Mapping TradeTech:
Trade in the Fourth Industrial Revolution

INSIGHT REPORT

Cover: Getty Images

Contents

Foreword

The COVID-19 pandemic has revealed the urgent need for customs and all supply chain stakeholders to digitize procedures and apply technology to achieve more efficient connectivity and collaboration.

Kunio Mikuriya
Secretary-General,
World Customs Organization,
Brussels

Global trade is experiencing a technological revolution and the area of customs clearance is no exception, given its mandate to facilitate trade, protect society and ensure effective revenue collection while making processes as smooth as possible for all actors along the supply chain. In this regard, emerging and enabling technologies based on the use of big data, telematics and cloud computing can positively impact the overall performance of customs administrations.

The topic of digital customs has been high on the customs agenda for many years. Customs administrations are already making some use of digital systems to collect and safeguard customs duties, control the flow of goods, people, conveyances and money, and protect cross-border trade from illicit trafficking. The World Customs Organization (WCO) has developed several instruments to guide its members along the path of digitization.

In the context of the COVID-19 pandemic, it has become apparent that automated clearance systems for issuing declarations, performing risk management, undertaking validation and possibly delivering approvals, coupled with the use of high-tech devices to perform non-intrusive inspections, have made a significant difference on the ground.

The current worldwide health crisis has revealed the urgent need for customs and all supply chain stakeholders to digitize procedures and apply technology to achieve more efficient connectivity and collaboration using harmonized approaches and interoperability based on the implementation of international standards, such as the WCO Data Model.

Studies to implement some emerging technologies, such as blockchain, biometrics, artificial intelligence and the internet of things, are well under way in customs administrations, and their use could provide a much needed leap forward for customs in the fight against illicit trade and trafficking, while boosting efficiency and equity.

By virtue of their strategic location along the supply chain, customs administrations can contribute to large-scale deliberations on making greater use of technological innovations in the international trade arena for the benefit of all. In cooperation with the World Economic Forum, the WCO is pleased to contribute to a global discussion on the convergence of technology and trade.

In 2021, as reflected in the theme of International Customs Day (26 January), the customs community will unite around the theme of "Customs bolstering Recovery, Renewal and Resilience for a sustainable supply chain". The WCO looks forward to working with the international community on how best customs agencies can strengthen collaboration, harness technology and heighten stakeholder preparedness in order to enter tomorrow's world with confidence.

Executive summary

The TradeTech survey results show that "fundamental" technologies such as digital documentation, digital platforms, digital payment and cloud computing are perceived as most relevant in the shorter term, along with IoT, digital services and 5G.

TradeTech is the set of technologies and innovations that enable global trade to be more efficient, inclusive and equitable. The interplay of technology and trade has a long history, spanning from advances in transportation to the advent of the container to the emergence of coordinated production networks.

This report considers modern TradeTech in two layers: (1) a first layer in which trade data and processes are transformed from analogue to digital; and (2) a second layer in which trade process optimization and synchronization occurs between different parties, and where emerging technologies play a key role. TradeTech solutions work in bundles. While the second layer depends on data generated in the first one, it is also hard to separate artificial intelligence (AI) from robotics or the internet of things (IoT) from 5G.

Business perceptions show that many technologies have a significant impact on trade. The World Economic Forum launched a global survey to understand how firms are currently using technologies in international value chains and to assess which technologies will have the biggest impact on global trade. The results are being used to determine a landscape of technologies that have the biggest effect on trade in the short and medium term. According to this survey on TradeTech, conducted from June to September 2020, "fundamental" technologies such as digital documentation, digital platforms, digital payment and cloud computing are perceived as most relevant in the shorter term, along with IoT, digital services and 5G. Technologies expected to affect trade in the longer term are robotics, virtual reality, 3D printing and AI.

The major benefits of TradeTech are efficiency gains (often thanks to collaboration between different parties), the emergence of new digital products and services, positive environmental impacts and the inclusion of smaller players in trade. Yet the survey results also show the potential negative effects of TradeTech adoption in terms of job displacement and competition.

This report aims to shed light on the landscape of emerging trade technologies and consider the opportunities and challenges for each, with case studies used for illustration.[1] Chapter 1 offers an overview of TradeTech and highlights seven current trends. These range from geopolitical considerations to the restructuring of the logistics market as a result of the adaption of emerging technologies to the role of TradeTech in supply chain resilience amid COVID-19.

Chapter 2 considers the application of major technology groups, describing the trade-related problems they purport to solve and implications for trade policy. Chapter 3 covers the major challenges for TradeTech adoption and suggests a way forward for solutions. Chapter 4 describes the potential that further TradeTech adoption could have for micro-, small and medium-sized enterprises (MSMEs) and developing countries, while Chapter 5 outlines key takeaways and next steps.

Some new and innovative trade agreements, initiatives such as Data Free Flow with Trust under the Osaka Track, and harmonized principles around new technologies such as the Organisation for Economic Co-operation and Development (OECD) Principles on Artificial Intelligence, among others, are working towards facilitating the wide adoption of TradeTech. At the same time, international tension regarding trade and technology – especially around 5G technology – risks expanding beyond legitimate security safeguards to techno-nationalism.

A fragmented international tech environment might be harmful for standard setting and, ultimately, affect affordability for smaller firms and developing countries. Consequently, their competitive advantage in trade could also be affected, as digitalization and emerging technologies have an enabling role not just in trade facilitation but in overall trade.

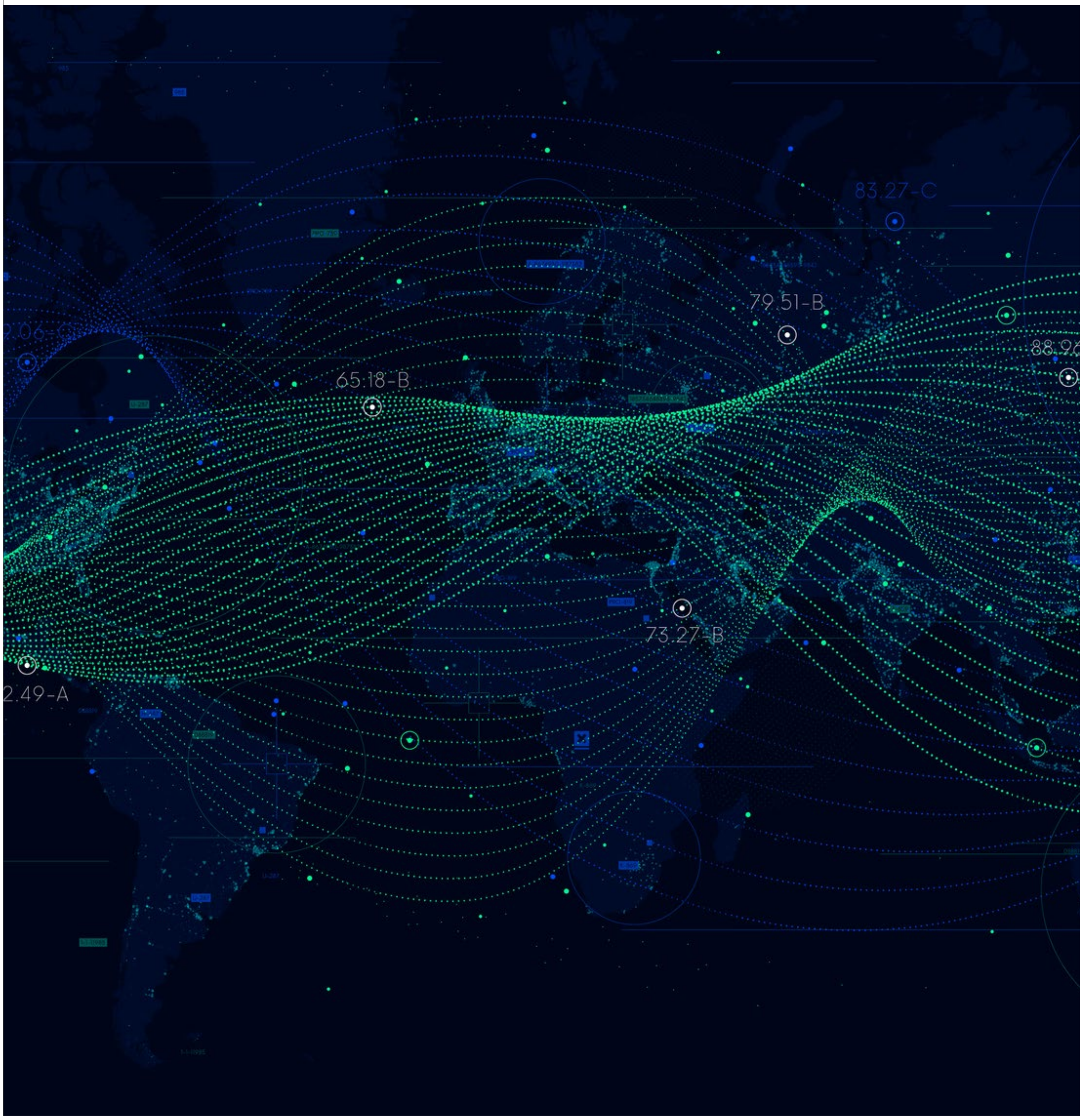
The traditional perception that economic interdependence is driven by low-wage labour arbitrage or access to resources is now challenged. Only 18% of trade in goods is driven by labour cost.[2] Meanwhile, value chains are becoming more and more knowledge intensive, in part thanks to embedded technology. Knowledge-intensive goods and services account for half of all cross-border flows and are growing faster than labour- or capital-intensive flows.[3]

The democratization of technology can help close the gaps between developed and developing countries, as well as between small and large firms, even offering "leapfrog" opportunities. The further widening of the digital divide must be prevented, also in the trade space. As any other technology application, TradeTech is here to stay. Thus, the focus needs to be on fostering public-private partnerships and international cooperation to ensure efficiency gains and advance development for all.

Below: Getty Images

1 TradeTech: An Overview

TradeTech is fundamental to harnessing the innovations of the Fourth Industrial Revolution to support the public good.



1.1 What is TradeTech?

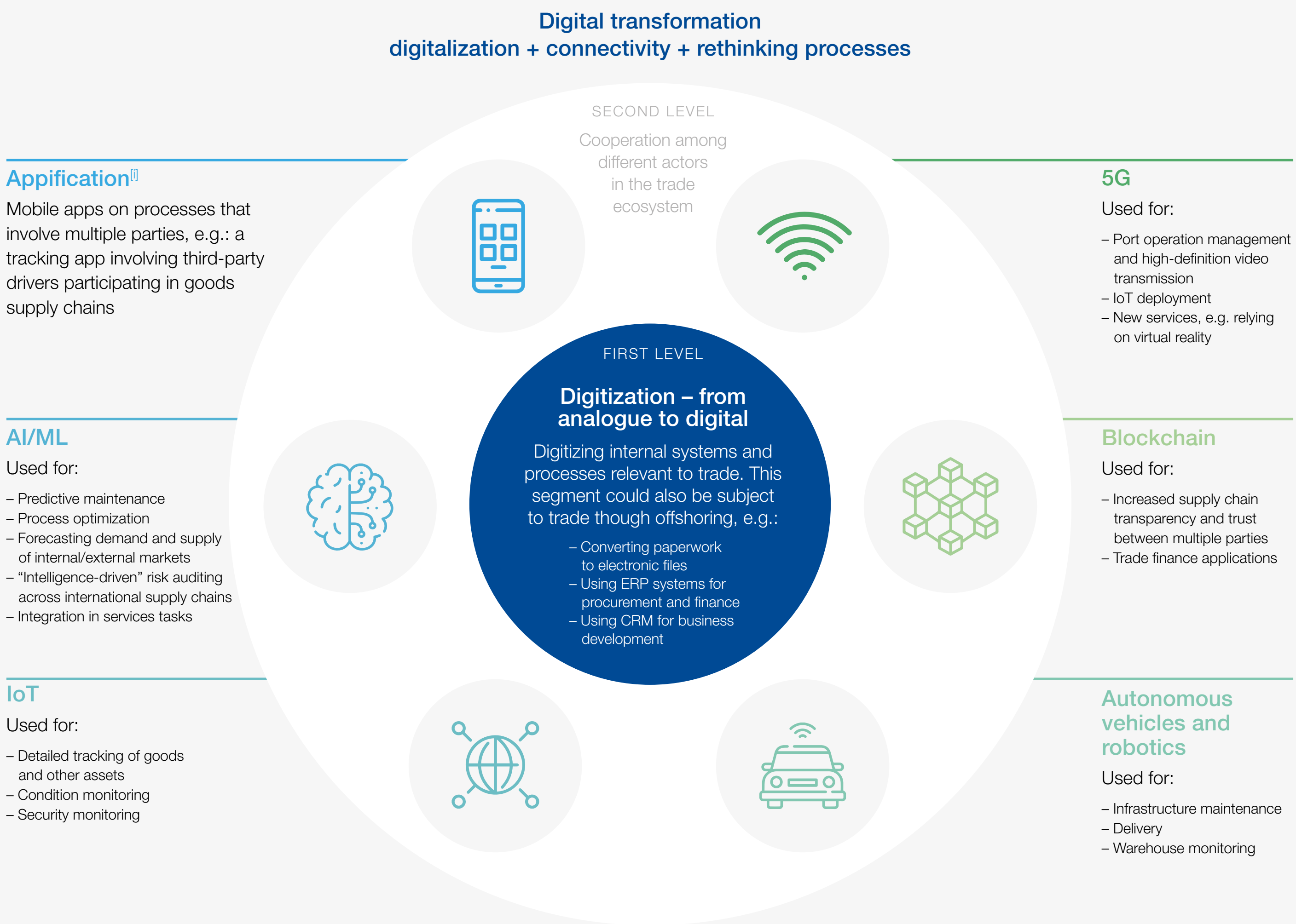
Technologies and innovations have interacted with trade for thousands of years, from advancing transportation methods to the advent of the container to the emergence of fragmented production networks. TradeTech, or the set of technologies and innovations that enable trade to be more efficient, inclusive and equitable, is fundamental to harnessing the innovations of the Fourth Industrial Revolution to support the public good.

TradeTech's importance is shown by the disruptions that technologies are causing to business models, the reconfiguration of value chains, efficiency gains, the achievement of sustainable outcomes and the inclusion of micro-, small and medium-sized enterprises (MSMEs) in trade. Yet less positive consequences also exist and need to be mitigated to ensure TradeTech works for all.

TradeTech can be understood in two layers (Figure 1): (1) a first level of transforming internal systems and processes from analogue to digital, ultimately useful to streamline trade processes; and (2) a second level in which trade process optimization and synchronization between different parties is possible thanks to new technologies and greater connectivity.

The second level involves the transformation of processes and relies on the data generated by the first to further enhance trade operations or introduce a new class of service. Emerging Fourth Industrial Revolution technologies play an enabling role at this second level, working in bundles. For example, it is hard to envision autonomous robotics operating without relying on artificial intelligence (AI), or AI services without cloud computing, or extensive internet of things (IoT) deployment without 5G networks.

FIGURE 1 **TradeTech digitalization levels**



Notes: ERP – enterprise resource planning;
CRM – customer relationship management

[i] appification: for a definition, see EASA, "What is 'Appification'?", EASA Blog, https://easasoftware.com/democratization/what-is-appification/# (accessed 30 November 2020).

Source: World Economic Forum

Taking, for example, the proliferation of 5G, drastic changes can be expected in virtually all areas of business, and trade is no exception. Supply chains stand to gain tremendously from real-time product tracking, the automation of processes through robotics as well as wireless sensors on roadways, in railcars, at airports, in seaports, at customs, at yards and in warehouses. The decentralization of business processes beyond the confines of one organization promises to enable transparency from end to end for the first time. Moreover, the availability of data allows moving from reactive event mitigation to proactive event management, anticipating late shipments, for example (Box 1).

BOX 1

The evolution of TradeTech mobile applications

Enterprise computing today is increasingly augmented by decentralized, highly distributed applications that allow access to and capture of data at any time and in any place. Increasingly capable hardware allows many business processes to be handled on mobile devices. Close to 9 million mobile applications are available across the globe, with over 200 billion downloads worldwide. Shipments and the movement of freight are among the most active trade applications. The underlying concept of a first generation of these applications was ensuring supply chain visibility: users see what is happening in logistical processes across different actors in the supply chain.

Until recently, GPS tracking systems, electronic logging devices and other hardware-based solutions provided some relief in this area through a "dot on a map". Yet, transportation mistakes, other errors and miscommunication are still rife. In the United States, for example, 35% of shipments experience irregularities.[i] The fact that these problems still exist is proof that the first generation of GPS-type mobile supply chain tools does not effectively address them.

A new class of supply chain visibility applications recently emerged to drastically reduce and anticipate these issues through intelligent data sharing and real-time updates based on mobile data capture and IoT sensors. Some companies, such as Truckl, have demonstrated the potential of these new applications, where transportation drivers record their arrival and departure times, capture documents through images that are instantly converted into PDFs, take photos of freight, work through checklists and obtain proof of pickup or delivery signatures. This data is shared with all parties to a supply chain transaction immediately using collaborative dashboards that do not require application programming interfaces (APIs) or electronic data interchange (EDI). The resulting cost and time savings can be substantial, but it is ultimately the gain in quality of service and customer satisfaction that often makes the case for innovative and enhanced supply chain visibility.

[i] Communication from Chris Hanebeck, Chief Executive Officer, Truckl.io, USA

Source: Contributed by Truckl

> The availability of data allows moving from reactive event mitigation to proactive event management, anticipating late shipments, for example.

The diffusion of TradeTech does not stop at national borders, making it relevant for global supply chains and trade networks. This is not just a private-sector-led initiative, as governments are also adopting TradeTech internationally to facilitate customs clearance and trade single window interconnections.

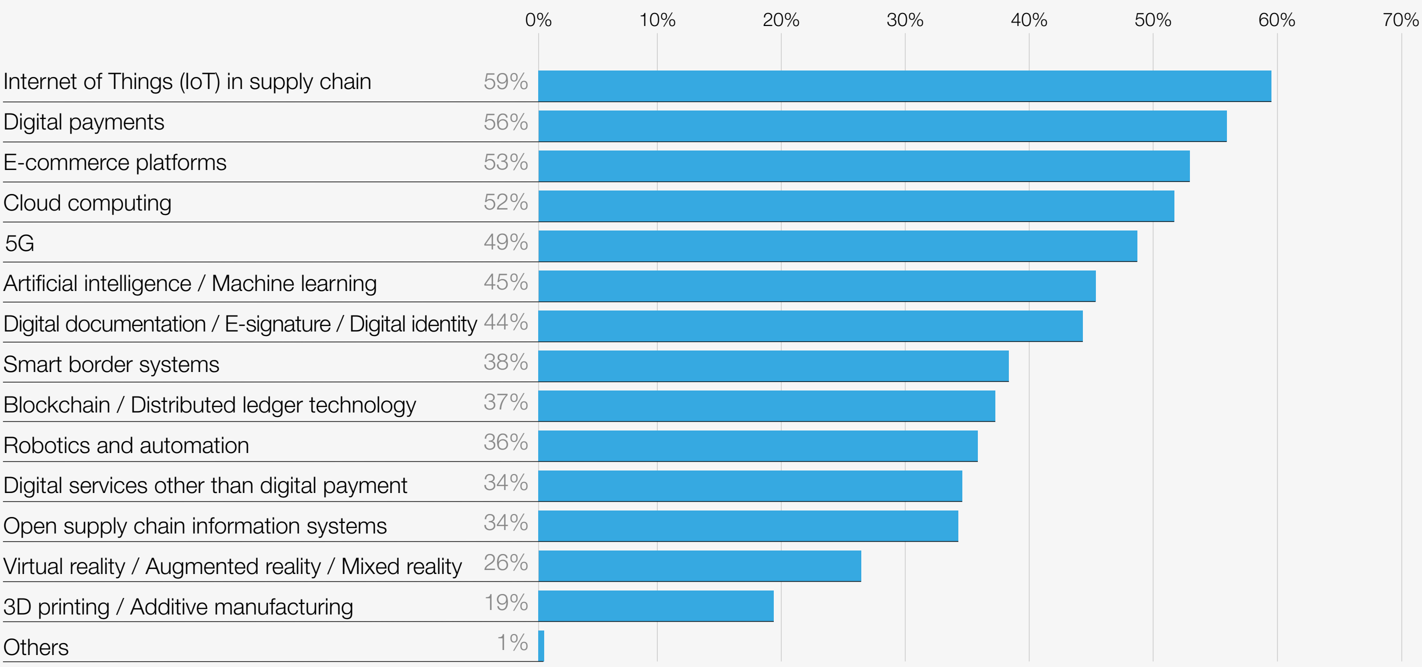
Yet key challenges persist, from the lack of human capital in certain sectors to the lack of interoperability of tech infrastructure/ecosystems, to resistance to share data with other actors. Collective action to increase international supply chain security and visibility can realize tremendous efficiency gains, although incentives to move in this direction might not be high for individual companies.

1.2 Most transformative TradeTech

The Forum's global survey aimed to understand how firms are using technologies in trade and to assess which technologies will have the most impact on global trade going forward. The survey insights are based on 340 responses from firms of different sizes across sectors and from the world over. All respondents were from companies currently engaged in international trade operations.[4]

The survey results identify the most transformative technologies to be IoT, digital payment, e-commerce platforms and cloud computing, as presented in Figure 2.

FIGURE 2 **Most transformative technologies for trade**

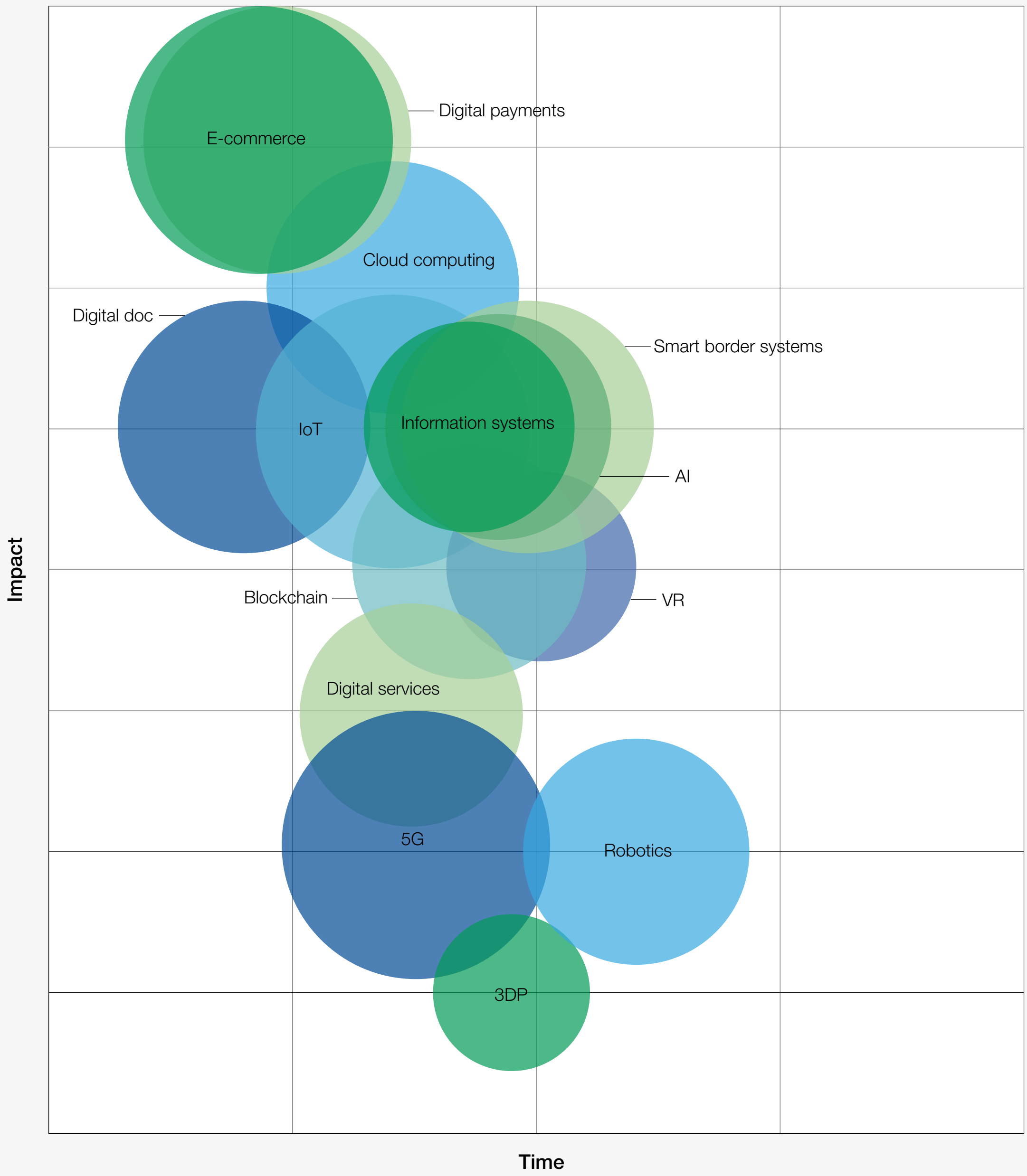


Source: World Economic Forum 2020 global survey on TradeTech

Figure 3 maps TradeTech – and some of its specific applications in the trade ecosystem – in term of time to impact. Technologies that are thought to have their full impact on trade the soonest are e-commerce, digital payments, cloud computing, IoT, digital services, digital documents and 5G. Technologies expected to impact trade in the longer term are robotics, virtual reality (VR), 3D printing (3DP) and AI. Chapter 2 discusses each technology in detail.

FIGURE 3

Technologies with the most impact and years to full potential

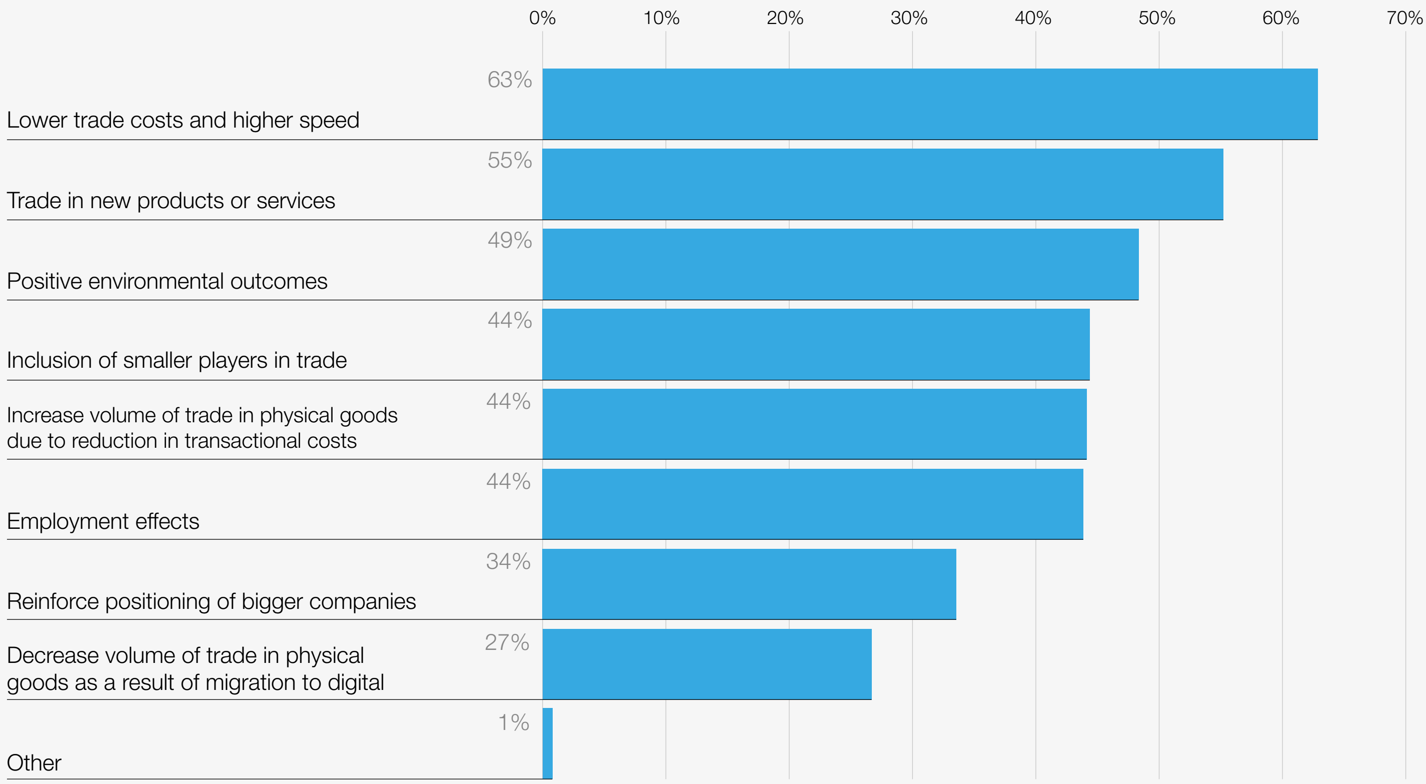


Source: World Economic Forum 2020 global survey on TradeTech

1.3 Fourth Industrial Revolution technologies disrupt trade

According to the survey results, major outcomes expected from the incorporation of technologies in trade (Figure 4) are efficiency gains derived from trade facilitation and supply chain enhancement (63% of responses); the emergence of new digital products and services (55%); positive environmental gains from more efficient logistics coordination (49%); and the inclusion of smaller players in trade (44%). Yet the survey results also show negative perceptions if there is further TradeTech adoption in terms of employment effects (also 44% of responses) and the reinforcing positioning of bigger companies (34%).

FIGURE 4 **The impact of TradeTech**



Source: World Economic Forum 2020 global survey on TradeTech

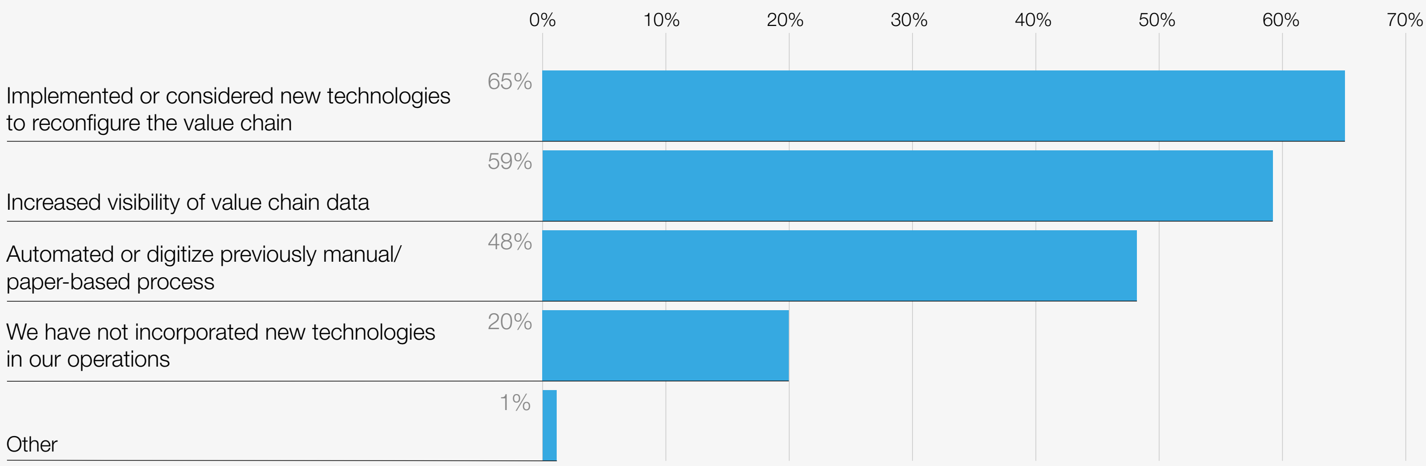
1.4 Trends in TradeTech

TradeTech for supply chain resilience

Amid COVID-19, organizations all over the globe have had to quickly adjust and adopt digitalization and emerging technologies to keep operating. As Figure 5 shows, the vast majority of survey respondents have opted for some kind of TradeTech adoption: 65% have incorporated new technologies resulting in reconfigured value chains, while 59% have increased the visibility of value chain data.

Lockdown measures due to the health crisis have put pressure on companies to adjust their value chains. Two-thirds (66%) of global electronic manufacturers, for instance, expected a supply chain delay of more than four weeks in March 2020 and sought new ways to cushion the delay, whether by alternative sourcing or 3D printing.[5]

FIGURE 5 | Companies' TradeTech adoption amid COVID-19



Source: World Economic Forum 2020 global survey on TradeTech

Impacts of techno-nationalism on TradeTech adoption

In past years, the trend has increased among governments to seek to "cleanse" supply chains of critical technologies due to national security or other concerns, including telecommunications and video surveillance technologies supplied or developed by certain competitor nations and perceived adversaries.[6] This has led to the blacklisting of key technology suppliers, significant disruptions to the tech supply chain and strict government procurement restrictions.[7]

Governments are also intervening to restrict outbound flows of "critical technologies" under export controls, sanctions, trade secret laws and data privacy regulations, among others. For example, in 2018, the US Congress passed the Export Control Reform Act mandating an inter-agency review and the identification of "emerging and foundational technologies" not currently restricted for export. These can include machine learning, AI, data analytics, logistics technology, quantum computing and others.

As a prime example, the future export potential of 5G technology from China to several jurisdictions hangs in the balance due to both blacklisting by potential purchasing nations and increasingly restrictive Chinese technology and export controls.

In some cases, governments push to create opportunities for local technology champions through state subsidies and preferential treatment, despite their discriminatory nature.

In this increasingly fragmented world, multinational companies (MNC) are caught in the middle of growing tensions between market interests and national security grounds. Some MNCs are responding by redesigning their supply chain networks and accelerating TradeTech adoption to experiment with new risk management tools, such as microscopic RFID technology that could be used to trace supply chains involving restricted technologies.[8]

Tensions around technology will have implication not just in their trade but in overall trade. This is the case as value chains become more knowledge intensive, in part thanks to embedded technology. Only 18% of trade in goods is driven by labour costs,[9] while knowledge-intensive goods and services account for half of all cross-border flows and are growing faster than labour- or capital-intensive flows.[10]

Emerging data sharing initiatives

Data sharing across the supply chain would produce cost efficiencies and transparency. Although the collective gains are clear, how each player will benefit individually is a battle that feeds into a general reluctancy to share data even within the same supply chain.

Yet the appetite and willingness to share data and data insights are shifting in some arenas. Common purpose initiatives that might accelerate recovery from a pandemic that impacts trade, supply chains and livelihoods can be seen as incentive to collaborate. For example, logistics and consumer

❝ Data sharing across the supply chain would produce cost efficiencies and transparency. The availability of data transfer mechanisms is key to ensure free data flows with trust across jurisdictions.

companies are collaborating with public bodies on a new initiative to support humanitarian response activities. The initiative entails establishing an open-source visibility tool, comprising elements of near-real time, aggregated and anonymized data from across the global essential goods and transport supply system, with no commercial purposes.[11] Data sharing initiatives in trade facilitation are also prominent. For instance, ASEAN Digital Trade Connectivity aims to connect all trade facilitation actors into a single platform across all 10 member states, building on existing efforts of the National Single Window and ASEAN Single Window initiatives.

Efforts to create commercial data marketplaces are also being explored. For instance, Ocean Protocol and dexFreight co-built a blockchain-powered logistics data marketplace for the transportation and logistics industry that enables companies to aggregate and monetize operational data, in a cost effective and secure manner.[12] The marketplace helps sellers and buyers put a price on data, such as shipment bookings with origin-destination and associated freight charges. Access to aggregate data in logistics can provide efficiency and environmental gains.

These efforts are bolstered by a maturing wave of solutions enabling and incentivizing data sharing, while ensuring privacy and security, managing diverse regulatory requirements and protecting commercial interests.[13] For example, privacy-enhancing technologies such as decentralized learning and homomorphic encryption are enabling value creation by helping businesses share data and insights, or conduct a joint analysis without exposing the raw data. The availability of data transfer mechanisms is key to ensure free data flows with trust across jurisdictions.

Effects of TradeTech on logistics intermediaries

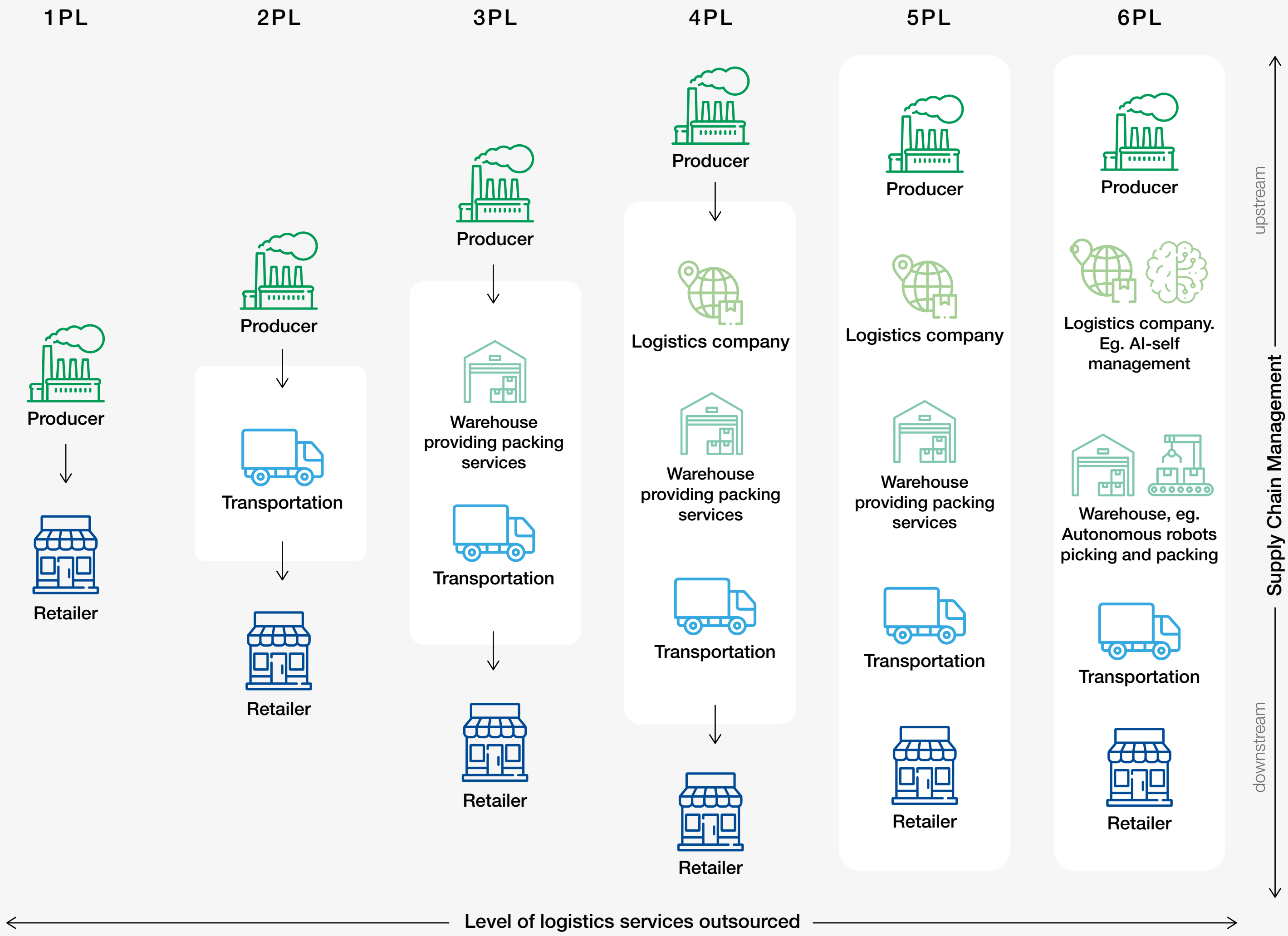
In the traditional retail model, products arrived in warehouses, moved around in pallets and were shipped out to stores in bulk. Omnichannel retailing drives demand for the inventorying and picking of individual products, which autonomous robotics facilitates.

Carriers are leveraging digitalization and have begun selling transport capacity directly to shippers, putting pressure on logistics and freight forwarding service providers to strengthen their value proposition in the digital trade ecosystem.[14]

Business models beyond third-party logistics (3PL) are developing and entail a higher level of outsourcing of supply chain management and service integration served by emerging technologies (Figure 6). These models allow higher customization and, ideally, the eventual self-running of the supply chain thanks to the incorporation of AI. Greener, safer and more inclusive supply chain practices enabled by technology can drive efficiency and data visibility and meet high social accountability standards.[15]

FIGURE 6

The advance of third-party logistics



Two trends are mutually reinforcing: the diversification of the range of services that are outsourced and the integration of these services under end-to-end supply chain control

1PL	2PL	3PL	4PL	5PL	6PL
The manufacturer handles its shipping and warehousing needs, owning its own fleet of trucks.	A courier delivers goods from the manufacturer to the retailer.	A fulfilment centre packages the goods and then transports them to the retailer, as it owns its own fleet.	The logistics company does not own physical assets, such as a fleet of trucks or warehouses. It manages the whole supply chain for its clients, contracting third-party logistics, freight companies and others as needed.	The whole supply chain is integrated, including the producer and retailer's supply chain. The logistics company combines the needs of multiple third-party logistics, which allows it to negotiate favourable carrier rates.	The whole supply chain management incorporates new technologies, such as AI and robotics, for predictive analysis and picking and packing. The supply chain will be expected to manage itself.

Adapted from source: AK Logistics and Supply Chain, "1PL 2PL 3PL 4PL 5PL 6PL – The Advancement of Party Logistics", 2020, https://aklogisticsandsupplychain.com/2020/03/02/1pl-2pl-3pl-4pl-5pl-6pl-the-advancement-of-party-logistics (accessed 30 November 2020)

TradeTech for greener trade

More efficient supply chain management and logistics thanks to TradeTech can help lower carbon emissions across distribution processes. Although largely related to domestic emissions, the last mile is nonetheless an important part of trade processes, and one that can contribute to climate action (Box 2).

BOX 2

TradeTech for CO2 emission reduction

In 2005, Walmart committed to doubling the efficiently of its fleet by 2015 by incorporating loading, routing and driving technologies, and enhancing collaboration with supply chain partners. By 2015, the company improved its efficiency by 102.2% over its 2005 baseline, with savings of nearly $1 billion per year, and avoided emissions of almost 650,000 metric tons of CO_2, equivalent to the annual greenhouse emissions of 140,500 passenger vehicles.

Source: Smart Freight Centre and World Business Council for Sustainable Development, "Smart Freight Procurement Guidelines", 2019, https://docs.wbcsd.org/2019/09/WBCSD_Smart_Freight_Centre_procurement_guidelines.pdf (accessed 30 November 2020)

Emerging technologies such as AI and robotics can help optimize freight capacity as well as routing (Box 3). IoT can contribute to tracking carbon emissions across supply chains at a consignment or product level, thus facilitating the calculation of Scope 3 emissions, which are emissions not controlled by the reporting organization but within its supply chain, and the emergence of carbon labelling.

TradeTech can allow freight forwarders and shippers to compare the environmental performance of carriers at a trade lane or even consignment level, possibly making carbon intensity a more important carrier selection criterion. International Maritime Organization member states have committed to cutting greenhouse gas emissions from international shipping by at least 50% by 2050 compared to 2008 levels.[16] The International Chamber of Shipping underscores the important role of technology in working towards this goal.[17]

BOX 3

Road transportation: Machine learning offers new pathways to a competitive advantage in sustainability

Ground transportation markets have struggled with poor efficiency. The problem is sizeable considering that shippers in the United States direct 75% of their $1 trillion transportation spend per year towards trucking.[i]

On the surface, inefficiency is structural. Extreme fragmentation characterizes many markets. The United States counts 580,000 trucking companies, 97% of which have fewer than 20 trucks.[ii] Economic profits near zero, however, leaving precious little for investment in sustainability. The inefficiency is also informational. There is little data sharing on truck availability, loads, etc., to unlock true network effects. Information technology offers new possibilities to solve that, and the number of online logistics exchange marketplaces is growing. It should be noted that competition laws against collusive conduct may be violated by certain horizontal cooperation agreements.[iii]

Once paired with the right business model and data of shippers, machine learning can offer carriers the possibility to unlock network opportunities despite their small size. Machine learning enabled optimization is territory where the financial and environmental objectives of business are finally no longer at odds, but beautifully in sync.

School transportation provider Zum Services and truckload logistics provider Haulistix, among others, build their initial competitive advantage on technology enabling small carrier operations alongside an aggressive sustainability commitment.

[i] Council of Supply Chain Management Professionals and AT Kearney, *2020 State of Logistics Report*, 2020, https://hub.kearney.com/2020-state-of-logistics-report.

[ii] US Federal Motor Carrier Safety Administration, "Pocket Guide to Large Truck and Bus Statistics", 2020, https://www.fmcsa.dot.gov/safety/data-and-statistics/commercial-motor-vehicle-facts.

[iii] Mason, R., and I. Harris, *A review of freight and the sharing economy*, UK Government Office for Science, 2019, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/777699/fom_freight_sharing_economy.pdf.

(Documents accessed 18 November 2020).

Source: Contributed by Haulistix

Emerging tech in trade finance

Trade transactions are valued at $15 trillion per year today[18] and will reach $25 trillion by 2027.[19] Eighty percent of these operations rely on trade financing. Trade finance is designed to allow companies and financial institutions to manage the risks associated with transactions that take place in situations where the buyer and seller have limited visibility of each other. The process can be complex, considering:

- The requirement for paper-based documentation – processing trade transactions includes an exchange of an average of 36 documents and 240 copies[20]

- The need to comply with numerous regulatory environments – global, regional and national rules on money laundering and sanctions screening, among others.

A survey by the Asian Development Bank in 2017 suggests that over half of trade finance requests from MSMEs go unfulfilled, resulting in an estimated $1.5 trillion gap in unmet global trade finance demand.[21] This trend translates into a reduction in trade flows, as 60% of companies that received a trade finance rejection did not complete the trade.[22] Small players are among those most affected. Almost half (45%) of applications are rejected because of the lack of risk data on MSMEs, especially since the size of revenues drives most credit decisions.[23] The incorporation of technologies could help address the trade finance gap and result in MSME inclusion in trade.

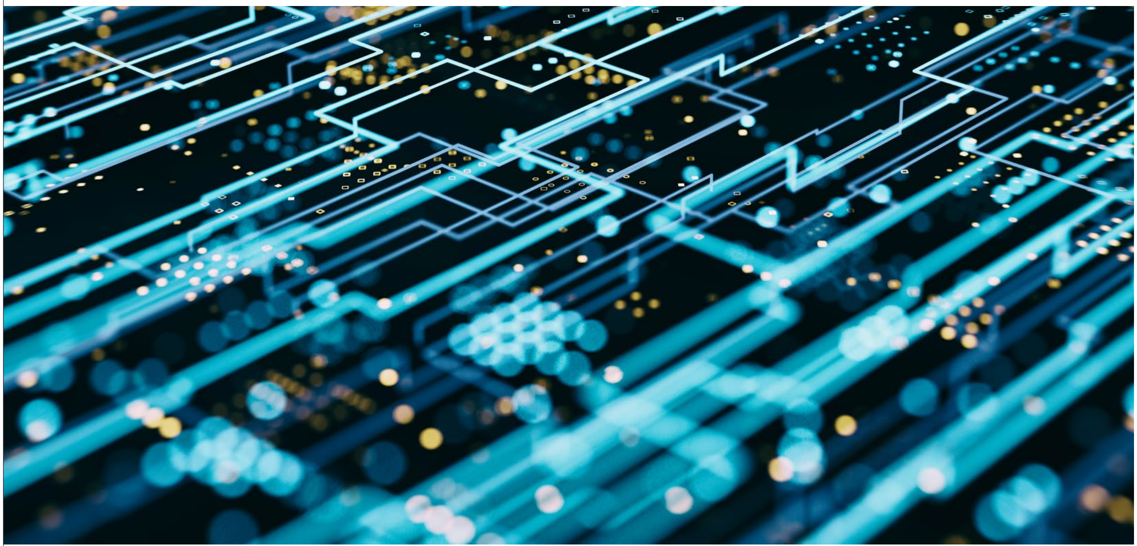
Fintech allows leveraging alternative financial data, improving cash flow especially for MSMEs.

First and second layers of digitization

Trade finance has been around for centuries and the letter of credit has been used as far back as ancient Greece. Over the years, trade finance models have adapted, and technology and digitization have enabled better and more automated ways to trade between parties. Digitizing trade documents is the foremost opportunity to make the trade finance space more efficient. For digitization to happen, e-invoicing is needed. As of today, the bulk of e-invoices are just digital images of paper documents.[24]

Once in the second layer of TradeTech (Figure 1), various Fourth Industrial Revolution technologies play a key role, benefiting MSMEs, in particular. Fintech allows leveraging alternative financial data, improving cash flow by recording and "cashing in" invoices on blockchain and at an aggregate level – more appealing for banks and other companies than just dealing with an individual invoice from a MSME – and forming digital registries.

Blockchain, in particular, has the potential to improve the workings of trade finance. Its ledger system offers parties an opportunity to update, in real time, a secure, single version of the truth,



Increasing reliance on digital platforms

Digital platforms facilitate matchmaking in trade and have helped democratize trade by allowing more MSMEs to have access to the international market. Cross-border business-to-consumer e-commerce represents 12% of global trade in goods and is expected to grow at twice the rate of domestic e-commerce.[26]

Business-to-business platforms are also relevant for matchmaking and transparency purposes. These are transforming traditional sectors, where face-to-face interactions were the norm and where there are transparency issues. Box 4 presents a case study of a digital platform in metal commodities.

BOX 4 | Business-to-business platform in metal commodities

The Open Mineral Digital Platform (OMDP) is an online marketplace for base and precious metal concentrates and secondary products, thereby establishing a conduit for trade, transparency and commercial intelligence.

Base and precious metal concentrates are complex, include a continuous range of grades, by-products and deleterious elements. Consequently, commercial terms, such as treatment and refining charges, penalties, freight and payable scales charged between miners, traders and smelters, are complex and negotiated on a spot or annual basis. In addition, this deep commercial intelligence resides with just a few players, representing a tiny percentage of the overall market.

A digital platform could address some of these challenges by increasing transparency and greatly reducing market information asymmetry, while providing a service to match buyers and sellers of raw materials globally. The immediate benefits of the digital platform include:

- **Increased transparency through pricing algorithms:** These are freely provided to the industry to allow estimating the value of each concentrate at current (real-time) market terms.
- **Increased transparency through live offers:** Material is often placed on the platform from miners/traders with commercial terms visible for all to see.
- **Matchmaking through intelligent global buy/sell campaigns:** Through the development of the largest product and contact databases in the industry and advanced data analytics, matchmaking takes places efficiently and shows prices relevant for each party: Free On Board for exporters and Cost, Insurance and Freight for importers.
- **End-to-end solution:** This process provides full services, including taking title, providing trade financing, logistics and support across the value chain, as well as KYC and recording transactions for compliance and regulatory requirements.

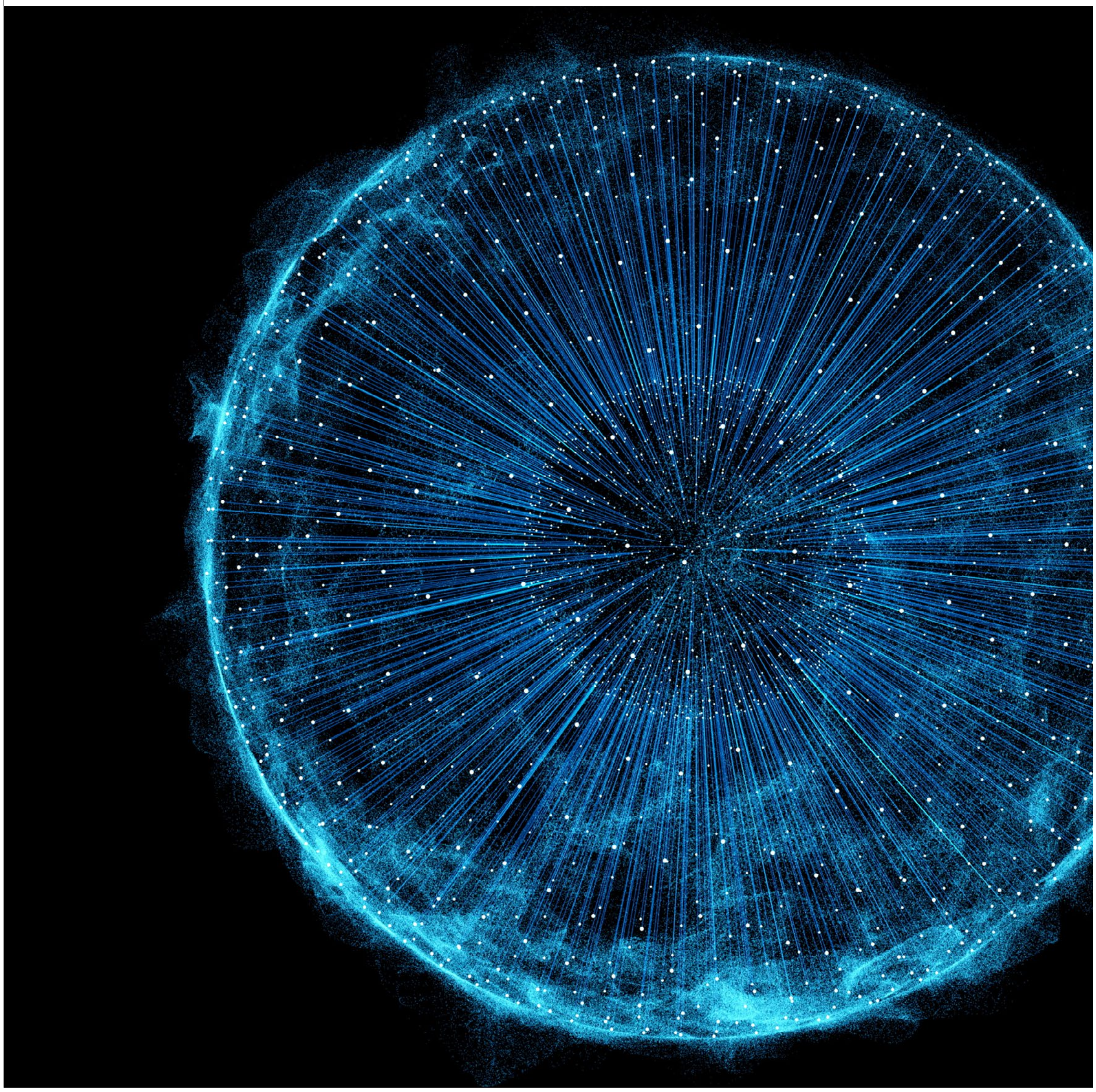
Source: Contributed by Open Mineral

Platforms are increasingly offering enabling services that facilitate cross-border transactions beyond matchmaking, sometimes developing their own payment to logistics solutions. While this is convenient, especially for small vendors, competition is increasingly being seen across entire business ecosystems rather than individual companies. This might make the transition from one platform to the other more costly for companies.

Below: Getty Images

2 Use of technologies in trade

This chapters presents a selection of Fourth Industrial Revolution technologies that are deemed potentially transformative. Each section considers the trade-related issues that the technology can solve and introduces tech-specific policy considerations.



2.1 Artificial intelligence

AI and trade

AI is allowing process automation and the development of new products and services, improving quality and efficiency. AI has the potential to impact virtually every sector of the economy and every facet of trade, especially services.

AI will have the most impact on more-routinized information-based functions, which tend to be low value-added service tasks in business process outsourcing (BPO) and information technology outsourcing. These include back-office functions, making loans, processing accounts or analysing medical tests, among others.[27] As the production of these services shifts from labour-intensity to AI-intensity, the competitive advantage of low-cost countries for service offshoring might dilute (Box 5). Thus, the evolution of AI-based services will most likely impact the configuration of global value chains, as regards services tasks.

BOX 5

AI-based services are shifting the attractiveness of some traditional services' offshore locations

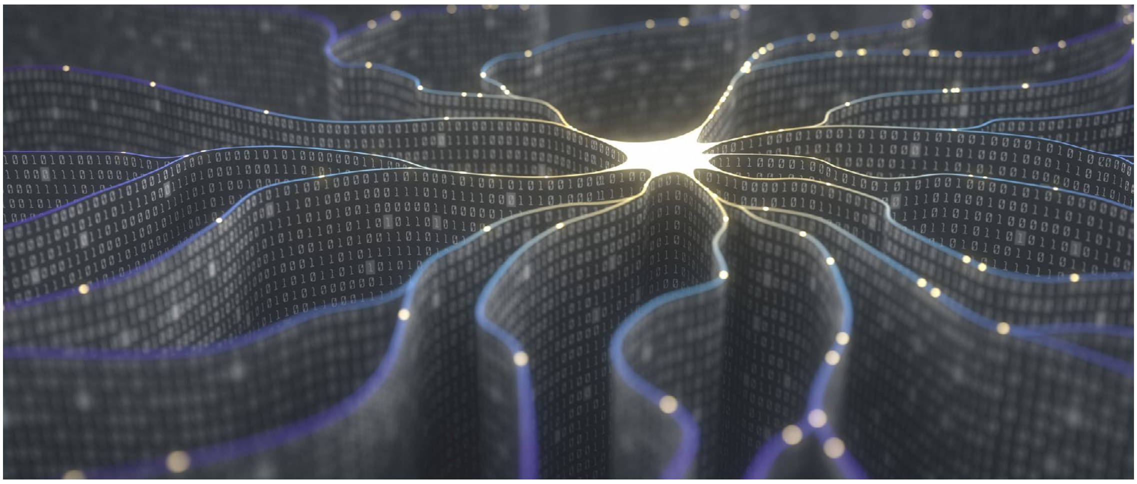
Telecommunications company Vodafone has announced its intention to lay off 1,700 service centre employees in Romania, India and Egypt – 8% of the workforce – as it implements new automation solutions. Within their Czech BPO segment, software robots are replacing 4,000 employees, which represents 4% of the total BPO labour force.

Yet the company has generated 1,200 new jobs in programming and implementing automation systems in the Czech Republic. While the jobs lost are simpler functions executed in low-cost countries, the new ones require higher qualifications and creativity and are mostly located in higher-cost on- or near-shore countries, such as the Czech Republic. This is the case not just thanks to skill availability but to higher reliance on cybersecurity and data protection as service offshore becomes more AI- and machine-intensive.

Source: Kearney, "Digital resonance: the new factor influencing location attractiveness – The 2019 Kearney Global Services Location Index", 2020, https://www.co.kearney.com/digital-transformation/gsli/2019-full-report (accessed 18 November 2020)

At the same time, AI can support broader trade through improved trade facilitation and trade promotion. Both applications help more firms engage in trade, especially MSMEs, as they reduce the time, cost and complexity of identifying and delivering on export opportunities.

AI will be at the heart of digital trade facilitation – the use of modern communications technology to streamline the movement of goods across borders. The World Trade Organization estimates that inefficient customs procedures account for around 6% of total variance in trade costs.[28] More and more countries are exchanging electronic (rather than paper-based) data and documents for trade, thus allowing AI to help authorities improve tariff and duty collection and to identify non-complying or illegal goods.[29] AI improves risk-based targeting as it analyses large volumes of data to identify patterns and the goods, people and firms that require closer inspection (Box 6). Predictive AI improves risk management and preparedness, as well as cargo inspection through X-ray scanners on containers.[30]



BOX 6 | **Getting ready for AI-powered customs**

In recent years, AI has moved from science fiction to real-life applications in the customs domain. Five key cognitive technologies are involved in AI: computer vision, natural language, virtual assistants, robotic process automation and advanced machine learning.

Complex patterns – such as movements in the price of goods, illegal drug traffic, import routines for smuggling counterfeit goods, potentially high-risk conveyances or the frequently occurring misclassification of goods declared under the wrong Harmonized Commodity Description and Coding Systems (HS Code) – can be difficult to detect. Cognitive applications, such as anomaly detection systems that apply neural networks, understand the "deep context" of a particular situation and identify pertinent patterns in both structured and/or unstructured data.

AI's strength in analysing data and identifying patterns could be used to immediately ascertain the legitimacy of a trade transaction and allow customs controls to concentrate their limited resources on the high-risk targets without sacrificing any capacity to the detriment of the compliant operators. A collaborative group of experts, BACUDA (BAnd of CUstoms Data Analysts), has developed a groundbreaking neural network model called DATE (Dual Attentive Tree-aware Embedding) to detect undervalued imports while estimating the additional revenue that could be collected from the inspection of these imports.

The opportunity to accelerate the implementation of data-driven risk management systems exists, as customs administrations have taken steps to adapt to the "new normal" amid COVID-19. The WCO's Capacity Building Directorate is in the process of finalizing a Framework for Data Analytics, which aims to provide a holistic view of the data analytics strategy and a high-level overview of an AI competence development plan.

Source: Contributed by the World Customs Organization

AI-based services can also further close the information gap by connecting more firms to export opportunities. For example, Turkey's AI-based Easy Export Platform gives potential exporters tailor-made recommendations on the top 15 markets to appraise for their product, including a criteria-based score that considers the country's tariffs and regulations. It takes into consideration customs duties, non-tariff measures and rules of origin, among other details.[31] International agencies are also active in offering digital tools to close information gaps. The International Trade Centre (ITC), for instance, offers export potential maps and a rules of origin facilitator to smooth MSMEs' access to the international market.[32]

AI and policy considerations

Early international efforts to govern AI and international trade

The Organisation for Economic Co-operation and Development (OECD) Principles on Artificial Intelligence (adopted in 2019) represent the most high-profile and comprehensive consensus view on AI among many major economies.[33] It is at the basis of the G20's joint statement on human-centred AI Principles[34] and of the G7's Global Partnership on AI, which is a multistakeholder initiative to guide the responsible development and use of AI, grounded in human rights, inclusion, diversity, innovation and economic growth.[35]

AI and trade are a new but still rare feature of modern trade negotiations and domestic and regional regulatory debates. For example, the Australia-Singapore Digital Economy Agreement includes a memorandum of understanding on AI to allow the sharing of best practice regulations for human-centred and ethical AI, to facilitate access to AI technologies, and to build linkages between AI-focused research and industry centres.[36] The Chile-New Zealand-Singapore Digital Economy Partnership Agreement (DEPA) contains similar commitments for the parties to work together on AI governance and AI-driven trade.[37] These countries are using these agreements to build early cooperation and compatibility between their respective AI regulations so they do not become a barrier to AI-based trade.

The European Commission (EC)'s proposal for an ex ante conformity assessment framework could require firms to validate that their AI products and services adhere to certain EU-specific requirements before they could enter the EU market, even if their products are safely and effectively used in other jurisdictions. The EC may force certain firms to have their AI tested at centres within the EU, thus creating a localization testing barrier. The potential for the EU to require foreign AI systems to be retrained locally using certain EU-approved data adds another potential barrier. Some experts believe this ex ante conformity test could become a barrier to AI-based digital trade.[38]

The growing role of AI in trade and the long-term implications of divergent regulatory frameworks will likely affect economic productivity and innovation. An innovation-friendly framework would embrace the interdependence of AI and the need for early and ongoing international cooperation to ensure shared concerns are addressed, while guaranteeing that regulation does not become an unnecessary barrier to trade. Data Free Flow with Trust[39] across countries and across firms will be equally important to thriving innovation and to making sure that AI works based on the largest data set possible to avoid biased results.

2.2 Internet of things

IoT and trade

IoT depends on large-scale deployment of sensors to monitor large quantities of data in real time, such as temperature, humidity, speed. Data could be leveraged to make informed decisions and orchestrate predictive analysis. The global wireless data communication market is forecasted to reach $1867.8 million by 2023, while it was estimated at $794.6 million in 2018.[40]

IoT data can mitigate supply chain disruptions by accurately estimating times of arrival, managing congestion in ports and cargo yards, and keeping track of perishable cargo or medications that may have gone bad due to temperature deviations. IoT can help solve three major trade problems:

1. **Tracking assets:** IoT devices placed with cargo allow real-time geolocation from departure to final destination. IoT is also used to track inventory levels at the point-of-consumption in real time, enabling firms to reduce stock-outs and to better plan replenishments to their customers. This sensor technology is deployed both in business-to-business (e.g. tanks in chemical plants, shelf-scanning robots in supermarkets, professional coffee machines in bakeries) and business-to-consumer (e.g. detergent in washing machines, goods in smart fridges) settings.
2. **Condition monitoring:** Monitoring the condition of perishable goods, including pharmaceutical cargo, gives supply chain managers a major advantage. Through IoT devices, supply chain managers can be alerted to issues, and reconcile them sooner rather than later. Supply chain managers can leverage historical data and identify where issues tend to arise so they can be prevented from occurring.
3. **Security monitoring:** IoT devices cannot prevent theft or other irregularities from occurring but can inform when and where they occurred. If an asset is stolen, its location can be tracked. Similarly, a government IoT application in customs clearance can contribute to security and legal compliance, while helping identify priority cargo and high-risk shipments.

IoT and policy considerations

Challenges for IoT in trade include security concerns, connectivity issues and technology evolution.

Security, connectivity and lack of standardization
Challenges for IoT in trade include security concerns, connectivity issues and technology evolution. First, IoT devices are yet one more way through which hackers can get access to a company's network. The problem is compounded by lack of compliance on the part of IoT manufacturers, combined with lack of user knowledge and awareness.

Second, connecting hundreds of thousands of IoT devices is a major hurdle. High volumes defy the very structure of current communication models and the underlying technologies that support it. Centralized, server/client models are currently relied upon to authenticate, authorize and connect different nodes in a network. When devices number in the billions, centralized systems are a bottleneck.

Third, no standard for IoT devices exists at a global level. Many different technologies are competing to become the standard, including BLE (Bluetooth Low Energy), Wi-Fi and LoRa, though distance and data rate transmission will probably determine which wireless connection to use.[41] This is a major headache when a company is choosing IoT devices. Compatibility issues occur also in the area of cloud services, lack of standardized machine-to-machine protocols, diversities in firmware and multiple operating systems among IoT devices. Some of these technologies will become obsolete in the next few years, which will cause many devices to become outmoded, which might disincentivize adoption or upgrading especially for smaller players.

2.3 Robotics and automation

Robotics, automation and trade

Autonomous robotics have the potential to optimize logistics and work processes by enhancing modelling, prediction, optimization, dynamic planning and autonomous execution capabilities, thus creating a more stable, simple and transparent supply chain system for global trade enterprises. Yet only 3% of container terminals are currently automated. Smart ports offer opportunities to optimize logistics, enhance supply chains and reduce emissions and waste.

As contactless trade has become the new norm of the COVID-19 pandemic, the use of autonomous robotics and vehicles, including drones, for warehouse stock counting and goods delivery is gaining traction (Box 7). Warehouse drones have been shown to scan pallets in under 30 minutes with 99.7% accuracy for a task that usually takes 100 minutes.[42] Amazon has more than 200,000 robots working in warehouses in the United States and is planning to build a $40 million robotics research hub in Westborough, Massachusetts.[43]

BOX 7

SaaS platforms and robotics for enhanced logistics

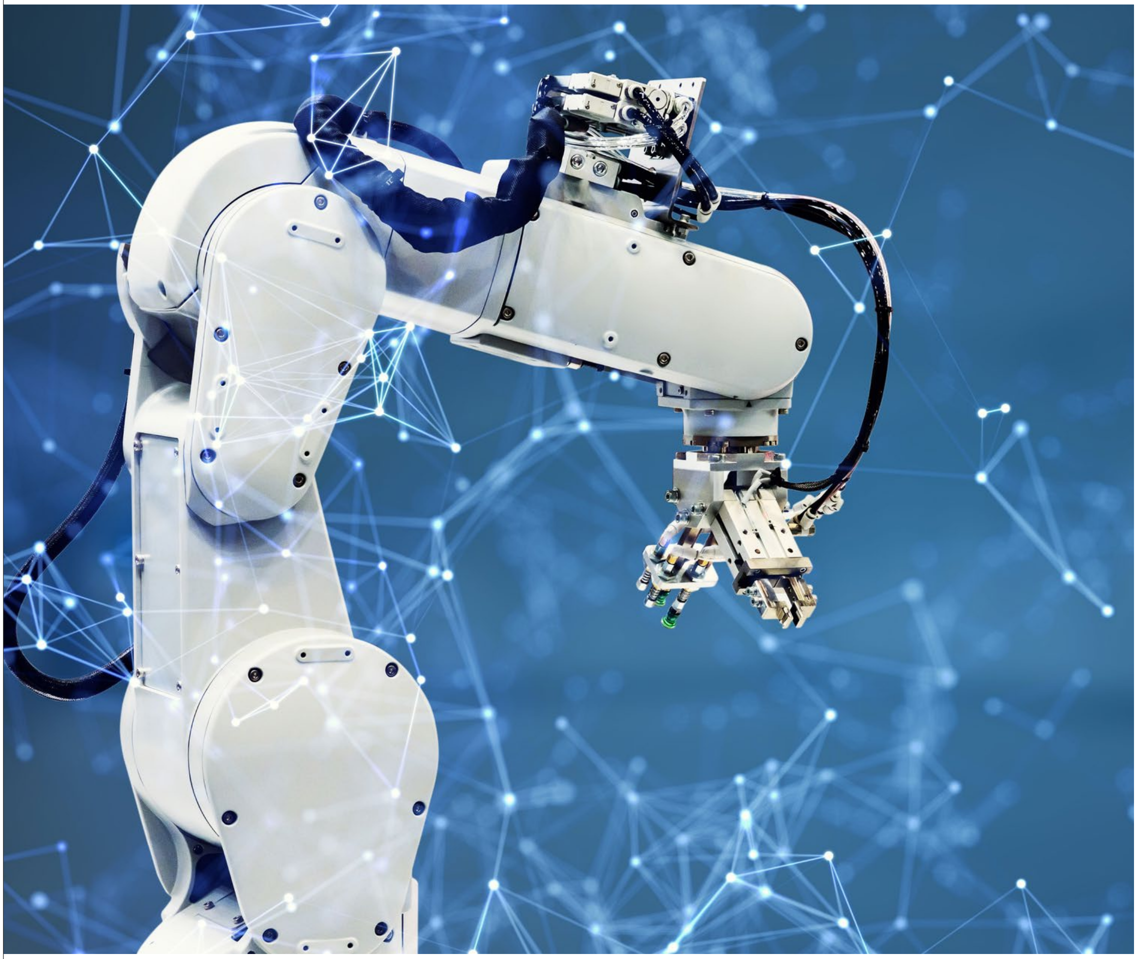
Companies are offering AI solutions as software as a service (SaaS) to allow effective remote collaboration across the supply chain. Dorabot, for example, has developed the AI-CLP (container load planning) SaaS platform to improve the spatial utilization of containers and reduce the operational cost involved in container loading processes, optimizing time, cost and carbon emissions as the container space is fully used. In one use case in Shenzhen, an ocean liner's operations have achieved 9% efficiency improvement in consolidating and loading cross-border shipments using such a platform.

AI-powered robots have "eyes" and a "brain". Equipped with computer vision, motion planning and machine learning, these robots automatically conduct tasks like loading, unloading, palletizing and depalletizing. With higher efficiency than manual work, they move non-uniform items onto pallets or into containers or trucks.

Source: Contributed by Dorabot

ASYAD Group, an Oman-based integrated end-to-end logistics provider, launched several pilots relating to the use of drones as part of their Tech Try initiative.[44] Other entities, like the Port of Rotterdam, are also implementing similar solutions. Uses include underwater drones; port infrastructure drones; drone delivery; and warehouse stock counting drones. Underwater drones are used to inspect marine infrastructure in the port, detecting cracks and corrosion in the under structure. They also serve an important role in inspecting and surveilling inaccessible areas above ground, such as fenders, cracks in jetties and other potential defects, in addition to the inspection of cranes and other equipment.[45]

The use of drones for port infrastructure inspection can prevent inefficiencies in logistics operations. A Trelleborg barometer report shows that 90% of ports surveyed have unscheduled downtime at their facility, costing approximately £100,000 per year.[46] With an estimated $40 billion market value, ports can benefit from using complementary predictive maintenance tech to ensure minimum downtimes.[47]



Robotics, automation and policy considerations

Impact on labour and agile licensing procedures
The increasing use of autonomous technologies will likely have an effect on labour. From drivers or pilots in the case of drones, to operators in warehouses, companies and governments are considering upskilling or reskilling current workers to manage the application of emerging technologies while preventing job displacement. According to 2018 estimates, 14% of the global workforce – 375 million workers – will have to switch occupations due to job displacement caused by automation and advances in AI by 2030.[48] Yet other estimates show that job creation around new technologies can actually offset those displaced. While robotics and AI will make 75 million jobs obsolete, estimates suggest 133 million new jobs will be created by 2022.[49]

In the case of drones in particular, licensing approvals are usually required. While well intentioned, the time and cost of obtaining the licences may limit access for smaller firms. Agile policies, such as performance-based regulation, allow governments to close policy gaps as the technology continues to develop.[50] Rwanda was the first country to pass this kind of regulation for drones. The government specifies the safety standard needed for the activity, while the drone operators state how they will meet it. The country has three types of permit, one of which allows unmanned aircraft to access the airspace on a mission-specific basis; this permit is valid to conduct a single activity or a block of repeated activities.[51]

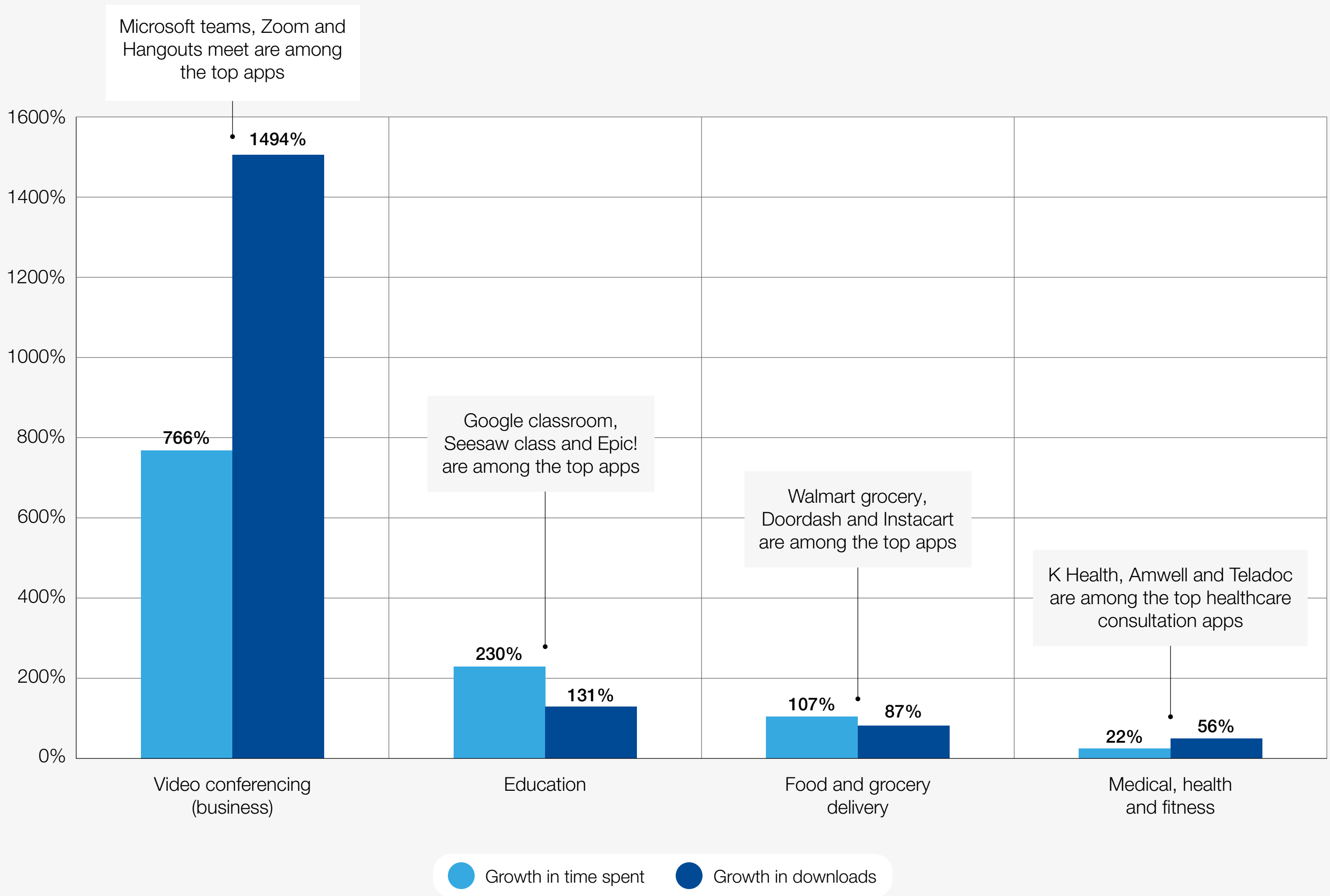
2.4 5G

5G and trade

5G, the next generation of wireless networks, is characterized by massive machine-type communications, enhanced mobile broadband, excellent reliability and reduced latency. Peak download speeds are expected to be as high as 20 gigabits per second.[52]

5G deployment will enable trade, especially in services. The currently available 4G network is already supporting access to online services, from e-commerce to e-payment, videoconference and online education. Figure 7 shows the sharp increase in app usage in the United States during the pandemic, with videoconferencing apps experiencing the highest growth.[53]

FIGURE 7 **Surges in demand for digitally enabled services**



Base: Smartphone users aged 15-69 in the US

Source: Ericsson, "Navigating a crisis", 2020, https://www.ericsson.com/en/reports-and-papers/consumerlab/reports/keeping-consumers-connected-during-the-covid-19-crisis (accessed 2 December 2020)

At a lot lower latency, 5G deployment will not just improve mobile broadband, but will change the experience in service provision. From retail and entertainment to education and medicine, services will change as they leverage the use of the IoT, virtual and augmented reality, as well as remote control of vehicles, infrastructure and even medical procedures. Support on 5G, big data and AI can also unlock a range of new services opportunities, from automatic interpretation and speech recognition to shipment routing automation – all services that could be traded internationally. This will extol the relevance of data and intellectual property regulations.

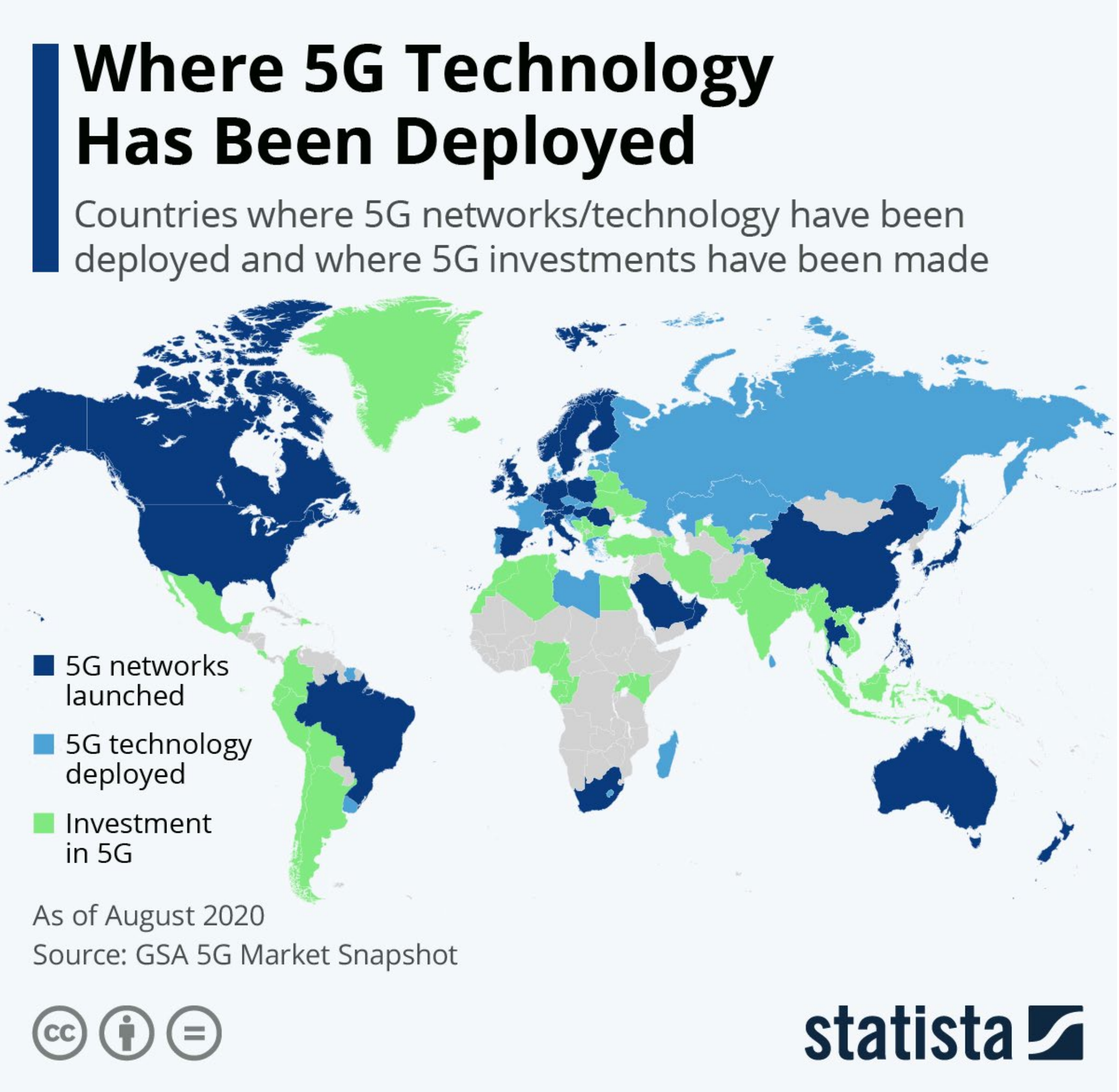
Yet 5G will also facilitate trade in goods. Several ports already rely on 4G technology for operation management and HD video transmission. The application of 5G together with AI and IoT is expected to bring the digitalization of trade processes to a new level, making port operations, warehouse management and customs bonded supervision much easier and cost efficient, and improve risk-based import procedures.

Future port intelligence systems could facilitate information sharing across parties and promote supply chain security. The 5G+AI Intelligent Port Operation has been successfully implemented in Shanghai Yangshan Port. Tens of kilometres of container-to-mobile lines are operating extremely efficiently with no sight of workers in Yangshan Terminal IV. This "perfect cooperation" relies on 5G-enabled heavy trucks. Automatic driving, optimal route planning and transportation are accurately carried out to the designated place. Cargo loading and unloading is completed within 15 seconds.[54]

BOX 8

5G deployment around the world

A total of 38 countries had 5G networks as of August 2020 and more have deployed the technology partially. Though 5G will not replace 4G overnight, and stations might be multimodal to allow a smooth transition, 5G is expected to reach 1 billion users in 3.5 years, while 4G and 3G reached that volume in 4 and 12 years, respectively.



Source: Statista, "Where 5G Technology Has Been Deployed", 14 October 2020, https://www.statista.com/chart/23194/5g-networks-deployment-world-map/?utm_source=Statista+Global&utm_campaign=c6c201646b-All_InfographTicker_daily_COM_PM_KW42_2020_Th&utm_medium=email&utm_term=0_afecd219f5-c6c201646b-309729421 (accessed 1 December 2020)

5G and policy considerations

Geopolitical concerns on 5G
Political tension continues regarding 5G, especially between the United States and China.[55] The situation could drive fragmentation, especially as other countries might be forced to buy from one or the other – not just for geopolitical alignment but given existing and concrete barriers to trade, such as blacklisting by potential purchasing nations and export controls.

This tension will not just affect leadership in 5G deployment but also the possibility to build a competitive advantage in 5G-enabled services.

2.5 Blockchain

Blockchain and trade

Distributed ledger technology (DLT), commonly referred to as blockchain, enables the decentralized and secure storage and transfer of data. Use cases are being explored in trade-related sectors, from trade finance, to customs and certification processes, insurance, logistics and distribution, supply chain traceability, intellectual property and government procurement.[56] Its integration into trade single windows is also being explored.[57]

A fair share of pilots have taken place, and more and more of these projects are being rolled out. Some platforms, like TradeLens (IBM), Insurwave (EY), Skuchain, and Vakt are in commercial operation; other platforms focusing on trade finance are also gaining momentum, such as Marco Polo, Komgo, Trusple (Ant Group), Crowdz and the People's Bank of China Blockchain Trade Finance Platform.[58]

Blockchain and policy considerations

Data privacy and blockchain interoperability
Challenges for further blockchain adoption relate to data privacy and blockchain interoperability.

– **Data privacy within an ecosystem:** Trade needs selective transparency. Information about estimated arrival times, the origin of goods, quantity and the like is relatively innocuous and can be supplied to parties who are not an immediate counterparty, but some commercially sensitive information cannot be shared. Both the Corda and Hyperledger blockchain protocols have advanced to the point that applications built on them can enable originators of data on blockchains to have much more granular control over who can see what.

– **Interoperability between blockchains:** Convergence is possible around different players in the blockchain industry but not around blockchain networks. Once put into place, it is hard for tech adopters to change the underlying infrastructure. Therefore, interoperability between blockchains becomes key and is a major challenge today. This is concerning from an operational perspective and for the sake of scalability as well as from a competition perspective. Several promising projects have yielded robust interoperability protocols, such as Cosmos for public blockchains, Skuchain's Popskip protocol for traceability and DLPC CorDapp for trade instruments, among others. These will allow parties who are part of the same trading ecosystem, but on different blockchains, to transact and communicate data with one another.

Standards for data formats and documents will likely emerge from document digitization, but enterprises are no longer willing to wait for collective decision-making. The new class of assets on the blockchain that has emerged after the wave of initial coin offering failures is growing in sophistication and legitimacy.[59] The Distributed Ledger Payment Commitment (DLPC), a global standard for a payment commitment on a blockchain from the Bankers Association for Finance and Trade, is one such example, and so is stablecoin issued by central and commercial banks. More importantly, building an enabling legal and policy infrastructure such as the recognition of electronic signatures would be key for further adoption.

“ The lack of interoperability between blockchains is concerning from an operational perspective, for the sake of scalability as well as from a competition perspective.

2.6 3D printing

3D printing and trade

3D printing revenues were less than 0.1% of global manufacturing revenues in 2018, though they have been rapidly growing at an average annual rate of 26.9% over the last 30 years.[60] The versatility of 3D printing has proved helpful to address supply–demand imbalances and delays in established supply chains due to confinement measures during the COVID-19 pandemic.[61] 3D printing production has surged in personal protective equipment, medical and testing devices, personal accessories, visualization aids and even emergency dwellings.[62]

Further 3D printing adoption may eventually impact trade volumes and the structure of value chains, as some production moves to consumption markets directly. Yet estimates vary on whether further 3D printing will result in an overall increase or decrease of trade volumes (Box 9).

BOX 9

Will 3D printing slow down or accelerate trade?

Slow down: The International Trade Analysis team at ING estimated that one-quarter of world trade could be decimated by 2060 if half of manufacturing is displaced by 3D printing[i]. McKinsey Global Institute estimated that 3D printing will reduce physical trade by 1-2% by 2030.[ii]

Accelerate: A World Bank study found that trade in hearing aids increased 58% when 3D printing started dominating hearing aid production.[iii] By analysing 35 products that are partially 3D printed, the study found positive and significant effects on trade. It also pointed out that product weight and its effect on logistics costs will be drivers for shifting production close to consumption.

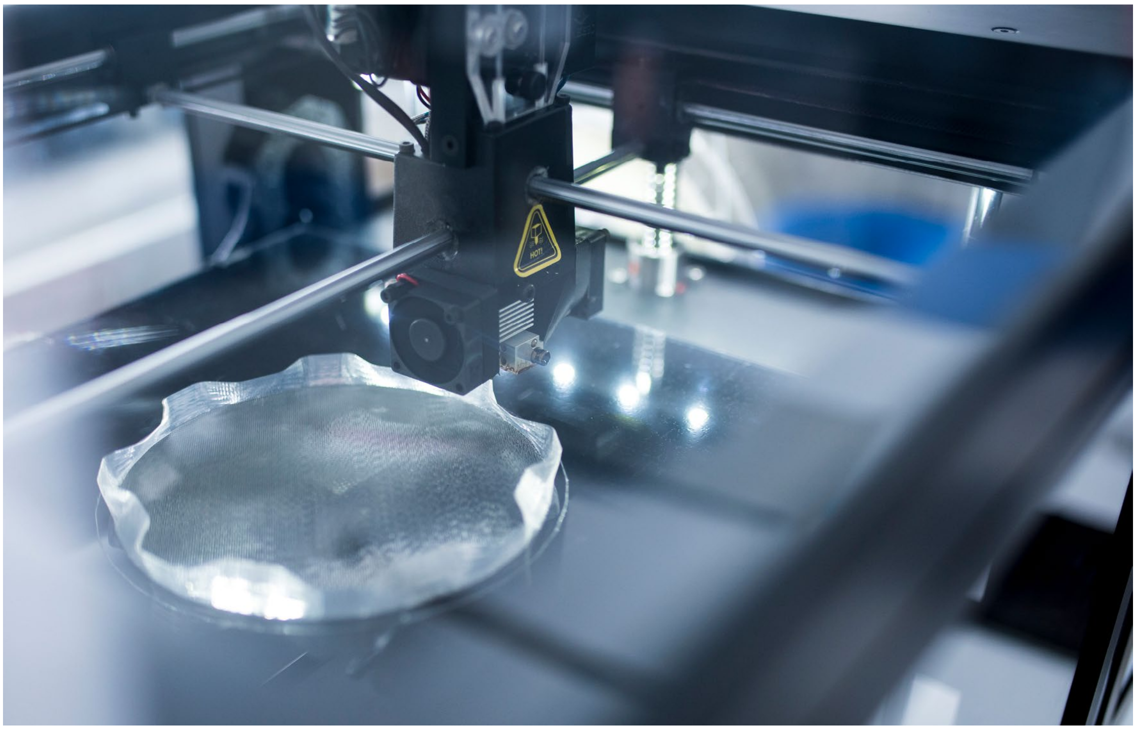
[i] Leering, Raoul, "3D printing: a threat to global trade", ING, 2017.

[ii] Lund, Susan, et al., *Globalization in Transition: The future of trade and value chains*, McKinsey & Company, 2019.

[iii] Freund, Caroline, Alen Mulabdic and Michele Ruta, "Is 3D printing a Threat to Global Trade? The Trade Effects You Didn't Hear About", Policy Research Working Paper 9024, World Bank, 2019.

Source: World Economic Forum, "3D Printing: A Guide for Decision-Makers", White Paper, January 2020, http://www3.weforum.org/docs/WEF_Impacts_3D_Printing_on_Trade_Supply_Chains_Toolkit.pdf (accessed 18 November 2020)

Still, three trends are likely if 3D printing expands globally: (1) a shift in physical trade flows from finished goods to 3D printing input/raw materials, such as filaments ("ink"); (2) a reduction in trade in intermediary products if 3D printing is highly adopted and results in the production of final goods directly; and (3) an increase in cross-border electronic transmissions.[63]



3D printing and policy considerations

How do existing trade instruments fit in a world of further 3D adoption?

Three major areas are worth exploring to determine the relevance of existing trade instruments in the scenario of increased cross-border transmissions of 3D printing computer-aided design (CAD) files:[64]

- **Classification:** Whether to classify 3D printing CAD files as goods or services

  - This will determine whether General Agreement on Tariffs and Trade (GATT) or General Agreement on Trade in Services (GATS) commitments apply to such files. GATT imposes most-favoured-nation (MFN) and national treatment (NT) obligations horizontally, while the GATS structure is more flexible, and market access and NT obligations vary depending on the specific commitments of countries in their schedules.

- **Customs revenues:** Customs revenues and the moratorium of customs duties over electronic transmissions

  - In 1998, World Trade Organization members adopted a Declaration on Global Electronic Commerce, which included a commitment not to impose customs duties on electronic transmissions for the following two years, known as the "moratorium". This moratorium has been extended indefinitely. While some countries value the moratorium as an instrument to facilitate online and even offline trade, others consider it a potential source of revenue loss.

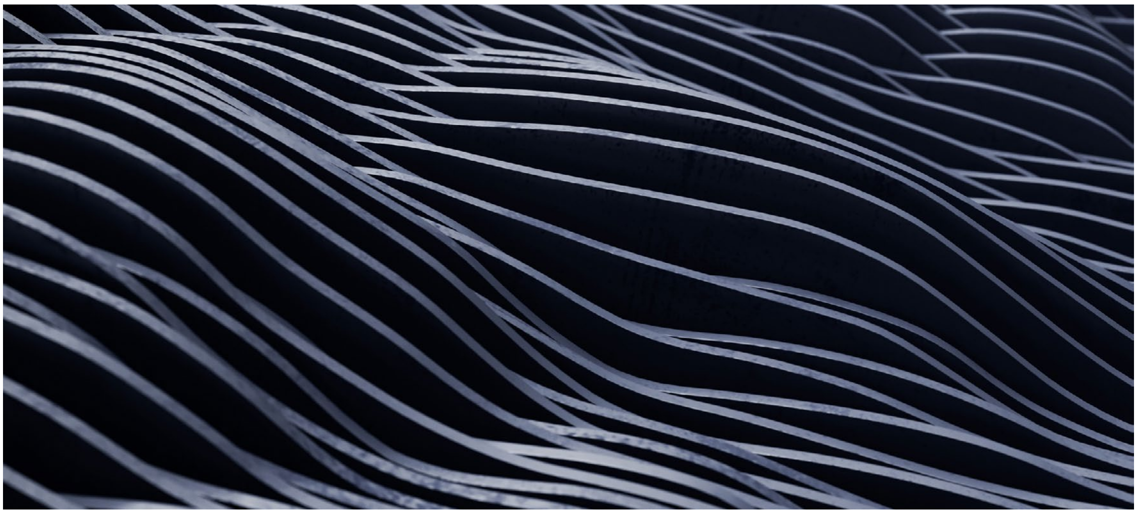
    Any imposition of customs duties on electronic transmissions would imply having the same level of control over digital flows as over trade in goods. Technology solutions would be needed to track 3D printing design files and other e-transmissions crossing borders. Such processes could also add new frictions to digital trade.[65]

- **Rules of origin (RoO):** The relevance of existing rules of origin to 3D printing

  - The printing of 3D objects requires the design of the CAD files, the printing instructions (known as G-code) and the actual printing of the object. In trade policy, RoO are defined in such a way as to determine where the last "substantial transformation" took place. This is relevant for determining whether a product originated from a member of a preferential trade agreement (PTA) and thus qualifies for a reduced tariff or no tariff. This is an important feature of trade policy as current production patterns are spread over global supply chains. The question then arises of where the last substantial transformation takes place for 3D-printed products: is it at the design stage or at the time of printing?

    This is more of an issue for RoO that are based on a change of product classification under the Harmonized Commodity Description and Coding Systems (HS Code). Virtually any 3D-printed product would qualify for a change in product classification, as it would have been transformed from a filament or other raw material to a different product, thus following a different classification under the HS Code.[66]

Other areas that deserve analysis as regards the intersection of 3D printing and trade are customs valuation, security and intellectual property rights.[67] Questions about the latter have been raised during the pandemic; a copyright infringement lawsuit was considered when hospitals were anticipating the availability of a 3D-printed redesign of a commercial respiratory valve that was direly needed for coronavirus patients but unavailable.[68]

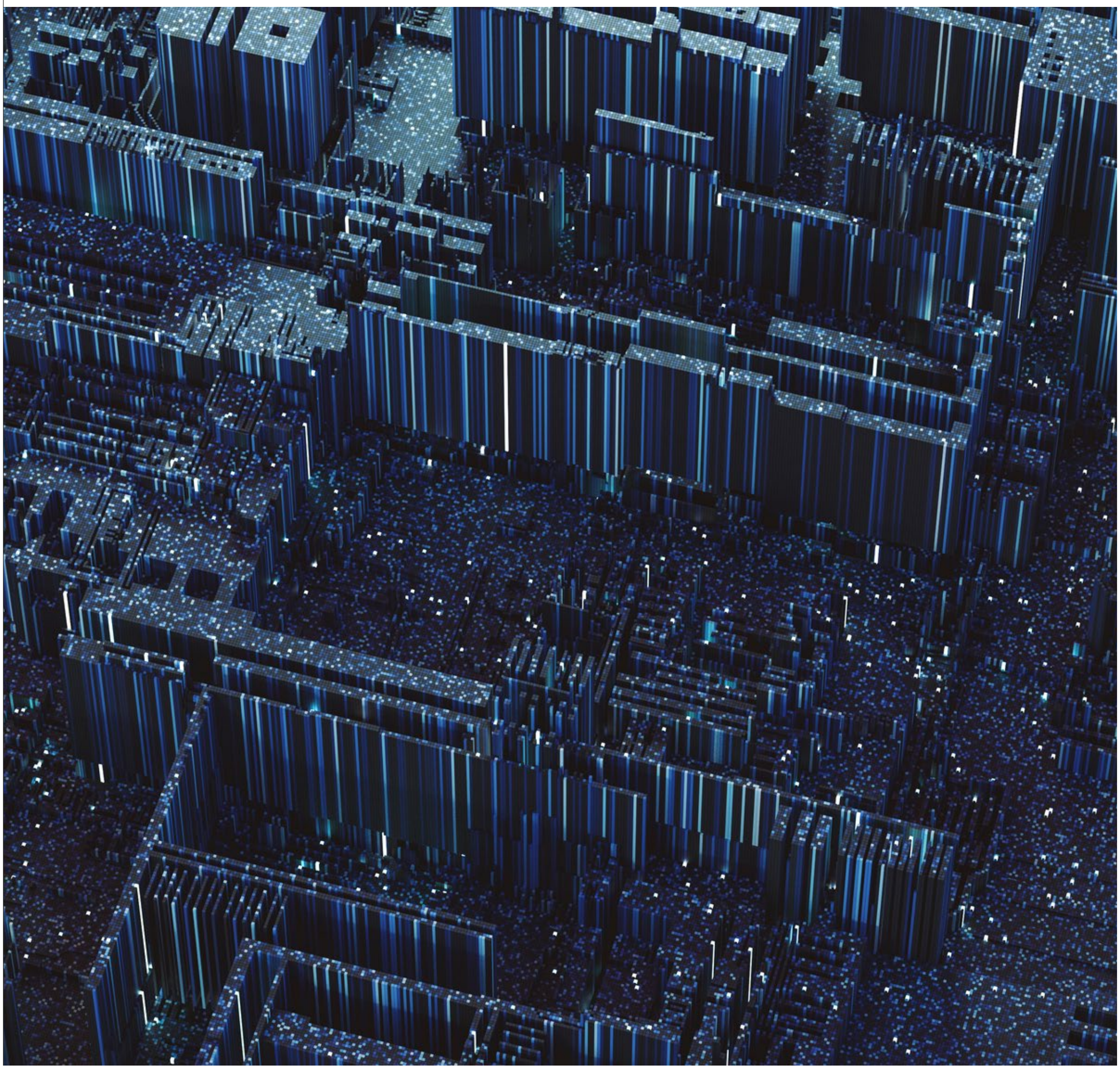


Below: Getty Images

3

Challenges for TradeTech adoption

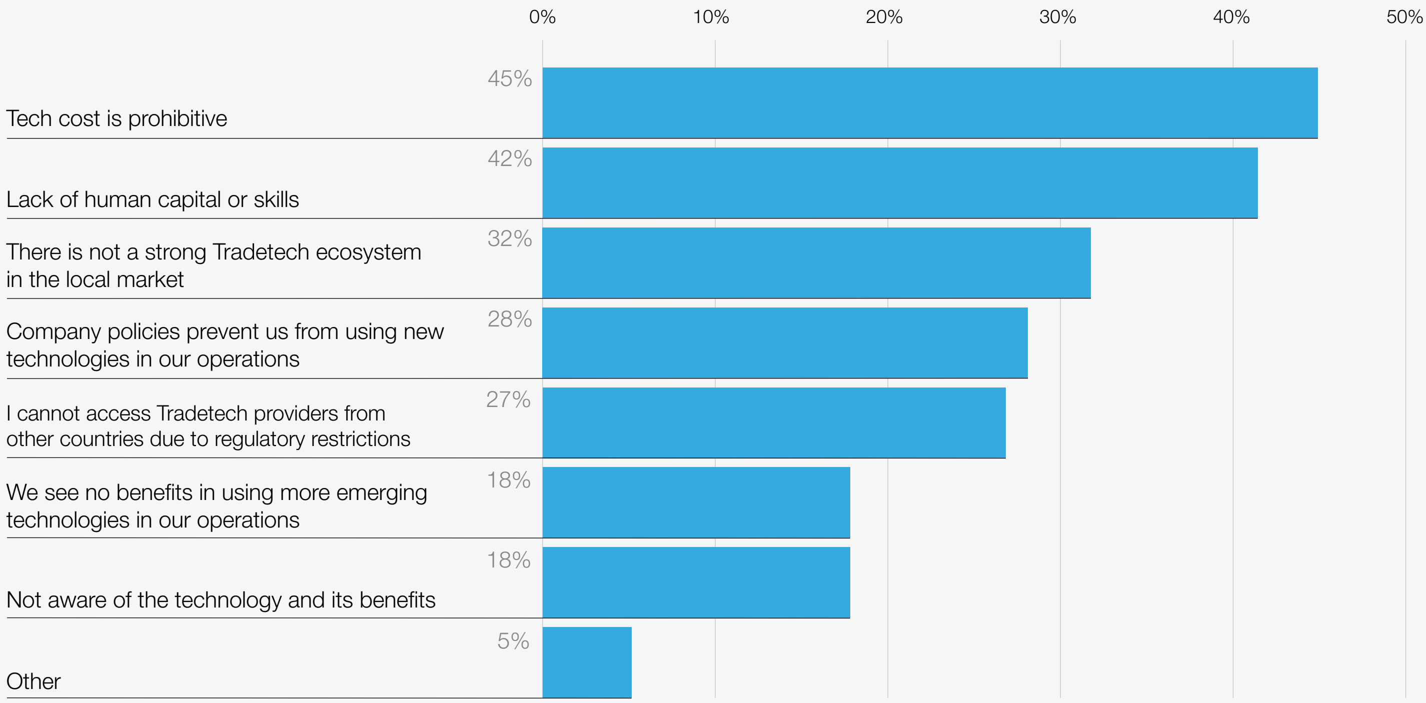
Unforeseen challenges in TradeTech include customs system design and duplication, lack of tech interoperability and data standarization, fragmented national regulation, and cybersecurity threats.



The Forum's survey results show that the most pressing barriers for companies to adopt TradeTech are the cost and the lack of human capital or skills (Figure 8). Other major challenges include the lack of strong TradeTech ecosystems locally as well as the inability to access international providers due to regulatory restrictions.

FIGURE 8

Barriers for TradeTech adoption



Source: World Economic Forum 2020 global survey on TradeTech

While TradeTech emerges to solve several trade-related problems as discussed in Chapter 2, it also creates new and unforeseen challenges: the need to deal with different tech regulations across jurisdictions, a lack of digital literacy, higher capital requirements, fragmented markets with distinct technology ecosystems in terms of infrastructure and standards, and data oligopolies (Figure 9).

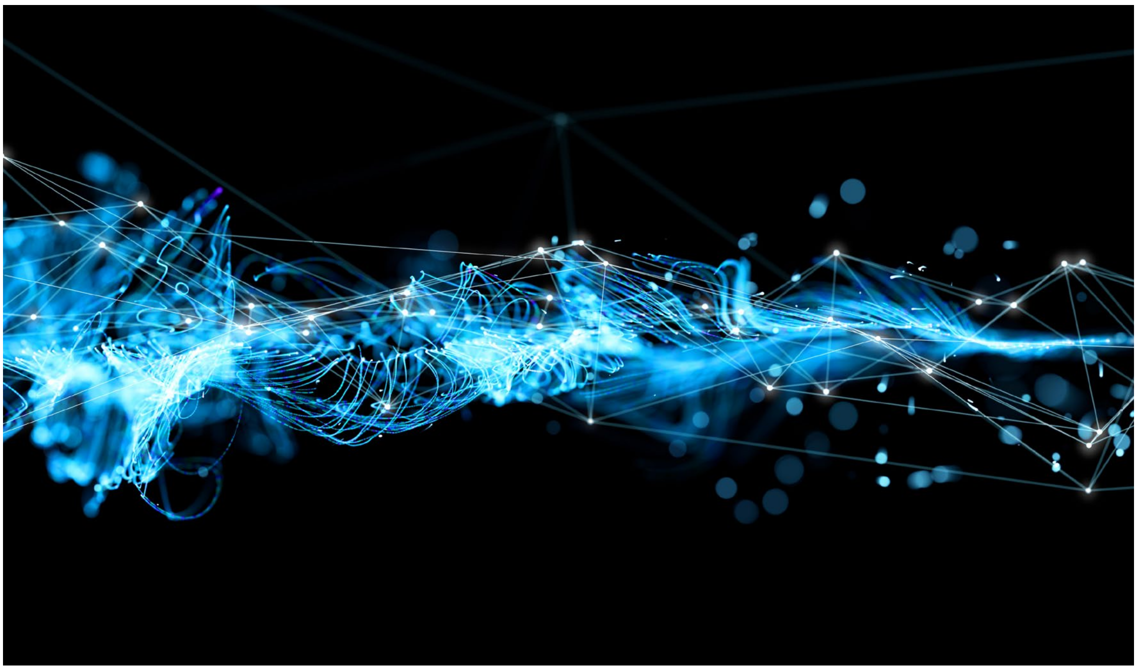
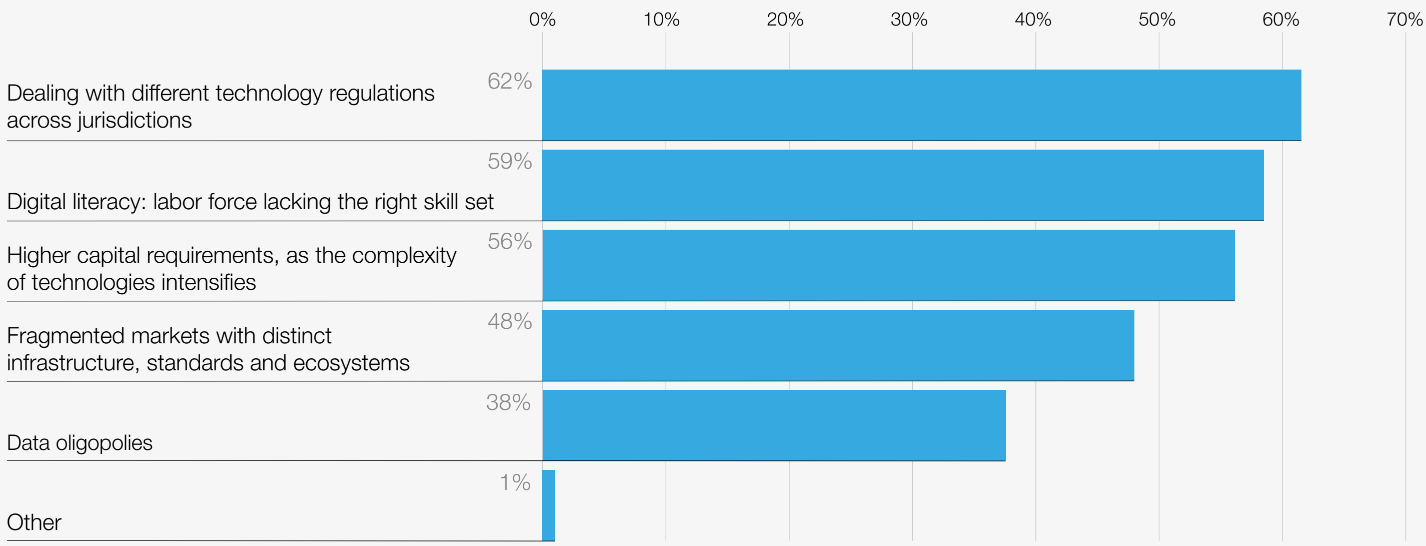


FIGURE 9 | **Emerging challenges associated with TradeTech**



Source: World Economic Forum 2020 global survey on TradeTech

3.1 Customs systems design and duplication

In many countries, customs clearance remains an arcane process that creates uncertainties, delays and additional costs. TradeTech can significantly increase the efficiency of customs processes and reduce errors and fraud. The earliest known TradeTech in this area was the Palmyrian Tariff, a text carved in stone tablets from the time of Emperor Hadrian (137 AD). A mark of innovation, the text was inscribed in both Greek and Aramaic and set tariffs to be paid by merchants and travellers.

Electronic single windows are among the most useful tools deployed today. At their best, these systems clearly communicate requirements to trade participants, enable them to comply electronically and aggregate reporting requirements across agencies and, in some cases, even across multiple countries. Such systems can be readily integrated with technology solutions used by traders in their own operations, propelling new efficiencies.

However, border agencies around the world still vary widely in their adoption of single windows or new technologies – and those that have adopted single windows still interoperate poorly, resulting in a duplication of efforts both for the agencies and for traders. Even customs agencies that are fully electronic may have a manual interface for users to upload data, a rigid application programming interface through which data can be sent only in a single specified format, or even still require the presentation of physical documents.

Useful steps to support progress include:

– In the transition from paper to electronic systems, process mapping and consultation with stakeholders can minimize bottlenecks and help avert duplicative requirements. Information digitization and exchange could result in a $5.2 trillion increase in trade per year by 2050.[69]

– System design should be aligned with user capacity. The capacities of the target traders should inform system interface planning and outreach programmes to prepare traders to use new systems. This in turn can help reduce the period of time during which duplicative protocols remain in place, such as requiring or allowing both electronic and paper submissions of data for a standard import or export process.

– Enabling interoperability among single window systems creates future value, preventing corruption and undervaluation. Initially, systems may work in isolation. But as they grow more sophisticated, they can usefully be connected to each other. This interaction requires infrastructure for both technology interoperability and data standardization.[70]

3.2 Tech interoperability and data standardization

> “Dark data” – data collected and not analysed – is massive. IBM estimates that 90% of data generated by sensors and analogue-to-digital conversions is not used.

Global trade needs a common language, both in terms of data standardization and technology interoperability. Limited data standardization and interoperability prevents higher levels of TradeTech implementation by companies – traders are essentially stuck on their respective islands without bridges.

Challenges around data include: (1) the firm’s ability to collect data and derive insights for decision-making; (2) the willingness to share data; and (3) the level of standardization of data.

First, “dark data” – data collected and not analysed – is massive. IBM estimates that 90% of data generated by sensors and analogue-to-digital conversions is not used.[71] In addition, there is tension between the micro and the macro perspectives, as each firm creates and manages its own data. For example, the generation of data from labelling processes is very manual and will only serve the company doing it but not other parties in the same value chain.

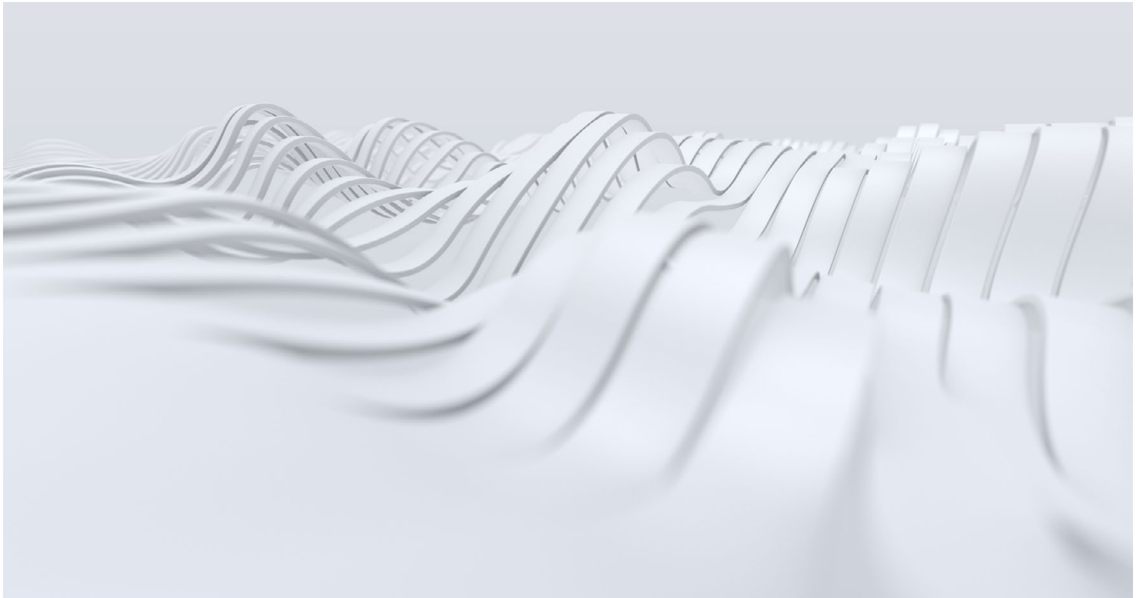
Second, data sharing would allow for cost efficiencies across the supply chain. How these would be distributed among players is an open question and probably the reason why individual actors are not incentivized to share their own data with other actors even in their own supply chain. Moreover, the market positioning of some companies might be reinforced by holding onto this data.

Third, regarding the issue of data harmonization and standardization, public- and private-sector technology providers have adopted various operating standards that are often not compatible. A number of initiatives in data sharing exist in logistics, including the DataPorts initiative in the EU aimed at building an open platform for the connection of smart ports.[72] The key is to avoid silos and advance harmonization. In addition, there are policy challenges. Restrictions to cross-border data flows hold back the potential of TradeTech development internationally.

Useful steps for data standardization and sharing

Building on existing data standardization models can contribute to effective services and interoperability, including:

- **The World Customs Organization Data Model** helps to harmonize business processes, data collection requirements and codification (Box 10). It enables the standardization of data requirements by customs and other agencies in exporting, transiting and importing countries; pre-arrival data processing; the exchange of information within and among single windows; and the reuse of commercial data by operators to reduce the need to re-input information.
- **Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT) standards developed by the United Nations Centre for Trade Facilitation and Electronic Business (CEFACT)** are often expressed in XML/EDIFACT. While most technologists can list several shortcomings of XML, its widespread use makes it an effective common format for data exchange, and its integration into the efforts of the WCO and UN/CEFACT builds a useful bridge for interoperability.



BOX 10 | **WCO Data Model**

The WCO Data Model was originally a G7 initiative to expand cross-border trade procedures by harmonizing data requirements and standardizing the exchange of information.

This Model aims at enabling:

– The harmonization and standardization of regulatory data requirements by customs and partner cross-border regulatory agencies (CBRAs) across the supply chain, in exporting, transiting and importing countries

– Pre-arrival data processing

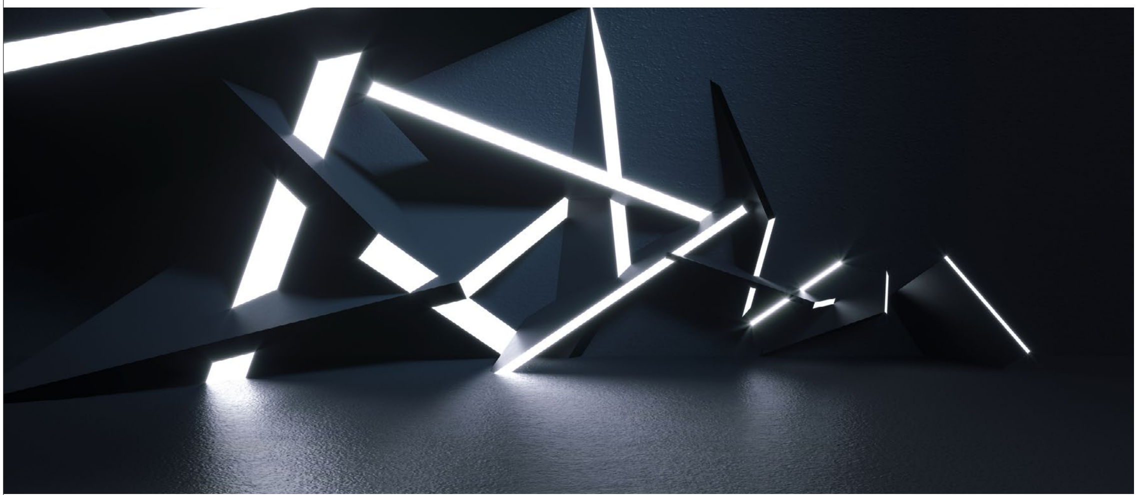
– The cooperation and exchange of information in end-to-end supply chain management, either at the national level within a single window or at the international level between CBRAs in different countries

– The reuse of commercial data by economic operators to comply with customs data requirements that allow direct interfacing between their IT systems and regulatory ones, reducing the need to retype/re-input information, and increasing data quality and accuracy by reducing the possibility of errors and the need for excessive data input

– The reduced fragmentation of standards within supply chain communities, which represents the main barrier to implementing new and emerging technologies, such as DLTs.

Source: World Customs Organization, "WCO Data Model", http://www.wcoomd.org/DataModel (accessed 2 December 2020)

Beyond the standardization, Data Free Flow with Trust across countries – the key underlying concept of the Osaka Track, launched by heads of government under Japan's G20 leadership in 2019 – must be ensured. The availability and wider use of data transfer mechanisms are essential to facilitate cross-border transactions, which are natural in the digital space. Reliance on these would facilitate cross-border data flows without compromising legitimate public objectives such as privacy or security.[73]



Useful steps for tech interconnectivity

In addition, the need for standardization at the level of technology protocols and commercial software features is pressing (Box 11). Different tech standards prevent interconnection, and thus competition. Fragmented tech ecosystems slow down innovation and adoption as companies are not keen on investing in new solutions, once they have undertaken sunk costs on other TradeTech solutions that will not speak to each other.

Practical solutions to consider include:

– Building momentum on the implementation of the Trade Facilitation Agreement and exploring how data and tech standardization could complement those efforts

– Expanding existing initiatives that promote open source, leveraging private-sector leadership for faster response, as well as expanding the use of the WCO Data Model and UN/CEFACT model

– Promoting the inclusion of firms from least developed countries that are still early in their digital journey.

BOX 11

Lori Systems, a case for data and tech interoperability

Since the advent of global supply chains, the logistics industry is under increasing pressure to standardize. The intermodal container, standardized port equipment and hazardous goods labelling are all examples of how the logistics world has standardized to gain efficiency. Yet the processes undergirding transactions are still arcane and analogue. Over-reliance on hard-copy documents and the lack of digital standardization ownership globally have held the logistics industry back.

Lori Systems operates in developing markets where up to 75% of a product's cost is attributable to logistics (compared to just 6% in the United States). Lori provides real-time data to cargo owners (shippers) and transporters (carriers) that reduces loading times, improves turnaround and decreases the frequency of empty backhauls. Through leveraging data to drive efficiency, cost savings of up to 25% on key routes have been achieved.

Because of the size of Lori's shipper/carrier network, it and other platforms can be leveraged in the push for standardization (e.g. acceptance of soft-copy documents, electronic proof of delivery). Lori already shares "reverse invoices" with carriers based on digital copies of documents collected and uploaded at the point of delivery. If carriers opt for speed, Lori makes payment before touching a physical proof of delivery. Lori Systems has achieved 80-90% tech adoption of its core internal applications. Collective action is needed. Groups like the Digital Container Shipping Association can make headway on standardizing key electronic documents (e.g. bill of lading).

Source: Contributed by Lori Systems

3.3 Fragmented national regulations

Further challenges to the deployment of TradeTech are divergent national policies, driven by concerns regarding the negative effects of digital technologies on society and markets, rising digital protectionism, and growing national security concerns around sophisticated technologies (as covered in Chapter 1).

The EU, for instance, is considering the introduction of the Digital Services Act package (Box 12).[74] This would include new rules that increase and harmonize obligations on online platforms. In addition, certain ex ante rules are being considered for large online platforms that hold a "gatekeeper" position to prevent anticompetitive harms that are not sufficiently addressed by competition law enforcement. This is relevant, as 47% of EU businesses use social media to market their goods and services, and 82% of EU small and medium-sized enterprises rely on search engines for their promotion.[75] Other jurisdictions – including the United Kingdom[76] and China[77] – are also considering competition regulation for dominant digital platforms. Different regulatory approaches and requirements in diverse markets increase the costs of operating across borders.

BOX 12

EU Digital Services Act package

The regulation scope of the EU Digital Services Act is broad, expanding beyond the rules in the E-Commerce Directive that this Act is meant to replace, including:

– **Liability:** While liability for content platforms (video, images, text) might remain the same, liability for platforms that sell products online might increase as they earn a commission on each transaction, even those involving counterfeit or dangerous goods.

– **Competition:** Updated enforcement powers and new regulation are considered for the digital "gatekeepers". New rules could prevent self-preferencing practices, for instance banning pre-installed apps on smartphones as well as more favourable treatment towards one or more digital service providers.

– **Employment:** A unified approach to the gig economy is under review so the self-employed do not lose benefits and protections due to their status.

– **Advertising:** Rules addressing targeted advertising and greater user control of data may be tightened.

Source: European Commission, "Single Market – new complementary tool to strengthen competition enforcement", June 2020, https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12416-New-competition-tool; Brookings, "How the EU plans to rewrite the rules for the internet", 21 October 2020, https://www.brookings.edu/techstream/how-the-eu-plans-to-rewrite-the-rules-for-the-internet (both accessed 18 November 2020)

Towards international cooperation for TradeTech

Some countries are working together to enact domestic regulations and digital trade provisions that ensure key digital policies and standards do not act as barriers to trade. For instance, Australia, Chile, New Zealand and Singapore are working together – as part of the next generation digital economy partnership agreements – to ensure that their respective domestic approaches to key digital policies are compatible. This includes cooperation on how to ensure their rules and regulations on AI, digital identity, data privacy, open data and other issues are in agreement. Similarly, the OECD and the Asia-Pacific Economic Cooperation (APEC) call for "interoperability" as a key objective in their data initiatives.

Plurilateral and regional efforts towards digital trade could be a stepping stone towards international cooperation. Plurilateral negotiations on e-commerce could help develop international standards on some of these issues, including data flows, and lay the foundation for further development of global digital trade. The Digital Free Trade Area (DFTA) programme adopted by the Common Market for Eastern and Southern Africa (COMESA) can increase regional integration and trade facilitation. Moreover, the Pacific Alliance included a goal of establishing a regional digital market in the bloc's 2015 roadmap.[78]

3.4 Cybersecurity threats

As the global trade ecosystem digitizes, cybersecurity issues are becoming increasingly important to the global trade community. The losses from attacks can be significant: in June 2020, Maersk was hit by a cyberattack that cost the company $200-300 million; MSC and COSCO experienced attacks earlier in 2020 and 2018, respectively.[79]

Beyond infrastructural investment, human capital is critical for cybersecurity. Governments and traders alike need to urgently train their staff on good cybersecurity practices and data protection. A balance between security and usability should also be considered to ensure further adoption.

Towards a safe global cybersecurity environment

> **Enhancing cybersecurity globally can prevent a fragmented environment for data and, ultimately, TradeTech, as the location of data will not determine whether data is more or less secured.**

Enhancing cybersecurity globally can prevent a fragmented environment for data and, ultimately, TradeTech, as the location of data will not determine whether data is more or less secured. Considering trade spans across countries, international coordination on cyber-risk control is increasingly necessary.

A supply chain is as safe as its weakest link. Thus, cybersecurity is equally important for big and small companies across the chain. Yet companies' needs differ. While MNCs can invest in hardware and integrate security measures into their access systems, MSMEs might not be able to do so. Thus, increasing the national average levels of cybersecurity would benefit MSMEs in particular and would attract foreign direct investment, resulting in increased knowledge spillover. Governments can raise awareness of the importance for MSMEs to be cyber-ready and encourage them to undertake training, such as that offered by the Cyber Readiness Institute.[80]

MNCs also have a key role to play by developing products that cater to the need of MSMEs, engaging in more partnerships with local suppliers and investing in skills development and knowledge transfer. Solutions should balance security and usability to ensure further TradeTech adoption.

Below: Getty Images

4 TradeTech for development

The incorporation of technologies in trade could result in unintended consequences that should be addressed to ensure TradeTech works for all companies regardless of their size, and for all countries regardless of their level of development.

4.1 TradeTech for micro-, small and medium-sized enterprises

As the Fourth Industrial Revolution sets in, MSMEs face both opportunities and challenges in this wave of technological transformation. New technologies in trade, such as cloud computing, blockchain, IoT, big data and AI, present MSMEs with opportunities to tap into the technological edge previously only available to large firms. The application of new TradeTech can help MSMEs save costs, improve efficiency, streamline operations and scale up. Software as a service (SaaS) and e-commerce platforms have made trade more inclusive as there are no upfront costs (Box 13).

BOX 13

E-commerce helps MSMEs reach global market

E-commerce is helping MSMEs enter the international market. An ITC survey shows that around 80% of companies that engage in international trade through e-commerce only are micro and small enterprises.

However, these companies still face setbacks. MSMEs in developing countries report particular challenges, including the lack of technical knowledge, poor online visibility, the high cost of and difficult access to global e-commerce platforms, and the lack of adequate infrastructure and delivery options. The ITC's survey reveals that the share of logistics costs over final price is almost double in developing countries than in developed economies.

Source: International Trade Centre, "New Pathways to E-Commerce: A Global MSME Competitiveness Survey", September 2017, https://www.intracen.org/publication/New-Pathways-to-E-commerce (accessed 14 August 2020)

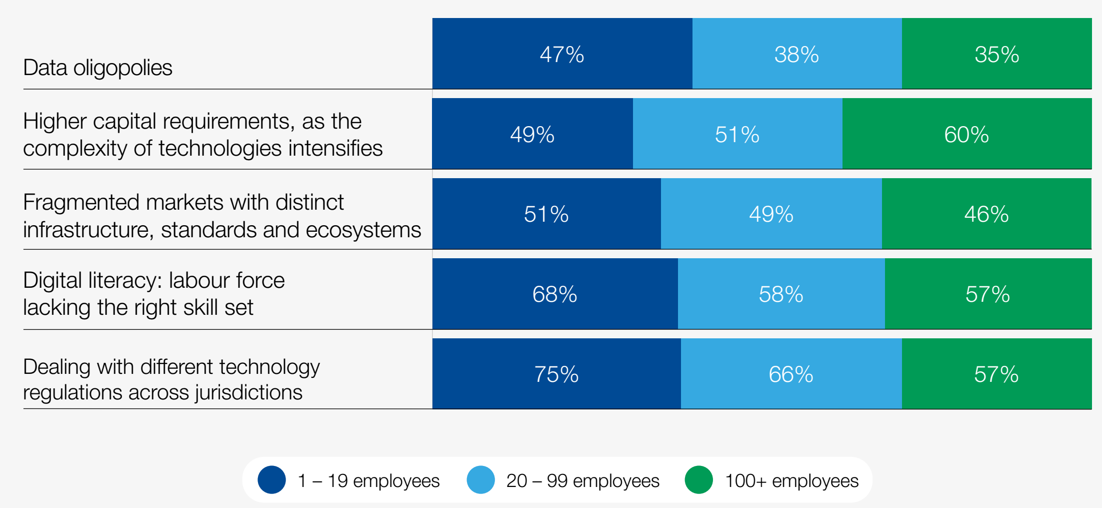
Moreover, MSMEs are agile in technology adoption once they have easy and affordable access to these technologies. This is especially true in cases where the adoption of technologies would reduce fixed costs associated with entering the international market. The adoption of digital platforms has helped MSMEs cut the cost of exporting by 83%, as compared with offline channels.[81] The quick development of mobile payment in East Africa also illustrates this case.

Challenges for MSMEs to adopt TradeTech

The burden of TradeTech challenges differs with company size. The Forum survey reveals that smaller companies stress difficulties in dealing with different regulations in different jurisdictions and the lack of digital skills (Figure 10). Meanwhile, larger companies tend to be more concerned with the increasingly higher capital requirements of technology applied in the trade ecosystem.

FIGURE 10

TradeTech adoption challenges by company size



Note: The percentages are based on the total number of companies by size that took the survey. Companies could select more than one answer.

Source: World Economic Forum 2020 global survey on TradeTech

The increasing demand on knowledge and skills may further increase the competitiveness gap between MSMEs and large firms, especially for micro and informal businesses in developing countries.

It remains to be seen how using rather than developing TradeTech and data might affect trade possibilities in the long term. MSMEs may have a competitive advantage because they can adopt technologies faster than MNCs given their flexibility, particularly as data sets become more available. MNCs may still have a competitive advantage in owning larger data sets, key to developing new business models, and in proving and scaling new technologies first and adjusting their development to their needs.

Supporting TradeTech adoption by MSMEs

Governments could support MSMEs in a number of ways, including by:

- Promoting education and IT skills development, through the inclusion of IT in school and university curricula, and encouraging public-private partnerships through internship programmes

- Facilitating big data and AI tools that help MSMEs reduce market research costs and improve online visibility

- Improving information and communications technology (ICT) and logistics infrastructure

- Providing cybersecurity training

- Setting up a TradeTech network, composed of key stakeholders, that has the potential to maximize the scope and outreach of any given solution while encouraging the development of local solutions (for instance, a single web page might compile and easily display all the resources, tools and services offered by the members of the TradeTech network); given the lack of skilled human resources affecting companies, external experts might bridge the gap by providing qualified advice

- Establishing a benchmark for TradeTech adoption by MSMEs, which could help incentivize government reform actions to promote TradeTech adoption.

Internationally, an increasing number of trade agreements include chapters on e-commerce and digital trade. Recent agreements, such as the Digital Economy Partnership Agreement (DEPA), include provisions on MSMEs and digital inclusion specifically. Commitments go from information sharing to enhancing public-private dialogue and cooperation involving e-commerce platforms.

4.2 TradeTech for developing countries

TradeTech offers developing countries leapfrog opportunities. The potential to seize these opportunities may vary by technology. TradeTech that requires higher capital, such as robotics and IoT, may be more challenging to diffuse in low-income country settings than technologies that are mainly software defined (e.g. blockchain, AI and digital platforms).

The network nature of TradeTech's benefits, in which the more users there are of the technologies, the more value each user can derive from them (positive network externalities), creates incentives for the diffusion of technology worldwide.

The most straightforward opportunities might come from the first layer of TradeTech, that is the digitalization of trade and logistics-related documents. This is a mature innovation in developed countries, where the opportunities for additional market expansion are limited, although certain developing countries have also advanced significantly in this area, for instance regarding e-invoicing.

“ TradeTech that requires higher capital, such as robotics and IoT, may be more challenging to diffuse in low-income country settings than technologies that are mainly software defined (e.g. blockchain, AI and digital platforms).

Challenges for developing countries to adopt TradeTech

The main issue for developing country adoption will not be related to the technology itself (as it is transferable) but to the enabling infrastructure and regulatory environment for the digital economy (in terms of data and cybersecurity, for example).

TradeTech is linked with digitalization and, therefore, an important precondition for its use in developing countries is the availability and quality of digital infrastructure. Although mobile networks reach 95% of the global population, global internet access only stood at 53% in 2019.[82] Digital infrastructure investment is critical to addressing the inequalities in internet access and leveraging the benefits of TradeTech for all.[83]

Moreover, internet access requires affordable, accessible and reliable electricity, which still constitutes a challenge in many developing countries. As many as 770 million people had no access to electricity in 2019, of which 75% reside in Sub-Saharan Africa, a share that has risen in recent years.[84] In fact, energy consumption is likely correlated with ICT industry growth, where the ICT sector is responsible for 3-4% of global electricity consumption.[85] Bridging the infrastructural gap as a precondition to benefit from TradeTech more broadly highlights the relevance of the investment facilitation negotiations at the World Trade Organization.

In addition to the infrastructural constraints, soft technological capacity gaps between developed and developing countries limit the potential adoption of TradeTech – shown, for instance, by the gap in R&D intensity across countries.[86]

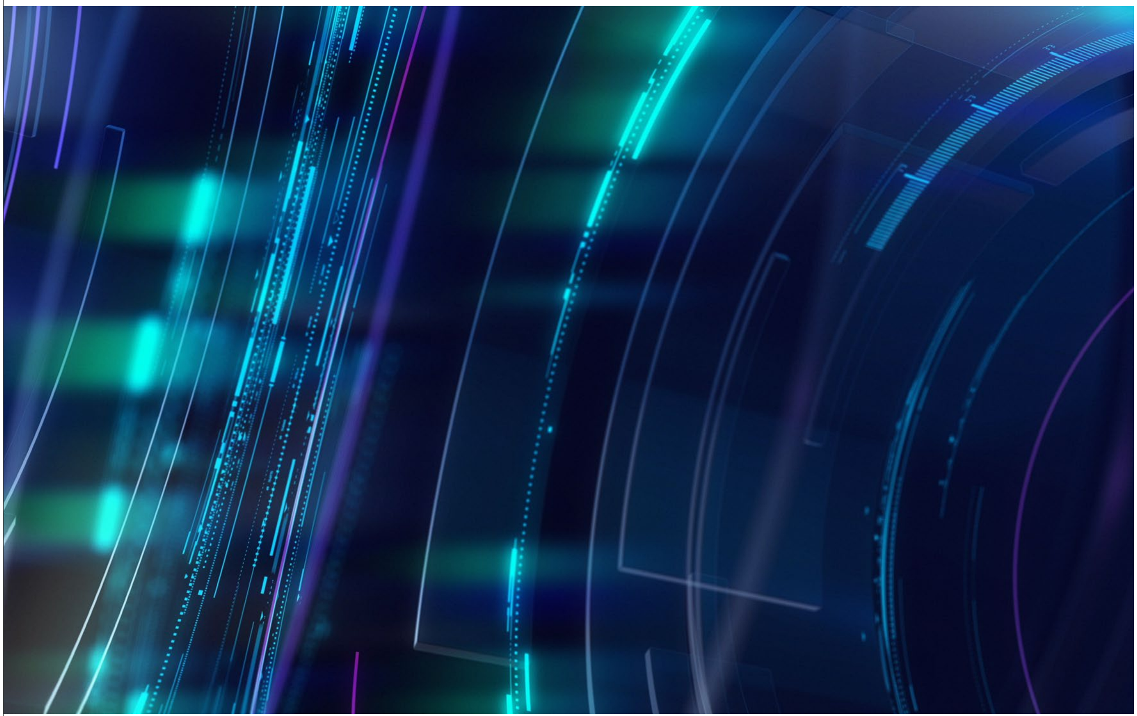
In least developed countries, small-scale agricultural and large informal sectors dominate the production structures, leading to gaps in technological absorptive capacities and shortages in high-skilled workers. A sizeable highly skilled labour force in these countries would be key to leapfrog into TradeTech and cutting-edge manufacturing technologies (Box 14).

BOX 14

Labour cost considerations for AI adoption

Because AI investments may not necessarily be cheaper than labour in some developing countries, the incentive for developing countries with low-wage workers to substitute human labour with machines is lower. In this context, the adoption of AI as a TradeTech is more likely in processes where labour costs are high; otherwise, labour-intensive processes are likely to continue.

Source: Contributed by United Nations Conference on Trade and Development (UNCTAD)



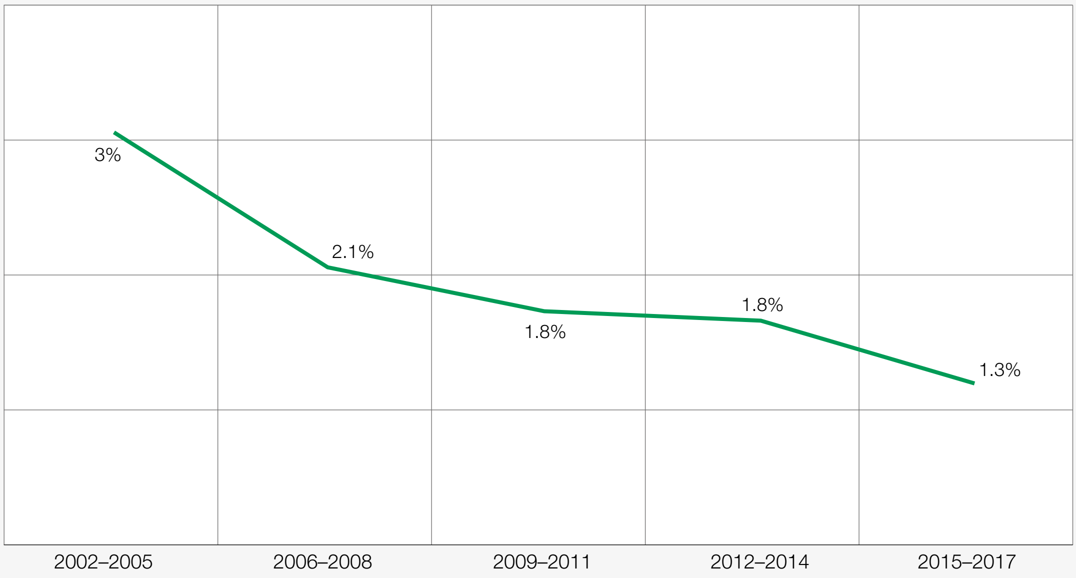
Supporting TradeTech adoption by developing countries

The deployment and impacts of TradeTech will be significantly affected by the infrastructural, skills and innovation-related gaps between regions and countries as described. The democratization of technology is important and the open source movement is helping the adoption of software and hardware across countries.[87]

International cooperation and multistakeholder engagement will need to expand to prevent the evolving digital economy from leading to widening digital divides and greater income equalities. Such cooperation should include ICT education and training to build digital capabilities, as well as entrepreneurship training (given that risk-taking entrepreneurs are key to the adoption and diffusion of TradeTech).

The decline in the share of ICT in total aid for trade should be reversed: it was only 1.3% on average during the 2015-2017 period, in comparison to a 3% average during 2002-2005 (Figure 11).[88] Considerations to allocate a proportion of aid for trade for activities relating to the use of TradeTech could be useful to realize leapfrog opportunities for smaller countries.

FIGURE 11 **Disbursements in communications as a percentage of total aid for trade (averages, 2002-2017)**



Source: Based on OECD-WTO, *Aid for Trade at a Glance 2019: Economic Diversification and Empowerment*, 2019, https://www.oecd-ilibrary.org/development/aid-for-trade-by-category_39516369-en, and OECD-WTO, *Aid for Trade at a Glance 2017: Promoting Trade, Inclusiveness and Connectivity for Sustainable Development*, 2017, https://www.oecd-ilibrary.org/development/aid-for-trade-at-a-glance-2017_aid_glance-2017-en (both accessed 2 December 2020)

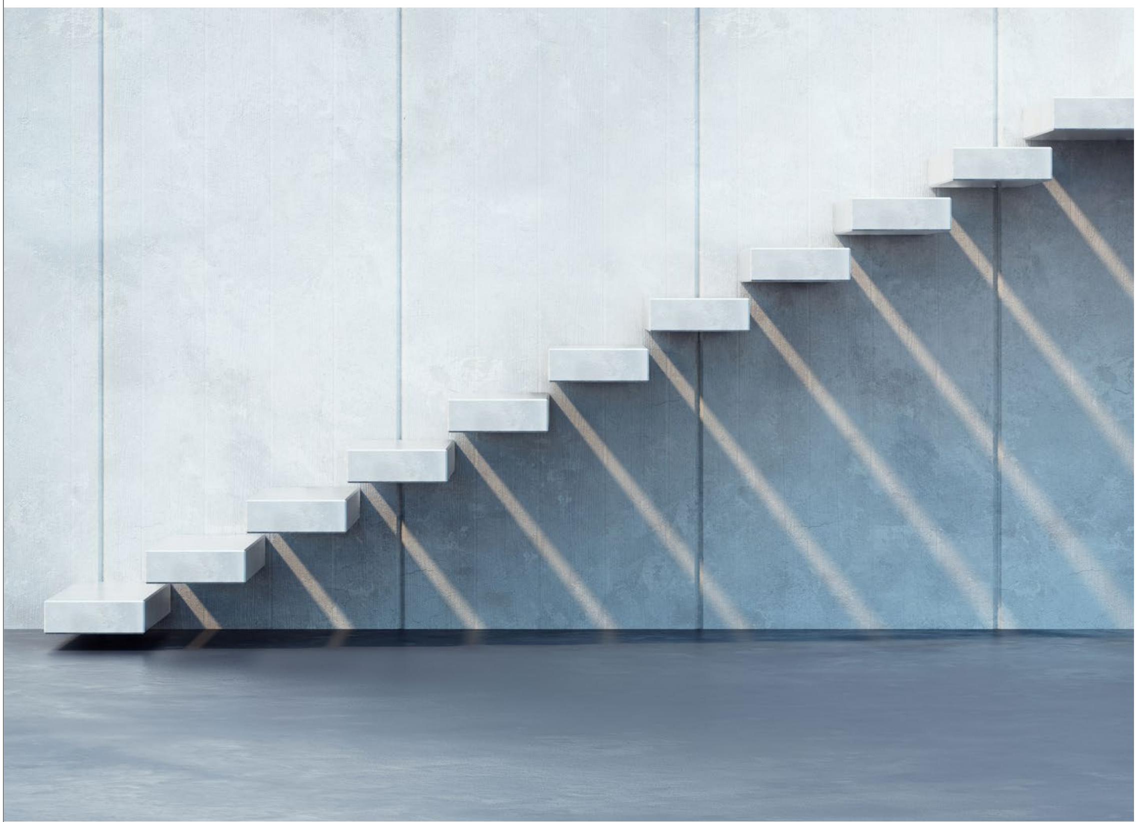
At the national level, governments in developing countries could use several policy instruments, such as tax incentives for technology upgrading by companies. For instance, Thailand offers a tax incentive to promote national product and process innovations, allowing companies to base their tax reduction on three times the firms' expenditure on R&D, and cover their expenditure on licensing in foreign technology as well as advance technology training, collaboration with universities and the development of local suppliers.[89]

Governments can also remove trade tariffs for hardware needed in TradeTech deployment, building on Information Technology Agreements I and II. Access to these technologies could facilitate knowledge transfer and become a driver for adoption and diffusion. The public sector can also support tech upgrading through the public procurement of TradeTech solutions for customs and other trade-related services. Finally, business associations could play a key role in promoting the development of skills and knowledge relevant for innovation, while encouraging TradeTech adoption when scale is needed.

5

Conclusions and next steps

The COVID-19 pandemic has significantly accelerated the adoption of digital technologies. The moment should be seized to use TradeTech to make global trade more efficient, inclusive and equitable.



TradeTech has the potential to facilitate and promote further international trade by lowering barriers for companies to enter new markets. Major TradeTech gains originate in good coordination between the different actors in supply chains. TradeTech, especially in its second layer, allows holistic decisions that can result in efficiency and environmental advantages for the whole value chain. Yet unintended consequences in terms of job displacement, competition and techno-nationalism trends require attention.

TradeTech's impact will depend on how data and tech interoperability are addressed, regulations are harmonized, and inclusive access to close the digital divide, also present in the trade space, is ensured. To deliver on TradeTech's promise, action is needed to build the trust required for supply chain transparency, to promote cooperation in tech regulation, to drive a trade facilitation agenda around interoperability, and to provide training for upskilling and reskilling workers.

The COVID-19 pandemic has significantly accelerated the adoption of digital technologies and opened a window of opportunity to drive tech innovation in trade. The moment should be seized to use TradeTech to make global trade more efficient, inclusive and equitable. The World Economic Forum is prepared to continue working with a diverse group of stakeholders to expand TradeTech for the benefit of companies of all sizes and all countries, to leverage leapfrog opportunities in development.

Endnotes

1. This publication mentions companies' cases to illustrate how technologies intersect with trade, with no endorsement or commercial intent.
2. McKinsey Global Institute, *Globalization in transition: The future of trade and value chains*, 16 January 2019, https://www.mckinsey.com/featured-insights/innovation-and-growth/globalization-in-transition-the-future-of-trade-and-value-chains (accessed 19 November 2020).
3. McKinsey, "Harnessing the power of shifting global flows", *McKinsey Quarterly*, February 2015, https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/harnessing-the-power-of-shifting-global-flows (accessed 19 November 2020).
4. To ensure the quality of responses, respondents were managers, directors, vice-presidents or C-level executives. Several questions provided the opportunity to pick more than one answer, including those on the most transformative technologies and the barriers for TradeTech adoption.
5. Statista, "Coronavirus: Impact on the tech industry worldwide", 2020, https://www.statista.com/study/71685/impact-of-the-coronavirus-covid-19-pandemic-on-the-global-tech-industry (accessed 10 September 2020).
6. Government discretion through possible bans on the sale and export of technology manufacturing tools to certain jurisdictions will also affect technology supply chains and diversification efforts. Semiconductor manufacturing is already seeing a significant impact, as reflected in the Baker McKenzie report *Supply Chains Reimagined: Recovery and Renewal in Asia Pacific and Beyond*, 17 August 2020, https://www.bakermckenzie.com/en/insight/publications/2020/08/supply-chains-reimagined (accessed 30 November 2020).
7. Capri, Alex, "Techno-Nationalism: What Is It And How Will It Change Global Commerce?", *Forbes*, 20 December 2019, https://www.forbes.com/sites/alexcapri/2019/12/20/techno-nationalism-what-is-it-and-how-will-it-change-global-commerce/?sh=130489be710f (accessed 18 November 2020).
8. Goldsmith, Courtney, "Microscopic 'smart dust' sensors are set to revolutionise a range of sectors", The New Economy, 3 June 2019, https://www.theneweconomy.com/technology/microscopic-smart-dust-sensors-are-set-to-revolutionise-a-range-of-sectors; Hornyak, Tim, "RFID Powder", *Scientific American*, February 2008, https://www.cs.virginia.edu/~robins/RFID_Powder.pdf (both accessed 30 November 2020).
9. McKinsey Global Institute, *Globalization in transition: The future of trade and value chains*, op. cit.
10. McKinsey, "Harnessing the power of shifting global flows", op. cit.
11. See the Global Supply System Dashboard, https://www.globalsupplysystem.org (accessed 20 November 2020).
12. dexFreight and Ocean Protocol, "Introducing Blockchain-Powered Minimum Viable Logistics Data Marketplace", 10 September 2020, https://blog.oceanprotocol.com/introducing-blockchain-powered-minimum-viable-logistics-data-marketplace-56b1be9a4e01 (accessed 27 October 2020).
13. World Economic Forum, "A New Paradigm for Business of Data", Briefing Paper, July 2020, http://www3.weforum.org/docs/WEF_New_Paradigm_for_Business_of_Data_Report_2020.pdf (accessed 29 July 2020).
14. Freight forwarders are companies that specialize in arranging storage and shipping merchandise on behalf of shippers, usually consolidating cargo as needed. They provide various services, including tracking inland transportation, preparing export/import documents, managing warehousing, booking cargo space, consolidating freight and offering cargo insurance, among others.
15. Alvarez, Ricardo, "Types of Logistics Providers Explained in Plain English", ShipLilly, 16 July 2020, https://www.shiplilly.com/blog/types-of-logistics-providers-explained-in-plain-english (accessed 27 October 2020).
16. International Maritime Organization, "UN body adopts climate change strategy for shipping", 13 April 2018, https://www.imo.org/en/MediaCentre/PressBriefings/Pages/06GHGinitialstrategy.aspx (accessed 18 November 2020).
17. International Chamber of Shipping, "Shipping Industry Unites to Propose Ambitious Co2 Reduction Objectives to Global Regulator", Press Release, 22 June 2017, https://www.ics-shipping.org/press-release/shipping-industry-unites-to-propose-ambitious-co2-reduction-objectives-to-global-regulator (accessed 18 November 2020).
18. "Trade finance is nearing a much-needed shakeup", *The Economist*, 24 October 2019, https://www.economist.com/finance-and-economics/2019/10/24/trade-finance-is-nearing-a-much-needed-shakeup (accessed 3 December 2020).
19. Ramachandran, Sukand, et al., *Digital Ecosystems in Trade Finance: Seeing Beyond the Technology*, Boston Consulting Group, SWIFT and the International Chamber of Commerce, September 2019, https://image-src.bcg.com/Images/BCG_Digital_Ecosystems_in_Trade_Finance_tcm9-229964.pdf (accessed 3 December 2020).
20. Fletcher, Laurence, "Forget the paper trail — blockchain set to shake up trade finance", *Financial Times*, 3 December 2019, https://www.ft.com/content/04a4fcde-dfb5-11e9-b8e0-026e07cbe5b4 (accessed 27 October 2020).
21. Asian Development Bank, "$1.5 Trillion Global Trade Finance Gap Frustrating Efforts to Deliver Crucial Jobs and Growth — ADB", News Release, 3 September 2019, https://www.adb.org/news/15-trillion-global-trade-finance-gap-frustrating-efforts-deliver-crucial-jobs-and-growth-adb (accessed 27 October 2020).
22. Asian Development Bank, "2017 Trade Finance Gaps, Growth, and Jobs Survey", ADB Briefs, no. 83, September 2017, https://www.adb.org/sites/default/files/publication/359631/adb-briefs-83.pdf (accessed 3 December 2020).

23. Asian Development Bank, "$1.5 Trillion Global Trade Finance Gap Frustrating Efforts to Deliver Crucial Jobs and Growth — ADB", op cit.

24. Koch, Bruno, "E-Invoicing/E-Billing: Significant market transition lies ahead", Billentis No. 180517 5, 18 May 2017, https://www.billentis.com/einvoicing_ebilling_market_report_2017.pdf (accessed 27 October 2020).

25. Marantis, Demetiros, "Cross-border data flows power small business recovery", Visa, 10 November 2020, https://usa.visa.com/visa-everywhere/blog/bdp/2020/11/09/cross-border-data-flows-1604955432332.html?utm_source=DemetriosLinkedIn&utm_medium=OrganicSocial&utm_campaign=DataFlows (accessed 18 November 2020).

26. International Trade Centre, *New Pathways to E-commerce: A Global MSME Competitiveness Survey*, 2017, https://www.intracen.org/publication/New-Pathways-to-E-commerce (accessed 14 August 2020).

27. Mediaan, "Intelligent Automation in Business Process", 18 January 2019, https://www.mediaan.com/mediaan-blog/optimize-business-process-using-intelligent-automation (accessed 27 October 2020).

28. World Trade Organization, *World Trade Report 2018*, 2018, https://www.wto.org/english/res_e/publications_e/world_trade_report18_e.pdf (accessed 27 October 2020).

29. World Customs Organization, *Study Report on Disruptive Technologies*, 2019, http://www.wcoomd.org/-/media/wco/public/global/pdf/topics/facilitation/instruments-and-tools/tools/disruptive-technologies/wco_disruptive_technologies_en.pdf?la=en (accessed 27 October 2020).

30. Ibid.

31. "Turkey launches AI-based platform for trade digitalization, export-oriented growth", *Daily Sabah*, 28 August 2020, https://www.dailysabah.com/business/tech/turkey-launches-ai-based-platform-for-trade-digitalization-export-oriented-growth (accessed 27 October 2020).

32. International Trade Centre, "Market Analysis Tools", 2019, https://marketanalysis.intracen.org/en; International Trade Centre, "Rules of Origin Facilitator", 2020, https://findrulesoforigin.org (both accessed 18 November 2020).

33. OECD, "Whare are the OECD Principles on AI?", 2020, https://www.oecd.org/going-digital/ai/principles/#:~:text=The%20OECD%20Principles%20on%20Artificial,Council%20Recommendation%20on%20Artificial%20Intelligence (accessed 27 October 2020).

34. Ministry of Foreign Affairs of Japan, G20 Ministers and Digital Economy Ministers, "G20 Ministerial Statement on Trade and Digital Economy", 2019, https://www.mofa.go.jp/files/000486596.pdf (accessed 27 October 2020).

35. United States Department of State, "Joint Statement From Founding Members of the Global Partnership on Artificial Intelligence", 15 June 2020, https://www.state.gov/joint-statement-from-founding-members-of-the-global-partnership-on-artificial-intelligence (accessed 1 December 2020).

36. Australian Government, Department of Foreign Affairs and Trade, "Memoradum of Understanding between the Government of Australia and the Government of the Republic of Singapore on Cooperation on Artificial Intelligence", 23 March 2020, https://www.dfat.gov.au/sites/default/files/australia-singapore-mou-artificial-intelligence.pdf (accessed 27 October 2020).

37. New Zealand Foreign Affairs & Trade, "Digital Economy Partnership Agreement", 11 June 2020, https://www.subrei.gob.cl/docs/default-source/default-document-library/depa-signing-text-11-june-2020-gmt.pdf?sfvrsn=43d86653_2 (accessed 1 December 2020).

38. In the context of foreign AI developed by firms in authoritarian countries (presumably China and the Russian Federation), the European Commissioner for the Internal Market Thierry Breton said manufacturers could be forced to "retrain algorithms locally in Europe with European data", adding that "We could be ready to do this if we believe it is appropriate for our needs and our security". See Stolton, Samuel, "High-risk Artificial Intelligence to be 'certified, tested and controlled,' Commission says", EURACTIV, 19 February 2020, https://www.euractiv.com/section/digital/news/high-risk-artificial-intelligence-to-be-certified-tested-and-controlled-commission-says (accessed 27 October 2020).

39. World Economic Forum, "Data Free Flow with Trust (DFFT): Paths towards Free and Trusted Data Flows", White Paper, May 2020, https://www.weforum.org/whitepapers/data-free-flow-with-trust-dfft-paths-towards-free-and-trusted-data-flows (accessed 18 November 2020).

40. MarketersMedia, "Wireless Data Communication Market 2019: Company Profiles, Global Trends, Industry Segments, Size, Landscape and Demand by Forecast to 2027", Press Release, 10 July 2019, https://marketersmedia.com/wireless-data-communication-market-2019-company-profiles-global-trends-industry-segments-size-landscape-and-demand-by-forecast-to-2027/88894831 (accessed 23 November 2020).

41. TECHDesign, "Discover the Most Promising Wireless Technologies in IoT world: BLE, Wi-Fi, and LoRa" 13 January 2020, https://blog.techdesign.com/most-promising-wireless-technologies-iot-ble-wi-fi-lora (accessed 27 October 2020).

42. ASYAD Group, "Tech Try: Stock counting with Drones", 26 July 2020, https://www.youtube.com/watch?v=WCNafXPBY2c&feature=youtu.be&ab_channel=AsyadGroup (accessed 23 November 2020).

43. Edwards, David, "Amazon now has 200,000 robots working in its warehouses", Robotics & Automation News, 21 January 2020, https://roboticsandautomationnews.com/2020/01/21/amazon-now-has-200000-robots-working-in-its-warehouses/28840 (accessed 27 October 2020).

44. Oman Logistics, "Tech Try", 2020, https://logistics.om/technology-initiatives/tech-try (accessed 18 November 2020).

45. World Economic Forum, “This is how drones and other ‘tradetech’ are transforming international trade”, Agenda, 12 August 2020, https://www.weforum.org/agenda/2020/08/this-is-how-drones-and-other-tradetech-is-transforming-international-trade (accessed 27 October 2020).

46. Port Strategy, “Costs Spiral for Unscheduled Downtime”, Press Release, 13 June 2020, https://www.portstrategy.com/news101/products-and-services/unscheduled-downtime-getting-worse (accessed 18 November 2020).

47. Business Wire, “COVID-19 Impacts: Ports and Terminal Operations Market Will Accelerate at a CAGR of over 2% through 2020-2024: Growth of Containerization to Boost Growth”, 4 August 2020, https://www.businesswire.com/news/home/20200804005321/en/COVID-19-Impacts-Ports-Terminal-Operations-Market-Accelerate (accessed 18 November 2020).

48. Manyika, James, et al., “Jobs lost, jobs gained: What the future of work will mean for jobs, skills, and wages”, McKinsey & Company, 28 November 2017, https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages (accessed 2 December 2020).

49. World Economic Forum, *The Future of Jobs Report 2018*, Insight Report, 2018, http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf (accessed 27 October 2020).

50. World Economic Forum, “What the world can learn from Rwanda’s approach to drones”, Agenda, 16 January 2019, https://www.weforum.org/agenda/2019/01/what-the-world-can-learn-from-rwandas-approach-to-drones (accessed 18 November 2020).

51. Government of Rwanda, Civil Aviation Authority, “Flying of RPAS (Drones) in Rwanda: Frequently Asked Questions”, 2020, https://caa.gov.rw/fileadmin/templates/Regulatory_Services/Frequently_asked_questions_on_flying_drones_in_Rwanda.pdf (accessed 27 October 2020).

52. Turner Lee, Nicol, “Navigating the U.S.-China 5G Competition”, 2020, https://www.brookings.edu/wp-content/uploads/2020/04/FP_20200427_5g_competition_turner_lee_v2.pdf (accessed 18 November 2020).

53. World Economic Forum, “What’s an ‘essential service’? Not knowing could block access to key digital services during COVID”, Agenda, 21 August 2020, https://www.weforum.org/agenda/2020/08/defining-essential-services-ensure-access-to-key-digital-services-during-covid (accessed 27 October 2020).

54. SAIC Motor, “SAIC 5G truck makes its debut at Yangshan Port”, 29 August 2019, https://www.saicmotor.com/english/latest_news/saic_motor/52655.shtml (accessed 18 November 2020).

55. Capri, Alex, “Techno-Nationalism: What Is It And How Will It Change Global Commerce?”, op. cit.

56. Ganne, Emmanuelle, *Can Blockchain revolutionize international trade?*, World Trade Organization, 2018, https://www.wto.org/english/res_e/booksp_e/blockchainrev18_e.pdf (accessed 27 October 2020).

57. The World Economic Forum Centre for the Fourth Industrial Revolution and the Inter-American Development Bank (IDB) have joined forces to guide public-sector stakeholders to make informed decisions about using emerging technologies to facilitate trade, drive economic development and improve competitiveness – particularly in the case of blockchain deployment in trade single windows.

58. Patel, Deepesh and Emmanuelle Ganne, “Blockchain & DLT in Trade: Where do we stand?”, Trade Finance Global and World Trade Organization, November 2020, https://www.wto.org/english/res_e/booksp_e/blockchainanddlt_e.pdf (accessed 18 November 2020).

59. Taking advantage of a weak regulatory environment and lack of understanding about blockchain, several entities launched initial coin offerings without a solid business plan. As a result, speculators and investors buying into the hype around cryptocurrency invested in coins that became worthless shortly thereafter.

60. Wohlers Associates, 2019, *Wohlers Report 2019: 3D Printing and Additive Manufacturing*, 2019.

61. Petch, Michael, “3D Printing Community Responds to COVID-19 and Coronavirus Resources”, 3D Printing Industry, 29 April 2020, https://3dprintingindustry.com/news/3d-printing-community-responds-to-covid-19-and-coronavirus-resources-169143/ (accessed 18 November 2020).

62. Choong, Yu Ying Clarrisa, et al., “The global rise of 3D printing during the COVID-19 pandemic”, *Nature Reviews Materials*, vol. 5, September 2020, pp. 637-639, https://www.nature.com/articles/s41578-020-00234-3.pdf (accessed 18 November 2020).

63. World Economic Forum, “3D Printing: A Guide for Decision-Makers”, White Paper, January 2020, http://www3.weforum.org/docs/WEF_Impacts_3D_Printing_on_Trade_Supply_Chains_Toolkit.pdf (accessed 18 November 2020).

64. Ibid.

65. For more details, see World Economic Forum, “Would a digital border tax slow down adoption of 3D printing?”, Agenda, 8 January 2020, https://www.weforum.org/agenda/2020/01/would-a-digital-border-tax-slow-down-adoption-of-3d-printing (accessed 2 December 2020).

66. World Economic Forum, “3D Printing: A Guide for Decision-Makers”, op. cit.

67. World Customs Organization, *Study Report on Disruptive Technologies*, op. cit.

68. Brown, Faye, “Firm ‘refuses to give blueprint’ for coronavirus equipment that could save lives”, Metro, 16 March 2020, https://metro.co.uk/2020/03/16/firm-refuses-give-blueprint-coronavirus-equipment-save-lives-12403815 (accessed 18 November 2020).

69. Tradelens, “Trade Made Easy”, 2020, https://www.tradelens.com (accessed 27 October 2020).

70. The World Economic Forum and the Inter-American Development Bank are working on this aspect and assessing the use of blockchain in trade single windows; see World Economic Forum and Inter-American Development Bank, “Windows of Opportunity: Facilitating Trade with Blockchain Technology”, White Paper, July 2019, http://www3.weforum.org/docs/WEF_Windows_of_Opportunity.pdf (accessed 27 October 2020).
71. Johnson, Heather, “Digging up dark data: What puts IBM at the forefront of insight economy”, 30 October 2015, https://siliconangle.com/2015/10/30/ibm-is-at-the-forefront-of-insight-economy-ibminsight (accessed 27 October 2020).
72. DataPorts, “A Data Platform for the Connection of Cognitive Ports”, 2020, https://dataports-project.eu (accessed 27 October 2020).
73. World Economic Forum, “Data Free Flow with Trust (DFFT): Paths towards Free and Trusted Data Flows”, op. cit.
74. The European Commission is also considering the introduction of an ex ante conformity assessment framework for AI products and services (see *Artificial Intelligence* in Chapter 2).
75. European Commission, “How do online platforms shape our lives and businesses?”, 18 September 2019, https://ec.europa.eu/digital-single-market/en/news/how-do-online-platforms-shape-our-lives-and-businesses-brochure (accessed 18 November 2020).
76. The Rt Hon Philip Hammond MP and The Rt Hon Greg Clark MP, *Unlocking digital competition: Report of the Digital Competition Expert Panel*, Government of the United Kingdom, March 2019, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/785547/unlocking_digital_competition_furman_review_web.pdf (accessed 18 November 2020).
77. Yu, Sophie and Brenda Goh, “China ups scrutiny of tech giants with draft anti-monopoly rules”, Reuters, 10 November 2020, https://www.reuters.com/article/us-china-regulation-ecommerce-idUSKBN27Q0K1 (accessed 18 November 2020).
78. Pacific Alliance, “Pillars”, 2018, https://alianzapacifico.net/wp-content/uploads/MatrizSGAD-Marzo-2018.pdf [in Spanish] (accessed 18 November 2020).
79. Lord, Nate, “The Cost of a Malware Infection? For Maersk, $300 Million”, Digital Guardian, 7 August 2020, https://digitalguardian.com/blog/cost-malware-infection-maersk-300-million (accessed 27 October 2020).
80. Cyber Readiness Institute “Protect Your Business With the Cyber Readiness Program”, https://cyberreadinessinstitute.org (accessed 23 November 2020).
81. McKinsey, “Harnessing the power of shifting global flows”, op. cit.
82. United Nations Conference on Trade and Development (UNCTAD), *Fifteen Years Since the World Summit on the Information Society*, 2020, https://web.archive.org/web/20200625072209/https:/unctad.org/en/PublicationsLibrary/dtlstict2020d1_en.pdf (accessed 4 December 2020).
83. Ibid.
84. International Energy Agency (IEA), *SDG7: Data and Projections: Access to affordable, reliable, sustainable and modern energy for all*, Flagship report, October 2020, https://www.iea.org/reports/sdg7-data-and-projections/access-to-electricity (accessed 27 October 2020).
85. World Bank Group, *World Development Report 2016: Digital Dividends*, International Bank for Reconstruction and Development, 2016, https://www.worldbank.org/en/publication/wdr2016 (accessed 27 October 2020). Note that fiber-optic networks are reducing energy requirements for high-volume data traffic.
86. UNESCO, “New UIS Data for SDG 9.5 on Research and Development (R&D)”, 29 June 2020, http://uis.unesco.org/en/news/new-uis-data-sdg-9-5-research-and-development-rd (accessed 27 October 2020).
87. United Nations Conference on Trade and Development (UNCTAD), *Fifteen Years Since the World Summit on the Information Society*, 2020, op. cit.
88. United Nations Conference on Trade and Development (UNCTAD), *Information Economy Report 2017: Digitalization, Trade and Development*, 2017, https://unctad.org/system/files/official-document/ier2017_en.pdf (accessed 27 October 2020).
89. Intarakumnerd, Patarapong, “Thailand’s Middle-Income Trap: Firms’ Technological Upgrading and Innovation and Government Policies”, *Seoul Journal of Economics*, vol. 32, no. 1, 28 February 2019, pp. 107-135, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3344154 (accessed 18 November 2020).