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Supply Chain

Recent Advances and New Perspectives
in the Industry 4.0 Era

*Edited by Tamás Bányai,
Ágota Bányai and Ireneusz Kaczmar*



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Meet the editors



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Preface

This book offers a selection of chapters in the field of supply chain management in the era of Industry 4.0, promoting new research results in the field. It is written by experts from Botswana, China, Egypt, Greece, Hungary, Ireland, Italy, Japan, Malaysia, Poland, South Africa, the United Kingdom, and the United States. The transformation of conventional manufacturing and service processes into cyber-physical systems using Industry 4.0 technologies influences the complexity of connected supply chain solutions. The book covers eleven topics determined by the theoretical and practical aspects of supply chain solutions based on Industry 4.0 technologies.

Chapter 1, “Industry 4.0 and Its Implications: Concept, Opportunities, and Future Directions”, introduces the framework of Industry 4.0 and discusses the drivers, potential effects, and obstacles of the Industry 4.0 paradigm.

Chapter 2, “Enabling Sustainable Supply Chains in the Industrial 4.0 Era”, focuses on the potential of Industry 4.0 technologies. As the chapter shows, these technologies offer solutions for environmentally and commercially sustainable processes.

Chapter 3, “Industry 4.0: The Tenets of the Next Generation of Supply Chain Management”, describes the supply web concept and its distinctive tenets focusing on vertical, diagonal, and horizontal dimensions.

Chapter 4, “Application of Internet of Things in the Movement of Goods at Customs Level during Covid-19 Pandemic”, identifies potential governmental solutions at the customs level for improving customs operations and enhancing their efficiency and effectiveness in a pandemic situation.

Chapter 5, “Industry 4.0 Technologies Impact on Supply Chain Sustainability”, describes the most important Industry 4.0 technologies including big data analytics, artificial intelligence, machine learning, Internet of Things, sensors, blockchain technology, robotic systems, cloud computing, cyber-physical systems, additive manufacturing, virtual reality, augmented reality, and autonomous vehicles and drones and focuses on their impact on sustainability, efficiency, cost reduction, transparency, traceability, and collaboration.

Chapter 6, “Open Innovation Strategies on New Product and Process Development Prospects: A Case of the Automotive Component Manufacturers in South Africa”, discusses potential open innovation practices and their impact on the processes of automotive component manufacturers focusing on sustainable new product development.

Chapter 7, “Shipping Digitalization and Automation for the Smart Port”, describes a potential framework for shipping digitalization and port automation. It presents a case study to illustrate the advantages of blockchain technology applications.

Chapter 8, “Enhancing the Resilience of Sustainable Supplier Management through Combination with Lean and Audit”, shows how to pull production and employee involvement under lean practices to strengthen supplier management robustness and enhance the prevention ability of resilience in dealing with opportunistic behavior. It also highlights how the combination of lean practices with an audit mechanism strengthens the practice effect of pull production and employee involvement.

Chapter 9, “Production Systems Performance Optimization through Human/ Machine Collaboration”, chapter presents potential robotic displacement solutions in production systems. It also proposes solutions for human-machine interaction problems.

Chapter 10, “Supply Chain: A Modeling-Based Approach for Cyber-Physical Systems”, focuses on the optimization of green supply chain solutions using Industry 4.0 technologies. The mathematical model and the computational results validate that Industry 4.0 technologies can improve the performance of supply chain processes.

Finally, Chapter 11, “Sustainable and Efficient City Logistics”, describes the main trends, impacts, and challenges of city logistics solutions. It also discusses the importance of smart technologies, with a focus on last-mile delivery operations.

The aim of this book is to help students as well as managers and researchers to understand and appreciate the concept, design, and implementation of supply chain solutions in the Industry 4.0 era.

The editors thank the chapter authors for their scientific contributions. The chapters were edited and published following a rigorous selection process. We also wish to thank and acknowledge the many individuals who helped us throughout the editorial process that made this book possible.

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Chapter 4

Application of Internet of Things in the Movement of Goods at Customs Level during Covid-19 Pandemic

*Erica Varese, Maria Chiara Cesarani
and Magdalena Wojnarowska*

Abstract

The rapid growth of trade volume makes it necessary on the one hand to increase the safety and security of international trade and, on the other hand, to leave the flow of goods unobstructed. The Covid-19 pandemic severely impacted the world goods and services trade which, after almost 2 years, are still not back to December 2019's volumes. This chapter investigates some of the different suggestions proposed by international organizations to mitigate the pandemic effect on international trade, with a specific focus on trade facilitation measures such as international certifications (i.e., Authorized Economic Operator), risk management strategies and new technologies which are deeply transforming and helping the movement of goods at customs level. After reviewing published reports, this chapter aims to verify which are the most feasible solution to be implemented by the government at the customs level for improving customs operations enhancing their efficiency and effectiveness.

Keywords: Covid-19, trade facilitators, Internet of Things (IoT), authorized economic operator (AEO), customs

1. Introduction

As of March 2020, the Covid-19 pandemic has had an enormous impact on trade volume, disrupting international and sometimes even national trade exchange for several months [1]. As experienced worldwide, the first common reaction to the widespread of the SARS-CoV-2 has been the implementation of travel restrictions and closures of borders, with the obvious consequence of directly affecting goods and services trade. From the first case identified in Wuhan (China) on December, 31st 2019 until March, 11th 2020 when the World Health Organization declared the pandemic, as shown in **Figure 1**, most countries have progressively introduced severe travel restrictions and border closures with the highest expression of this hard situation reached between April and May 2020, leading to a constant increase of shipping costs and transport duration [2].

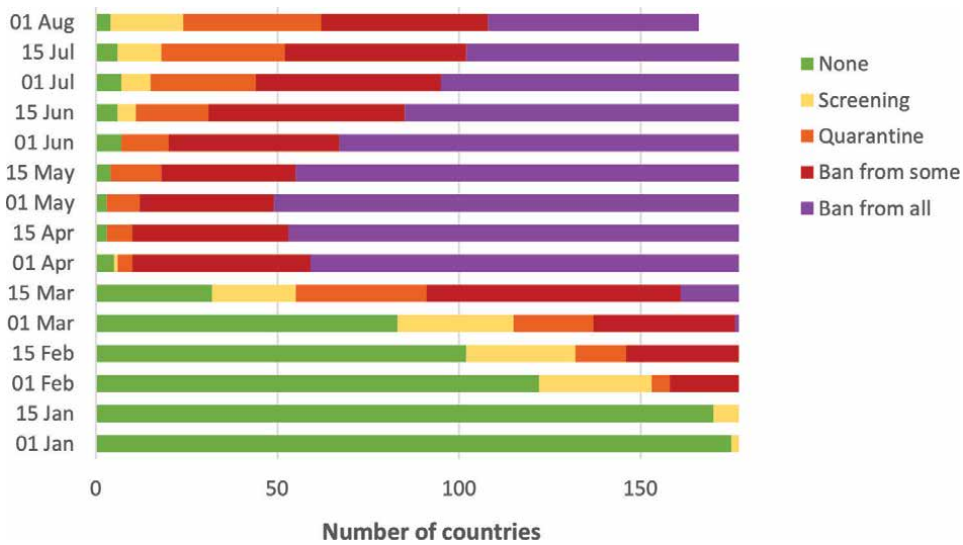


Figure 1. International travel controls by stringency and date (1st January–1st August 2020). Source: World Trade Organization [2].

Given that, it is estimated that regulatory and legislative differences, as well as trade policy barriers, still count for no less than 10 per cent of trade cost [2] it is of the utmost importance to ensure a safer and faster international trade: this concern is even truer in hard times as the one we are facing. As known, safety is often defined, in international trade, as the condition in which the various risk, which is linked to the exercised activity, has been acknowledged, in which the likelihood of some specific adverse events have been identified and in which all the feasible special measures have been taken to limit, as far as possible, the associated risks [3]. To achieve safety and velocity, several instruments could be taken into consideration, including trade facilitation. In this regard, the World Trade Organization (WTO) specifically highlights that, as done in the current pandemic time on medical products and personal protective equipment, countries should put in place electronic systems and certificates [2] to achieve the above-mentioned goals. Before specifically focusing on this issue, it is useful to recall some of the most efficient tools proposed and adopted by the World Customs Organization (WCO) Council in the last 20 years to reach velocity and safety in international trade: (i) SAFE Framework of Standards to Secure and Facilitate Global Trade (SAFE Framework) in 2005 and (ii) the Authorized Economic Operators (AEO) Program in 2007. The SAFE Framework is a non-binding unique international instrument that ushered in the supply chain which comprised technical security customs standards without obstructing international trade and creating a closer partnership between customs and business operators [4, 5], while the AEO is a voluntary certification that allows traders who meet certain criteria to assure the supply chain security and then to enjoy customs benefits throughout the European Union [6, 7]. Although, the SAFE Framework has proved to work well, in 2021 the WCO undertook a revision of it aiming at “strengthen[ing] co-operation between Customs and Other Government Agencies; promot[ing] smart security devices to optimize Customs control and effectively monitor the movement of goods in a real-time basis; and, includ[ing] baseline provisions on the development of regional Customs union AEO programmes and the implementation of mutual recognition” [8].

Similarly, after the period 2016-2020 where the goal was to support European Union's (EU) competitiveness on the world markets, the—at the time—EU Commission's candidate U. Von Der Leyen highlighted those further steps should be taken to lead Customs Union up to the next level, as it is necessary to equip it with new and stronger legislation and framework which would eventually allow the Union to better protect the single market and the citizens [9]. As a result of the Covid-19 pandemic, the 2020–2024 Strategic Plan developed by the European Commission's Directorate-General for Taxation and Customs Union (DG TAXUD) highlights that the European Union needs today more than ever tax and customs policies which can support economic recovery and to guarantee that all the financial resources are correctly and sustainably allocated to create a level playing field capable of higher protection to both the citizens and the Single Market [10]. To achieve this ambitious plan, DG TAXUD started developing trader portals and single EU access points accelerating electronic exchanges between customs authorities and traders enabling 24/7 operativity to Union customs.

As known, to effectively guarantee safety and security in goods and services' trade, it is essential to develop a close partnership between national customs and businesses. To do so, one of the aspects to be taken into consideration consists in ensuring to have implemented an in-depth risk analysis enabling each custom to correctly assess its own procedures. A tool that is commonly accepted and that is gaining more and more importance is the Authorized Economic Operator (AEO) together with the information management and information technology (IT) tools.

As above-mentioned, AEO is recognized as a certification scheme using shared information to assess and lower risks associated with trade. The companies which can gain such certification are allowed to have softer or removed border controls that other companies normally undergo [11].

Given the above, this chapter presents an analysis of some of the Covid response papers issued by international organizations and bodies in the period 2020–2021 with a focus on the new technologies, to understand whether there could be some efficient trade facilitator in this global pandemic era to implement the performance of the whole supply chain.

With the purpose to achieve the aim of this research, the following hypothesis has been developed:

H. In international trade there is an increasing need to monitor the supply chain also about the movement of goods, furthermore, it is necessary to increase and facilitate the safety and velocity of these exchanges particularly in this pandemic period. Since the Internet of Things is considered a strategic tool in many sectors, it would be significant to identify nowadays strategies to help international trade to recover during the Covid-19 pandemic.

To the Author's knowledge, this is the first manuscript that analyses the international bodies' responses to the impact of Covid-19 and the different suggestions issued by the International Organizations.

The study is therefore organized in 3 further sections: Section 2, review on international bodies recommendation; Section 3, discussions and implications and, in Section 4, conclusions are presented.

2. Review on international bodies recommendation

The International Chamber of Commerce (ICC) [12] after reminding that every exceptional time increase the risk for illicit behavior affecting business such as

corruption, money-laundering and fraud, called for the drivers that businesses and policy makers should follow not to be overcome by the pandemic: transparency and integrity in all procurement stages which are helped by the digitalization of permits and licensing; keeping the due diligence process ongoing to mitigate supply chain's risks; fighting corruption in the context of borders and customs; and, protecting the rule of law.

In such a contest, where states closed upon themselves and made trade extremely difficult, in the last 2 years several international organizations presented different suggestions to mitigate the Covid-19 trade-related effects.

The United Nations Industrial Development Organization estimated in July 2020 that, among the 49 countries which represent almost 87% of world manufacturing value-added, about 81% of countries faced a decrease of an average of 6% in industrial production comparing the dataset in December 2019 and March 2020, and an average of 20% in 93% of nations comparing December 2019 and April 2020 [13]. The situation has not changed afterward, with several and severe economic consequences hitting countries until June 2020 [14] where the index of industrial production kept on decreasing, although with a small improvement: from -5.6% in March 2020 to -2.5% in June 2020.

The export of goods has had a particular trend which is indicated in **Table 1** from the 4th quarterly 2019 to the 3rd quarterly 2021 (Q4-2019–Q3-2021), the tendency is expressed in billions of US dollars, for each member of the Group 20 (G20). **Figure 2**, furthermore, highlights that the export of goods of these countries has marginally been impacted in 2020 Q1-2020, and then has had a strong downshift in Q2-2020. Starting from Q3-2020, G20 countries have seen a positive trend of it and in Q4-2020 they exported more goods than in Q4-2019, the quarterly previous the start of the pandemic. In the following quarterlies (Q1-2021 and Q2-2021), this trend has continuously increased reaching, in Q3-2021, the amount of 4262.96 billion US dollars.

Given the above, in 2020, the United Nations Conference on Trade and Development (UNCTAD) drafted a report suggesting some measures to efficiently manage the pandemic consequences [16]. While the world would have needed higher agility and efficiency, trade experienced extensive disruptions, with medical devices and personal protective equipment firstly affected by the export restriction. Therefore, four main interventions categories were identified:

- i. Process optimization;
- ii. Cost reduction;
- iii. Transparency and cooperation;
- iv. Technology.

With regards to “process optimization”, UNCTAD recommended following the criteria specified by art. 7.8 of the WTO Trade Facilitation Agreement introducing, among others, fast tracks lanes, prioritization, implementing the trusted traders such as the AEO and simplifying the declarations. About “cost reduction”, the UNCTAD remarked the importance of reducing some tariff, accepting some goods received as gifts by approved organizations free of charges, while on point (iii)—“transparency and cooperation”—it highlighted the necessity of having prompt and transparent information among all countries not only about the pandemic itself but also on the

Time	2019		2020			2021		
	Q4-2019	Q1-2020	Q2-2020	Q3-2020	Q4-2020	Q1-2021	Q2-2021	Q3-2021
Country								
Argentina	15.25	17.41	13.26	13.53	12.85	17.82	18.83	21.37
Australia	64.92	61.21	59.57	60.79	68.06	80.01	88.26	90.79
Brazil	51.98	55.37	51.32	52.19	52.81	60.60	78.44	73.21
Canada	110.75	105.19	76.86	101.81	107.09	118.85	123.53	126.08
China (People's Republic of)	537.83	610.89	627.36	676.10	711.99	844.08	822.95	835.76
France	140.42	131.44	93.17	126.17	137.49	141.89	144.02	145.57
Germany	370.83	358.48	277.83	355.92	383.74	400.96	406.73	399.44
India	72.07	80.05	52.14	75.16	76.20	86.24	97.29	104.10
Indonesia	42.77	42.22	35.23	39.88	45.00	50.59	54.94	58.50
Italy	135.65	128.02	94.04	132.73	143.59	147.67	153.66	151.45
Japan	174.47	167.25	133.35	158.21	180.19	184.39	189.74	190.23
Korea (Republic of)	133.38	135.04	108.97	129.50	138.89	151.79	155.04	163.84
Mexico	112.09	113.74	73.30	110.31	118.38	119.14	122.37	121.98
Russia	90.57	100.85	75.12	81.44	83.77	95.32	124.04	138.14
Saudi Arabia	52.97	61.05	33.81	43.03	43.93	58.54	65.76	73.72
South Africa	22.98	21.97	15.56	21.93	25.01	29.33	35.48	30.03
Turkey	45.53	43.38	32.62	43.63	48.48	51.35	55.39	57.66
United Kingdom	109.09	101.25	76.27	92.92	105.12	98.72	111.23	106.27
United States	407.15	396.38	289.37	356.01	383.17	407.25	434.93	439.34
European Union—27 countries (from February 01, 2020)	1448.62	1406.18	1107.99	1415.85	1525.91	1596.34	1650.68	1646.72
G20	3595.82	3416.03	2862.11	3472.27	3726.85	4050.35	4228.90	4262.96

Source: authors' own elaboration on Organization for Economic Co-Operation and Development [15].

Table 1.
Quarterly (Q4-2019–Q3-2021) of G20 export of goods (value—US dollar, billions).

transported goods. Lastly, about “technology” it remarks that efficient, rapid, and centralized processing should be further implemented.

Linked to this remark, in 2021 WCO together with WTO, drafted a paper [17] whose objective was to provide an evidence-based picture on three different

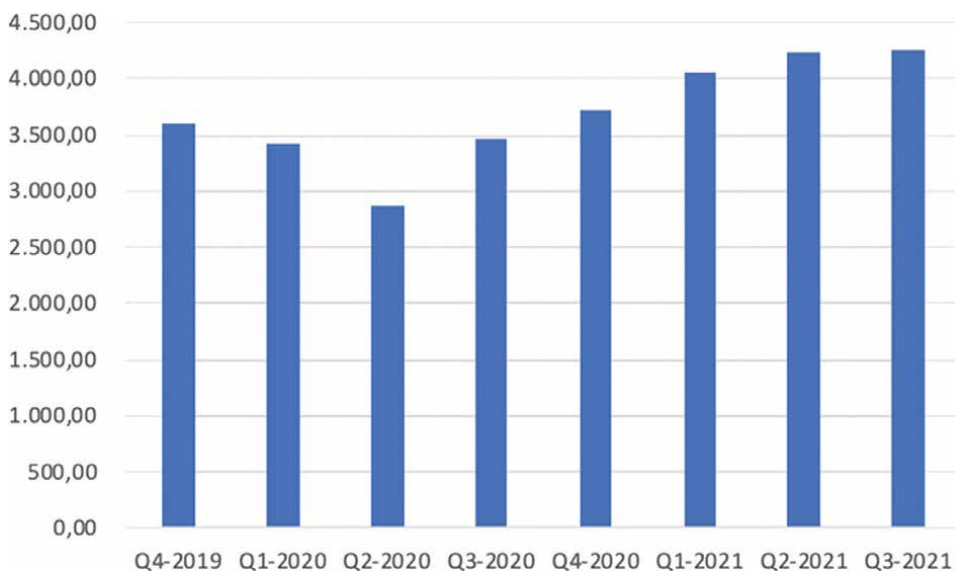


Figure 2. Export of goods of G20 members (Q4-2019–Q3-2021)—US dollars, billions. Source: authors’ own elaboration on Organization for Economic Co-Operation and Development [15].

technologies that Customs could utilize as trade facilitators to achieve safety and velocity, fundamental main stones in this period. The suggested tools are blockchain; IoT and Big Data. Specifically, WCO found that blockchain is still enduring an experimental phase, mainly involving private and permissioned blockchains. Many customs faced a certain hesitancy towards this technology, but the WCO paper highlight that there is a common “*reasonably optimistic concern*” towards blockchain’s potential as it could lead to greater efficiency and reliability in risk management, revenue collection, and trade facilitation as well as creating an environment where public authorities can cooperate with private industry from the early stage of production and trade. Further recognized benefits were identified in transparency, immutability and accessibility of information, lower transaction and verifications costs, and increased availability of information and quality data from different sources. About IoT, WCO found that these tools are used by more than 50% of the respondent, mostly in the area of X-ray and computed tomography, QR Code and barcode readers, electronic seals and automated license plate readers, and radio frequency identification (RFID) antennas or e-seals to ensure traceability of mean of transport and goods. It has also been highlighted the importance of implementing IoT solutions, as they enable them to have better risk management, greater customs clearance process efficiency and improved analytics. Regarding Big Data, data analytics, artificial intelligence and machine learning even if it is quite commonly utilized, there still are multiple obstacles in common usage. Particularly, benefits linked to these technologies have been identified in risk management, fraud detection, and audits’ facilitations, while the barriers were identified in associated costs, and lack of expertise and good practices.

Again in 2021, the United Nations Economic Commission for Europe (UNECE)—United Nation Center for Trade Facilitation and Electronic Business (UN/CEFACT) published a white paper [18] to provide some best practices ensuring efficient trade control together with facilitation measures to be implemented during the pandemic to avoid a total interruption of commercial trade. The measures to mitigate the

impact on trade should involve several stakeholders, including the public sector (i.e., customs, and border authorities), public-private partnership (i.e., National Trade Facilitation Bodies), and private sector stakeholders (i.e., logistic, transport, production, and manufacturing sector) and shall be aimed to cross border cooperation with an increase of trust between partners. This could be achieved with special regimes, special economic zones, expedite pre-arrival clearance procedures, reliable exchange of information, and coordination between integrated risk management and sharing and combination of data into governmental databases accessible by other interested agencies. Similarly, further inputs should be given to National Trade Facilitation Body and external coordination within multilateral, regional and bilateral agreements as well as to trusted trader schemes. The last category includes, as known, the AEO together with the trusted trader. Given the strict requirements provided by the regulations governing the two schemes, governments can trust certified companies which shared with their border authority's information on how they are structured, and on the management procedures and internal structures (i.e., compliance functions, supply chain management, and codes of conduct). Another proposed solution is to efficiently involve private sector actors who mainly run logistical supply chains who can control their workforce and share the records collected with the border authorities or by using packaging materials that are less likely to keep the coronavirus alive for long hours. Finally, a strong recommendation is given on the usage of technologies. The UNECE reminds that to reduce contagions it is important to limit human contact which can be done by introducing system-to-system electronic data interchange (EDI) such as the National Single Window¹, the port community systems and single submission portals. All these automated systems may have several usages in commercial, logistics, and transport exchanges as well as in the regulatory field.

3. Discussions and implications

Covid-19 pandemic has presented a never seen before (at least in the last century) threat to international trade, leading to an important economic downturn. From the 1,179 billion dollars value of world exports of commercial services in 1995 to the 4,872 billion dollars value in 2014 [20] to 5,898 billion dollars in 2019 [21], the trend has almost always been upwards.

In 2020 Q2 [22], commercial services plunged by 30% and merchandise trade volume by 14.3% [23] on a year-on-year review and while they are now rising back up (respectively, +26% and +1.6% on a year-on-year comparison [24, 25] it will take time for them to be back at the pre-crisis level.

To reach a faster recovery, technological tools are definitely something States and governments should invest on.

The first one to invest on is blockchain, which has been recognized as an instrument that facilitates trade by helping risk management [17]. Nevertheless, it has only been fully deployed by 2% of WCO Members, while more than 40% do not even yet start planning its introduction [17].

¹ The National Single Window is defined as “a facility providing trade facilitation that allows parties involved in trade and transport to lodge standardized information and documents with a single entry point to fulfill all import, export, and transit-related regulatory requirements. Individual data elements should only be submitted once electronically” [19].

Introducing a standardized dataset between economic operators and government agencies as well as developing common, interconnected, and interoperability blockchain solutions, shared legal requirements and definition of blockchain technology should help a wider usage of this particular tool.

Nevertheless, the actual usage of blockchain covers different areas in the countries where it has been fully or partially used: it may be found in e-commerce environments, in supply chain interconnectivity as well as in electronic certifications and licensing. Particularly, the EU started both a research program to investigate the usage of blockchain in protecting geographical indications, and certification of product origin and in helping VAT collection [17, 26], and the TRICK project in the context of the textile industry funded by Horizon 2020 [17, 27]. Indonesia is currently experimenting with blockchain to automate documentation, simplify the exchange of goods and increase communication and cooperation between counterparts [17].

Other countries are seeking to link it with AEO and container movements: it has been hypothesized that using blockchain in these contexts may faster registration systems and entrust the system and the relationship between counterparts. Among these, it can be named the Malesia experience [17] trying to make the system more competitive and the example of the CADENA project which is a blockchain solution that enables efficient, automated and secure information sharing on AEOs among the Border and Customs authorities of Costa Rica, Peru and Mexico in the context of further implement the mutual recognition agreements [28].

These experiences shall be of guidance and the positive effects that they proved out shall be replicated in other geographical areas.

A second instrument is IoT, which is wildly used to share information with different stakeholders, leading to better risk management, data analysis and efficiency in the Customs clearance process [17]. For example, the usage of QR Codes for transit, the usage of e-lock, GPS tracking, X-ray scanners, and CCTVs cameras interconnected with national or regional Customs are services that help an automatization of border crossing procedures. For example, the Italian Customs and Monopolies Agency is conducting IoT projects based on IoT_ID code to completely digitalize the procedures for goods transported by road and rail transiting in Italian ports [29] while Hong Kong has implemented the GPS technology and e-lock connecting their data with the one of China Mainland [17].

Other instruments that stakeholders can implement are linked to big data, data analytics, artificial intelligence and machine learning technologies. The more common advantages are seen in data quality, predicting future trends and facilitating customs audits [17]. These have been utilized, among other uses, to ameliorate the efficiency of financial and tax data, to respond to the most common questions through chatbots, to find anomalies in high revenue areas, to find illicit traffic and goods, to enhance Customs clearance efficiency.

Almost half of the WCO members already use them [17] and only less than a quarter have not started planning to introduce them.

To implement such technologies would require States to invest money in new technologies, to overcome the lack of knowledge and expertise, to find a common and shared legal background, and to strengthen trust between counterparts, finally leaving aside cautiousness and lack of trust towards technologies. Nevertheless, governments, as highlighted in the literature [30], face other challenges such as handling the complexity arising from a massive data extraction and converting it into a meaningful model parameter.

4. Conclusion

This chapter has analyzed several strategies related to the movement of goods during the Covid-19 pandemic and expressed by international organizations, including ICC, WTO and WCO. Knowing that the pandemic is not likely to end soon, and that automatization may be the path to be followed to pursue a faster and more secure trade exchange, the common idea is to emphasize the usage of new technologies such as blockchain, IoT, machine learning, data analytics, artificial intelligence, and big data.

Although, most countries have already started implementing some or all of them, getting several advantages by their use such as speed control and tracking—as collected in the WCO annual consolidated survey—, there still are several issues to face to have widespread usage. Costs, lack of knowledge, good practices and/or trust, legislation and privacy issues, and lack of governmental strategy and coordination are the one to be faced shortly to ensure an interconnected international customs system.

This chapter focuses only on strategies proposed by international organizations, without acknowledging national responses to the pandemic, and this may represent a limit in the investigation.

Future research directions may be, on the one hand, understanding whether any country would be able to implement the proposed approaches, investing in new technologies for its borders and Customs, and seeing the actual improvements in the relationship among the international trade stakeholders; on the other hand, selecting a specific geographical scope, examining regional and national response to the downshift of international trade and the proposed solutions at a local level.

Conflict of interest

The authors declare no conflict of interest.

Other declarations

All authors have equally contributed to this chapter.

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