwhelming consensus on which technology is necessarily right for which vehicle, it seems clear that electric or electric hybrid technology is being favored for vans, especially for intraurban deliveries although hydraulic hybrids are also being developed (see below for an explanation of terms).

The advent of electric-powered heavy goods vehicles is much further off, despite work being undertaken by manufacturers in the US such as Tesla. Indeed, the UK's National Grid takes a very negative view of the potential for electrically powered heavy goods vehicles. It says that "currently the electrification of heavy goods vehicles is not considered viable and other fuel types are considered more likely for these larger vehicles." It believes that natural gas would be the fuel of choice (National Grid, 2017). This is not a view shared by all. Pasquale Romano, president and CEO of ChargePoint, has commented, "The drivetrain debate has ended and electrification has won out as the propulsion method of choice across transportation categories, as evidenced by the growing interest in electrifying semi-trucks, aircraft and beyond" (Behr, 2018). This would suggest he believes that advances in technology would reduce the size and weight of the batteries whilst still providing the power to carry large payloads over long distances (as do Tesla).

Biofuels

The development of biofuels (any fuel which has been derived from organic matter or animal waste) is becoming increasingly important not only for commercial vehicles but as a replacement for bunker fuels for ships or aviation gas. The type of biofuel adopted relies to a certain extent on the availability of the raw materials. Although seemingly a sustainable alternative to fossil fuels, there are problems with the environmental credentials of biofuels. Evidence on carbon dioxide emissions is ambiguous depending on the life cycle assessment (LCA) used due to the carbon emissions involved in the growing, harvesting, production and transport of biofuels (RAE, 2017).

Natural Gas (NG)

There are around 220,000 medium and heavy-duty trucks powered by NG in the world, their popularity is driven by low emissions of nitrogen oxides and particulates. They are also quieter than equivalent diesel-powered engines, which makes them well suited to urban deliveries. One of the operational disadvantages of the fuel is that fuelling stations need expensive and complicated equipment (such as cryogenic storage tanks) adding to costs and availability. Another major disadvantage of natural gas is its environmental credentials. As a fossil fuel, it is considered unclean.

Hydrogen Fuel Cell

Hydrogen has the potential to be a completely clean form of energy in terms of tailpipe emissions. Electricity is produced from the chemical reaction between hydrogen and oxygen leaving only water vapor as the waste residue.

The electricity is then used to power the vehicle. However, hydrogen is not the answer to all pollution problems as the element has to be produced and depending on the energy source used (coal or gas for example) there could be high levels of carbon emissions involved. Another issue would be the development of a hydrogen refueling network.

Electric Vehicles

Electric vehicles (EVs) have attracted much of the publicity in recent years as "zero-tailgate" emissions have become the political imperative. From an operational perspective, the main challenges facing electric van and truck manufacturers are the range (dealt with earlier in this paper) and that the batteries required to power freight carrying vehicles are relatively large and heavy. This means that the vehicles are only appropriate for certain sectors, such as city logistics. Hybrid vehicles, which use a combination of diesel fuel and electric, have, however, become more widely adopted. The advantage of electric vehicles is that there are virtually no emissions from the exhaust pipe and they are also very quiet. Whilst local pollution may be eliminated, in terms of carbon emissions, the sustainability of electric vehicles is reliant on the type of fuel used to generate the electricity that charges the batteries. Tesla and other automanufacturers are investing huge sums in battery technology and it seems inevitable that in the next five years it might become feasible for even the largest trucks to be powered by electricity. Up to then, electric vehicles could probably be restricted to urban deliveries, although given the growth of cities this is an important sector in its own right.

IDB Proposition: Adoption of alternative business models such as the shared economy and clean fuel technologies would increase supply chain sustainability and reduce societal impact

5.3 WHAT IS NEEDED TO ACHIEVE THE STATE PROPOSED?

A partnership between governments, non-governmental organizations and business would be required to develop an effective approach to increasing levels of sustainability in the supply chain and logistics industry. To encourage the development of technologies which could mitigate environmental impact, a range of government support or tax breaks may be necessary. Many governments have also taken the step to combine this approach with one of regulation, for example, introducing bans on the movements of cars and trucks in urban areas.

According to the United Nations' climate and clean air coalition, 9 out of 10 people around the world live in an environment where pollution levels exceed World Health Organization limits (WHO, 2018). Diesel emissions are regarded as a primary source of pollutants and have been blamed for the premature deaths of 3 million people a year. A report by the French Senate estimated that air pollution cost the country €100 billion a year (Euractiv, 2015). In this respect, political momentum is gathering pace. The Institute for Public Policy Research has stated that "it is likely that diesel cars [and trucks] will have to be completely phased out … over the next decade in order to reach compliance with safe and legal levels of air pollution" (Coates, 2016).

Typically, regulations on urban freight operations have included:

- Restrictions on delivery times.
- Routing schemes which regulate when and where goods vehicles can go.
- Loading/off-loading zones.
- Weight and size restrictions.
- Arbitrary day bans on vehicles (such as odd/even number plate measures).

In December 2016, the mayors of Paris, Mexico City, Madrid and Athens committed to ban not only diesel-engined trucks but also cars from their cities by 2025. They say that they would, at the same time, incentivize the use of alternative fuels and electric vehicles. However, a number of measures in cities around the world have already been implemented to regulate the use of vehicles. London has been at the forefront of introducing controls to limit

the amount of congestion and pollution on its roads:

- Congestion charge is in place since 2003.
- London's Low Emission Zone was introduced in 2008.
- Vehicles registered before 1 October 2006 entering a designated zone have to pay a charge.
- London Lorry Control Scheme is another initiative designed to minimize noise pollution rather than air pollution.

As one of the cities to agree to a ban on diesel-engined vehicles by 2025, Mexico City already has advanced plans for the implementation of a Low Emissions Zone to reduce air pollution. The city —part of a wider conurbation comprising 25 million people with approximately 4 million cars— is situated in a valley, which has exacerbated the problem of pollution. The city already implements so-called license plate bans which allows the authorities to regulate the number of days individual vehicles are allowed within a proscribed area. This works by prohibiting vehicles whose license plate ends with a certain number from entering the city between certain times (usually 5:00 a.m. to 10:00 p.m.).

Apart from the parallel development of alternative power sources to the phasing out of diesel, there are ways in which logistics in inner-city urban areas can be made more efficient through public-private initiatives. One such option is the development of Urban Logistics Centers (otherwise known as Urban Consolidation Centers) or cross-docking facilities. ULCs are designed to:

- Reduce the number and loaded/unloaded mileage of vehicles in the inner city area.
- Increase the intensity of use of vehicles by ensuring greater utilization rates.

They do this by consolidating consignments from a range of shippers for delivery in a more efficient way to end-recipients in urban areas, potentially by electric vehicle.

Any diesel ban would create the need for large numbers of consolidation centers located on the main arterial routes into an urban area. These routes are already often characterized by competing land use needs, not least housing. The additional stage, and consequent delays, in the supply chain created by consolidation would mean that there would also be a requirement within the urban area for additional holdings of inventory to ensure that just-in-time deliveries could be maintained. These would be much smaller units.

5.4 WHAT BARRIERS MAY LIMIT ADOPTION?

The development of alternative fuels is taking place in competition with existing diesel technologies. There is no doubt that if diesel engine technologies had not advanced to the extent that they have, the adoption of hydrogen cells, electric vehicles or biofuels would have been much faster. As diesel-engined vehicles have become more efficient they have consolidated the technology's market leading position in terms of cost and all-around utility. Manufacturers believe that there are many enhancements to come, and if it hadn't been from the public policy imperative, there would be few commercial reasons for change.

In addition to this is the concept of an innovation ecosystem (Adner and Kapoor, 2016). This essentially means that the required infrastructure needs to be in place before an innovative new business model can be adopted. Alternative fuels are, again, a good example. Before drivers or companies feel confident in investing in the new type of electric propulsion system, a comprehensive charging network must be built to address concerns over "range anxiety." It is only when old technology has no more room for improvement, and when the infrastructure that supports the innovation is in place, that substitution can start to happen. Until then, technologies would exist side-by-side for a period until old technology or business models are abandoned. Hybrid engines are a very good example of this coexistence. The new technology works in parallel with the "old" removing the problem of the lack of charging infrastructure.

A fundamental question for the electric vehicle sector is whether enough electricity can be

generated to cope with the vast numbers of cars and trucks which are being forecast. One piece of research undertaken for a power network provider, National Grid (2017), forecasts that an additional 18GW of demand would be created in the UK alone by a take-up of electric vehicles (both cars and commercial vehicles) by 2050 —almost a third more than the peak power required in 2017. Power demand would be at its highest if consumers (and businesses) charge their vehicles at peak times —a real challenge to the grid in developed countries and perhaps overwhelming in many countries with less developed generation capacities. However, the best case scenario suggests that if consumers and businesses charge at off-peak times, the peak demand would be much more manageable.

To spread demand there would need to be a combination of:

- Tariffs to encourage efficient charging behavior by consumers and businesses.

- Smart technology which identifies the best time to charge vehicles.

It is not only power generation which would be an issue, local grid infrastructure constraints are one of the main barriers to their large-scale uptake, especially in urban areas.

5.5 WHAT ARE THE RISKS?

Environmental risks from poor public policies

Land use

Policy decisions related to land use can have implications for supply chain sustainability. One such challenge at the moment in many cities is that the amount of space allocated for distribution facilities is significantly reducing due to the increasing demand for residential real estate. This is already leading to what is termed "logistics sprawl" as warehousing becomes suburbanized, as warehouse owners seek lower cost land. This has implications for transport and, subsequently, emissions and congestion, as final delivery to urban consumers becomes more extended. This has been recognized in London, where in Greater London warehousing floor-space fell in all central London boroughs over the decade between 1998 and 2008 (by 82% in the City of London, 51% in Westminster), and also in many other inner London boroughs. In contrast, growth in warehousing space was strong in many outer London boroughs over the same period (Allen et al., 2012). According to a report for the London Mayor, between 2010 and 2015, 528 hectares of industrial land was released to nonindustrial uses, a 7% contraction in the stock of industrial land (TfL, 2015). The report concluded that this relocation of warehouses outside of the inner urban area could result in increased congestion, higher emissions and higher consumer prices. Diesel bans would inevitably consolidate the trend towards suburban warehousing as warehousing would cluster around main arterial routes at the edge of the low emissions zones. This runs counter to the growing need by e-commerce providers for local facilities for on demand deliveries (see above).

Climate change

The risks of climate change to the supply chain are likely to be severe in terms of disruption:

- Increased temperatures can lead to the melting of tar and bitumen, degrading road surfaces and warping of bridges, rail tracks and other structures.

- Extremely low temperatures lead to the creation of potholes, as water in cracks expands and contracts. This also means greater costs in terms of repair.

- Increased rainfall leads to flooding which also threatens the integrity of road and railways as well as threatening bridges.

- Rising sea levels and storm surges can affect coastal road/rail infrastructure as well as ports and airports located close to the sea (for example, Hong Kong Airport).

- Increased severity of snow storms and ice can disrupt airports as well as road and rail.

- High winds can close bridges and damage overhead electric cables on railways as well as bring down trees blocking roads.

- Lightning strikes can impact on information and communication systems.

As well as reducing carbon emissions through cleaner technology and more efficient digital supply chains, risk will be mitigated by climate proofing logistics infrastructure, for example, by using more heat resistant materials in road surfaces or rail tracks, which are better able to cope with contraction and expansion in extreme temperatures.

Economic risks from poor public policies

There are also economic risks from the implementation of poor public policies. The effect of regulations and bans on diesel-engined vehicles on supply chains and the wider logistics sector is yet to be fully understood and this could reduce cities' ability to compete globally. New solutions regarding public policy which address economic, societal and environmental concerns would be required.

Many countries around the world have already instituted controls on vehicles (including trucks) entering urban areas. For example, low emissions zones have been established in major cities such as Delhi, Tokyo, Beijing, Singapore, and Mexico City, as well as most of those in Europe. However, there is very little consistency in the forms of regulatory measures imposed within these zones. This is perhaps unsurprising given the diverse characteristics of each urban area. Some ban certain types of engine standard whilst others impose a charge on them. There is also a lack of consistency in how the regulations are imposed. Some use a "sticker" system, others more sophisticated number plate recognition technology. As many of these challenges are new to policymakers, pilot initiatives are required to determine which are most effective.

Presently, electric vehicles are not sufficiently developed to provide a practical alternative and the costs would be prohibitive. It may be at least ten years before electric vehicles are able to replace diesel trucks in any great quantities. There is not only the issue of the technological development required, but also (perhaps most importantly) the impact that a large scale migration from combustion engine power to the use of grid energy would have on national power generation strategies. In many countries, electricity grids often struggle to provide the power required for existing use without the enormous additional demand for new electric trucks and, of course, cars.

5.6 WHAT ARE THE OPPORTUNITIES?

Logistics and supply chain technologies would play an important role in mitigating the impact of the industry on the environment. Many of the innovations discussed elsewhere in this paper will improve the industry's sustainability due to their focus on efficiency improvements. For example, Digital Logistics Markets, which better match demand with trucking capacity, would result in the need for fewer trucks on the road. Consequently, there would be less embedded carbon and, of course, fewer emissions. A whitepaper on the sector by the Ellen MacArthur Foundation (EMF, 2015) sets out ten circular economy opportunities in five sectors:

Table 1: Ten opportunities for the circular economy

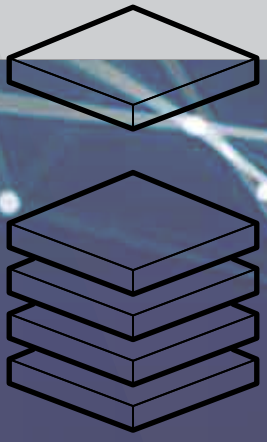
Food and beverage	• Value capture in biorefineries • Reduction of avoidable food waste
Construction and real estate	• Industrialized production and 3D printing of building modules • Reuse and high value recycling of components and materials • Sharing and multipurposing of buildings
Machinery	• Remanufacturing and new business models
Packaging	• Increased recycling • Bio-based packaging
Hospitals	• Performance models in procurement • Waste reduction and recycling

The report claims that in Denmark, where the research was undertaken, 10-15% of building materials are wasted and food waste amounts to 80-90kg per person per year. These could be reduced to less than 1% and 40-50kg per capita per annum respectively by 2035 if a circular economy was achieved. Conservatively this would lower Denmark's CO2 footprint by 2.5% in terms of million tonnes, increase jobs by 0.4% and add 0.8% to the Danish economy by 2035. More ambitious targets would lead to a reduction in CO2 of 6.9%, create 0.6% more jobs and add 1.4% to the Danish economy by 2035. Interestingly, the authors believe that 3D printing and industrialized production of building modules could create the greatest annual value in terms of the potential economic impact of circular economy opportunities (33% of the total). However, they do recognize that the technology is not yet available at the required scale to deliver these benefits as yet. Should the technology come to maturity, this would have a significant impact on the logistics sector and will be discussed at more length below. According to another report, "London: The Circular Economy Capital", the circular economy could bring London benefits of at least £7 billion "every year by 2036" (LWRB, 2015). This not only refers to products but also to construction projects; for example, where there are opportunities to reuse existing materials. In this respect, London is a good model for many cities being developed in Latin America.

5.7 WHAT POTENTIAL FOR THESE INNOVATIONS TO BE IN PLACE IN 2030?

In a fast developing region where economic goals can achieve higher public policy status than sustainability, there is a risk that rising standards of living and consumer spending result in pejorative impacts on the environment and society. Such an example would be an explosion in the number of vehicles on the region's roads and the congestion and emissions this would cause. However, far-sighted governments would encourage many of the sustainable benefits of technology innovations such as the sharing economy and digital logistics platforms as a solution to these challenges. Investment in alternative fuels would rise significantly, driven not least by public policy decisions to impose diesel bans in urban areas. However, improvements in diesel technology and delays in the construction of charging networks could delay the adoption of alternative fuels.

- Circular supply chain – low to medium probability.
- Recovery and recycling – medium to high probability.
- Sharing Economy – medium probability.
- Servitization – medium to high probability.
- Alternative fuels – medium to high probability.



CHAPTER SIX:

3D PRINTING

06

Innovation	3D printing
Trends	• 3D printing is a manufacturing technology, originally designed for prototypes, but now increasingly used in mainstream production. • Items can be produced on demand, fully customized and utilizing sophisticated designs, resulting in less waste, lighter parts and lower lead times. • Eventually, supply chains which rely on outsourced component suppliers and the movement of large volumes of intermediate goods could be replaced by 3D printing facilities located close to end-markets.
Proposition	3D printing technologies will transform global value chains providing more opportunities for product customization and consumer choice.
What is needed to achieve the state proposed?	• Investment in research and development centers specializing in this technology. • Funding by governments of pilot projects. • Establishing a regulatory framework addressing IP, product quality standards and product liability.
What are the risks?	• Deglobalization as emerging markets lose low labor cost advantage as automation reduces the numbers of manufacturing workers required for mass production. • Emerging markets remain "commoditized" due to their inability to capture added value by developing material refining facilities. • Lower volumes of international shipments, impacting on shipping and air cargo companies. • Loss of tariff and duty revenues as fewer goods cross international borders. • Potential for lower product standards as fewer controls on manufactured goods.
What are the opportunities?	• Increased demand for mineral resources from emerging markets to supply the 3D Printer materials required. • MSMEs can design and produce goods without huge capital outlay. • Reduction in inventory and postponed manufacturing opportunities. • Fewer emissions due to less production waste and fewer transport movements.
What barriers may limit adoption?	• Manufacturers have been slow to change their production strategies due not least to the historic investment in traditional technologies. • Lack of knowledge resources, training and skills. • Regulatory issues related to IP, counterfeiting, quality control and liability. • High cost per piece and time take to print multiple parts.
What is the potential for these innovations to be in place in 2030?	• The technology would take time to be assimilated into existing manufacturing strategies and therefore there is a low-to-medium probability of adoption by 2030.

3D printing was originally developed as an automated method of producing prototypes. Although there are several competing technologies, most work on the basis of building up layers of material (sometimes plastic, ceramics or metal powders) using a computer-aided design. Hence, it is referred to as an "additive" process; each layer is "printed" until a three-dimensional product is created. Products can be lighter than those manufactured traditionally, but just as strong, and there is also less wastage. Mechanical parts, shoes, fashion items and accessories and other consumer goods, can all be printed for review by the designer or engineers, and revisions printed equally as easily.

3D printing is now becoming more regularly used for mainstream production although confined to certain specialist parts of the manufacturing process. It has many benefits over traditional reductive production techniques, these being:

- Faster iteration of prototypes.
- Lower lead times.
- Elimination of tools and molds.
- Reduction of component weight without compromising on strength ("light weighting").
- Reduction of material loss.
- Replacement of parts quickly and easily.
- Optimizing computer aided designs.
- Customization of parts.
- Postponed manufacturing opportunities.
- Reduction in supply chain risk through less out-sourcing.
- Elimination of "bull whip" inventory effect and safety stocks of intermediate goods.

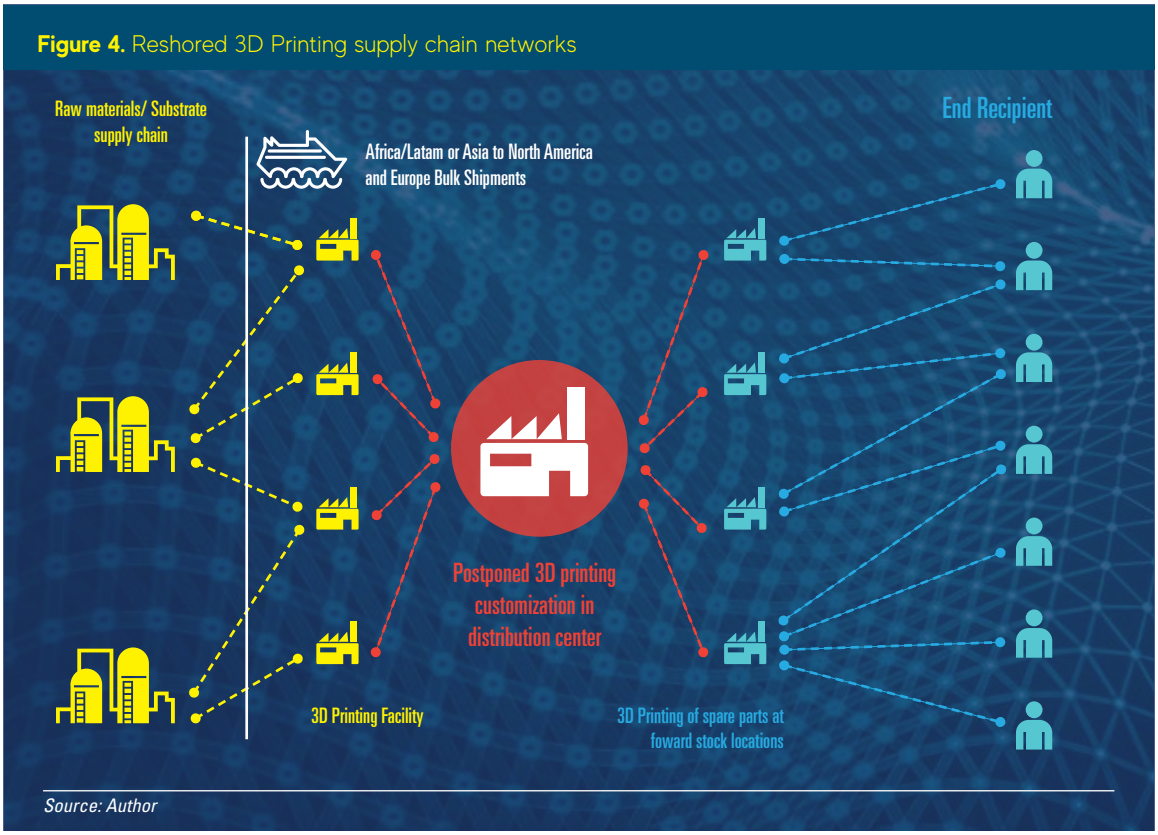
According to a report by consultancy Deloitte (2018), 3D printing is to be most widely adopted in automotive design-rapid prototype printing, aerospace and defense parts printing. The authors predict that the market would grow from US$13 billion in 2016 to US$36 billion in 2021. The way in which each product is individually manufactured means that it is ideal for "mass customization" techniques. Consumers would, in theory, be able to have a much greater say in the final format of the product that they are buying, and have it manufactured to their precise specifications. As yet, traditional manufacturing holds sway in sectors where mass production is still required, but this is likely to change as printer technology becomes cheaper and printers get faster.

Why will 3D printing disrupt supply chains?

In a whitepaper on the subject (Manners-Bell and Lyon, 2015), it was asserted that 3D printing had the potential to become the biggest single disruptive phenomenon to impact global industry since assembly lines were introduced in early 20th century America. The authors went on to say, "New technologies which are currently being developed could revolutionize production techniques, resulting in a significant proportion of manufacturing becoming automated and removing reliance on large and costly work forces. This in turn could lead to a reversal of the trend of globalisation which has characterised industry and consumption over the last few decades, itself predicated on the trade off between transportation and labour costs." This assertion still holds true, although the adoption of the technology has been slower than originally thought. Many people focus on the higher cost per piece as a reason for the slow take-up, although lower prices for 3D Printers and the materials which they use would address this issue. Likewise, the speed of 3D Printing would also increase as technology develops.

However, it is likely that these challenges would be overcome not least due to the enormous value to be released within the supply chain. One estimate suggests that inventory and waiting comprise 92% of assembly time in the automotive industry and that transport output related to these parts amounts to 45.3 billion ton-miles in the US alone (Dohnalek, 2018). These hidden costs are rarely taken into account when com-

Figure 4. Reshored 3D Printing supply chain networks



Source: Author

paring traditional manufacturing techniques with 3D Printing. Presently, in lean supply chain terms, transport is seen as a "necessary waste"; this may well change to "unnecessary waste" in the coming years. 3D Printing would mean that the intermediate goods in the supply chain can be replaced by the raw materials needed to make the printing materials. Multiple tiers of inventories held upstream and downstream would be eliminated as would be the need to move them from location to location, often on a global basis. Instead, much simpler supply chains involving the bulk storage and movement of printer materials would develop.

Less likely is the scenario that manufacturing is "consumerized", that is, 3D printing allows individuals to print products in their own homes. Although this is already possible for hobbyists, it is not likely that the type of industrial 3D printing machinery needed to produce most goods would be affordable.

However, if an element of 3D printing could be introduced to households:

- The movement of goods throughout the supply chain would become redundant.
- This would be replaced by the flow of materials which are required for use in the printers.
- Raw materials from predominantly developing regions such as Latin America would be refined into printer materials. The final movement (whether domestic or international) would depend on the location of these refineries.
- Large warehouses would be required to store these printer materials replacing storage of intermediate or finished goods.

IDB proposition: 3D printing technologies would transform global value chains providing more opportunities for product customization and consumer choice.

6.1 WHAT IS NEEDED TO ACHIEVE THE STATE PROPOSED?

In order for manufacturers, governments and consumers in Latin America to benefit from the opportunities provided by 3D printing, a framework policy must be put in place which would facilitate the adoption of the new technology. Without such a framework, emerging markets would continue to be regarded solely as a source of basic raw materials, unable to exploit the potential for developing added value processes.

A framework would include:

- Establishing and/or improving research and development within the region's universities.
- Encouraging foreign investment in R&D facilities.
- Establishing pilot projects with global and local manufacturers.
- Facilitating funding mechanisms for projects.
- Establishing regulatory framework addressing issues such as product quality and IP.
- Developing an internationally consistent approach to product liability.
- Focusing on the growing importance of Intellectual Property in terms of a basis for taxation policy rather than physical goods.
- Developing mitigation strategies to account for the potential of lost tax revenues.

As with many of the innovations already discussed in this paper, the development of intellectual resources in the region would be essential to exploit the opportunities that the technology provides.

6.2 WHAT ARE THE RISKS?

The biggest threat of all is probably tech-driven deglobalization in which developing countries would lose cheap labor advantage. The logic goes that technologies such as improved automation, computerization and 3D printing would undermine the economics of manufacturing in emerging markets. In the future, many companies would instead produce as close to

end markets as possible. For example, shoes usually made by hand in Asia are now being made by robots in one of the highest-cost economies in the world, Germany.

Of course, 3D printing would not only impact on global flows of goods but on the labor forces required to produce them. There could be significant social consequences from a reduction in employment as many low skilled jobs were replaced by automation. Governments throughout the region will need to ensure that workers are equipped to compete in a market where a much higher skill set is required as the industry becomes servitized.

There are also fiscal-related challenges linked to the reduction in the international movement of goods. Presently, customs authorities collect tariffs and duties on imported goods, as well as playing an important role in preventing the shipment of counterfeit or substandard goods. From a tax revenue generating perspective, if products are produced locally by 3D printer, it is logical that tariffs and duties would decline in line with a drop in international shipping volumes, thus creating a shortfall for national exchequers. This means that governments would need to seek new sources of revenue. This shall not be easy. For example, how can duties be levied on a download of a design if that design is originated overseas? In a cloud computing world, digital libraries could be located anywhere. Other questions relate to where VAT/GST should be levied if normal distribution channels and chains of taxation are disrupted. It is also yet to be seen how authorities would react to the risk that businesses (and individuals) would be able to produce goods which may have lower than regulated standards (electrical fitments, for example, made from inadequate materials) with no traceability.

6.3 WHAT ARE THE OPPORTUNITIES?

3D printing would rely heavily on the use of mineral resources, many of which are found in Latin America. These minerals need to be refined and this process could potentially occur in markets close to extraction, capturing more value added. The fast-growing consumer markets in Latin America would attract manufacturers willing to invest in new 3D printing technology. Those countries which are at the forefront of developing the technology may become 3D printing hubs, distributing products throughout the region. Automotive, aerospace and electronics companies, in particular, would adopt the technology reducing the importation of intermediate goods into the region from Asia.

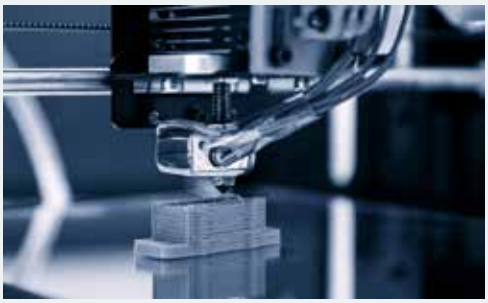
The technology would benefit MSMEs in the region, which would be able to design and produce goods without major capital investments or long production runs. In conjunction with global e-platforms, this would allow MSMEs to produce goods on demand for a worldwide market. 3D printing would result in far less inventory being required, which would have many supply chain benefits in terms of invested capital. Supply chains might also become far more responsive to consumer demands. 3D printing would let later decisions to be made in the production process, allowing for postponed manufacturing to occur at locations much closer to the end user. Customization would be able to take place, for instance, at downstream facilities, such as large distribution centers run by major logistics service providers. The techniques in 3D printing would mean far less waste and, consequently, the embedded carbon element of products would be significantly reduced. This would have positive implications for product sustainability.

In terms of transportation, the technology would reduce dramatically the level of intermediate and finished product movements on an intercontinental basis as a place of manufacture is reassociated with a place of consumption. This would reduce shipping and air cargo carbon emissions as well as the congestion and pollution in and around ports and airports. Finally, 3D printing has the potential to have a positive societal impact. For example, one project being proposed has been a “floating fab”, which would take 3D printers on a boat up the Peruvian Amazon to remote locations. This would allow essential items to be produced in regions that would not have access to the products, or at least only at a high cost.

6.4 WHAT BARRIERS MAY LIMIT ADOPTION?

Although the technology has been around for some time, progress towards adoption has

Aerospace sector leads the way in 3D printing



3D printing offers enormous potential for the production of aerospace components primarily due to their light weight nature and strength. The sector can claim leadership in the application of the technology, with Boeing using 3D printed parts since 2003, originally in the air defense sector. The US Department of Defense was interested as a customer due to the potential to print spare parts quickly even on the battlefield. Today, Boeing has 50,000 3D printed parts flying in a variety of aircraft and the company is in the process of introducing titanium 3D printed parts for the 787 Dreamliner. GE meanwhile plans to print 35,000 injectors for its LEAP jet engine by 2020. One of the key benefits is the reduction in complexity as a 3D printed turboprop engine reduces the number of parts required from 855 to 12 —a fact that would have huge implications on the aerospace supply chain.

been slower than first thought. The following factors have inhibited progress:

- Inherent inertia of big manufacturers and complacency around the need to change —transforming corporate strategy takes time not least due to huge historic capital investment in existing manufacturing facilities and technologies;
- Sophistication of the parts that can be produced;
- Regulatory issues related to quality assurance, reliability and liability as well as risk of counterfeiting and concerns over intellectual property;
- lack of available talent;
- time taken to print parts;
- cost of printers and raw materials, and
- cost per piece.
- In addition to these is the broadband and mobile telecommunications infrastructure required that would enable manufacturers from Latin America access to 3D printing designs. Only when these issues and worries have been addressed will the technology become more widely adopted. Many of the above are related to corporate or operational concerns.

6.5 WHAT IS THE POTENTIAL FOR THESE INNOVATIONS TO BE IN PLACE IN 2030?

3D printing might become an increasingly important part of the manufacturing process but it would be towards the end of the decade, before costs fall to a level that would see it integrated into mass production. At this point, there would a major opportunity for countries in Latin America to benefit from this manufacturing technology by exploiting their natural resources to supply the 3D printing materials. Full value would only be achieved if an investment is made in developing refineries rather than solely exporting the extracted minerals in bulk. Encouraging 3D printing facilities to the region would be important, else there is the risk that the region might suffer from premature deindustrialization as low-cost labor loses its draw for global manufacturers. The ability for consumers to print some objects in their home, or at least visit a local facility and have them printed there, would not become mainstream for several decades:

- 3D Printing – low to medium probability.

CHAPTER SEVEN:

BEYOND 2030: INNOVATIONS OF THE FUTURE

07

Just a few years ago, many of the technological innovations already outlined in this paper would be considered as in the realms of fantasy. Therefore, although it would be easy to regard a number of the transport-related concepts as unrealistic, they may well prove their detractors wrong. Three of these are highlighted below.

7.1 THE PHYSICAL INTERNET

Some academics believe that maximum value would accrue to the supply chain and logistics industry, as well as the wider economy, only if a completely new system can be designed to leverage the benefits of the new technologies and organizational structures (and cultures) being developed. A discussion paper written for the International Transport Forum (Tavasszy, 2018) describes the Physical Internet (PI) as "...the only comprehensive vision [in which] these innovations could converge into a single logistics system." The concept had been developed in the United States —the brainchild of professor Benoit Montreuil in the mid-2000s and supported in Europe by ALICE (Alliance for Logistics Innovation through Collaboration in Europe), a European-funded research organization. The concept is certainly bold as it calls for the reimagining of the entire logistics industry on a system level. In the keynote speech at the 2017 Physical Internet conference, professor Montreuil described PI as a "hyperconnected global logistics system enabling seamless open asset sharing and flow consolidation through standardized encapsulation, modularization, protocols and interfaces" (Montreuil, 2017). The basic ambition of the PI is to make logistics networks as efficient as those in the digital world. However, for that to occur there needs to be root-and-branch transformation of the existing systems which have been in place, in many cases, for centuries (Montreuil, 2011). Montreuil believes that the industry would evolve from one that could be described as fragmented or atomised; to integrated; to collaborative; to finally one that is hyperconnected.

Transport and delivery

Perhaps the biggest change would be to the existing distribution structures. The proponents of the PI see private networks, hubs and transportation fleets as inherently inefficient. To achieve a step-change in efficiency, logistics companies would need to open their networks to competitors, allowing interoperability across transport assets, information technology platforms and warehousing. Logistics hubs would become public in much the way that ports deal with containers from a multitude of shipping lines, freight forwarders or other cargo owners. They would be cross-docked rather than stored, leading to a compression of the supply chain. Long distance journeys would be eliminated, as each consignment would be dropped at a regional cross-dock hub and then collected promptly by another driver. Driver overnight rest periods would no longer be an issue, cutting overall transit time significantly. By sharing logistics assets, it has been estimated that there could be up to a third in cost savings. In addition to this, greenhouse gas emissions would be reduced by 60%. Although relevant on a regional basis, the need for better utilization of transport is even more pressing in an urban context as congestion levels and emissions rise. This is a key area in which it is hoped that the PI would have an impact.

Packaging

Within the PI, all goods would be stored and moved in standardized modular containers. These, according to Montreuil, would be a cross between "a lego block and a Russian doll" (2017). That is, smaller containers could be consolidated in larger ones efficiently with a minimum of wasted space. These modular containers would be smart, reusable, recyclable and secure. As in the shipping industry, these standard containers would allow faster flows through warehouses and transport hubs as well as providing better visibility and traceability, to item level. The PI doesn't deal as such with freight but only the containers in which the freight is stored, in much the same way that modern ports only deal with containers. Supporters of the concept believe that it is a development of the sharing economy. Amazon, by opening up its distribution centers to third-party retailers through its Fulfilled by Amazon program, has already gone some way to creating a hyperconnected logistics network. However, the key challenges that must be overcome before the PI can become a reality will be to prove to shippers and logistics companies:

- That it makes financial sense to share networks and assets.

- That containerization of all products leads to more efficient use of space, not less.
- The technology exists, or would exist, that facilitates the data sharing.
- Operationally, the processes work.

In addition to this, there is the cultural barrier of giving up elements of competitive advantage. Would DHL be happy to ship UPS or FedEx packages and vice versa? This may be the biggest stumbling block to adoption. Those promoting the idea certainly don't believe the PI to be imminent, setting 2050 as the year in which they hope it would become a reality.

7.2 HYPERLOOP

Hyperloop is an ambitious project that uses a sealed capsule inside a vacuum tube propelled by magnetic levitation. The capsules could conceivably transport passengers or freight across long distances at speeds of 600-1,000 km/h. Taking the possible top speed of 1,000 km/h, Hyperloop would allow a 4-day truck journey, or 23-hour flight, to be completed in 16 hours. It is also claimed the cost is just 1.5 times more than trucking although this does not account for the vast sums needed to build the infrastructure in the first place. One of its uses could be for urban e-commerce deliveries. Hyperloop could give shippers the opportunity to build large distribution centers further outside population centers, thus making savings on more expensive city warehouse space. Hyperloop would be able to transport products into the city center at rapid speeds, saving time despite the longer distances between warehouses and population centers. The system would also allow larger distribution centers to serve multiple population centers at once. One touted proposal is for a Hyperloop connecting Barcelona and Madrid in just half an hour. DP World and Virgin have partnered on a Hyperloop project at the port of Dubai. The limitations for inner-city delivery clearly apply here too, and the system would require a vastly different approach to handling than ordinary container freight movements, which is where DP World would look to lend their expertise.

7.3 ELECTRIC ROADS

An alternative to many electric vehicle models that rely on recharging vehicle batteries either at charging stations, depots or at home is the "Electric Road". In Sweden, two types are presently being trialled: electric rails and overhead cables. The first road using an electric rail is being trialed in Sweden, outside Stockholm. The concept involves a moveable arm suspended beneath a car or truck which conducts electricity to the vehicle battery from a rail embedded in the road. When overtaking or leaving the road, the arm retracts. The way the rail is designed means that it is perfectly safe for pedestrians, even if the road becomes flooded. The idea has several advantages over existing technologies. For a start, batteries are charged more often which means that they don't have to be as big or heavy. This is important in terms of payload. According to the developers, eRoadArlanda, it would reduce carbon emissions by 80-90% and would be 75% cheaper than diesel. The battery is still an important part of the model. The company behind the scheme estimates that only 3% of the country's roads would need to be electrified, charging batteries for the shorter distance movements across the rest of the network. In terms of construction, up to one kilometer of rail can be installed per hour, minimizing roadwork. The other option being trialed in Central Sweden uses electric cables which supply power to the trucks through a pantograph mounted behind the cab. When the truck leaves the overhead cables, it is powered either through its battery or by a hybrid engine. The Swedish transport authority Trafikverket, the Swedish Energy Agency Energimyndigheten, innovation agency Vinnova, Scania and Siemens are the main funders of the technology, while Region Gävleborg is the project coordinator.

CHAPTER EIGHT:

CONCLUSION

08

Whether the outcome of these logistics and supply chain innovations would be positive or negative for developing economies would depend on public policy choices being made in the coming years. The impact of 4IR on employment is a case in point. A number of the most significant innovations being considered could eliminate many millions of jobs as supply chain functions become automated by driverless vehicles, robots in the warehouse or 3D printing. Unless education and training is put in place which would equip future employees with skill sets that enable them to adapt to the changing industrial environment, a large proportion of society could find itself excluded. Without good foundations, it would be impossible to grasp the opportunities offered by innovative new technologies and business models.

These include:

- Good education and training policies.
- Good transport/warehousing infrastructure.
- Robust information and communications technology, power, financial networks.
- Strong legal structures/compliance/investment environment.
- Stable security environment.
- Economic stability and openness.
- Transparent and connected Customs procedures.
- Stable trading relationships.

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