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FRAMEWORK FOR INTEGRATED MULTISECTOR SMART LOGISTICS

Authored by

Salma Abbasi
Chairperson and CEO, eWorldwide Group and
Vice Chair, Digital Resilience Initiative, IEEE

Rezwanul Haque Jami
Head of eCommerce, a2i, ICT Division
People's Republic of Bangladesh

Md Sahariar Hasan Jiisun
National Consultant, a2i, ICT Division
People's Republic of Bangladesh

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The Institute of Electrical and Electronics Engineers, Inc. 3 Park Avenue, New York, NY 10016-5997, USA

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FRAMEWORK FOR INTEGRATED MULTISECTOR SMART LOGISTICS

1. INTRODUCTION

This paper is second in a series of five papers on integrated multisector smart logistics. The first paper introduces the diverse players in the smart logistics ecosystem with case studies from some of the players on how they have contributed to and impacted the smart logistics ecosystem. This second paper delves deeper into the challenges and gaps in ensuring a resilient and sustainable smart logistics ecosystem, and proposes an integrated multisector smart logistics framework to address these challenges and gaps. An integrated multisector smart logistics framework will be critical for the sustainable growth of the logistics industry, and in turn for commerce and trade, and for the achievement of the sustainable development goals (SDGs).

The logistics system is a complex system that involves the management of the flow of goods, resources, and information between the point of origin and the destination. It requires an integrated process of planning, optimizing, and implementing the multimodal transportation of goods by air, rail, road, and/or sea, as well as warehousing, which includes receiving and recording goods from different suppliers, storing goods at appropriate locations, retrieving and picking goods when they are needed, and preparing shipment to buyers. The food, pharmaceutical, and vaccine supply chains require careful temperature control across a cold chain, which adds to the logistics complexity.

The challenges and gaps in the smart logistics ecosystem, and strategies for addressing them can be divided into eight interrelated pillars: (1) critical infrastructure; (2) core logistics; (3) industries; (4) digital economy; (5) policies, regulations, and standards; (6) human capacity building; (7) startup ecosystem; and (8) cooperation and collaboration.

Section 2 discusses the challenges and gaps in each pillar of the logistics ecosystem and looks at how an integrated, multisector, and smart approach can help address them. As concluded in the first paper, while digital technologies form the backbone of a smart logistics ecosystem, links to reliable and sustainable power sources, water supply and the digital infrastructure for end-to-end tracking and tracing are vital for preventing spoilage and wastage, and ensuring that products are safe for consumption when they reach the end users.

Digital transformation serves as an impetus to address the various challenges and gaps, but it must also include the reskilling and upskilling of human resources, as well as considerations for their safety, security, and well-being. An enabling policy, regulatory, and standard environment and available human resources are crucial to ensuring resilient logistics systems. Digital transformation must also be inclusive of startups, micro, small, and medium enterprises (MSMEs), and gig workers in the logistics ecosystem.

As all sectors and industries rely on the logistics supply chain to store and transport materials and products developed for businesses and consumers, and the demand for logistics services is increasing, which calls for an integrated multisector framework that considers the logistics needs of all sectors and industries, which can only be achieved through multistakeholder cooperation and collaboration.

2. CHALLENGES AND GAPS IN LOGISTICS AND POTENTIAL EFFECTS OF DIGITAL TRANSFORMATION

2.1. CRITICAL INFRASTRUCTURE

Access to reliable infrastructure such as railways, roads, ports, airports, warehouses, information and communications technology (ICT), and energy sources is fundamental and foundational for a resilient and sustainable logistics supply chain.

The logistics supply chain generally involves three main types of infrastructure flows: (1) the **physical** flow of goods by air, sea, and road; (2) the **information and data** flow along the ICT infrastructure; and (3) the **financial** flow associated with supply chain transactions and operations that are increasingly going digital with increasing adoption of mobile and online payments. Fundamentally, the logistics supply chain also requires a robust **energy** infrastructure to power these flows. However, in many rural and remote areas, there is a shortage of such infrastructure. Globally, there are still 733 million people without reliable access to electricity.[1]

[1] United Nations, "SDG Goal 7: Progress and Info 2022," https://sdgs.un.org/goals/goal7.

2.1.1. PHYSICAL INFRASTRUCTURE

Globally, 1 billion people still lack access to an all-weather road and adequate transport services, especially in rural parts of developing countries. In Africa alone, 450 million people (more than 70% of the total rural population) remain unconnected to transport infrastructure and systems. [2]

Transportation is a critical part of logistics systems, especially road transportation for reaching the last mile. Innovative ways to finance and build the infrastructure networks in rural and remote regions are needed. At the same time, it is important that the transport sector leverages the potential of digital technologies to enhance efficiency, optimize operations, and reduce carbon emissions through the implementation of **intelligent transportation systems**. These systems have been implemented in some countries to reduce travel time and fuel consumption, improve road safety, monitor air quality, and realize future autonomous driving. Intelligent transport systems, using the Internet of Things (IoT), artificial intelligence (AI), and big data can be used to provide real-time data in mobile apps to help drivers determine the quickest and safest traffic routes. Intelligent transport systems with the exchange of real-time traffic data can also enhance the tracking and tracing of the movements of goods and transactions along the logistics supply chain.

A cost-effective way to build the physical infrastructure and implement intelligent transportation systems is through the **"codeployment"** of infrastructure in which infrastructure sectors (road, rail, energy, ICT) collaborate to jointly construct and share infrastructure, which has proven to reduce construction costs by half and accelerate rollout. [3] Fiber-optic cable codeployment along infrastructure such as major roads, railways, power transmission lines, and pipelines can save significant costs and resources as it allows one-time investment in land acquisition and construction. Most of the cost savings in codeployment are derived from eliminating overlapping civil works. Other benefits of codeployment include the ease of obtaining rights of way and various other permits and approvals, minimization of disruptions to road traffic or the functioning of utilities as a result of repeated civil works, and streamlining of maintenance and repairs.

2.1.2. SMART HIGHWAYS AND SMART MOTORWAYS

Highways and motorways are critical links for robust transportation systems, particularly for landlocked countries, for connecting ports with cities and villages, and for operationalizing regional free trade agreements such as the African Continental Free Trade Area (AfCFTA). Smart highways and motorways involve adopting an

[2] United Nations, "Sustainable transport, sustainable development: Interagency report for second Global Sustainable Transport Conference," 2021, https://sdgs.un.org/sites/default/files/2021-10/Transportation%20Report%202021_FullReport_Digital.pdf.

[3] ESCAP, "ICT Infrastructure Co-Deployment with Transport and Energy Infrastructure in North and Central Asia," February 2020, https://www.unescap.org/sites/default/d8files/knowledge-products/ICT%20Infrastructure%20Co-Deployment%20Transport%20Energy%20NCA.pdf.

integrated and holistic approach in designing and deploying technology systems across sectors in transportation, energy, and ICT, allowing seamless connection of critical infrastructure and services to the people.

Smart highways and motorways combine physical infrastructures such as sensors and solar panels with software infrastructure like AI and big data. These technologies are embedded in smart highways and motorways to improve visibility, monitor road conditions, and communicate with autonomous and connected vehicles. This requires exchanging and sharing real-time traffic information among different transport modalities across borders to enhance the tracking and tracing of the movement of goods and services from ports to warehouses.

The benefits of smart highways and motorways include improved traffic management, integrated police security using CCTV cameras, and recognition systems for face, vehicle, license plate, etc., and fleet management through access to real-time traffic information on highways and motorways. Smart highways and motorways can also improve energy efficiency and reduce carbon emissions. Some European countries are using solar cells embedded in tempered glass panels to pave roads. These panels contain snow-melting heating devices and inductive charging capability for electric vehicles while driving. Moreover, glass is renewable and can be engineered to be stronger than steel and allows cars to stop safely even when traveling at high speeds.[4] While this technology has gained widespread support, scalability is a challenge as it remains expensive.

In addition, smart technologies can help automate and improve the performance of recurrent logistics operations such as roll-on/roll-off where loaded road vehicles are driven on a ferry or ship, and off at the port of destination. It involves using sensors to detect obstacles and AI to dynamically learn the required operations including lane-following, obstacle avoidance, and rolling cargo placement.[5] Major benefits of automated roll-on/roll-off operations are reduced handling of the actual goods and packages, thus reducing the time and cost to successfully deliver goods and services.

In Europe, smart highways and motorways are key components of the Strategy for Cooperative Intelligent Transport Systems (C-ITS) adopted in 2016 by the European Commission. In 2017, Italy approved a framework document for infrastructure development ("Connettere Italia") that included 108 priority infrastructure projects with the aim to promote accessibility to territories, Europe and the Mediterranean; support sustainable and safe mobility; improve the quality of life and competitiveness of urban and metropolitan areas; and support industrial supply chain policies. One of the projects is the ANAS Smart Road that aims to invest an estimated €1 billion to

[4] Viro, "Smart Road Technology: Digital Highways Of The Future," https://vrioeurope.com/en/smart-road-technology-digital-highways-of-the-future/.
[5] Rachid Oucheikh et al., "Rolling Cargo Management Using a Deep Reinforcement Learning Approach," *Logistics*, vol. 5, no. 1 (2021), https://www.mdpi.com/2305-6290/5/1/10/htm.

make 3000 km of roads "smart" by 2030.[6] The project is taking a three-pronged approach consisting of ICT connectivity, autonomous driving capability, and sustainable energy. The highway will be 5G-enabled for real-time monitoring of road infrastructure, traffic and freight transport, and the environment and weather conditions. This will allow highway users to stay informed about hazards, slowdowns, accidents, constructions, etc., and be provided with alternative routes. The ANAS Smart Road will also allow vehicles to interact directly with each other and with the road infrastructure for autonomous driving. The electricity required to manage the highway's technology systems will come from renewable energy sources, including solar and wind power.[7]

To enable cross-border logistics and trade, it is critical that smart highways and motorways are interoperable across localities. The C-roads platform is a cooperation of European Union (EU) member states and road operators working on the deployment of harmonized and interoperable C-ITS services in Europe. The aim is to test innovative traffic technologies, including connected vehicle technologies, using traffic simulation software to provide a digital twin to help understand the impact of a massive rollout of C-ITS services across a huge range of hypothetical scenarios. This platform has been tested in Spain and has successfully sped up C-ITS large-scale deployment in Spain and Europe by analyzing the scalability and replicability of results. The simulation of C-ITS services was able to not only predict future problems but also reduce the cost of implementation.[8]

These examples of integrated transportation systems from Europe can be applied as good practices to leapfrog critical infrastructure for physical infrastructure.

2.1.3. ICT INFRASTRUCTURE

Although 4G network coverage has reached 88% of the world's population,[9] almost half are not connecting to mobile internet services for various reasons, including lack of affordability and digital skills.[10] A reliable fixed-broadband infrastructure is essential for building a smart logistics system that leverages digital technologies to enhance operations and coordination among logistics stakeholders. In addition, the utilization of a mix of digital technologies to connect the unconnected, including Wi-Fi and satellite broadband, is important for smart logistics systems.

Various global positioning, navigation, and tracking systems, together with IoT technology and predictive analytics using AI and machine learning (ML), enable logistics stakeholders to monitor operations in real-time,

[6] Global Infrastructure Hub, "ANAS Smart Road project," 26 January 2021, https://www.gihub.org/quality-infrastructure-database/case-studies/anas-smart-road-project/.
[7] Enrico Punsalang, "Salerno-Reggio Calabria In Italy Set To Be Europe's Longest Smart Road," Ride Apart, 11 March 2022, https://www.rideapart.com/news/572791/salerno-reggio-calabria-longest-smart-road-europe/.
[8] Aimsun, "C-ROADS Spain," https://www.aimsun.com/research-projects/ccam/c-roads-platform-spain/.
[9] United Nations, "SDG Goal 9: Progress and Info 2022," https://sdgs.un.org/goals/goal9.
[10] GSMA, "The Mobile Economy 2021," 2021.

predict arrival times, calculate estimated delivery times for improved logistics planning, optimize transport routes for faster transit times and reduced transport costs, and forecast changes in shipping demands and supply for better decision-making.

In Africa, for example, the Regional Electronic Cargo Tracking System, launched in 2017, integrates tracking platforms in the Democratic Republic of Congo, Kenya, Rwanda, and Uganda to help reduce transit time, enhance cargo safety, and better predict the arrival of goods, which are particularly critical for perishable goods. This is achieved with tracking devices that use radio frequency identification (RFID), global positioning system (GPS), and general packet radio service (GPRS) technologies. The system allows the countries to jointly track in real time the movement of goods from the port of entry to the final destination, reduce the number of manual inspections required, and enable better planning upstream and downstream. The system has reduced transit time between Mombasa and Kampala from an average of 21 days in 2017 to an average of five days in 2020.[11] With IoT, the system can also monitor other ambient conditions such as pressure, temperature, and humidity in real time and check the status of goods' security as they move along the supply chain.

In addition, digital technologies have been used for smart warehousing. Solutions include autonomous forklifts to load and unload goods, and stocktaking robots for inventory monitoring in large storage spaces. The IoT technology can be used to detect and communicate open spaces in a warehouse for transportation systems and manage energy use in warehouses, including lighting, heating, and cooling to conserve energy.

Another emerging technology being used in the logistics industry is the digital twin for simulations and real-time tracking. Digital twins pull relevant data that are captured across the supply chain through IoT sensors and other technologies for representation in virtual or simulation environments.[12] For example, warehouses and facilities can use the technology to create 3D models of their centers and experiment with layout changes or the introduction of new equipment to see their impact, risk-free. Logistics hubs can create digital twins to test out different scenarios and increase efficiency. Delivery networks can use the technology to provide real-time information that will improve delivery times and aid autonomous vehicles in their routes.[13]

Countries and localities without access to reliable fixed-broadband infrastructure will not be able to leverage the benefits of these digital technologies and risk being left further behind.

[11] United Nations, "Sustainable transport, sustainable development: Interagency report for second Global Sustainable Transport Conference," 2021, https://sdgs.un.org/sites/default/files/2021-10/Transportation%20Report%202021_FullReport_Digital.pdf.
[12] Mike Walker, "Top 10 Digital Ecosystem Trends In Supply Chain And Logistics," Forbes, 8 February 2021, https://www.forbes.com/sites/forbestechcouncil/2021/02/08/top-10-digital-ecosystem-trends-in-supply-chain-and-logistics/?sh=5196e9e3f738.
[13] Transmetrics, "Guide to Supply Chain and Logistics Technology," 7 January 2022, https://www.transmetrics.ai/blog/supply-chain-logistics-technology-trends/.

2.1.4. PORTS AND TERMINALS

At ports and airport terminals, high dwell times (the amount of time that cargo or ships spend within a port or terminal) add to the high logistics costs. The main reasons for high dwell times include delays in customs clearance and border control, and inefficiencies in multimodal transitions between vessels, planes, trains, and trucks. Digital technologies have helped to increase real-time end-to-end visibility, allowing logistics companies to plan ahead in automating the preparation of paperwork online for customs clearance and arranging downstream distribution. Digital technologies have also enhanced efficiencies and supported collaborative border management and customs clearance through one-stop shops or single-window systems. [14]

The establishment of digital systems such as single windows in Ghana and Rwanda, for example, has improved their logistics performance. The Ghana National Single Window has reduced the time and cost of import procedures per consignment by 40 h and $50, respectively. In Rwanda, the introduction of the single window system has reduced the time needed to clear goods from 11 days in 2010 to 34 h in 2014. [15]

Angola implemented the Automated System for Customs Data World (ASYCUDAWorld) system in 2017 using Cargo XML standards defined by the International Air Transport Association that allowed digital communication between airlines, shippers, freight forwarders, customs, and security agencies. Customs were streamlined and digital payments were introduced. As a result, the customs clearance process of goods was reduced from 30 to 7 steps, paperwork for goods clearance was reduced by 70%, and revenue increased by 44% in 2018 and by a further 13% in 2019. [16]

2.1.5. LAST MILE

At the last mile, there are a number of significant challenges. As much as 53% of the logistics costs are incurred in the last mile, making it the most expensive leg of logistics operations. [17]

Challenges related to the last mile include **congestion and delays**, especially on roads. According to a World Bank study in Bangladesh, data from GPS devices fitted on delivery trucks indicates that the average speed is

[14] Logistics companies engaged in international trade must submit large volumes of information and documents to terminal operators, port authorities, and other public sector bodies, in order to comply with regulatory and port entry requirements. These include, among other things, maritime agencies, customs, health, border police, immigration, agriculture, and defense authorities. Often information must be submitted through several different authorities, each with its own specific system, and/or paper forms. These requirements, together with the associated compliance costs, constitute a burden both to governments and to the business community. The inefficiencies and resulting increase in costs represent a major barrier to the development of international trade. A single window or one-stop shop environment is a system that allows the submission and handling of all data and documents on a single platform to fulfil regulatory requirements, customs clearance, etc.

[15] United Nations, "Sustainable transport, sustainable development: Interagency report for second Global Sustainable Transport Conference," 2021, https://sdgs.un.org/sites/default/files/2021-10/Transportation%20Report%202021_FullReport_Digital.pdf.

[16] World Economic Forum, "Growing Intra-African Trade through Digital Transformation of Border and Customs Services," May 2022, https://www3.weforum.org/docs/WEF_Regional_Action_Group_for_Africa_2022.pdf.

[17] Soham Chokshi, "Five ways an efficient supply chain and logistics management system can boost business," Business World, 19 May 2022, https://www.bworldonline.com/technology/2022/05/19/449334/five-ways-an-efficient-supply-chain-and-logistics-management-system-can-boost-business/.

about 19 km/h. If there were no congestion on roads, logistics costs would be at least 7%–35% lower.[18] Beyond logistics costs, congestion accounts for almost 60% of the annual carbon dioxide emissions from interdistrict road freight transport, and the social costs of which are estimated to be 1.2% of gross domestic product. Studies show that the cost of congestion will rise, particularly in the cities of developing and emerging economies.[19] Digital technologies are being used to plan and optimize transport routes and scheduling to mitigate congestions and delays. Increasingly, logistics players are also looking into the use of renewable, low-carbon energy sources to power the logistics supply chain, such as zero-carbon marine fuels like green hydrogen or green ammonia, alternative jet fuels using biofuel blends, and solar-powered warehouses.

Another last-mile delivery challenge is related to locations that **lack addresses**. The Universal Postal Union reports that about 60 countries lack a postcode system,[20] and billions of people could be without access to an address.[21] A quality address infrastructure is another foundation for logistics, and more broadly, as a fundamental human right as addresses are closely tied to personal identity and access to basic services. Recently, some tech companies have stepped in to tackle this issue. For example, in India, the startup Delhivery is using ML to subdivide India's postcodes to map idiosyncratic descriptions. In Kenya, OkHi seeks to assign physical addresses to people who do not have one.[22] What3words,[23] which assigns a unique series of three words to every 3 m by 3 m^2 of the Earth's surface, has been adopted by many governments, transport and logistics companies, and emergency services worldwide to pinpoint exact locations.

Even where delivery points have been located, **payment** needs to be collected from the buyers. In many developing countries, cash on delivery remains the predominant payment option in the last mile, although the adoption of mobile and online payments has accelerated during the pandemic as part of the effort to promote contactless transactions (see Section 2.4 on digital payment systems).

In the process of developing reliable critical infrastructure that is foundational for the logistics supply chain, digital technologies can help improve efficiency and reduce costs in both the transportation and warehousing of goods, as illustrated previously. Another breakthrough in logistics improvement is the use of drones to deliver goods in rural and remote areas where road infrastructure is poor. For example, startup Zipline featured in the

[18] Matías Herrera Dappe and others, *Moving Forward: Connectivity and Logistics to Sustain Bangladesh's Success* (Washington, DC: World Bank, 2020), https://openknowledge.worldbank.org/bitstream/handle/10986/32597/9781464815072.pdf.
[19] Asian Infrastructure Investment Bank, "Transport Sector Study," May 2018, https://www.aiib.org/en/policies-strategies/_download/transport/2018_May_AIIB-Transport-Sector-Study.pdf.
[20] Universal Postal Union, "Postcode Addressing Issues," 2021, https://www.upu.int/UPU/media/upu/documents/PostCode/General-Addressing-Issues.pdf.
[21] Universal Postal Union, "Addressing," https://www.upu.int/en/Universal-Postal-Union/Activities/Physical-Services/Addressing.
[22] Ankur Huria, "Facilitating Trade and Logistics for E-Commerce: Building Blocks, Challenges and Ways Forward," World Bank, December 2019, https://openknowledge.worldbank.org/handle/10986/33174.
[23] What3words, https://what3words.com/.

first paper of the series, has been collaborating with the governments of Rwanda, Ghana, and Nigeria in the use of drones to deliver blood, vaccines, and medical supplies. However, a report cautions that investments in drone delivery systems may delay investments in road infrastructure development and upgrading that could have an impact on other important social and economic indicators, such as rural communities' access to health care and education.[24] It is important to emphasize that such tech initiatives should not lead to delays in the building of foundational critical infrastructure.

2.2. CORE LOGISTICS

Core logistics includes the logistics infrastructure and equipment providers and the logistics service providers. The logistics infrastructure providers are the air freight companies, rail companies, truck companies, and ocean freight companies that own or lease their fleets to transport goods by air, rail, road, and sea, respectively. Logistics infrastructure providers also include airport terminals and ocean port operators, warehouses, and distribution centers where goods are sent, received, handled, processed, and managed for onward logistics. The equipment providers manufacture, own, or lease the containers, and other assets needed to transport goods. Logistics service providers administer and manage goods as they flow along the supply chain. They may provide services for all or part of the supply chain, or they may specialize in specific aspects of the supply chain such as order management, inventory management, warehousing, cold storage, packaging, or reverse logistics. These service providers enter into contracts with the logistics infrastructure providers and arrange the movement of goods, and for international shipments, prepare and process customs documentation and clearance.

Many logistics providers have invested in the digitalization of their systems to enhance efficiency and optimize operations. They include sensors and asset tagging and tracking, inventory management systems, blockchain for greater visibility and security in the supply chain, logistics analytics, fleet management, smart warehousing, enterprise resource planning, e-commerce logistics, autonomous vehicles and drones, and innovative last-mile delivery services.[25] However, challenges in digitalization, especially for MSMEs, include the lack of access to finance and skills.

Some countries are investing in logistics parks, hubs, and clusters to enhance efficiency and reduce logistics costs for companies. They are designed for storage, management, distribution, and transportation of goods within

[24] Modestus Amaechi et al., "From A to O-Positive: Blood Delivery Via Drones in Rwanda," Reach Alliance, April 2021, https://reachalliance.org/wp-content/uploads/2021/03/Zipline-Rwanda-Final-April19.pdf.
[25] CB insights, "From Tracking Food To Last-Mile Delivery, 125+ Startups Disrupting The Supply Chain & Logistics Industry," 30 August 2018, https://www.cbinsights.com/research/digitizing-supply-chain-logistics-market-map/.

which logistics service providers collaborate to offer value-added services by sharing assets. Logistics parks, hubs, and clusters are particularly beneficial for supporting MSMEs as they help to increase the scale, visibility, and influence of MSMEs, encourage resource pooling, facilitate access to private and government funding, as well as to advance technologies, know-how, and equipment.[26]

2.3. INDUSTRIES

Logistics is needed across all sectors and industries to transport materials and products developed for businesses and consumers, and the demand for logistics services is increasing. This calls for an integrated multisector framework that considers the logistics needs of all sectors and industries to create synergies and partnerships for mutual benefits.

During COVID-19, the key supply chains that have received the most attention include the agriculture, food, and beverage supply chain due to rising food insecurity, as well as the health and medical supply chain to transport essential medical supplies such as masks and personal protective equipment, and later, vaccines. This paper examines the COVID-19 vaccine supply chain to better understand the complexity of logistics systems and the urgent need for an integrated multisector smart logistics framework to address challenges.

As of June 2022, 72% of people in high-income countries had been vaccinated with at least one dose of the COVID-19 vaccine, whereas the figure was a mere 18% in low-income countries.[27] Unequal access to vaccines is a key hindrance to global recovery from the pandemic, yet there are many challenges in distributing COVID-19 vaccines equitably, from boosting production and addressing vaccine hoarding to ensuring an adequate network of trained, technically competent personnel across the vaccine supply chain and addressing concerns over vaccine hesitancy. Some of the main challenges, however, are logistics-related.

Logistically, the management of large volumes of multiple vaccines with different temperature requirements, including ultralow temperature conditions across a cold chain, to rural and remote areas that are often without electricity is a significant challenge. Many low-income countries do not have a cold chain infrastructure and do not have a supply chain management system for end-to-end tracking and tracing. Errors in handling, scheduling, documentation, transportation, temperature control, and storage across the supply chain will have significant

[26] FAO, *The State of Food and Agriculture 2021. Making agrifood systems more resilient to shocks and stresses* (Rome, 2021), https://www.fao.org/3/cb4476en/cb4476en.pdf.
[27] United Nations, "UN expert urges States to end 'vaccine apartheid'," Press Release, 14 June 2022, https://www.ohchr.org/en/press-releases/2022/06/un-expert-urges-states-end-vaccine-apartheid.

consequences and can lead to vaccine spoilage. Millions of doses have already expired and been wasted.[28] Moreover, millions of doses remain unused in storage facilities due to the lack of medical supplies like needles and syringes.[29]

Ideally, critical logistics infrastructures are in place and supply chain management systems could leverage the wide range of digital technologies such as temperature sensors and IoT to capture and integrate real-time data across the vaccine cold chain and related medical supply chains like needles and syringes. All these data sources can be analyzed and displayed on dashboards for supply chain stakeholders, healthcare workers, and policymakers to monitor the status of the end-to-end supply chain and facilitate cooperative and collaborative efforts.

But in addition, there are a wide variety of human capacity challenges that need to be addressed, including the lack of frontline workers and transporters to assist in the complicated handling, storage, and distribution of COVID-19 vaccines; the lack of digitally-skilled personnel to design, deploy, and manage digital systems; and the lack of data analysts to generate actionable insights and solutions for improved delivery of vaccines, particularly in underserved areas. Furthermore, there are trade barriers such as export restrictions and regulatory bottlenecks that are preventing or delaying the distribution of COVID-19 vaccines. Collaborative efforts across countries and sectors are needed to address these multidimensional barriers.

2.4. DIGITAL ECONOMY

Digital technologies and their ability to capture, process, and analyze vast amounts of data in real time are transforming all sectors and industries, including the logistics supply chain. At the same time, dynamic growth in the digital economy is resulting in a rising demand for logistics, especially to deliver goods ordered online or through mobile phones. In 2019, an estimated 1.5 billion people, or 27% of the global population aged 15 and older, shopped online.[30] During the COVID-19 pandemic, restrictions on mobility further accelerated the growth of the digital economy, pushing millions of people online to purchase goods and services for the first time. The pandemic has also been a catalyst for existing digital users to adopt new online services and increase their frequency of use and spending on these services.[31] Innovations and new business models are driving the digital economy. Moreover, the digital economy has enabled new players such as mobile operators, mobile agent

[28] Indermit Gill and Michele Ruta, "Why global vaccine equity is the prescription for a full recovery," Brookings, 11 February 2022, https://www.brookings.edu/blog/future-development/2022/02/11/why-global-vaccine-equity-is-the-prescription-for-a-full-recovery/.
[29] Al Jazeera, "Poorer nations forced to dump close-to-expiry COVID vaccines," 13 January 2022, https://www.aljazeera.com/news/2022/1/13/poorer-nations-dump-dose-to-expiry-covid-vaccines-unicef.
[30] United Nations Conference on Trade and Development, "Digital trade: Opportunities and actions for developing countries," UNCTAD Policy Brief No. 92, January 2022, https://unctad.org/system/files/official-document/presspb2021d10_en.pdf.
[31] Google, Temasek and Bain, "e-Conomy SEA 2021," 2021, https://services.google.com/fh/files/misc/e_conomy_sea_2021_report.pdf.

networks, e-commerce platforms, and internet companies to engage in the logistics ecosystem. However, it is important that policies and regulators foster innovations that are not only sources of competitiveness but also beneficial to the public good.

2.4.1. DIGITAL PUBLIC GOODS

Digital public goods are defined as: "Open-source software, open data, open AI models, open standards, and open content that adhere to privacy and other applicable laws and best practices, do no harm, and help attain the SDGs."[32] The presence of digital public goods enables countries to fast-track implementation and lower risk by replicating and amending proven solutions, rather than building from scratch. Digital public goods come with a community of contextual knowledge with technical documentation and guides, and people who have supported implementations. Although digital public goods require funds to implement, they reduce overall lifetime costs since they are open source and do not come with licensing fees. Digital public goods also prevent vendor lock-in and promote interoperability of systems. At the onset of the COVID-19 pandemic, the presence of digital public goods like the District Health Information System 2 (DHIS2) enabled countries to quickly adapt it to support effective responses. A COVID-19 surveillance module of DHIS2 created in Sri Lanka was quickly adopted by more than 50 countries.[33]

The Digital Public Goods Alliance is a multistakeholder initiative facilitating the discovery, development, use of, and investment in digital public goods. The Digital Public Goods Alliance verifies all digital public goods against best practices and do-no-harm by design indicators embedded in the Digital Public Goods Standard,[34] and maintains a registry[35] that contains 113 accredited digital public goods and 217 nominees that are in the process of being accredited, as of July 2022. Currently, there is only one logistics-related digital public good—OpenLMIS—a cloud-based electronic logistics management information system built to support national supply chains manage medical supplies and avoid stockouts. In addition, there are two nominated solutions that are awaiting accreditation. They include OpenBoxes that is also a logistics management information system, and ekShop, an e-commerce platform that supports rural MSMEs in moving their businesses online and incorporates smart logistics management and tracking. There is clearly a dearth of logistics-related digital public goods and more efforts are needed to increase the number and diversity of logistics-related digital public goods. Support is also needed in the greater adoption of logistics-related digital public goods.

[32] Digital Public Goods Alliance, "About Us," https://digitalpublicgoods.net/about/.
[33] DHIS2, "Innovative management of COVID-19 vaccine delivery in Sri Lanka," https://dhis2.org/sri-lanka-covid-vaccine/.
[34] Digital Public Goods Alliance, "Digital Public Goods Standard," https://digitalpublicgoods.net/standard/.
[35] Digital Public Goods Alliance, "Registry," https://digitalpublicgoods.net/registry/.

2.4.2. DIGITAL PAYMENT SYSTEMS

The rapid growth in mobile phone uptake has resulted in its innovative use to deliver financial services. Mobile money service has allowed buyers to pay for goods and services, and sellers like smallholder farmers to receive payment more quickly and conveniently.[36]

However, the wide adoption of mobile and online payments depends on other factors in the integrated framework, such as an enabling regulatory framework that supports mobile and online payments, people's access to digital devices and the skills to safely use them for making payments, a robust fintech startup ecosystem to innovate in this area, cooperation and collaboration among many stakeholders to enable fast payments on e-commerce and social media platforms, and interoperability of QR code and mobile wallet schemes.

A number of large platform businesses have grown beyond their initial core business to target several other areas and establish new business models for bundled services combining seller and buyer engagements, payments and logistics, quality control, and warehousing. For example, Meta (formerly Facebook) offers payment services through WhatsApp and Messenger in some countries, which allow buyers, sellers, and logistics providers to transact on these platforms.[37] Ride-hailing companies like Grab and Uber have expanded their service platform to offer food delivery using their network of on-demand drivers, as well as financial services such as payment, peer-to-peer lending, credit, and insurance. Grab Kios connects e-commerce players and online merchants with offline customers through agents, onboarding the unbanked into digital transactions. Alibaba, China's e-commerce giant, invested in critical infrastructure including in rural villages, explored other modes of transport for last-mile delivery such as drones and autonomous vehicles, provided training in e-commerce and entrepreneurship, and offered financial services through Ant Financial, a subsidiary of Alibaba to grow its Taobao platform.

2.4.3. E-COMMERCE PLATFORMS

E-commerce has expanded business-to-consumer logistics services. Many retail stores have also launched online ordering options during COVID-19, increasing the need for last-mile delivery services to end customers. The pandemic and rise of e-commerce have together triggered transformations across multiple dimensions of the logistics supply chain ecosystem and have driven new logistics entrants, particularly in the last-mile delivery

[36] GSMA, *2019 State of the Industry Report on Mobile Money* (2020), https://www.gsma.com/sotir/wp-content/uploads/2020/03/GSMA-State-of-the-Industry-Report-on-Mobile-Money-2019-Full-Report.pdf.
[37] Maria Fernandez Vidal, "Platform Business Models: Financial services for poor people in the digital economy," *CGAP*, May 2020, https://www.cgap.org/research/slide-deck/platform-business-models.

market to meet the surge in last-mile logistics demands from e-commerce growth. These e-commerce and payment platforms increase access to goods and services. However, they also create a number of risks as follows:

- **Digital divide**—Platforms can widen the digital divide by serving only those with access to smartphones and internet connectivity, and risk deepening exclusion for those offline as more opportunities move online. Access to critical infrastructures, skilled populations, and enabling policies and regulations remain key in leveraging the opportunities of the digital economy.
- **Data privacy and security**—Data that platforms collect from users can be used to provide better services, but they can also be used to exclude or harm vulnerable people. Data may be sold to third parties or accessed through a data breach. This can undermine digital inclusion efforts by making people lose trust.
- **Quality of work**—Platforms and technology can expand income opportunities for low-income people. However, these jobs generally lack the security of a fixed salary and benefits like paid sick leave.
- **Competition**—As platforms need to scale, the space is likely to be dominated by only a few players. Limited competition can affect fees and prices.

Not everyone is able to reap the benefits of these digital platforms due to barriers such as the lack of access to affordable devices and broadband, skills development, entrepreneurship financing, and a legal framework for electronic transactions, data protection, and online consumer protection in countries.[38]

2.5. POLICIES, REGULATIONS, AND STANDARDS

As illustrated, governments play an important role in the development of a smart logistics ecosystem that cuts across multiple sectors and encompass a broad spectrum of policies, regulations, and standards related to industrial development and trade, ICT and data, and safety, security, and protection, including cybersecurity and environmental and social safeguards. An example is the inclusion of the transport and logistics industry as one of four national development policy priorities in the Twelfth Malaysia Plan 2021–2025, discussed in the first paper.[39]

Holistic policies and regulations need to be in place to develop critical infrastructure, particularly in rural and remote areas to enable good quality and reliable rural connectivity and rural–urban linkages. This includes

[38] United Nations Conference on Trade and Development, *Digital Economy Report 2019* (New York, 2019), https://unctad.org/en/PublicationsLibrary/der2019_en.pdf.
[39] Government of Malaysia, "Twelfth Malaysia Plan 2021-2025: Executive Summary," 2021, https://policy.asiapacificenergy.org/sites/default/files/Twelfth%20Malaysia%20Plan%2C%202021-2025%20%28Summary%29.pdf.

promoting investments in the ICT, road, electricity, and logistics infrastructure (ports, terminals, warehouses, etc.). It also involves investing in human capacity building, including digital skills building, safeguarding individuals' security and privacy rights, supporting the startup ecosystem, enabling fair competition in digital markets, and promoting research and development.

These related policies, regulations, and standards steer investments in infrastructure and systems, and provide direct or indirect incentives that encourage private sector investments in the smart logistics ecosystem, such as enabling the use of drones for tracking cargo and last-mile delivery.

Government efforts to streamline licensing, permitting, taxation, and import/export processes for infrastructure and logistics operators can also accelerate private sector participation and investment in the smart logistics ecosystem. A key bottleneck in logistics is delays in border control and customs clearance processes. Studies indicate that an additional day's delay in transit time from origin to destination due to customs procedures is estimated to cause as much as 1.4% decline in the export growth rate.[40]

Challenges include the use of manual paper-based processes in many countries, lengthy and costly customs clearance procedures, a lack of capacity among customs officers, poor traceability requiring logistics companies to search for their containers, limited cooperation between border agencies requiring logistics companies to interact with multiple agencies, multiple physical inspections of goods and vehicles/containers, and slow turnaround times for the granting of permits for the movement of goods across borders.

Digital transformation of the logistics industry can serve as an impetus to address these challenges. For example, the Maritime and Port Authority of Singapore is implementing a digitalPORT@SG plan to digitalize all port processes, including port terminal and marine support services that would improve port clearances—streamlining up to 16 regulatory applications that were previously submitted via three separate portals into one integrated port clearance service—and reduce container shipping turnaround times.[41]

2.5.1. LOGISTICS-RELATED STANDARDS

A number of global organizations, such as the International Maritime Organization (IMO), United Nations Conference on Trade and Development (UNCTAD), World Customs Organization (WCO), and World Trade Organization (WTO), and international development banks such as the World Bank and Asian Development Bank

[40] World Economic Forum, "Growing Intra-African Trade through Digital Transformation of Border and Customs Services," May 2022, https://www3.weforum.org/docs/WEF_Regional_Action_Group_for_Africa_2022.pdf.
[41] Maritime and Port Authority of Singapore, "About digitalPORT@SG," https://digitalport.mpa.gov.sg/about.

have been advocating the accelerated digitalization of cross-border trade processes and documentation, including the automation of online forms and clearance, particularly during the COVID-19 pandemic. They have also been developing logistics- and trade-related data standards for harmonization, interoperability, and easy exchange across systems and countries. The objectives have been to not only keep trade flowing in current and future crisis events but also protect frontline logistics workers while enabling remote working, with contactless digital solutions replacing paper documents.

Since April 2019, the IMO, under the Facilitation (FAL) Convention, has imposed mandatory requirements for all ports to transition to full-fledged maritime single windows with data on arrival, stay, and departure of ships, persons, and cargo, although implementation has been slow. The IMO has developed a Compendium on Facilitation and Electronic Business to ensure that the maritime single windows data are interoperable to facilitate data exchange between systems.[42]

Subsequently, on October 28, 2020, the European Commission proposed the EU Single Window Environment for Customs to enhance cooperation and coordination between different authorities and support the automated verification of non-customs formalities for goods entering or leaving the EU. The system includes government-to-government cooperation between customs and authorities, as well as business-to-government cooperation to streamline clearance processes for logistics companies.[43]

Despite these efforts, the lack of global standards to facilitate logistics and trade remains a significant challenge. Freight companies have cited a lack of common data standards as a major industry problem, making it more difficult to conduct business between carriers.[44] The Australian Logistics Council continues to call for improved supply chain visibility and the adoption of global data standards to improve collaboration between logistics players.[45] Fissures between standardization groups have led to slow adoption and questions about the technology's viability in the logistics industry.[46] The lack of industry data standards complicates the exchange of information, which in turn limits innovation by providing an incomplete picture of issues that may be affecting logistics companies.

[42] World Bank, "Accelerating Digitalization: Critical Actions to Strengthen Resilience of the Maritime Supply Chain," December 2020, https://openknowledge.worldbank.org/handle/10986/35063.
[43] European Commission, "The EU Single Window Environment for Customs," https://ec.europa.eu/taxation_customs/eu-single-window-environment-customs_en.
[44] Brian Aoaeh, "Commentary: What role will data standards organizations play in a world powered by artificial intelligence?" Freight Waves, 18 June 2019, https://www.freightwaves.com/news/commentary-what-role-will-data-standards-organizations-play-in-a-world-powered-by-artificial-intelligence.
[45] Australian Logistics Council, "A Common Data Set for Our Supply Chain," 2018, https://www.austlogistics.com.au/wp-content/uploads/2018/10/A-Common-Data-Set-for-our-Supply-Chain.pdf.
[46] Transmetrics, "Logistics Data Standards: Challenges and Benefits," 19 March 2021, https://www.transmetrics.ai/blog/logistics-data-standards/.

2.5.2. CYBERSECURITY MEASURES

The increasing digitalization of the logistics industry is accompanied by increasing cyberthreats. Cybersecurity is now one of the major challenges facing the logistics industry with cyberattacks targeted at logistics companies on the rise, particularly ransomware attacks.[47] Policymakers need to work with the private sector to ensure critical infrastructure, and personal data are adequately protected while continuing to help achieve the full benefits of new technologies in a sector where the digital transition has been uneven across countries. A successful smart logistics ecosystem needs to serve the interests of all its stakeholders and needs to be trusted. It also needs to be secure and resilient to disruptions and crises.

The International Telecommunication Union's Global Cybersecurity Index 2020 shows that many countries enacted new cybersecurity legislation and regulations to address areas such as privacy, unauthorized access, and online safety. More than half of the world's countries now have a computer incident response team and almost two-thirds have some form of a national cybersecurity strategy guiding their overall efforts to build cyber resilience, including in the smart logistics ecosystem.[48] However, it is reported that capacity-building efforts in cybersecurity to help governments and businesses better prepare for and mitigate growing cyber risks are insufficient.

The smart logistic ecosystem can strengthen its cybersecurity by working collaboratively, like in a neighborhood watch scheme, to provide early warning of threats and engage in developing a body of knowledge, procedures and policies, and ensuring logistics staff is well trained in cybersecurity measures for improved resilience to cyberthreats.

2.5.3. ENVIRONMENTAL AND SOCIAL SAFEGUARDS

Logistics companies have come under mounting pressures from government legislations, as well as shareholders and consumers, to reduce the environmental and social impact of their supply chains, and be transparent and verifiable in their fair and equitable labor practices. Systems, therefore, need to be in place to capture and measure such environmental and social data and provide recommendations for minimizing carbon emissions, pollution and waste, and promoting social equity.[49] This will enable the development of effective strategies such as those that encourage a multimodal switch to achieve lower emissions, infrastructure building with higher

[47] Adrian Gonzalez, "You've Been Hacked! The Growing Threat Of Supply Chain Cyber Attacks," Talking Logistics, 23 February 2022, https://talkinglogistics.com/2022/02/23/youve-been-hacked-growing-threat-supply-chain-cyber-attacks/.
[48] International Telecommunication Union, "Global Cybersecurity Index 2020," https://www.itu.int/epublications/publication/D-STR-GCI.01-2021-HTM-E.
[49] Kimberley Botwright, "7 leaders at Davos 2022 on securing sustainable, resilient supply chains, despite global shocks," World Economic Forum, 19 May 2022, https://www.weforum.org/agenda/2022/05/leaders-supply-chains-davos-2022/.

carbon efficiency (e.g., upgrading of rail through electrification), and prioritization of projects that bring about greater emission-reducing innovation, as well as assurance of human rights, equity, and safety aspects.

Transport is responsible for around a quarter of direct carbon dioxide emissions from fossil fuel combustion.[50] The transportation of goods largely determines the sustainability of a logistics system, and digital technologies can be used for improving sustainability in different transportation activities. The integration of IoT and AI into a cloud-based platform enables real-time data processing and analysis of traffic conditions, vehicle information, and demand and supply matching in real-time, which can be used for better transportation planning and scheduling, and timely decision support to reduce transport delays, fuel consumption and costs, greenhouse gas emissions, exposures to risks and accidents, and workers' working hours.

Policies, regulations, and standards play key roles in determining the extent to which companies incorporate environmental and social safeguards in their operations and ensure the health, safety, and protection of their workforce and end users. The UNCTAD Global Cyberlaw Tracker reported that 71% (137 out of 194 countries) have passed data protection and privacy legislation. However, the share of countries with data protection and privacy legislation is low at 60% and 57%, respectively. The share in the least developed countries is only 48%.[51] The number of countries that have passed legislations to protect consumers online is even lower at only 59%.[52] Another challenge that countries are grappling with is the protection of the rising number of gig workers and informal workers.

Generally, policies, regulations, and standards for an integrated multisector smart logistics ecosystem remain inadequate. Furthermore, although policies, regulations, and standards are important for steering implementation, to guarantee their effective implementation, buy-in from stakeholders in the logistics ecosystem is vital. Garnering political commitment ensure that the required resources are made available, that challenges in implementation can be overcome, and that changes can be made across all agencies to benefit every stakeholder involved (e.g., all agencies will accept digitally submitted data and documents). Some stakeholders may resist changes as they rely on inefficient processes to circumvent laws and processes. These issues must be addressed when implementing new systems through public–private dialog, training, and working groups that enhance knowledge sharing and understanding.

[50] United Nations, "Sustainable transport, sustainable development: Interagency report for second Global Sustainable Transport Conference," 2021, https://sdgs.un.org/sites/default/files/2021-10/Transportation%20Report%202021_FullReport_Digital.pdf.
[51] UNCTAD, "Data Protection and Privacy Legislation Worldwide," https://unctad.org/page/data-protection-and-privacy-legislation-worldwide.
[52] UNCTAD, "Online Consumer Protection Legislation Worldwide," https://unctad.org/page/online-consumer-protection-legislation-worldwide.

2.6. HUMAN CAPACITY BUILDING

2.6.1. SHORTAGE OF SKILLED LOGISTICS PERSONNEL

There is a human resource crisis in logistics, which has been exacerbated by the pandemic. There are reports of driver shortages and low staffing levels in warehouses, as well as shortages of qualified logistics managers in both developed and developing countries.[53] These are due to a combination of various factors such as uncompetitive pay, poor, and unsafe working conditions, an aging workforce, the inability to attract young talent, and a lack of training and career progression.

There is an urgent need to attract and retain more skilled workers in logistics management roles. Increases in the technological sophistication of logistics operations and the complexity of supply chains call for new and varied skills at operational and managerial levels, which require reskilling and upskilling existing employees.

Yet, at both the national and organizational levels, education, training, research, and innovation have not been priorities. According to a survey conducted by PwC, the lack of digital culture and training is the biggest challenge facing logistics companies.[54] Moreover, efforts to professionalize employment have been undermined by the growth of the gig economy, which has fostered a pool of casual, part-time logistics workers. There has been a tendency for some companies to see training as a cost rather than an investment, partly because they have difficulty quantifying the returns.

Results from a digital supply chain transformation survey show that 39% of logistics executives cite the absence of the required technology skills and expertise—on-site and throughout the supply chain—as the major barrier to logistics digitalization. To accelerate digital transformation, 61% of companies are expected to rely on external partners—i.e., outsourcing, technology, and digital transformation consulting providers.[55] The same survey reported that 25% of logistics and transportation companies do not have a digital strategy in place, and 48% of businesses involved in product distribution rely on traditional technology and legacy software to communicate with partners and manage workflows. Only one-fifth of logistics executives admit having access to data from the extended supply chain and leveraging it for decision-making.

[53] World Economic Forum, "Supply Chains: Human Resource Issues," https://intelligence.weforum.org/topics/a1Gb0000000pTDoEAM/key-issues/a1Gb00000005QyaFEAS.
[54] PwC, "Shifting Patterns: The future of the logistics industry," 2016, https://www.pwc.com/sg/en/publications/assets/future-of-the-logistics-industry.pdf.
[55] Supply Chain Game Changer, "Digital Transformation Technologies and Predictions!" 1 May 2019, https://supplychaingamechanger.com/the-digital-transformation-in-logistics-technologies-barriers-and-predictions/.

A World Bank study reports that logistics companies in developing regions are lagging behind developed countries in terms of training budgets and capability, the range and quality of training provision, and the adoption of professional standards. Often, training is limited to short-term, on-the-job induction provided by colleagues during daily operations.[56] Addressing the logistics skills gap will demand a multistakeholder approach to train, assess, certify, and recruit logistics staff.

Some governments have invested in logistics education, training, and research, such as the Logistics Institute Asia Pacific in Singapore (a collaboration between the National University of Singapore and the Georgia Institute of Technology)[57] and the Malaysia Institute of Supply Chain Innovation (a collaboration between the Massachusetts Institute of Technology and the Government of Malaysia).[58] A particularly important function of these institutes is to bring together government, universities, and industry to innovate in the field of logistics.

In some countries, the logistics industry has taken a proactive role in promoting education and training. An example is the AllianceTexas logistics park in the U.S. employs 31 000 people at more than 290 companies, which does not include the companies and employment in the area surrounding the park. To help ensure a steady supply of logistics workers, the developer recruited a local community college to create a training center in the logistics park. Tarrant County College Corporate Training Center trains people to become foundation-level certified logistics associates (CLA) and mid-level certified logistics technicians (CLT). The training program includes industry-defined standards, online and classroom courseware, textbooks, instructor training, assessments, and credentials. The design of the training program was a collaborative effort among logistics companies, logistics associations, educators, and government agencies. Companies in the AllianceTexas logistics park helped to define the program and agreed to guarantee job interviews for new certificate holders. The U.S. Department of Labor paid for the training. In addition, Tarrant County College offers other courses to improve the logistics workforce's technical, computer, management, and communication skills. The certifications offer frontline logistics workers a chance to document their skills and provide a way to secure higher wages. The college also trains people to become CLA/CLT instructors themselves. This train-the-trainer strategy helps spread the knowledge in the logistics park and allows companies to create in-house training programs for CLA/CLT.[59]

[56] Alan McKinnon et al., *Logistics Competencies, Skills, and Training: A Global Overview* (Washington, D.C.: World Bank, 2017), https://openknowledge.worldbank.org/handle/10986/27723.
[57] The Logistics Institute Asia Pacific, https://www.tliap.nus.edu.sg/.
[58] Malaysia Institute of Supply Chain Innovation, https://www.misi.edu.my/.
[59] Yossi Sheffi, "Logistics Clusters," MIT Press on COVID-19, https://covid-19.mitpress.mit.edu/logics-clusters.

Despite the fact that a sound theoretical education is essential to understanding business processes, logistics staff acquires much of the required knowledge and skillset through practical application. Experiential learning approaches such as business games are useful tools for teaching and simulating logistics processes. The McKinsey & Company model warehouse is an example of how simulation can be used in a simple, affordable, and hands-on way. The experiential learning approach enables logistics staff from all levels to experience warehouse processes in one- to several-day workshops. By using scaled-down warehouse equipment and items, a standard warehouse environment is modeled in a few square meters of space. The equipment can be easily packed in a small container and shipped around the globe to teach logistics staff at any location.[60]

AI-enabled virtual reality and augmented reality technologies have also been used for training, including in dangerous operations, e.g., hazardous materials handling. Such immersive and human-centered digital learning applications can enable collaborative teamwork, tailored virtual assistance, real-time task instructions, and visualization to improve working experiences and effectiveness.

Singapore built an Integrated Simulation Centre with a full mission ship-handling simulator that covers tugboat pilotage, engine room operations, crisis management, vessel traffic management, and digital chart displays. Students of the PSA Institute, a training organization offering courses on port and terminal management, logistics, and warehousing, are able to take advantage of these simulations.[61]

As illustrated, numerous stakeholders are involved in the development, monitoring, and certification of logistics skills. Companies, governments, logistics associations, and academia must collaborate to identify and exchange best practices in skills development. Especially in less mature logistics markets, collaborations are needed to develop logistics training capability that can equip employees at different occupational levels with the necessary range of skills, including digital skills.[62] Digital technologies, from online learning platforms to virtual reality and augmented reality applications, can be used to enhance training and learning.

2.6.2. PROTECTION OF LOGISTICS PERSONNEL

In addition to capacity-building considerations for logistics staff, the fact that they are classified as frontline workers during emergencies to ensure the continuity of supply chains means that they need to be well **protected from harm**. Port and warehouse staff tends to operate in relatively dangerous environments with heavy

[60] Alan McKinnon et al., *Logistics Competencies, Skills, and Training: A Global Overview* (Washington, D.C.: World Bank, 2017), https://openknowledge.worldbank.org/handle/10986/27723.
[61] EduMaritime, "PSA Institute Singapore - Port and Logistics Training," https://www.edumaritime.net/singapore/psa-institute-singapore.
[62] Alan McKinnon et al., *Logistics Competencies, Skills, and Training: A Global Overview* (Washington, D.C.: World Bank, 2017), https://openknowledge.worldbank.org/handle/10986/27723.

machinery and equipment, and delivery workers' visit to multiple sites expose them to multiple health risks during pandemics. Measures need to be in place to safeguard logistics staff and ensure their well-being. Keeping the supply chains moving will rely on prioritizing the health and safety of the workforce, and the long-term health of the logistics industry relies on proper attention to and care for staff.

Some countries have started introducing **wearables** to improve the safety and productivity of their workers. Smart wristbands, helmets, glasses, and protective gears equipped with sensors can capture biometric and environmental data to identify when a worker has fallen, shut down machinery if a worker gets too close, indicate sickness at the start of a shift, or alert workers when they get too close to each other to comply with social distancing rules. To raise workers' productivity, barcode scanners on wrists and fingers can eliminate manual data entry, while smart glasses can help workers identify packages and products simply by looking at them.

As these devices track movement, location, and biometric data that can be used to identify trends and gain insights into workers' health and productivity, wearables have raised privacy concerns. For example, the number of steps taken by an employee with the wearable device can be monitored and tallied for a task being performed, and this information can be used to determine how the movement of the employee throughout the facility can be modified to improve performance. This same data, however, can also be used to penalize the lack of productivity of individual workers.

Truckers or pilots could be required to wear devices that monitor alertness or alcohol in the system. New sweat sensors can now not only detect alcohol but also a huge range of biomarkers that measure health and the potential for disease.[63] While wearables may be deployed to improve safety and warn employees to preempt medical conditions, their reliability, and privacy need to be carefully considered.

2.7. STARTUP ECOSYSTEM

The number of logistics startups is growing rapidly—according to PwC, most of the new entrants to the logistics industry are startups, and many leverage digital technologies to enter the industry.[64] Key challenges in building a startup ecosystem include the lack of public and private sector financing for startups, lack of robust policies

[63] Craig Guillot, "Wearables in the warehouse bring privacy concerns to the forefront," Supply Chain Dive, 21 May 2019, https://www.supplychaindive.com/news/wearables-IoT-tracking-workers/555232/.
[64] PwC, "Shifting Patterns: The future of the logistics industry," 2016, https://www.pwc.com/sg/en/publications/assets/future-of-the-logistics-industry.pdf.

and regulations to provide a sustainable startup environment, lack of local and foreign talent with the required technical and digital skills, and lack of support for startups from product ideation to commercialization.

In recent years, logistics startup funding has shifted from the U.S. to China and Asia, especially Hong Kong, India, and Singapore.[65] China has already some of the key incubators for many disruptive digital innovators and is a leading global investor in disruptive technologies through support from the government that provides infrastructure and capital to create an ecosystem in which entrepreneurs can cooperate and flourish. For example, Chinese venture capital firms have enjoyed a deduction on taxable income by 70% of their investment in seed or early-stage high-tech startups since 2019. Small companies can also qualify for significant tax relief if their income does not exceed $435 800.[66]

Logistics incumbents are also increasingly partnering with or acquiring startups. For example, UPS Ventures, a venture capital arm, has invested millions of dollars in companies such as trucking platform—TuSimple, crowdsourced delivery service—Deliv, inventory/return management company—Optoro, and more.[67]

In Singapore, the Maritime and Port Authority of Singapore and National University of Singapore initiated a startup program since 2018 called PIER71 that includes the following:[68]

- **PIER71 accelerate**—A six-week market validation and customer discovery program with workshops and masterclass sessions conducted by industry veterans and domain experts. Startups are paired with a mentor and get connected to maritime corporates, investors, venture capitalists, serial entrepreneurs, as well as PIER71's networks of resources.
- **PIER71 ascend**—A 12-month, by-invite-only scale-up program, with curated masterclasses, industry networking sessions, and an immersion program aimed at connecting startups to overseas markets and government stakeholders, as well as prospective maritime customers. Promising scale-ups can apply for grant support to scale their solutions.

Solutions addressing the safety and well-being of maritime personnel, and environmentally sustainable shipping operations featured strongly in 2021 and 2022, in line with the increased attention paid by the industry in these areas.

[65] McKinsey & Company, "Startup funding in logistics: New money for an old industry?" February 2020, https://www.mckinsey.com/industries/travel-logistics-and-transport-infrastructure/our-insights/startup-funding-in-logistics.
[66] Ibid.
[67] UPS, "UPS Ventures," https://about.ups.com/mx/en/our-company/ups-ventures.html.
[68] Pier71, "What We Do," https://pier71.sg/about-pier71/what-we-do/.

Funding for African startups is at record highs with Nigeria and Kenya as the main startup hubs in the region through support from their governments.[69] In 2021, for example, Kenya introduced a Startup Bill that, among other things, proposes to establish a Kenya National Innovation Agency to foster partnerships among startups, incubators, and investors.[70] Ethiopia's draft Startup Act provides startups with access to financial and fiscal incentives, streamlined business processes, and a regulatory sandbox to test their business models.[71]

Overall global trend shows that governments are introducing reforms to create more startup-friendly environments, including nurturing talent and increasing access to capital and customers. Incubators and accelerators need to be fostered to enable startups to grow, supported by academic research, skills development and retraining, and outreach to attract talents and a new generation of digital trade and logistics professionals in the public and private sectors.

Another trend is the increasing fragmentation of the startup ecosystem with emerging regional hubs such as Singapore and Dubai building technologies catering to their geographies. People seem to be adopting solutions customized with local preferences and built by local entrepreneurs, instead of patronizing a handful of powerful global corporations,[72] which is a positive direction for more diverse players in the ecosystem.

2.8. COOPERATION AND COLLABORATION

The stakeholders in a traditional logistics network are often siloed from each other—warehouse management has separate dashboards from freight forwarders. An integrated smart logistics system breaks these silos and gives each stakeholder in the logistics network end-to-end visibility. With enhanced visibility and transparency, trust can be built to share infrastructure and resources, such as warehousing and transportation facilities, across the logistics supply chain through a digitally integrated cross-border logistics system.

A promising technology for trust-building is blockchain. Blockchain that does not allow records to be changed once validated provides a secure and trusted way for logistics stakeholders to collaborate. Blockchain can, for example, speed up administrative work by automating agreements using smart contracts. These contracts execute automatically when certain conditions are met—e.g., when two parties agree on the price of a shipment. Once the contract has been executed, it cannot be changed. This provides all stakeholders with the confidence

[69] Startup Genome, "The Global Startup Ecosystem Report 2021," https://startupgenome.com/report/gser2021.
[70] Republic of Kenya Parliament, "The Startup Bill 2021," http://www.parliament.go.ke/sites/default/files/2022-03/The%20Startup%20bill%202021.pdf.
[71] Business Info Ethiopia, "7 Things You Might Want to Know About Ethiopia's Draft Startup Proclamation," 22 February 2022, https://businessinfoeth.com/7-things-you-might-want-to-know-about-ethiopias-draft-startup-proclamation/.
[72] StartupBlink, "Global Startup Ecosystem Index 2022," https://lp.startupblink.com/report/.

that the information is reliable while reducing manual paperwork. Blockchain also provides a secure, auditable trail of all transactions, enabling the monitoring of goods across the supply chain, avoids tampering, and reduces the risk of fraud.

During COVID-19, the key supply chains that have received the most attention include the agriculture, food, and beverage supply chain due to rising food insecurity, as well as the health and medical supply chain to transport essential medical supplies such as masks and personal protective equipment, and later, vaccines. Building the resilience of these supply chains is critical in preparation for future crises and emergencies.

Strategies that many countries have adopted to strengthen supply chain resilience include building a more diverse network of partners, reducing import dependency by creating domestic or regional sources of supply, and shortening the supply chain, such as by placing additional shared warehousing capacity or dry ports near demand centers to shorten the time to get goods to market. These trends have raised the need for local, national, and regional **logistics clusters** to facilitate and implement this integrated framework (encompassing the eight pillars of critical infrastructure, core logistics, industries, digital economy, policies, people, startups, and collaboration) toward a resilient and sustainable smart logistics ecosystem.

2.8.1. CHALLENGES OF LANDLOCKED DEVELOPING COUNTRIES

About one in five countries in the world is landlocked; 20 out of 54 low-income economies are landlocked, the majority of them in Sub-Saharan Africa. Their lack of access to maritime trade and logistics systems, higher transport and trade costs, dependence on their neighbors' infrastructure to transport goods to port and often burdensome administrative practices for border crossings, as well as dependence on their neighbors' peace and stability and political relations present serious challenges for many landlocked developing countries. Transit neighbors can easily block borders or adopt regulatory impediments to trade. During the pandemic, landlocked developing countries have been hampered in their access to global markets by restrictions on mobility imposed both at the national level and in transit countries. Although there is a legal basis for the rights of landlocked transit as outlined in Article 125(1) of the United Nations Convention on the Law of the Sea, in practice, this right of access must be agreed upon with the transit neighbor and is determined by the relationship between the countries. Addressing these complex challenges require regional and subregional cooperation on fundamental transit policies and on building infrastructure and skills in a holistic and integrated manner as described in this paper.

2.8.2. BILATERAL TRADE AGREEMENTS

The increase in bilateral trade agreements over the last decade has affected cross-border trade, reorganizing the global flow of goods and services. Bilateral agreements that eliminate trade barriers such as tariffs, import quotas, and export restraints to encourage trade and investment between two countries can expand markets for the two countries, and enable swift border control and customs clearance to prevent spoilage of perishable goods. However, bilateral agreements often result in competing agreements with other countries, eliminating the advantages of free trade agreements. The bilateral trade agreements between African and nonAfrican countries in Europe, North America, and Asia, for example, impact intraAfrican trade and the implementation of the AfCFTA, as more investments are placed in improving the logistics infrastructure and border control processes made through the bilateral agreements.[73] Moreover, bilateral trade agreements can skew a country's markets when large multinational corporations, which have significant capital and resources to operate at scale, enter a market dominated by smaller players, creating an uneven playing field.

Nevertheless, the growing collaboration across the African continent, underpinned by AfCFTA, for instance, represents an opportunity to pilot this integrated framework to not only safeguard citizens against shocks and crises but also act as an engine for regional competitiveness and sustainable growth. The eWorldwide Group is working closely with strategic partners, including United Nations agencies, governmental organizations, and logistics companies like DP World, on a number of interrelated initiatives, including COVID-19 vaccine supply chain management, smart shea butter village industry clusters, and smart logistics and supply chain center of excellence for Africa, to build these local, national and regional logistics clusters through multisectoral, multidisciplinary, and multistakeholder cooperation and collaboration.

3. CONCLUSION AND WAY FORWARD

The COVID-19 crisis has exposed the vulnerabilities, gaps and digital divide that exist in the logistics ecosystem. While some developed countries and large multinational companies have developed integrated smart logistics systems, emerging economies, and MSMEs barely have the foundational infrastructure and resources for digitalization and continue to struggle with reliance on paper-based transactions and personal interactions.

[73] Kingsley Ighobor, "AfCFTA: Africa readying for free trade come January 2021," Africa Renewal, 30 November 2020, https://www.un.org/africarenewal/magazine/november-december-2020/afcfta-africa-readying-free-trade-come-january-2021.

Since the onset of COVID-19, international organizations and development banks have stepped up efforts in supporting countries in digitalizing and upgrading logistics systems to improve performance, competitiveness, resilience, and sustainability using advanced technologies such as AI and ML, data analytics, IoT, autonomous systems, digital twin, blockchain, and other smart technologies.

In summary, the benefits of a smart logistics ecosystem include the following:

- Provides end-to-end visibility and transparency along the entire supply chain by tracking the real-time movement of goods with GPS, IoT, and other systems, and creating a blockchain-based auditable trail of all transactions.
- Optimizes end-to-end logistics planning and management processes based on warehouse location and targeted delivery location, suggesting appropriate transport modes, and factoring the impact of weather conditions, port and traffic congestion, and natural disasters and other disruptions.
- Enables collaboration, such as the sharing of warehousing and transportation facilities across the logistics supply chain through a digitally integrated cross-border logistics system.
- Reduces risks and failures with real-time monitoring and predictive analytics, enables timely mitigation of disruptions along the supply chain, and provides actionable insights and solutions for improved resilience and sustainability and logistics supply chains.
- Improves efficiency through the use of autonomous forklifts for loading and unloading, robots for managing inventory, and drones and autonomous vehicles to deliver goods.

Yet, the digitalization of the logistics industry towards a resilient and sustainable integrated smart logistics ecosystem is not just a matter of technology. It must encompass a holistic approach that addresses barriers related to critical infrastructure and core logistics, policies, regulations and standards, human capacity building, developing a startup ecosystem and digital economy, and cooperation and collaboration across sectors and industries.

It must leverage integrated infrastructure development that codeploys physical infrastructure (electricity, utilities, roads, highways, motorways, ports, and terminals) with digital infrastructure to create integrated smart logistics systems, allowing seamless connection of critical infrastructure and services to the people.

However, there is a general lack of holistic consideration of the pillars in the integrated multisector smart logistics ecosystem framework, which can jeopardize the resilience and sustainability of the smart logistics ecosystem. For instance, investment in digital technologies must go hand in hand with addressing the anxiety of

employees who worry about job losses and their careers, and the difficulties, especially for aging workers, both technically and psychologically, to adapt to this transformation.

Without this holistic approach, the digital and socioeconomic divides are likely to widen, and inequalities further exacerbated. We have seen that the COVID-19 pandemic has hindered the flow of goods, increased logistics costs, and imposed a higher risk on vulnerable groups related to the shortage of medical supplies, food, and other necessities. Similar pandemics and crises are likely to occur in the future, and the logistics ecosystem needs to be prepared.

Based on the good practices and lessons learned from the pandemic and other crises, some actionable recommendations are proposed for realizing this integrated framework, as follows:

- Promote and enable the co-deployment of infrastructure in which infrastructure sectors (road, rail, energy, ICT) collaborate to jointly construct and share infrastructure, and build intelligent transportation systems, smart highways, and smart motorways.
- Invest in logistics parks, hubs, and clusters to increase the scale, visibility, and influence of MSMEs, encourage resource pooling, facilitate access to private and government funding, as well as advance technologies, know-how, and equipment.
- Provide financial and skills development support to MSMEs and startups in the logistics ecosystem, especially in landlocked developing countries.
- Offer support both in increasing the number and diversity of logistic-related digital public goods in the Digital Public Goods Alliance Registry and in greater adoption of logistics-related digital public goods.
- Prioritize digital solutions that strengthen resilience, benefit vulnerable groups, advance environmental and social sustainability, and promote economic efficiency.
- Enshrine international standards for data security, privacy and protection, and safeguard consumers' and gig workers' rights.
- Expand opportunities for logistics personnel to retrain and upgrade skills, through the provision of digital and cybersecurity skills development programs, role models, and networks, as well as incentives.
- Promote entrepreneurship and build a startup ecosystem through digital logistics skills development, financial incentives such as tax cuts, low-interest bank loans and digital MSME support funds, and public-private partnerships.

- Standardize and streamline border control and customs clearance processes through initiatives like single window systems, ensuring the interoperability, and cybersecurity of systems.

Recovery from the pandemic is a chance for all actors to rethink logistics and come up with integrated solutions for withstanding future crises, as well as support the achievement of the SDGs. It is vital that countries and logistics stakeholders collectively engage in a holistic digital transformation of their logistics industry to create a resilient and sustainable integrated smart logistics ecosystem and ensure that no country or group is left behind as those outside the ecosystem risk higher logistics costs and slower socioeconomic growth, and may even face shortages of essential goods.

RAISING THE WORLD'S STANDARDS

3 Park Avenue, New York, NY 10016-5997 USA http://standards.ieee.org

Tel.+1732-981-0060 Fax+1732-562-1571