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## Joint Working Party on Agriculture and Trade

# Digital opportunities for trade in agriculture and food sectors

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# *Note by the Secretariat*

This report forms part of the work mandated under Output Area 3.2.3.1.5 of the Committee for Agriculture and 3.1.3.1.1 of the Trade Committee of the 2017-18 PWB. The report builds on the approach set out in the scoping paper TAD/TC/CA/WP(2017)7 and interim draft TAD/TC/CA/WP(2018)4 presented to the 78th and 79th sessions of the Joint Working Party on Agriculture and Trade.

This report explores ways in which digital technologies can support trade in the agriculture and food global value chains, in particular in relation to market access, traceability and trade facilitation.

This document was declassified at the 80th session of the Joint Working Party on Agriculture and Trade.

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# *Executive summary*

1. This report discusses how new opportunities to create and share information are shaping the digital transformation of the agriculture and food system, potentially fostering its reorganisation. It focuses particularly on cross-border trade aspects along the global agriculture and food value chain and looks at how changes brought about by digital technologies can influence who participates in the value chain, where value added is created and how value is distributed between actors in the chain. But it is not only changes in the agriculture and food sector from digital technologies that matters, but also the digital transformation of other actors in the global value chain such as support services, logistics and governments. This report focuses on the potential of digital technologies to reduce trade and transaction costs, including those related to identifying and negotiating a deal, proving compliance with standards and to delivering products across borders quickly and efficiently.

2. These new opportunities are particularly important in the context of significant changes in trade in agriculture and food over the past two decades. Two trends are particularly notable: first, the increase in overall trade flows, and in particular new and increased trade between developing countries; and second, the development of global value chains (GVCs) in the agriculture and food sector. Both these changes have been influenced by the evolving domestic and international policy environment and have opened new opportunities for consumers around the world to increase variety in their consumption patterns.

3. A range of technologies are contributing to the digital transformation of agriculture and trade: Electronic Data Interchange (EDI); platforms, sensors and the Internet of Things (IoT); Cloud computing, Big data; Artificial intelligence (AI) and distributed ledger technologies such as blockchain. Beyond their individual impact, the combination of these technologies is fostering the digital transformation of the food system. These technologies are mainstreamed to different degrees: EDI has been used since the 90s, but Blockchain technologies and AI applications in agriculture and food are still being developed.

4. A critical development is the "datafication" at the core of the digital transformation, as the increased capacity of sensors to transpose the real world into machine-readable formats creates new information that can be analysed and used in new ways, including in data management and analysis tools. The agriculture sector has become central in the data chain as both an important consumer and supplier of data, with new opportunities to foster value added creation in the agro-food value chain, enable market access and improve the management of GVCs. However, it is not necessarily the large quantity of data that matters, but its quality and whether it is fit-for-purpose. If the best algorithm is calibrated using poor quality data, the results will also be poor.

5. The digital transformation and increased capacity to create and share data provide an opportunity to reduce some longstanding regulatory constraints to trade and related market failure (missing information and information asymmetries; leading for example a misalignment between supply and demand. For example, stakeholders in the supply chain might have different preferences and incentives (non-alignment of incentives). This creates transaction costs, which, when too high, can prevent otherwise beneficial transactions from happening. Digital transformation, although at an early stage, is also already providing opportunities for the entry of new actors into the international agro-food value chain. Producers, even small ones, increasingly have access to a range of digital tools allowing

them to access information (for example, product prices, standards) and various services (such as payment services) more easily and at a much lower cost, reducing the cost of negotiating and undertaking trade transactions. Small firms can now be "born global" and consumers can directly participate in trade, substituting traditional wholesalers or retailers with new types of digital intermediaries. These intermediaries often also provide an additional range of services in digital or physical form through the use of digital applications and platforms.

6. Digital technologies can also provide new ways to solve supply side constraints to smallholder participation in GVCs. First, new digital platforms and applications, available even in remote areas, give smallholders access to agricultural extension and advisory services that previously required the physical presence of experts. These services provide direct access to information about inputs and product markets, reducing the reliance on traditional intermediaries, and better aligning production with demand to reduce risk as well as waste. Smallholders can also access new and more lucrative markets. Production processes can be registered and evaluated, with full traceability through to consumers, enabling producers to receive a price premium for consumer preferences related to quality or positive externalities from production practices, or from "fair trade" systems for producers. They can also facilitate timely payments to farmers.

7. However, some constraints remain; access to (efficient) transport and trade infrastructure still matters for accessing quality inputs and export markets, particularly for perishable products. Therefore, while digital technologies can provide access to some new digital advisory services, advice must be adapted to production constraints (for example whether the farmer has access to certain types of inputs). In other words, while digital technologies show impact when constraints are mainly access to information, they have more limited impact when change requires addressing more complex systems. The same holds for access to new export markets, for which exporters need to make sure they can actually export the quantity and quality required. Nevertheless, it is envisaged that part of those constraints can also be solved by digital technologies, from the use of UAV (drones) for delivery to the increased capacity of remote and in-situ sensors which might change the way compliance to standards can be checked (for example the presence of pests in a field.)

8. By filling information gaps, digital technologies may facilitate the implementation of trade regulations by providing more automatic checks for compliance with standards and a more transparent and efficient trade regulatory environment. Increased data management capacity can support not only improved product traceability, but also better monitoring of product integrity. That is, in addition to product safety, particularly for perishable products, digital technologies can make it possible to verify that a product is what it claims to be.

9. Access to increased information can also create new expectations and requirements from consumers, which can represent new sources of value in the agro-food chain. With consumers placing higher values on product attributes, particularly after a series of food scandals around the world, more information about where the product is sourced and how it was produced is of increasing commercial value. How those new possibilities will shape the food system and how much of this additional value will reach farmers is not yet known. Furthermore, in capturing these new opportunities, new services will be needed to create and translate new data flows into information useful to consumers.

10. For trade facilitation, digitalisation is increasing the efficiency and reliability of customs management and the trade logistic chain, reducing trade costs. Implementation of a range of Articles of the WTO Trade Facilitation Agreement (TFA) can be enabled by digital technologies, in particular those related to automation of processes and

communication of information. There are also implications for the way trade facilitation polices are implemented. Artificial Intelligence (AI), for instance, is likely to enable new solutions that could change the way border services operate, in particular for risk management, and allow faster adaptation to the changing nature of trade. Finally, digital technologies can provide new solutions in the logistics chain for trade in agriculture and food, including new tools for trade finance.

11. This report shows how the co-ordination of international production networks, as well as trade logistics, is underpinned by data flows, and being able to pass on information, together with the traded goods, throughout the chain and across the border can create a competitive advantage. However, while digital technologies provide an opportunity to reduce some of the traditional constraints to participation in trade, the report also sets out a range of potential risks that might require action from governments.

12. A new divide between those who are able to access and use those new technologies and those who cannot, because of skills, regulations, infrastructure and costs is a clear challenge for governments. That said, the digital transformation could enable redirection of resources from burdensome compliance and administrative mechanisms towards building a regulatory environment which creates trust in data, and enables the devices and algorithms that can support compliance testing. Given that both public and private information is needed for a traded product to cross borders, the government has an important role in supporting co-ordination among actors to foster change, both between the public and private sector but also between countries.

13. Excitement has grown for a range of digital technologies, and imagining or testing what current issues they could address: from enabling further product differentiation and creating access to new markets, to proposing new paradigms governing the way transactions are operated and value is distributed along the value chain. However many of the new tools explored in this document are still at an early age of development. While innovation can benefit from such hype though increased investment in research and development to test scalability, governments have an important task in ensuring the security and quality of new technologies and services and preventing exploitation of vulnerabilities in the technology by unlawful actors. In addition, there is a need for greater knowledge among stakeholders, public and private, about the capacities and limits of new digital technologies. The risk, at this stage, is that the technology will fail to meet inflated expectations, simply because too much is expected from what are, in the end, programs that create efficiency.

# Digital opportunities for trade in agriculture and food sectors

## 1. Introduction

14. Digitalisation of the economy and society is a transformative process that holds considerable promise but also raises challenges, including for the agriculture and food sectors (OECD, 2015a). This transformation has various direct and indirect consequences, bringing innovation, changing market conditions and leading to new business models. First, opportunities offered by digitalisation are changing how trade is taking place, as well as who is trading and what is being traded. Previous analyses have highlighted two consequences of the digital transformation for trade [See OECD (2017d, 2017e) and OECD/WTO (2017)]. The first highlights how digitalisation changes the way economic actors engage in trade. The second looks at how digitalisation is changing the way international trade transactions are organised and managed, and in particular how digitalisation enables improvements in the trade logistics chain. Both are relevant for trade in the food and agriculture sectors.

15. This transformation also affects agriculture as well as, more broadly, the agro-food value chain, both of which are becoming increasingly data-intensive. In a world of increased integration of markets through global value chains[1] (GVCs), the regulatory environment, including traceability, and consumer preferences (for quality, sustainability and transparency from farm to fork, as well as social concerns) are all contributing to making the sector increasingly data-heavy. Management of value chains across borders is particularly challenging, particularly when dealing with perishable products, and requires the exchange and processing of large amounts of information. The increased capacity to create quantified digital data on agricultural assets and production processes, and digitisation of the trade logistics chain are progressively offering the opportunity to meet these increasing demands for information along the value chain

16. This paper aims to contribute to understanding the impact of the digital transformation on the food system. It discusses how new opportunities to create and share information are shaping the digital transformation of the agriculture and food sectors and how this is interacting with the digital transformation of cross-border trade processes, both public (in relation to cross-border agencies) and private (changes in the way the trade logistics chains is organised). The aim of the report is to open the discussion about these new trends and to highlight the range of trade-related constraints and opportunities for agriculture and food in the digital economy, and identify issues, which could be explored more thoroughly in the future.

17. At this stage, it is difficult to evaluate the impact of digital technologies on trade flows. In particular as applications of some potentially game changing technologies, such as artificial intelligence (AI) and blockchain[2], are at the pilot phase and still need to reach scale. These technologies are nevertheless recognised by both the public and private sectors

[1] The fragmentation of production processes across countries, characterised by an increase in trade in intermediates.

[2] The term *blockchain* in this paper encompasses a range distributed ledger technologies (DLTs), presenting different systems of governance. To avoid complexity, except in boxes and for specific examples, the paper only refers to the blockchain technology.

as having strong potential to solve a range of issues constraining trade integration in the food system and trade logistic chain (OECD 2017a). Finally, digital technologies can impact trade at many levels of the value chain.

18. Specifically, this paper seeks to:

- Identify new trends in the global food system in relation to digital technologies and focus on their potential impact on a series of trade costs, which are important determinants of the decision to trade and on the organisation of the transaction. In particular, to- and beyond-the-border trade costs relating to standards, access to competitively-priced services, and administrative procedures are explored.
- Identify the opportunities offered by the increased capacity to create and use data to support trade in agriculture and food. It focuses on how "data-driven innovation", defined by the OECD (2015a) as data and analytics to improve or foster new products, processes, organisational methods and markets, are changing the agriculture and food sector and the way trade transactions happen.[3]
- Provide snapshots of the issues at different levels of the agriculture and food supply and trade chains. It highlights how, at the agro-business value chain level – looking at how producers, agro-business intermediaries and final users organise transactions – digital technologies can solve traditional constraints shaping the way the agro-food value chain is organised and who participates in it. While helping to address some longstanding issues, although not all, digitalisation can also give rise to new issues, requiring new regulatory solutions.
- Given the importance of efficient trade logistics for perishable products in the agro-food chain, a greater focus is placed on how digital technologies can support the trade facilitation (cross border) authorities and efficiency of the trade logistics chain (freight forwarders, trade finance and insurance etc.). While covering a wide array of changes, the paper does not undertake an in-depth analysis of each topic.

19. This paper is structured as follows. The next section begins with some context on the current issues and constraints in agriculture and food value chains that digitalisation could help to address. It highlights the "datafication" process at the core of the digital transformation (a non-technical overview of the digital technologies referred to in this paper and considered as likely to be game changers for the agriculture and food sectors and for trade is in Annex 1). Section 3 then describes how the digital transformation of the agriculture and food sectors is affecting the organisation of the value chain, helping to ease some trading constraints and enabling trade and the entry of new actors, including smallholders, but also creating new requirements. Finally, section 4 explores how digital technologies can facilitate cross-border processes and increase the efficiency of the trade logistics chain.

## 2. Digital technologies and the "datafication" of the food system

20. A broad spectrum of digital technologies can have an impact on the agriculture and food sectors, many of which do not require large investments by users. These range from low-tech investments and use of mobile devices and platforms, to help users access services

[3] The paper focuses on technologies primarily based on using data and so does not look at technologies such as robotics, which could, in the future, influence processes and efficiency of agriculture and food production and trade.

supporting farm management decisions, to high-tech "digital farms" or logistics management services, making use of integrated systems involving drones, robotics, internet of things (IoT), sensors and big data analytics (an overview of key technologies for the sector is at Annex 1). Whether investments in technologies are made on-farm or by service providers (private or public), the main reasons to use digital technologies are that they reduce costs, or provide solutions to old or new constraints or requirements in a changing environment. The following sections provides context, highlighting why digital technologies are changing opportunities in trade in agriculture and food and presents the analytical framework used in this report.

### *2.1. Trends in trade in agriculture and food*

21. World trade in agriculture and food has changed considerably over the past two decades as a consequence of the decline in tariffs and trade costs – despite the persistence of some NTMs – added to the changing nature of demand – in diets and consumption patterns, such as demand for variety and year-round supply of fresh produce. These evolving domestic and international policy environments have supported an increase in trade flows and new entrants in international trade, in particular emerging and developing economies. Two trends are particularly notable: the increase in trade among developing countries and the development of GVCs in the agriculture and food sector (see Greenville, Kawasaki and Jouanjean, 2018a; Greenville, 2017).

22. Some of the drivers of this evolution in trade flows in agro-food sectors are similar to those in manufacturing; however, some characteristics of the agriculture and food sectors have influenced the pace and extent of GVC integration. This includes a sensitive policy and trade environment, in particular given differences in preferences related to food quality, food safety, and use of certain production practices across countries. However, the policy and economic context in which the agriculture and food sectors operate is changing rapidly. Approaches to agriculture and trade policy have changed in nature, including because of multilateral negotiations, which have resulted in a decrease in tariffs and in distortive domestic support over time (Greenville, 2017).[4] On the consumer and private sector side, changes are driven by population growth, urbanization, changing diets and consumer preferences, as well as structural transformation in retail markets (OECD-WTO, 2013, Greenville, 2017).

23. While these factors have supported the integration of a global food system and influenced the way in which food is produced, processed, and sold, trade in agriculture and food still faces high trade costs.

### *2.2. Identifying trade costs and the impact of digital technologies*

24. Trade costs broadly encompass all costs incurred in getting a good to a final user other than the marginal cost of producing the good itself (Anderson and van Wincoop, 2004). These include a range of costs, including the costs that traders have to bear to engage in trade and enable a trade transaction to happen, and the costs of moving the physical good from the production location to the consumption location. Such costs include trade policy measures in the form of tariffs, as well as transportation costs.

[4] While this is the case in most, but not all, OECD countries, the opposite trend can nevertheless be observed in many emerging economies.

25. While these are still very important barriers to trade, this report focuses on other types of costs which relate to access to information, and explores how digital technologies, and how the new capacity to create and transfer trusted data can reduce some of these types of costs and barriers to trade in agriculture and food. Of particular interest are transaction costs[5]. In this context, these represent the costs incurred in finding a trade partner and to reduce the risk of failure. These include costs of research and screening of business partners, and negotiation and implementation of contracts, including monitoring and execution. Transaction costs can be significant and even prohibitive in the presence of asymmetry of information or even of imperfect information as the cost of finding a trade partner or of obtaining the necessary information or guarantees to reduce the risks associated with the transaction can potentially erode most, if not all, of the gains from trade.

26. In addition, stakeholders in the supply chain may have different preferences and incentives. This can be referred to an as non-alignment of incentives. In case of opportunistic economic actors, non-alignment of incentives can cause stakeholders to work against each other to retain a larger share (a rent) of the value addition created across the chain, rather than working together to achieve a common objective[6]. Such behaviour has a cost for the partner dealing with this opportunistic stakeholder, which, if too high, can prevent an otherwise lucrative transaction from happening. One objective of regulations is to reduce imperfect information and information asymmetry, and create trust between partners in a transaction, even where there are incentives to cheat. These are often enshrined in consumer protection laws and laws governing business-to-business transactions. However, trade by its nature crosses jurisdictional boundaries and thus organising a transaction and going through all administrative steps required to secure a cross-border transaction is still burdensome, time consuming, and creates costs both for the public and private sectors. A smooth, rapid and trustworthy movement of goods across the value chain (seller, local aggregator, distribution intermediaries of wholesale and retail), and co-ordination among supporting services (freight forwarders, banks, insurance) as well as

[5] Economic theory has long relied on the principles of perfect information and zero transaction costs. Those assumptions have been challenged in particular by the New Institutional Economics which has drawn on a body of literature which views the formation of institutions as a response to missing markets in an environment of pervasive risks, incomplete markets, and information asymmetry (e.g., Bardhan, 1989). Imperfect information, information asymmetries and the presence of transaction costs constitute three key factors explaining why outcomes observed in the "real world" can systematically differ from predicted outcomes based on standard neoclassical economic theory, which assumes full information and (often) zero transaction costs. The first two are the subject of the strand of microeconomic theory known as information economics (pioneered by economists such as Hayek, Akerloff and Stiglitz), while transaction cost economics constitutes a separate-but-related branch stemming from seminal contributions by Coase (1937). Williamson (1998) and North (1990).

[6] Opportunistic behaviour refers to self-interest seeking by economic actors and to their calculated efforts to mislead, distort and disguise information (Williamson, 1985: 47) This is particularly the case for seller exploring new market opportunities and where repeat sales are unlikely – the 'games' are not repeated and therefore there are no reputational consequences to default or failure to respect a contract. In such instances, stakeholders in the value chain may have incentives to 'cheat' and exploit their information asymmetry to the detriment of the other stakeholders. For example, a buyer sets a contract with farmers, agreeing to the purchase of a certain quantity at a fixed price. At purchase, if the market price is lower than the negotiated price, the buyer may walk away from the transaction and decide not to honour the contract. In less extreme situations, these can create conflict over the distribution of value addition across the chain, and reduce its efficiency.

border agencies, is particularly important for trade in perishable products as well as in a just-in-time trade system.

27. These costs are all relevant to the agriculture and food sectors. For example, more than half of the lead firms in the agro-food supply chain have identified customs delays and high transport and logistics costs as the main trade problem when dealing with developing country suppliers.[7] Trade costs are also particularly relevant in the context of GVCs as they not only affect the capacity of primary producers to export (increasingly developing countries), but also affect the competitiveness of importers which rely on these intermediates for the production of their own exports.

28. The discussion in this report focuses on the potential of digital technologies to reduce these trade costs – from costs related to identifying and negotiating a deal, through to proving compliance with standards and being able to deliver products across borders quickly and efficiently.

### *2.3. The "datafication" of agriculture and creation of information*

29. While opportunities offered by digital technologies are often presented as the source of a new agriculture revolution (or agriculture 4.0), agriculture often ends up at the bottom of rankings of use of digital technologies by sector (See ABB, 2017 and McKinsey, 2015). While the opportunities to use digital tools in agriculture are increasing, adoption varies widely according to the type of technology and the level of investment needed. In general, adoption of digital technology in the agro-food sector seems to be lagging behind other sectors[8]. However, it should be noted that the indicators used to measure adoption focus on the mix of digital assets and usage within a sector. Even if processes in agriculture and food are increasingly digitized, the core assets and inputs in agriculture are still natural resources.

30. That said, the real revolution in the sector is in the increasing capacity to produce and use data that was not previously technically or financially feasible. This *datafication*[9] of agriculture refers to the capacity to create quantified digital data in relation to agricultural assets and production processes, allowing them to be monitored, tracked, analysed and optimised.

31. The digital transformation of agriculture not only has implications for agricultural productivity, sustainability, and for policy design and monitoring (see OECD, 2017a), but

[7] Results from a private sector survey conducted by the OECD and WTO, in collaboration with Grow Africa, identified binding trade-related constraints in connecting suppliers from developing countries to agriculture and food value chains (OECD-WTO, 2013). The results of the survey, which included 257 responses from private sector firms operating in agro-food value chains and located in 78 countries or territories. This includes trade finance in particular; the ability to meet product requirements and standards to deliver quality and safe products to the consumer, including certification costs; excessive delays, including from customs procedures and transport conditions; and trade barriers.

[8] The issue of factors influencing adoption of technologies on farm is not explored in this paper but could be one potential area for analysis in the future.

[9] Datafication refers to data generation through the digitisation of content, and monitoring of activities, including real world activities and phenomena, through sensors. Digitisation is the conversion of analogue source material into a numerical format (e.g. sound, image, printed text) (OECD, 2017d).

also for the entire supply chain. Historical on-farm knowledge about irrigation schedules, fertiliser injections, pesticide application, pest infestations, and harvests are more easily accessible, analysed, and weighed against the experience of others, all of which support better production management. This information is not only a way to increase knowledge on-farm. It can now be used further down the chain. A continuous flow of data along the agriculture and food value chain can now provide evidence about agriculture practices or the health and life story of each cow in a herd. The same data can follow products along the chain and other data can be added, for example related to the monitoring of transport conditions (register temperature and humidity levels in a container) – all of which can predict the condition of the cargo on arrival.

32. The agriculture sector is now becoming both an important consumer and supplier of data. In a series of feedback loops (see the data infrastructure in annex 2), the agriculture sector is an important provider of data upstream in the food system, potentially across borders. On-farm data can be useful for input providers and research & development, and the finance, as well as the more direct feedback loop of use of on-farm data to customise services to farmers. The sector is also a consumer of data to inform production decisions at the farm level, such as market, weather or pests alert forecasts, as well as other professional services using big data and farm data. Moreover, farm data can now also be used downstream to feed into the rest of the value chain: food processors, wholesalers, retailers, finance etc. Farm data can be particularly important across borders to create trust and facilitate GVC integration. The sector also provides important data to non-food downstream sectors for which agriculture provides primary product inputs, such as textiles and leather. For example, for the textile sector, there is increasing demand for data to meet life cycle assessment (LCA) and carbon measurement requirements, as well as due diligence more generally. The following sections in this report highlight more specifically how flows of data from and to the agriculture sector can support trade.

33. Access and use of data along the value chain can increase the transparency, efficiency and resilience of the food value chain – for instance, through traceability, assisting in certification of standards and by facilitating trade logistics chains and border processing. There is growing demand for traceability and transparency throughout the chain by public authorities for the purposes of monitoring food safety and illicit trade. These issues are explored in Section 3. Demand is also coming from the private sector, particularly food processors looking to improve their planning and logistics, support tracing and tracking, and to prove compliance with sustainability requirements at the retail level in line with consumer preferences. Delivering transparency and traceability requires the management of increasingly large amounts of data passed through and used by a large number of economic actors.

34. The creation of new data and knowledge using digital technologies is thus enabling agricultural production processes to be better understood, and managed, reducing uncertainty and increasing co-ordination capacities. The digital transformation of the agriculture and food system provides tools for reducing information asymmetries and creating knowledge about markets, products and opportunities, and helps to build trust among all actors in the chain (both public and private). It can thereby support better differentiation of products in a way that can open up new markets. This is particularly relevant in the context of GVCs in food and agriculture and in supporting the growing importance of services in increased creation of value added in the food and agriculture sectors (DeBoe and Jouanjean, 2018d *forthcoming*). It is also, as discussed in the rest of this paper, an opportunity to increase and facilitate the tradability of the agro-food sector.

## 3. Some features of the digital transformation of the global food system

35. The following section presents how the impact of digitalisation and the reduction of transaction costs is changing the traditional organisation of the food system. In particular, it allows entry of new actors in agro-food trade at all levels of the value chain. Among those actors are smallholders. A section specifically looks at how digital technologies might reduce some of their constraints to trade. Finally, the last part of this section presents how the increased access to information, and the new capacities to create value with access and transfers of information, is changing incentives and the ways actors of the value chain organise.

### *3.1. New ways of engaging, and new actors participating in international agro-food value chain trade*

#### *3.1.1. Know your trading partner*

36. At the core of the opportunities that digital technologies can offer for trade are transaction costs (which can be summarised as the sum of all costs that parties to a transaction incur in reducing transaction risks[10]). The incentive to engage in trade depends on this trade-off between transaction costs, and the risks of losses due to a failure of the transaction, compared to the gains from trading. The overall decline in trade costs – resulting from lower transport costs and policy barriers – has supported international trade integration and the development of GVCs (Baldwin, 2016). However, as the cost of physical movement of goods has declined, the share of trade costs represented by transaction costs has increased in relative terms: sellers and buyers have to deal with increasingly distant trading partners, about whom they have little information (Box 1). This has resulted in an increase in the relative share of transaction costs in total economic activity. Enabling more complex and remote transactions requires minimizing these transaction costs.

[10] This includes the cost of implementation of a contract between two parties, the creation of an escrow account, but also the cost of implementation of regulations and proving that a product crossing borders complies with the regulation. In other words, this includes all types of administrative costs needed to secure a transaction. Some are voluntary (the time spend searching for a trading partner) and some are mandatory, such as compliance with a regulation.

**Box 1. How digital technologies can help to identify trusted partners**

In global supply chains, trust is an issue and firms have developed management rules to reduce risks within their value chain. Supplier-related risks are increasing the focus on enhancing supply chain sustainability, Responsible Business Conduct (RBC) and supply chain ethics.

Digital technologies provide new opportunities to create greater transparency and security in value chains.

Digital marketplace platforms use grading systems to let buyers and sellers know about their respective records on transactions. Some platforms have their own litigation body because of the difficulty of addressing cases related to very small traded quantities through the usual institutions. Moreover, it can be difficult to access information beyond first tier partners in the supply chain.

New services are aimed at providing information about potential trade partners to mitigate the risks of dealing with certain suppliers, including risks of transaction failure, but also increasingly reputational risks. These services collect and interpret environmental, social and governance data about global supply chains using big data analytics. For instance, software services provided to multinational companies (including large stakeholders in the food and beverage sector well as pharmaceutical companies and chemicals makers) create scorecards with a range of parameters on value chain business partners, ranging from water consumption to energy efficiency or handling of toxic chemicals, all of which potentially affecting the supply capacity of the trade partner in the longer run as well as the quality of the products supplied and eventually the reputation of the buying companies.

Some of those companies are now investing in AI to automate the analysis of all the documentation, often in a number of languages, used for their scorecards. Machine learning is also seen as being able to more efficiently make sense of the "unstructured information" on emerging themes.

*Source:* Clancy (2017).

37. The ease or difficulty of entering into a contract between two stakeholders, and, to some extent, the type of contract they will enter, are determined by the availability and cost of information Technological change and changing information costs are major sources of changes in relative prices as well as in the way transactions are organised. As information costs fall, traders will have greater incentive to move towards efficient contracting structures rather than to vertical (or horizontally) integrate (North 2010). In the food industry, for instance, access to better information and ease of selecting partners and negotiating contracts can facilitate a shift from vertical integration of agriculture production to reliance on contract farming or on the spot market. Digital technologies enabling new access to information have therefore the potential to encourage changes in the structure of the value chain. The following sections unpack further how digitalisation can underpin or enable new trends in the global food system

### *3.1.2. Digital trade platforms allow entry of new actors in agro-food trade*

38. A range of digital technologies, including digital market places and information platforms as well as blockchain technology can decrease the need for intermediaries to secure the transaction (traders, banks and insurances).

39. International trade is increasingly facilitated by digital platforms (Box 2). The use of Business to Business (B2B), Business to Consumer (B2C) and even Consumer to Consumer (C2C) platforms is not only relevant for manufactured goods. An increasing amount of trade in agriculture and food is also taking place on such platforms. One well-known example is seafood trade from Canada to the People's Republic of China, (hereafter China), and the growing purchase of live lobsters made through a Chinese digital retailer.[11] The horticultural industry is also reported to have expanded globally through the emergence of e-commerce (Humair et al., 2015) as along with a range of niche markets of local agriculture and food specialties now traded globally.[12]

**Box 2. Digital reduction of information barriers to boost internationalisation of firms – ConnectAmericas.com**

Best practice on boxes: see page 20 of the OECD Style Guide. Do not forget to delete or replace this text Information costs are a significant obstacle to trade. Firms pursuing business opportunities abroad must engage in a costly process of identifying and assessing potential commercial partners. Online business-to-business platforms can reduce these information barriers by facilitating access to relevant knowledge and searches, contacts, and matchmaking, thereby assisting the internationalisation of firms. The Inter-American Development Bank (IDB) has developed a platform in partnership with Google, DHL, SeaLand (Maersk), MasterCard, and Facebook. The platform, called ConnectAmericas.com, was launched in 2014 and currently has almost 43 000 registered firms from more than 100 countries. It has two main functions:

- The learn function, which provides firms with general trade information through a number of capacity building services. These services include free online courses and free webinars on trade-related matters; access to trade datasets, business self-evaluation tools, video testimonials, and articles; and information about support available to firms in the countries where they are operating.
- The connect function, which provides firms with specific commercial information through a variety of means. It primarily allows firms to participate in business communities, which are forums where they can write posts about goods or services they want to buy or sell; be notified about and apply for business opportunities, in the form of purchasing announcements by large firms and governments; and, crucially, search for a company's profile and interact with members of its staff.

Carballo, Rodriguez Chatruc and Volpe Martincus (2018) have used detailed records on Peruvian firms' activities in ConnectAmericas.com along with transaction level export data from the Peruvian customs to assess whether the platform delivers on the promise to reduce information frictions by lowering firms' search costs and to boost international trade. Their preliminary estimates (based on more than 221 000 registered users) suggest that the use of ConnectAmericas has actually resulted in increased exports. This export increase (i) is primarily explained by access to relevant, specific commercial information as opposed to general trade information; (ii) can be traced back to expansions along both the product and buyer extensive margins, which are exporting activities facing more severe information problems than their respective intensive margin counterparts; and

[11] Reported to have reached 90 000 lobsters in one day in 2014 following a special offer. This example is referenced in series of newspapers articles including for instance: http://www.cbc.ca/news/business/alibaba-shakes-up-online-shopping-market-for-canadian-producers-1.2835737 and https://beta.theglobeandmail.com/report-on-business/international-business/asian-pacific-business/canada-claws-into-chinas-rich-lobster market/article25838615/?ref=http://www.theglobeandmail.com.

[12] Interview with one of the largest digital trade platform in Asia.

(iii) is more pronounced for firms with less market-specific export experience (less information capital), in less familiar countries (higher informational barriers), and in destinations with larger numbers of firms registered with the platform (more potential connections).

Among Peruvian exporting firms using ConnectAmericas.com around 10% operate in the agricultural sector and about 25% are active in the food manufacturing sector. Noteworthy, initial estimates allowing for heterogeneous effects across sectors reveal that these firms tend to experience substantial export gains from the platform usage. In particular, the increase in their exports associated with using ConnectAmericas.com is larger than that of their counterparts in several other sectors.

*Source:* Author's communication with the IDB, based on Carballo, Rodriguez Chatruc and Volpe Martincus (2018).

40. New actors are entering the international market: even small firms can now be "born global" and consumers can directly participate in trade, without relying on a wholesaler or retailer to import the product. One consequence is that, while digital trade is not necessarily changing the nature of what is traded, it is changing the nature of shipments: whereas the composition of trade flows was previously almost exclusively large or bulk shipments, now features higher numbers of low-value small shipments.[13] The ability to trade smaller quantities is an opportunity for smaller producers, in particular in developing countries where the ability to meet quantity requirements, (i.e. supply capacity) was a constraint to integration in GVCs (OECD-WTO, 2013).

41. However, in many areas of the world, such opportunities are not yet a reality due to continuing traditional constraints to trade. Physical costs of trade can still be insurmountable, more so for small quantities (OECD-WTO, 2017), and new actors, either buyers or sellers, can still face difficulties accessing information and complying with trade rules. To enter export markets, firms typically have to invest resources upfront, costs that are particularly difficult to cover for small firms, including small agro-food businesses. As most trade-related transaction costs are fixed per transaction,[14] they can be a greater constraint for small producers and their reduction decreases the need for scale and increases the incentives for small businesses to trade.

42. With digital trade, new business models have emerged to solve such issues, such as the growing role of aggregators of small orders (such as large digital marketplace platforms entering the trade logistics business) or more flexible shippers, able to organise and aggregate numerous individual small orders into larger consignments, to take advantage of economies of scale. Digital marketplaces are setting up logistics hubs providing a range of services including warehousing, allowing sellers to locate their stocks (even small stocks)

[13] Low-value shipments do not refer to shipments with low value-to-weight ratio. They are, rather, shipments of small quantities, even small parcels, which often tend to have a higher value-to weight-ratio than bulk shipments.

The OECD is currently exploring the issue of small parcels in the following: *Trade in the time of Parcels : A first proposal for analysis* TAD/TC/WP(2017)25.

[14] Some of the underlying costs can however be reduced with the repetition of transactions between trade partners.

closer to consumers, usually in free trade zones.[15] Such systems avoid having to ship products via postal services each time an order is passed on-line, reducing the cost of shipment as well as the delivery time.

43. Thanks to digital technologies, stakeholders in the agro-food chain, even small ones, increasingly have access to a range of digital tools, which reduce information asymmetry, lower co-ordination and transaction costs, and significantly improve access to and knowledge about trade opportunities. These tools can provide information about markets (e.g. prices, standards) and access to various support services (e.g. payment) more easily and for a much lower cost, reducing the cost of entering (agreeing on a transaction with a buyer) and engaging in trade (the actual physical transaction). Such tools also allow small firms to reduce information asymmetry when dealing with traditional trade intermediaries such as aggregators, wholesalers and retailers.

## *3.2. Digital technologies enable smallholders to reduce some constraints to participating in trade, in particular in developing economies.*

44. The same way as for other small businesses, in particular in developing economies, digital technologies can also improve smallholders', access to information about new market opportunities (including foreign markets and what is needed to access them) and enable new access to services (in particular leveraging differences in services development and efficiency across border). In doing so, it provides a better information base on which producers can make informed decisions regarding the markets in which to participate. This reduces the risks faced by both smallholders and their buyers when engaging in a transaction. Digital technologies can therefore offer some opportunities to help to reduce constraints preventing smallholder farmers from benefitting from opportunities offered by GVCs such as better access to inputs and knowledge upstream, and access to higher value markets downstream. In this way, digital technologies can facilitate smallholders' integration into domestic and even global value chains, both upstream and downstream. There are already many examples of such digitized old or new services.

### *3.2.1. Upstream, new access to agricultural extension and advisory services*

45. The use of digital technologies supports the provision of new forms of micro-insurance as well as extension services. These can facilitate better management of both the production and marketing of products and can allow traditionally highly risk averse smallholders to adopt more risky production strategies. This also allows them to make better use of their assets, which previously may not have been maximised. This is particularly the case in developing countries where smallholders have a tendency to adopt conservative strategies to ensure their food security. This, together with new availability of training and better information about demand, and quality requirements and the associated prices, can be an opportunity for smallholders to increase productivity as well as the quality of their production, and thus overall revenues.

46. These services can broadly speaking be referred to as agricultural extension and advisory services (AEAS), defined as services provided by the public or private sectors that

[15] Examples are Alibaba-led digital trade zone in Malaysia: "*The hub, "will function as a centralized customs clearance, warehousing and fulfilment facility for Malaysia and the region, to deliver faster clearance for imports and exports," Alibaba said in a statement*." https://www.reuters.com/article/us-malaysia-alibaba/alibaba-to-set-up-regional-logistics-hub-in-malaysia-idUSKBN16T0KW.

facilitate the access of farmers, their organisations and other market actors to knowledge, information and technologies; facilitate their interaction with partners in research, education, agri-business, and other relevant institutions; and assist them to develop their own technical, organisational and management skills and practices (Christoplos, 2010). Such services used to be mostly non-tradable, requiring the physical presence of experts or were simply not available. The ability to deliver such services digitally can provide access to new forms of AEAS previously not accessible to producers too remote or too costly to service. AEAS can now not only be delivered remotely, but also potentially across borders by lead companies as part of upstream integration in GVCs.

47. Remote sensing, IoT solutions using wireless sensor network systems, and applications based on machine learning and machine vision can support the provision of new services and enhance existing services in rural areas (in particular poor and remote areas, see Box 3). Such technologies have been identified as a way to support sustainable production of commodities such as palm oil and cocoa, which are both predominantly produced by smallholders and are often characterised by non-sustainable practices (World Bank, 2017). For instance, in Indonesia, 80% to 90% of cocoa production comes from small, family-run remote farms. While international demand is on the rise (World Cocoa Foundation, 2014), cocoa production in the country is affected by climate change, the aging of trees prone to pests and diseases, and by the lack of on-farm scientific knowledge, mostly resulting from the difficulty of accessing the fields by agronomists.[16] IoT technologies have allowed the creation of a research station that monitors environmental parameters, automatically manages data collection and storage, and transmits information to the Cloud. Data captured by sensors is then processed to provide information about production processes with the aim of enhancing the sustainability and commercial viability of the cocoa global value chain.

[16] See ICC (2016); Libelium (2015) http://www.libelium.com/sustainable-farming-and-the-iot-cocoa-research-station-in-indonesia/ and various news article such as https://internetofbusiness.com/indonesian-cocoa-farmers-are-hoping-iot-can-help-their-crops-survive-climate-change/.

**Box 3. Digital technologies for new support services in agriculture**

History has proven that diseases and pests can generate massive yield losses, potentially leading to famine. The world has now a lot more knowledge about growing more food and in many countries the spectre of famine has disappeared. However, pests and diseases are still a problem all around the world, but particularly in developing countries. Smallholders are particularly vulnerable to shocks to production as their relative impact on yields are much larger at this scale. (Collier and Dercon 2009, Foley et al. 2011). It is commonplace for smallholder farmers to routinely lose 80-100% of a given crop to pests and diseases (Oerke 2006). In particular, most subsistence agriculture today occurs around the tropics, which have a high diversity of infectious diseases (of humans, animals and plants), making the risks even higher. In addition, while human-assisted disease diagnosis is a powerful tool, visual diagnosis, so far requires humans. Disease phenotyping, when done by humans, usually involves a visual analysis of the presentation of the disease on the plant. Despite the challenge of crop health on an increasingly crowded planet, needing increased efficiency (including less losses) in food production, investment in training plant pathologists has not grown correspondingly, and often even decreased (Flood, 2010). Machine-assisted disease diagnosis is a solution to this constraint.

PlantVillage is public good unit, providing open access to science-based advice on crop health. PlantVillage is an online platform dedicated to crop health and crop diseases (available at www.plantvillage.org) created in 2013. This platform was modelled after popular online platforms in the computer-programming domain, in particular community driven forums where anyone can ask and answer questions related to programming. An open access repository of images on plant health has been created to enable the development of mobile disease diagnostics. In the fall of 2015, the platform welcomed its 2 millionth visitor from around the world in 2015. The number of visitors has since then exponentially increased to more than 7 million people (mid-2018).

More recently, activities have been developed, including in Africa with a range of tools to provide solutions to farmers and extension workers by leveraging advances in AI, mobile phones, drones, satellites and nanotechnology. The objective is to provide cheap, affordable technology and democratize access to knowledge on crops, crop diseases and agronomy practices. The platform is targeted directly to food growers, and great care has been taken to write the content in a way that is easy to understand.

The images span 14 crop species: apple, blueberry, cherry, corn, grape, orange, peach, bell pepper, potato, raspberry, soybean, squash, strawberry, and tomato. It was developed with the support of UN FAO, CGIAR in Africa, with the creation of an AI assistant, smartphone-based program accessible off-line, called Nuru (Swahili for light). As an assistant Nuru has learned to diagnose multiple diseases in Cassava, fall armyworm infections in African Maize, potato disease and wheat disease. She is also diagnosing spotted lanternfly pests in Pennsylvania. For cassava plants – the most widely grown root crop on Earth – with, according to Hughes and Salathé (2015), near 100% accuracy. Thereby, farmers in developing countries can now trade the expertise of a handful of specialists for increasingly omnipresent and powerful technology.

*Source:* Hughes and Salathé (2015), Mohanty, Hughes, and Salathé (2016), and https://plantvillage.psu.edu/.

### *3.2.2. Downstream, potential to reduce co-ordination costs, and create value addition opportunities*

48. Digital technologies can be particularly important in reducing a range of co-ordination constraints between buyers and sellers, which are an important source of high transaction costs for smallholders. Problems of co-ordination are particularly prevalent in

the agriculture and food sectors as they tend to be characterised by a large number of small players who remain disconnected from modern value chains, both in developed and developing economies (OECD, 2015b; OECD/WTO, 2017). These problems are particularly important in "traditional" agriculture value chains, governed by spot market transactions involving a large number of small retailers and producers. In remote and poorly economically developed areas, the primary interface of the farmer is with a buyer (trader), often with monopsony power[17] in which information asymmetry prevails. As a result, smallholders often suffer from the appropriation of benefits by intermediaries and poor "pass-through" of benefits from investing in quality.

49. Modern agro-food value chains require the supply of consistent quantity, quality and safety of products. This requires increasing organisation and co-ordination of a multitude of different production structures, as well as a degree of institutionalisation to enable standardisation. For instance, a large dairy co-operative may have to co-ordinate with 10 000 farmers, a task that becomes nearly impossible if those producers are scattered across areas with poor physical connectivity. In the past, co-ordination was usually achieved through vertical co-ordination or integration of the supply base, often with farmers forming co-operatives to process their own production.

50. To some extent, access to AEAS feeds downstream in the agro-food chain, with better alignment between smallholders' production and potential buyers' demand, also providing the possibility of increased bargaining power (see, for example, World Bank, 2011).

51. However, providing better training to smallholders is not always enough. One example is smallholders' production of high-value fruit and vegetable exports to supply the year-round demand in high-income economies. Smallholder production can have a comparative advantage for this type of labour intensive production. Many producers in developing economies invested in production, with the support of public and private initiatives aimed at organising and certifying them to tackle the scale and quality constraints to supplying new markets. Some producer groups successfully integrated into GVCs and secured contract farming arrangements. But in other cases, lack of co-ordination along the chain led to mismatches between supply and demand with excess production, falling prices and spoilage of unsold products (sometime even used as animal feed, see FAO, 2005; *The Economist*, Special Report, Nov 9, 2017). Moreover, other constraints related to farmer liquidity combined with limited access to cash by traders as well as lack of storage infrastructure typically led to high local price volatility and a sharp drop in prices in the immediate post-harvest period.

52. Most of these constraints are the consequence of a lack of co-ordination of stakeholders in the chain, asymmetry of information, lack of access to finance and lack of infrastructure. To address many of these issues, a range of digital technologies are currently being tested[18].

53. Increased connectivity and data management capacity facilitates co-ordination of a large number of stakeholders and reduces supply side constraints in relation to scale (Giagnocavo et al., 2017) (Box 4). Information and other types of marketplace platforms

[17] This can result from low levels of supply and poor infrastructure development, which makes supplying from the area only worth it for a few if not only one trader.

[18] Solutions are less focused on physical infrastructure and transport limitations at this stage. However, is does not seem unlikely that, in the future, drones could be a solution in remote areas.

also provide the opportunity to decrease co-ordination constraints related to scale. Platforms can provide more direct access to information about product markets, reduce the need for intermediaries, and better align production with demand, reducing risk as well as waste. Smallholders are responsible for the majority of the world's production of certain commodities, such as cotton, coffee and coco and new initiatives are mapping these smallholder supply chains and building smallholder databases. Platforms and social media can also help smallholders co-operate among themselves and increase their bargaining power. Various platforms have been developed to give buyers and sellers access to a range of information. Some platforms provide market information services with price information and a virtual marketplace for buyers and sellers of agricultural commodities. In developing countries, digital platforms that bring together small producers and traders, and facilitate payment and transparency of transactions, are a promising way of enabling remote and small producers to connect to markets and increase livelihood opportunities (OECD/WTO, 2017). For example, in East Africa, the development of "virtual marketplaces", bringing together livestock farmers and traders is seen as a promising way of enabling isolated pastoralists to connect to markets and increase their livelihood opportunities, reaping the benefits of unexploited trade opportunities in the region.

**Box 4. Platforms for the co-ordination of smallholders**

**Connecting smallholders to commodity trading: example of e-choupal in India**

e-Choupal is an initiative of ITC Limited (Imperial Tobacco Company of India Limited), one of India's largest agricultural exporters, to link directly with rural farmers via the Internet for procurement of agricultural and aquaculture products such as soybeans, wheat, coffee, and prawns.

The e-Choupal model was developed to tackle the challenges posed by fragmented farms, weak infrastructure and numerous intermediaries. The programme sets up Internet access kiosks in rural India to provide farmers with access to marketing and agricultural information and help them make more informed decisions and potentially increase their income by better aligning farm output to market demand.

The programme brings connectivity infrastructure and a portal to farmers. Computers, located at a "focal point farmer", with an Internet connection, serve 10 villages and reach 600 farmers on average. Then a portal echoupal.com provides access to dedicated services: information on farming best practices, market prices, weather forecasts, news and an interactive Q&A section with ITC's agricultural experts. ITC is also partnering with banks to offer farmers access to credit, insurance and other services. In addition, ITC has built a network of warehouses near the production centres, is providing inputs to farmers and is testing output at the individual farm level.

Access to information by farmers has helped improve both farming practices and the quality of products.

**Solutions to create supply chain efficiencies, linking farmers to commercial markets while facilitating productivity improvements: example from the Connected Farmer Alliance (CFA)**

The Connected Farmer Alliance (CFA),is a public-private partnership between U.S. Agency for International Development (USAID), Vodafone and TechnoServe. Its objective is to support commercial viability of mobile solutions for smallholder farmers to help farmers work with agribusinesses and better manage their own crops and finances. CFA uses Vodafone's M-Pesa mobile money solution to enable agribusinesses to transact with farmers for payments and loans. It allows the agribusiness to better manage their farmer data, drive business analytics, and develop deeper relationships with farmers through the sharing of information.

*Source:* http://www.itcportal.com/businesses/agri-business/e-choupal.aspx; Bhatnagar et al. (2003); http://www.technoserve.org and Technoserve (2016).

54. Moreover, increased transparency creates new opportunities for value creation in the chain for smallholders. Production processes can be registered and evaluated and information transmitted to consumers, who may be willing to pay a price premium for their preferences, be they in relation to quality, production practices or other social considerations, such as fair remuneration for farmers (see example in Box 5).

55. While these initiatives are useful, digital technologies offer no simple panacea – and indeed, can give rise to new issues. For instance, without interoperable approaches, the multiplication of initiatives could actually result in less effective co-ordination and traceability and potential lock-in of producers. The issue of interoperability could be explored further in future work planned on the regulatory issues in digitalisation for agriculture.

**Box 5. Machine vision, AI and blockchain for the coffee value chain**

Bext360 proposes a mix of machine vision, AI and blockchain to source high-quality agricultural products, in this case coffee, directly from the producer. Blockchain allows instantaneous digital/mobile electronic payments to all stakeholders (farmers, communities, banks, and other stakeholders) at the point of origin of the coffee. Machine vision and AI provides information about the quality of the coffee beans, and attaches a market price to the analysed batch.

The *bextmachine* is deployed at collection points where farmers deposit their coffee cherries for analysis at washing stations. The machine allows immediate evaluation of the coffee cherries, which is then used to provide technical advice to farmers about how to improve the quality of their beans. Coffee batches are then tracked to the end consumer, using crypto-tokens, allowing the consumer to interact directly with the communities that provide the goods.

A related application (API) allows wholesalers and retailers to embed this technology in their own websites, marketing, point-of-sale systems, and supply chain management tools. This system was originally developed to facilitate export of conflict-free minerals from the DRC to the US, with machine vision used to evaluate the quality of diamonds. The system was supported by miners who had greater trust in the machine than in local human agents.

Pilots for this system for coffee exports are underway for exports from Ethiopia and Uganda to the Netherland and United-States.

*Source*: https://www.bext360.com/.

56. A body of empirical research is aimed at assessing the increased availability of mobile phones and the multiplication of projects developing services to provide either market price information or AEAS and in particular knowledge about improved agricultural practices and technologies (see Nakasone, Torero and Minten, 2014, for a literature review). Despite the heterogeneity of contexts and analysis, results seem to go in the direction of the conclusion that access to mobile phones is related to better market integration and to less price volatility, but mostly for perishable, high value crops. Impacts were mostly through better arbitrage opportunities. However, there did not seem to be any impact on incomes. Extension projects are more difficult to assess and to compare as projects present different features. Nevertheless, results seem to show that awareness about new practices is not automatically translated into adoption of improved agronomic practices. There can be various explanations behind low adoption, such as the consistency of the new practice with the existing farm system and continued constraints such as limited access to inputs, credit, irrigation etc. While digital technologies show impact when constraints are mainly access to information, they have more limited impact when change requires addressing more complex systems.

## *3.3. Filling the information gap: digital technologies for standards in the food system*

### *3.3.1. Standards as an enabler of trade in agriculture and food*

57. The development of standards has created the degree of information and trust in the value chain which enabled the first wave of increased agriculture trade, characterised by commodity trading. Internationally recognised standards were important to make sure that the product bought on the other side of the world was the product expected. They also enabled a reduction in costs for the transport industry which could transports products in bulk, and for the food industry, which could use intermediate products from anywhere in

the world at a level of homogeneity needed for agro-industrial processes. In addition, countries have different historical constraints and preferences, in particular for food safety but also present different pest profiles according to climate, history and types of production. While adulteration of products can often be rather easily identified through visual checks, other attributes in relation to food safety and plant protection are more difficult, if not impossible, to identify at a reasonable cost, either for customs authorities or for other private traders. Given food safety and production conditions, including agriculture practices (for instance the use of particular pesticides) and the pest status of the production location, governments have historically set a range of sanitary and phytosanitary (SPS) measures governing the import of agriculture and food.

58. The regulatory objective of SPS measures is to address one of the biggest challenges facing trade in agriculture and food, in particular in fresh products, which is to manage trading billions worth of agriculture and food trade, without accidentally spreading human and plant diseases and pests. In other words, the objective is to allow consumers to benefit from trade and to protect them, but also animals, plants and native biodiversity from foreign diseases and pests. Therefore, SPS measures are not designed to restrict trade. Rather, they aim to meet legitimate health and biophysical protection objectives. Various food scares and scandals, and increased consumer awareness have increased demand for protection from food-borne diseases. This has resulted in the strengthening of regulations in many countries, including traceability requirements. To cross borders, agriculture and food products need to be accompanied by certifications proving they comply with importing market requirements.

59. With increasing consumer awareness of food safety issues, the private sector has an opportunity to compete on the basis of communication about quality and safety attributes. The private sector has developed codes of practice and certifications resulting in new market channels (product sold directly to supermarkets and not in bulk) for agriculture products and exports. This has also provided new opportunities for market valuation for producers. It has also led to some reorganisation of the chain, with food retailers and food industry companies reducing their reliance on brokers or terminal markets and increasingly sourcing directly from producers. This evolution has provided exporters with a way to differentiate their products in otherwise crowded commodity markets (Jaffee, Henson and Rios, 2011; Jouanjean, 2012).

60. Standards and certification of compliance have therefore become increasingly important in the world food trading system. However, their implementation creates costs and can limit the gains from trade liberalisation – and is often identified as a major factor influencing the ability of developing countries – and in particular their smallholders – to exploit export opportunities for agricultural and food products (Hanson and Loader 2001). This is why much attention has been given by economists and policy makers to the identification, measurement and economic implications of non-tariff measures (NTMs) and private standards, including to estimate the effective trade restrictive impact of standards and SPS measures (e.g. Disdier, Fontagné and Mimouni 2007, OECD, 2018b). These have been criticised for lacking transparency or for providing unjustified grounds for imports bans or to purposely (or not) imply prohibitive compliance costs for suppliers leading them to specialize away from sectors with heavier regulatory burdens (See, e.g. Essaji, 2008).

61. While the impact of SPS measures and private standards or codes of practices is still debated, it is now generally accepted that more nuance is needed, in particular when analysing the effect of harmonization of standards, or when introducing consumer preferences into the balance of gains and losses (e.g. Moenius, 2006; Munasib and Devesh,

2011). While some argue that food safety standards undeniably hamper the ability to export (Otsuki, Wilson and Sewadeh, 2001), others emphasize that medium- to long-term effects should be taken into consideration and provide evidence that they can also stimulate and enable competitiveness and grow overall exports through enhancing trust (Jaffee, 2005; Maertens and Swinnen, 2009). Standards create information that some consumers are willing to pay for. It has therefore been argued that standards could also serve as a "catalyst for realising pro-poor export-led growth in developing countries" (Maertens and Swinnen, 2007) and present an opportunity for exporters to "decommodify", in other words to better differentiate their products and to receive a premium in exchange. More recently, analysis of integration in GVCs using data on trade in value added have captured this conflicting impact at a more aggregate level (OECD, 2018a), identifying both positive and negative effects of NTMs.[19]

62. The creation of information through standards has been a trade enabler and value added creator in agriculture and food throughout history. There are multiple possibilities resulting from use of technology to reduce the information gap about product characteristics and compliance with public and private standards. First, with increased capacity to create information about the origin of a product and how it was produced, consumers can access enough information to make their own choices. While there is a risk that such initiatives, and their multiplication, lead to some form of saturation of information, they could also spur the creation of new markets for niche products or customisation of agriculture and food to respond to new consumer demand. Second, increased information could enable more transparent and efficient implementation of the current cross-border regulations, and make it easier to prove compliance with regulations. As such, technologies could reduce the need for certification, as compliance could be checked for 100% of products. These are discussed below.

### *3.3.2. Digital technologies as an enabler of standards*

63. The range of regulations and administrative processes needed for proof of compliance applied to agricultural and food imports often leads to lengthy and costly export processes. Improving the efficiency of these processes can reduce the burden on business and potentially encourage larger volumes of trade. In addition, lack of access to information about the implementation of regulations and their complexity can by themselves become a barrier to trade.

64. Under the WTO's Technical Barriers to Trade (TBT) and Sanitary and Phytosanitary (SPS) Agreements, the establishment of an enquiry point and an SPS notification authority are a transparency requirement. All new regulations with potential trade-restrictiveness effects should be notified. However, old regulations do not need to be notified; neither do those based on international standards. In addition, the removal of a regulation does not need to be notified. Finally, publication on the internet is not specified, but the implementation guidelines suggest that when a website is available, the notification should include a link. The TFA (see section 4.1.1. ) cover broader ground and encourages publication on the internet (not mandatory).

[19] While little impact was found in the case of domestic value added exports, both SPS and TBT measures had mixed effects on the shares of value added factors in gross production value. Further work is needed to better measure and explore the impacts of NTMs on GVC participation. Work being done in OECD (2018e) should aid in this.

65. In some countries, platforms notifying exporters and using a form of crowd-sourcing mechanism for the identification of NTMs have been developed to increase knowledge about the regulatory environment in partner countries. Platforms also allow governments to reach specific groups with information most relevant to their needs, offering the potential for better public-private sector communication. They can also allow governments to better identify the importance of some barriers over others, as well as to identify measures previously not registered or not falling strictly under the definition of NTMs.

66. SPS regulations are often complex legal instruments that can be particularly burdensome to monitor for customs authorities and to comply with and show proof of compliance for exporters. SPS certification procedures can be subject to duplicative, costly and inefficient processes due to the need for product inspection as well as, when required, sampling and laboratory testing in the exporting country. This can be particularly problematic in some developing countries which can lack capacities and institutions needed to enforce the requirements to access foreign markets (Jouanjean, Maur and Shepherd, 2016; World Bank, 2014). This, for instance, is the case in terms of the capacity of national plant pest organisations (NPPO) to update the listing of the geographical presence of pests in the country. They can also lack the capacities needed to provide necessary pre-shipment checks by laboratories.

67. Digital technologies and the range of available low-cost systems can enable leapfrogging[20] and relieve the burden created by such regulatory requirements by reducing the cost of proving compliance (Box 6). However, the availability of digital technologies should not lead to more complex systems and requirements. For digital technologies to enable leapfrogging and increase the capacity of developing countries to extract value from their exports, the governance of data and the complexity, affordability and governance of digital systems must not create new barriers or a "data gap" between developed and developing economies. In other words, the systems for data creation should not rely on high investments, nor should they require backing by heavy institutional frameworks.

[20] The concept of leapfrogging (technological leapfrogging) which may accelerate development by skipping inferior, less efficient, more expensive or more polluting technologies and industries and move directly to more advanced ones. "*The "leapfrogging" concept has its origin in the belief that some countries, which today find themselves in a state of relative underdevelopment, industrially and technologically, have nevertheless the preconditions, the potential and the historic opportunity to transit, in a relatively short span of time, from the condition of relative under development to that of an advanced industrial and technological state. The belief is grounded in the argument that, being underdeveloped, they are not held down by the burden of an outdated and ageing industrial and infrastructural system, which would otherwise cripple the transition. There is historical evidence and good analytical reasoning to support this belief.*" (see Bhagavan, M.R., 2009, p. 48).

**Box 6. Digital technologies to support compliance with SPS regulations**

**Digital technologies for compliance with traceability regulation for exports to the United States.**

About 80% of the snow peas consumed in the United States (a USD 280 million snow pea import market) are grown in Guatemala. Most of those snow peas are produced by smallholders. The system *Farmforce* was specifically developed for out-growers sourcing from smallholder farmers, in order to comply with new traceability regulations in the United States. The system provides full electronic traceability to the farm level. In addition, it registers all activities on farm, providing evidence of Global GAP (standard for Good Agricultural Practices, mainly adopted by the European private sector) implementation. It also tracks pesticide and fertilizer use, and maps routes for farm visits by technician. The wealth of data captured and shared not only helps build trust between producers and exporters, it also supports more effective farmer training by using data to identify which farms may be improperly applying pesticides or fertilizers. In 2016, six companies had purchased Farmforce in Guatemala, covering almost 3 000 smallholder farmers.

*Farmforce was developed by the Syngenta Foundation for Sustainable Development (SFSA) and is being commercialized in Guatemala with support from Mercy Corps, SFSA, and Feed the Future Partnering for Innovation (http://www.partneringforinnovation.org/), a USAID program that develops public private partnerships to commercialize agricultural technologies*.

*Source:* Agrilink (2016).

### 3.3.3. *Digital technologies as an enabler of traceability and integrity.*

#### Faster and more detailed traceability of food products

68. Following a number of food scares and scandals, traceability of agriculture and food products has become an important regulatory requirement, especially in many high-income countries.[21] However, this did not prevent the occurrence of new food related scandals, leading to consumer scepticism about their efficacy. While the number of food scares and scandals is limited compared to the volume of food produced and exchanged globally, current systems are criticised for the time needed, sometimes weeks, to identify the source of food-borne illnesses and to track harmful products. And while digital technologies will never eliminate food scares or acts that make food products risky to consume, they should improve the response and therefore reduce the costs of these events.

69. The increase in scale of GVCs, and the involvement of countries presenting regulation with different stringency levels as well as different capacities in compliance supervision, can pose new vulnerabilities. In response, some leading companies across the food supply chain, food industry and retailers (including e-commerce), have invested in

[21] *Tracking* is the concept of marking products with a unique identifier so they can be monitored at each step of the process from the point of production up to the point of sale, creating a time and location history for every step**.** *Tracing* is the ability to identify the past or current location of an item. Where an item is intercepted, tracing allows for verifying the product's route back to its origin and retrieving a specific product's time and location history. See http://ensp.org/wp-content/uploads/2017/07/Tobacco-track-and-trace.pdf for definitions.

testing the potential of new technologies for better traceability, and in particular in blockchain, to maintain secure digital records and improve the traceability of their foodstuffs (Box 7). The objective is to improve current traceability and data management processes across the complex network of farmers, brokers, distributors, processors, retailers, regulators, and consumers. Blockchain technologies are seen by some as able to facilitate and fast-track investigations and trace outbreaks back to specific sources, potentially reducing them from weeks to seconds.

**Box 7. Multiplication of initiatives developing permissioned blockchain for better traceability**

**A range of large retail and food industry companies are partnering with IBM to develop blockchain pilots for food safety and traceability**. The Consortium is bringing together Dole, Driscoll's, Golden State Foods, Kroger, McCormick and Company, McLane Company, Nestlé, Tyson Foods, Unilever and Walmart, to work with IBM to improve food traceability by providing trusted information on the origin and state of food.

**Alibaba pilot to use blockchain for cross-border e-commerce**, to track Chinese imports from Australia and New-Zealand as an effort to reduce fraud in the food supply chain. This pilot, developed in partnership with PricewaterhouseCoopers involves consortium called Food Trust Framework, which includes New Zealand dairy co-operative Fonterra, Australia vitamin and supplement supplier Blackmores, as well as Australian Post and New Zealand Post

*Sources:* http://www-03.ibm.com/press/us/en/pressrelease/53013.wss.
https://www.alizila.com/alibaba-ups-food-safety-via-blockchain/.

70. Various systems are being tested, enabling physical tracking of goods to match a digital asset on a blockchain. For example, an RFID[22] tag assigns a unique identification number to a shipment, which can link to a whole range of information about the products being shipped, from origin to processing, storage and transport (including the time spent in transportation and at which temperature), expiration dates etc. At each stage in the supply chain, the shipment can be checked using the number, and any new information about the journey of the shipment can be attached to the digital asset and registered on a blockchain, Through such processes, the shipment can be securely tracked over time across checkpoints. At each checkpoints, relevant stakeholders are able to monitor the shipment. The novelty of these systems lies in the (near) real-time updates and availability of securely stored information on a distributed network. .

### Integrity, and dealing with concerns over food fraud

71. As quality differentiation strategies become a way to create comparative advantage or to enter niche markets, concerns are also rising about agriculture and food product fraud. Concerns arise not only because of potential public health impacts but also because of their damaging reputational effects and consequences for market access and market returns (Spink and Moyer, 2011)[23]. While food safety is about preventing unintentional

[22] Radio Frequency Identification

[23] There is an issue about responsibility in the trading and logistic chain. Shipping and logistics companies may not see themselves responsible for the illegal acts of producers and importers, but some have been held accountable in cases of fraud or illegal transhipment. Retailers can be seen as

contamination; food fraud is the intentional adulteration of food for financial gain, and includes deliberate substitution, dilution, counterfeiting, or misrepresentation of food, ingredients or packaging; or even false or misleading statements made about a product (FAO, 2017). It is based on economic incentives and criminal behaviour and as a consequence, its management and identification in the supply chain is different from food safety (PwC, 2016; Nestlé, 2016).[24] Examples range from the introduction of melamine in Chinese milk products in 2008, to the introduction of horse meat labelled as beef in Europe in 2013.

72. From the consumer point of view, the loss of trust in brands as a guarantor of quality and safety is resulting in a tendency to increasingly look for alternatives.[25] One example is organic food, which was a niche market for a long period of time, and is now reaching scale and being mainstreamed by large retailers. Yet, with this mainstreaming, consumers are increasingly questioning its authenticity, with ever-expanding interpretations of the meaning of "organic food" (Hartman Group, 2016). More generally, there is increasing demand by consumers for more transparency throughout the supply chain. However, consumers face difficulties in acting on their preferences because of a lack of access to information.[26]

73. This loss of confidence of consumers and their trust in traditional quality signals such as brands and certification, as well as the loss of economic value by producers resulting from increased food fraud, led a range of private sector initiatives to (re)create trust and through this, create new source of value addition. More generally, this is leading some stakeholders in the food system to shift from discussion around traceability towards food *provenance* and *integrity*, the implementation of which is now feasible thanks to digital technologies allowing better and less costly recording of information and tracking in regulated industries. There is not yet an internationally recognised definition of "Food Integrity"[27], however it is referred to by the European Union funded research programme "FoodIntegrity" as "the state of being whole, entire, or undiminished or in perfect condition" and relates to "providing assurance to consumers and other stakeholders about the safety, authenticity and quality of food".

responsible as the last link in the chain and in any event suffer reputational damage when products are compromised by their suppliers. As a consequence, some companies have developed blockchain systems relying on a "transfer of responsibility" between actors of the chain (See OWNEST, https://ownest.io/).

[24] See *Food Fraud Initiative*, Michigan State University (MSU) http://foodfraud.msu.edu/.

[25] In reaction to various scandals, some consumers have had a tendency to feel that "small is beautiful" (The Centre for Food Integrity, 2017).However, small producers are not necessarily better able to comply with regulations about food safety. The same holds for organic food.

[26] Some analysis studying the "attitude-behaviour" or "value-action" gap has showed that 30% of consumers in the UK are concerned about environmental issues in the origin of products purchased but are struggling to translate this into purchases. (Young, et al. (2010).

[27] In May 2017, the Codex Alimentarius (CODEX, the world food code) initiated a major food fraud commitment by proposing an Electronic Working Group (EWG) to review other CODEX texts and to create a definition and scope for a number of related terms--food fraud, food integrity, and food authenticity. See http://foodfraud.msu.edu/2017/05/05/review-codex-ccfics23-meeting-summary-action-to-define-food-fraud-and-related-terms/.

**Box 8. Example of initiatives developing open blockchains for supply chain integrity and new certification mechanisms**

**Provenance** is a private company developing a system using the blockchain to enable the verification of sustainability claims in the supply chain. The project is supported by DFID. Provenance will be working with partners from the agro-food industry and value chain (support services) including Unilever, Sainsbury's, Sappi, and global banks Barclays, BNP Paribas, and Standard Chartered to explore the potential of blockchain technology for unlocking the financial incentives that reward sustainability in supply chains.

**WWF** is developing a project using the blockchain technology to differentiate fish caught sustainably from those caught illegally, or linked to human rights abuses; this could serve as a response to growing awareness of customers of food origin, both in terms of safety, but also social responsibility.

*Sources:* https://www.provenance.org/news/us/unlocking-financial-incentives-reward-sustainability-supply-chains; https://www.wwf.org.nz/what_we_do/marine/blockchain_tuna_project/.

74. A range of initiatives are now testing the potential of new digital technologies, and in particular blockchain, to scale up food integrity initiatives. Their implementation requires increased capacity to produce, manage and transfer data along the value chain, from farm to fork, in a more comprehensive and transparent way than traceability (Box 8). For instance, a study by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia sees distributed ledger technologies (the fundamental structure of blockchain) as a way to give consumers assurance about the provenance and the quality of imported meat products, preventing counterfeits and the negative impact on the reputation of their products.[28] This also applies to other value chains for which agriculture is an important provider of primary intermediate for manufacturing (Box 9).

[28] See CSIRO and Data61, Blockchain: what does the future hold for blockchain in Australia? Available at http://www.data61.csiro.au/en/Our-Work/Safety-and-security/Secure-Systems-and-Platforms/Blockchain.

**Box 9. Blockchain for due diligence in global garments supply chains**

The OECD Responsible Business Conduct team has convened a number of enterprises, policy makers and industry initiatives to form a garment and footwear sector working group to investigate the role blockchain technology could play in assisting enterprises to carry out due diligence on labour and human rights, environment and corruption risks in global garment supply chains.

A proof of concept for cotton supply chains presented by one brand highlighted the potential of blockchain technology to pass verified and credible information about a product along its supply chain from field or mine, to manufacturer, to consumer. A blockchain could contain not only data about the origin of the material, for example farm location, date of harvest and third party certification; but also transactional data, to track its legal status and traceability; and technical and due diligence information about the manufacturers, handlers and the product itself. Questions about which information is required, by whom, and what advantages blockchain technology can have, compared to already existing due diligence assurance and chain of custody schemes, are still to be explored.

The OECD is collecting information from stakeholders in the sector to synthesise the system requirements of brands, industry initiatives, suppliers and third party service providers for a blockchain for due diligence in cotton supply chains, with the potential to expand this line of enquiry to other core materials used by the garment sector, such as leather. Activities envisaged by the working group include collaboration on research, pilot testing and analysis of the impacts of blockchain-traced commodities on the quality, efficiency and robustness of enterprises' due diligence activities.

OECD Garment web page: http://mneguidelines.oecd.org/responsible-supply-chains-textile-garment-sector.htm.

## Digital technologies are shaking up traditional food distribution networks

75. These trends have led the way for changes in the agro-food value chain, changing the focus from food companies' brands to distribution services' brands as future leaders of the food industry. Retailers have developed private labels to differentiate themselves from competitors, to better control selection on their shelves, and attract repeat shoppers. These new retail brands often emphasize transparency and affordability, as retailers have the advantage of visibility across the whole chain, from producers and logistics to the consumer in their physical or on-line shops. Through this, retail brands are becoming increasingly important compared to traditional food industry brands (CBInsights, 2018). This control of the whole logistics chain has allowed new digital systems of traceability to be tested; Wal-Mart and IBM, for example, are in a partnership for the development of a blockchain. Another example is the development of a blockchain by Carrefour[29] for their own brand chicken, providing consumers with a range of information about the purchased chicken: date of birth, name of the breeder, slaughter date, but also veterinary treatments, and other elements allowing tracing back the elements of the life of the poultry bought by the consumer. The system even allows access to videos presenting the farm from where the product they purchase was supplied.

[29] http://www.lemonde.fr/economie/article/2018/03/06/carrefour-met-en-place-un-systeme-de-tracabilite-des-aliments_5266182_3234.html.

76. This is also leading to a consolidation between traditional and on-line retailers and the increasing importance of cross-border trade in high value niche products. For instance, one of the largest on-line retailers has purchased a retail chain selling high-quality, natural and organic food, enabling access to a distribution network and to develop a point-of-sale system. An important Chinese retailer is also developing an e-commerce platform to promote trade and help Southeast Asian SMEs access the Chinese market, including for food and fruits.

77. Digital technologies are already changing the rules in the agro-food industry and providing opportunities to reshape the food system. At both extremes of the value chain, they promise to empower small actors: upstream, smallholders and downstream, consumers.

78. However, it is still unclear where the equilibrium of the new distribution of value added will set. Many of the most disruptive new digital tools are still in their infancy, and the way regulations will influence their evolution and use will affect this equilibrium. It is currently unclear whether digital technologies are creating new market powers or whether more transparent competition is enabling a fair distribution of newly created value. Policies regulating the use of digital technologies are likely to influence the outcome, including broader policies about privacy, interoperability and rights over data use. Most of the relevant policies sit outside of the usual remit of agriculture and food ministries. It is therefore important that agriculture and food government bodies highlight the specificities of the food system to relevant domestic and international regulatory bodies and analyse potential consequences of domestic digital technologies strategies on their specific sectors, their competitiveness and capacity to trade.

## 4. Digital trade facilitation for agriculture and food

79. Fast and seamless trade is particularly important for sectors characterised by perishable products such as food and agriculture. The advances enabled by digital technologies promise particular benefits for the management and administration of food and agricultural trade. Digital systems are supporting the efficiency and reliability of both customs management and the trade logistic chain more broadly, and are reducing trade costs. This section discusses those advancements and the potential barriers to implementation. It presents how digital technologies can reduce the time and cost of compliance for traders and operators (a pure efficiency gain) but it builds on discussion of SPS measures in the previous section to suggest that progress in the capacity to produce information could also enable new SPS policy designs and implementation *at the border*, potentially enabling less trade restrictive measures.

### *4.1. Improving trade facilitation and cross border customs processing*

#### *4.1.1. Digital technologies support the implementation of the WTO Trade Facilitation Agreement*

80. While digital technologies can facilitate border procedures, a pre-condition is investments in the development of ICT infrastructure but also in the development of internationally interoperable systems. There is now evidence that such investments have benefits for trade. In the Asia-Pacific region, improvements to cross-border processes enabled by ICT have reduced export time and costs, by 44% and 33% respectively (UNESCAP, 2014). Such investments are becoming a high priority in the context of Aid for Trade programmes (OECD/WTO, 2017). In particular, the cost of implementation of

the WTO TFA, of particular importance for agro-food trade, [30] is likely to be reduced by the development of digital capacities at the border. Indeed, a range of Articles of the WTO TFA can be enabled by digital technologies. Of particular interest are:

- Publication and Availability of Information (Art. 1)
- Opportunity to Comment, Information before entry into force, and consultations (Art. 2)
- Pre-arrival processing (Art. 7.1)
- Electronic payment systems (Art. 7.2)
- Risk management (Art. 7.4)
- Expedited shipments (Art. 7.8)
- Acceptance of copies (Art. 10.2)
- Single windows (Art. 10.4)

81. The first two items, Articles 1 and 2 of the WTO TFA, relate to communication of information; the others, under Articles 7 and 10, relate to automation of processes. The next sections explore how digital technologies support the implementation of the TFA and, more broadly, how they could support new border processes.

### *4.1.2. Increased transparency and better communication of information*

82. The increased availability of data and information can support transparency in administrative rules and processes crucial for transactions involving lengthy and complex procedures. This is particularly relevant in the case of trade in agriculture and food, which are at the same time subject to complex requirements but are particularly time sensitive because of the perishability of products. In addition, differences across markets regarding conditions of access are relatively difficult to assess, resulting in uncertainty for prospective entrants as well as difficulty in diversifying export markets.[31] Transparency in trade policy, evaluated at the level of government transparency or provisions in regional trade agreements (RTAs), highlights that improved transparency can generate substantial gains in trade and investment flows (Helble, Shepherd and Wilson, 2009; Lejárraga and Shepherd, 2013). A range of databases and portals provide on-line information about trade policy measures, both tariff and non-tariffs.[32]

83. In order to encourage transparency, TFA Article 1 requires WTO Members to make information on the practical steps applicable to imports, exports and transit available through the Internet to facilitate traders' access to relevant information. However, the web-based instruments developed can vary from the simple access to a portable document format (pdf), to elaborate websites, not only providing structured, targeted and timely

[30] The OECD will be undertaking work on trade facilitation and perishables as part of the 2019-20 Trade Committee PWB.

[31] Cost of compliance with regulations from different countries can be particularly burdensome for small producers who end up "captured" in one market.

[32] See the WTO Integrated Trade Intelligence Portal (I-TIP), TRAINS, and other databases usually maintained by International Organisations.

information about trade requirements to stakeholders but also allowing for interaction between the private sector and relevant governmental bodies.

84. Focusing in particular on information made accessible through Customs websites, the OECD Trade Facilitation Indicators (TFIs) highlight that, among the types of information listed in TFA Article 1.1, countries across all income groups publish relatively widely the basic steps of importation, exportation and transit procedures (1.1.a), and applied rates of duties and taxes (1.1.b). Information regarding classification and valuation rules (1.1.d), appeal procedures (1.1.h) and agreements with third countries (1.1.i) is generally made available through paper publications, with online publication still lagging across low and middle income countries (OECD, 2018c).

85. In addition, Ing, Cadot and Walts (2018) have created a synthetic measure of transparency, which includes an indicator about the creation of a functional trade portal. In particular, the quality of portals was evaluated on a scale from 1 to 3 with 3 the best quality). To date and according to their research, only 23% of countries at the WTO have a functioning trade portal and this varies considerably across regions, with Latin America at the lower end with 6% and the highest incidence in Europe and Central Asia at 55%. Europe and Central Asia also holds the highest quality score, the lowest being South Asia. By income group, 81% of OECD countries have a trade portal, but less than 15% of high-income non-OECD countries and those in other income groups. The quality of the portal depends on income group: the quality of portals is falling from high to low income groups.

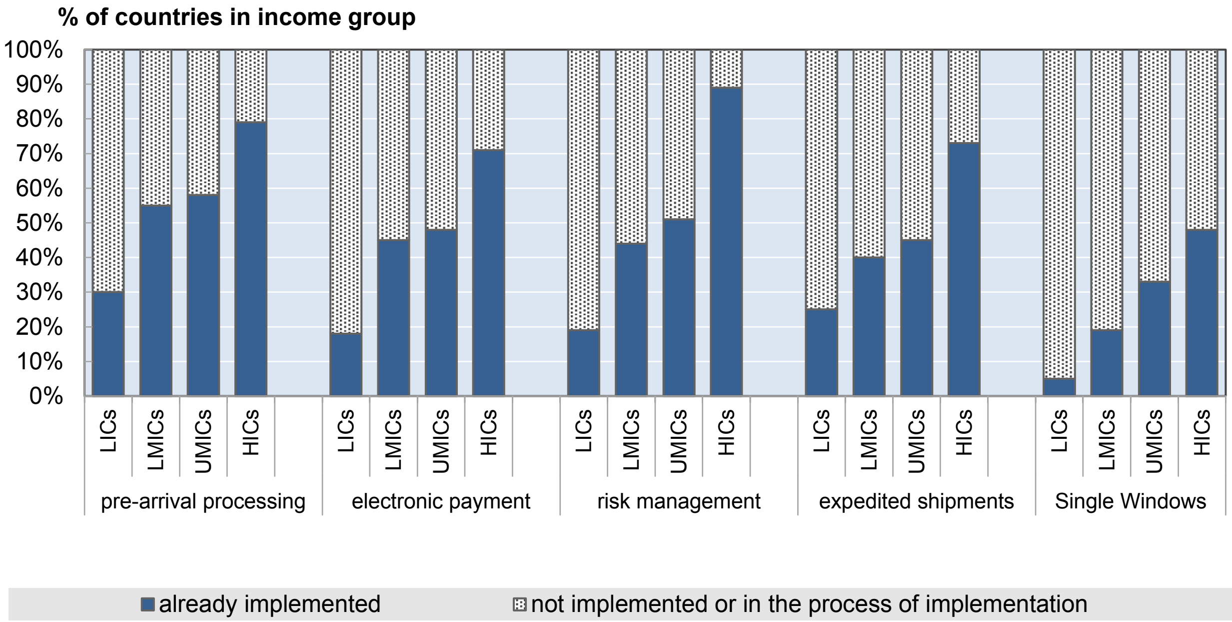
### *4.1.3. Automation of processes and documents*

#### Current implementation of the WTO TFA

86. Enforcement of the WTO TFA provisions related to licences, declarations and clearance could be improved by greater use of digital technologies supporting data transmissions, automation, payments, classification, and the transfer of access rights. TFA Articles 7 and 10 relate particularly to the automation of processes. For pre-arrival processing and its application in an automated environment, around half of the middle income countries (MICs) appear to have systems for the electronic payment of duties, taxes, fees and charges, integrated with an automated declaration/cargo processing system, as well as digital certificates and signatures. However, implementation of these features remains much lower in low income countries (LICs).

87. Most information technology (IT) systems in the lower middle income countries' (LMICs) and upper middle income countries (UMICs) are ready for electronic data interchange (EDI) systems, which are essential for reducing the complexity of document submission. In most of the LICs, these systems are still in the process of implementation (Figure 1).

**Figure 1. Automation tools in place, by type of tool and by country grouping**




*Source*: OECD (2017c), Trade Facilitation Indicators www.oecd.org/trade/facilitation/indicators.htm.

88. This picture is confirmed by the UN Global Survey on Trade Facilitation and Paperless Trade Implementation made available by UNESCAP[33]. The indicator on "paperless trade"[34] highlights that despite progress toward the implementation of the WTO TFA the past couple of years, digitalization of trade procedures remains very partial (Box 10).

[33] The first and second survey benefitted from inputs from many partners: Organization for Economic Cooperation and Development (OECD), the United Nations Conference on Trade and Development (UNCTAD), the International Trade Centre (ITC), Asian Development Bank (ADB), Oceania Customs Organization Secretariat (OCO) and Eurasian Economic Commission (EEC).

[34] Covering mostly to Articles 7 "Release and Clearance of Goods" and Article 10 "*Formalities connected with importation, exportation and transit*" of the WTO TFA (Joint United Nations Regional Commissions, 2017).

**Box 10. UN Global Survey on "Cross-border paperless trade"**

International trade requires that information pass between relevant parties, public and private, including suppliers, logistics providers, customs, regulatory agencies, sellers and buyers. Paperless trade refers to the digitization of trade-related data and documents, transforming what was traditionally a paper-based documentation system into an electronic format (UNECE-WEF, 2017). Efficiency in the management of trade regulations can be boosted through the adoption of paperless trade and electronic documents (OECD-WTO, 2017).

The UN Global Survey provides information on "Cross-border paperless trade" which looks at measures relating to the implementation of systems enabling the exchange of electronic trade-related data and documents across borders (Joint United Nations Regional Commissions, 2017). It indicates that work remains to be done on legal recognition of electronic data and documents across borders. Except for "Laws and regulations for electronic transactions" which has a relatively high level of implementation in many regions , implementation of other indicators is still very low, including in high income OECD countries (Figure 2).

89. The extent of burdensome red tape is an important factor in businesses' decision whether or not to engage in trade, particularly for SMEs and especially for e-commerce trade in low value parcels. A survey of e-commerce barriers in countries outside the European Union (Kommerskollegium – National Board of Trade, 2012) highlighted that customs procedures are problematic when shipping large numbers of small consignments, in particular when EDI files were not accepted, requiring each parcel to be declared individually to customs (contents, dimensions and weight).

90. Digitalisation reduces the costs associated with co-ordination and exchange of information between border agencies, thereby supporting the implementation of the WTO TFA. This increased management capacity by customs authorities is particularly important for the agriculture and food sectors, particularly for high risk (in terms of sanitary and phytosanitary, or SPS, issues) and perishable products. Data management technologies such as blockchain can also change the way Single Windows can be developed and operated, including in relation to Article 10.2 of the TFA "*Acceptance of copies*" and the concept of "copies" versus "originals". With such technologies, processes can shift from a reliance on documents toward a reliance on data (Hoffmann, 2017).

91. However, the most challenging area for TFA implementation, as also highlighted by the 2012 and 2015 TFIs, remains the set up and operation of Single Windows. Information on the progress achieved on IT and EDI systems, as well as on wide-ranging challenges in the area of border agency co-operation, suggests that the missing link in the development of Single Windows is the quality of co-operation and information exchange among the numerous government agencies, customs departments, and border control posts (OECD, 2017b; OECD, 2018c). Given that agro-food products require intervention by a number of agencies at the border (e.g., SPS authorities as well as Customs), implementation of Single Windows remains particularly important for the sector.

92. However, technology is not proving to be the key constraint to the implementation of automation of customs processes and documents. The more specific example of digitalisation certification and the some of the difficulties of adoption and implementation in the specific case of SPS are described below.

## Paperless trade for SPS management

93. The objective of paperless trade is making available and enabling the exchange of trade-related data and documents electronically. It require the digitization of all the information needed to move a good across borders and the digitalisation of all the processes needed to ensure the secure flow of information between stakeholders participating in the cross border trade transaction, both private and public. Stakeholders include not only the sellers and buyers, but also all actors enabling the movement of the good across the border, including logistics services as well as customs and relevant regulatory agencies. Despite technological progress, the process of trading is still largely paper-based in most instances, with the same paper-based documents needing to be passed along the trading chain among all these parties.

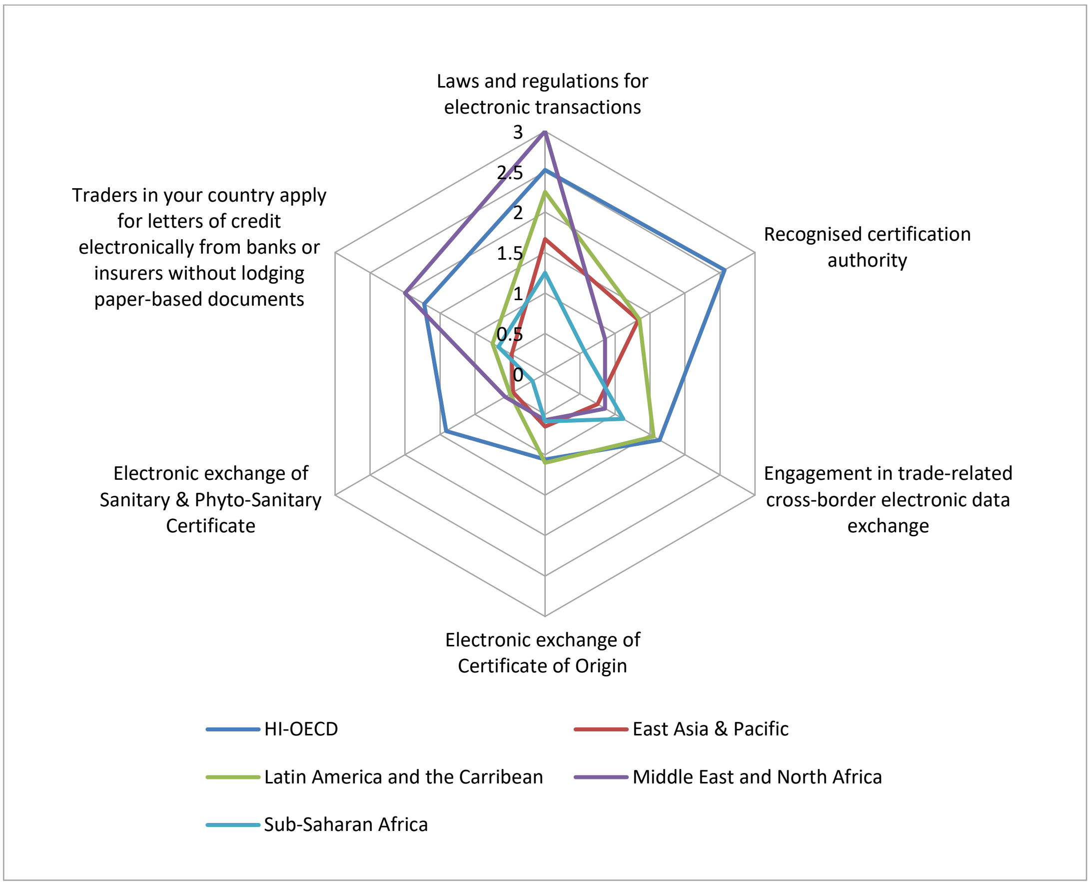
94. The rationale for moving from paper-based to digital documents is rather straightforward as the process of issuing and passing along a paper-based document involves many opportunities for inefficiencies and fraud. Documents can simply be lost[35] or damaged, and copies are not usually accepted due to the risk of fraud.

95. Paperless trade is particularly relevant for agriculture and food trade. Electronic documents can be made available to authorities before arrival of the cargo, increasing the speed of processing at arrival. SPS e-certificates are particularly relevant tools to speed-up clearance at the border. It becomes even more relevant in a world where B2C trade in plants, agriculture and food is developing.

96. From a technical perspective, there are various was to digitize this exchange in information. One easy and straightforward way is to have a digital copy of the document (scanned or a PDF version). However, the original of the document is required to prevent forgery. Other possibilities include internet web portals called data-trader interface (DTI), but these require the data to be recaptured by human intervention at each supply chain check point and are therefore subject to error. More recognised systems when discussing paperless trade at the government or B2G levels are EDI (see Annex A), for which data entry is reusable, enabling automation and more data reliability, or use of blockchain-based systems.

[35] Cases of loss and resulting issues for Port State Control (PSC) inspecting the certificated have been documented by the International Maritime Organisation (IMO).

**Figure 2. Cross-Border paperless trade indicator**




*Source*: UNESCAP Global Survey.

97. However, and despite many years of discussions and the technical possibilities, the implementation of "Electronic exchange of SPS certificate" (Figure 2) is particularly low. One important reason is that implementation is not straightforward: it requires not only ICT infrastructure, but also agreement between border authorities on standards for the way in which digital information is structured and shared.[36] For example, the adoption of electronic documents involves the recognition of electronic signatures, standardisation of data exchanges and interoperability across applications and systems, cybersecurity, and legal validity of electronic documents.

98. Paperless trade requires bilateral cross-border co-operation which entails complex technical arrangements. Each country has to translate their traditional paper-based analogue system, in this case information contained in certifications, into digital format. This digital format should be readable by the trading partner's system, which might not require the exact same information or the same format. Such digitalisation is not as straightforward as could be expected as each country has its own requirements, as well as its own treatment definitions. The additional burden on government bodies in developing these systems is also affected by the fact that there is no guarantee that partner countries are following

[36] See for instance data standards developed by the UN Centre for Trade Facilitation and Electronic Business (UN/CEFACT). See https://www.unece.org/cefact.html.

through with implementation of their own systems. Implementation of systems for the exchange of certificates between governments is thus based on bilateral agreements, and e-certificates can only be recognised and sent electronically to destination countries with which a system is in place.

99. One of the complexities behind the use of paperless trade is the need for all information to be clearly defined and unambiguous: trading partners need to ensure that they all understand the information in the same way. They also require co-ordination between agencies within countries, in particular customs and SPS authorities. In other words, the government body responsible for issuing phytosanitary certificates would need to engage in separate bilateral negotiations with all its partner countries. This would be an extremely costly process in time but also in resources as trading partners would have to make sure their systems are interoperable. The examples of implementation of the system for fruit and vegetables exports from Chile to China highlights that the success of the system required sustained bilateral efforts to standardize the electronic exchange of information and ensure that software interfaces could communicate directly with one another in a secure and timely manner (World Bank, 2017).

100. According to the World Bank 2017 *Enabling the Business of Agriculture* (EBA), Chile, Kenya, Korea, and the Netherlands have the capacity to generate, issue and send phytosanitary certificates in electronic form (World Bank, 2017). In Kenya, they have proven to positively affect not only exports, but also government revenues (less informal trade) and more generally the business environment, with increased trust in the value chain thanks to the enhanced authenticity and integrity of the data contained in the certificate (Stokes, 2017).

101. The International Plant Protection Convention (IPPC) is developing a project, the Global ePhyto Solution, with the objective of providing a solutions to this problem. The aim is to create a global ePhyto Hub sharing a common technical vocabulary and set of established trade rules to which each country's computerized trade system can interconnect seamlessly to exchange electronic phytosanitary certificates quickly, accurately, and at very low cost. More specifically, the project proposes to develop a "standardised approach to the security and method of exchange, code sets and message mapping to ensure that all countries are able to easily participate in electronic certification" (IPPC, 2016). This promises to reduce costs to exporters as well as for port authorities with fewer shipments detained at foreign ports of entry. The Hub also aims at facilitating participation of countries with limited IT capacity in ePhyto exchanges, facilitating the transfer of certificates from the national plant protection organization (NPPO) of the exporting country to the NPPO of the importing country using a harmonized protocol and a generic web-based system. An initial pilot phase involving 14 countries to test the Hub and generic web-based system was kicked-off in October 2017.[37]

102. The reality of paperless trade still needs to be more broadly discussed. In particular, fostering further sharing of experiences between countries could be greatly beneficial. As the World Economic Forum mentions: "*While many may be familiar with the concept of paperless trading, the mechanics of how exactly paperless trading works is one that most individuals involved with trade, whether from business or government, will have given little thought. Like many other elements of our digital world, it is simply a technical development*

[37] Selected countries for the pilot are: Australia, Chile, China, Ecuador, Egypt, Ghana, Guatemala, Kenya, The Republic of Korea, The Netherlands, New Zealand, Samoa, Sri Lanka and the United States of America. https://www.ippc.int/en/news/ippc-ephyto-hub-pilot-underway/.

*that is taken for granted* (WEF, 2017, p. 4). Better analysis of the costs and barriers to implementation, in particular institutional barriers, is also still needed, along with transparent dialogues and cross-border co-operation.

103. The increasing pressure and interest from both public and private sectors stakeholders in new technologies such as blockchain might help in moving forward. But instead of relying solely on technologies to solve problems, policy makers might need to take a step back to consider the scope for reducing the complexity of requirements. In other words, instead of creating costly systems to transpose the current analogue systems into digital forms, it might be worth considering whether some simplification of those systems and rules, should be undertaken first. This could also include consideration of whether new capacities to create, transfer and analyse information might enable updating of the way government bodies are enforcing the rules. That is, the increased availability of information might allow for new trade policy designs and implementation, integrating technologies as a new type of enabler and flexible enough to enable the use of new digital innovations to come (that is, preventing the need for new legislation when firms shift to other emerging technology). Indeed, when creating requirements for trade, regulation should be *tech-agnostic* and based on objectives. Regulation should remain focused on the results to be achieved, as much as possible, rather than require or be based on the use of a specific technology to let stakeholders remain free to adopt whatever technology they deem most appropriate to achieve results.

### Challenges and opportunities for risk management at the border

104. Digital technologies present both challenges and opportunities for risk management at the border and to reduce risks of entry of non-compliant products (fraud and non-compliance with import regulations, for example presence of pesticides residues on fresh products, but any form of adulteration or issues in relation to labelling, for example language or missing information). Looking at opportunities, digital technologies have already been used for risk management for a long time and many customs agencies around the world use algorithms and data analysis tools to increase the efficiency of cross-border trade, This use of technology has allowed customs agencies to continue fulfilling their monitoring mission, despite increasing trade flows (Jeacocke and Kouwenhoven, 2017). However, according to the 2017 TFIs, risk management is implemented in an automated environment only in in 35% of the countries in the sample.[38] The other countries, largely LMICs and LICs, either do not have an automated environment or are in the process of implementing one.

105. Some challenges result from the change in scale and nature of trade. The increased pressure on customs authorities to upgrade their risk management system is exacerbated by new trends in digital trade. Small parcels do not always follow the same pathway as large shipments: whereas large shipments continue to move through traditional transportation pathways such as overland freight, air-freight and ocean freight, smaller parcels often cross the border via postal or express services. But changes are also affecting traditional pathways, with logistics companies reducing costs by consolidating containers, mixing cargos of different types, originating from different sellers, in the same container. This can result in reduced accuracy in terms of the information about each cargo in the container (UNECE, 2011). This increases the burden on customs authorities, challenging their

[38] The TFIs cover 163 countries. See http://compareyourcountry.org/trade-facilitation.

capacity to fulfil their mission and forcing policy makers and customs authorities to rethink traditional enforcement tools.

106. Moreover, analyses show that often, very little is known or shared on e-commerce websites about the requirements for trading agriculture and food products. The IPPC, in analysing websites selling insects, or plants and plant products, found very little information about the requirements for imports into different countries, or whether or not these shipments were restricted (IPPC, 2012). Other analysis based on the survey of e-commerce trade on ten major online auction sites, such as eBay, shows that biosecurity is not effectively regulated in the online plant trade (Humair et al., 2015).

107. Digital technologies can enable new solutions that could change the way border services operate and allow faster adaptation to the evolving nature of trade. They could enable earlier detection of illicit behaviours, facilitate trade in a more automated way (Accenture, 2017) and be more adapted to the new trends of trade in parcels. AI can, for instance, be used as the first point of contact for online digital customer service interactions. AI robots are also envisaged as performing inspections on hazardous goods, such as chemical or potentially radioactive materials. AI can also be used for handling repetitive tasks, such as directing autonomous vehicles in ports or automated monitoring of containers and warehouses, freeing time for staff to focus on other tasks. They can also be decision-making or predictive intelligence tools, using big data analytics to notify border customs officers that they should perform an inspection on a high-risk cargo. Such decision-making tools can be developed by making better use of traditional border data as well as by relying on new types of data (Okasaki, 2017). For instance, AI systems can be trained to detect risk more effectively in conjunction with other tools, for instance drones and sensors.

108. In some way, AI, with machine vision and sensors, is simply the next step of already existing systems. However, the novelty lies in the extent of automation and more specifically the capacity to ultimately stop relying on probabilities to conduct cargo checks, but to automatically monitor 100% of cargo. That said, a complete reliance on technologies does not obviate the duty of care of customs authorities which would probably still have to use risk-based checks. A range of other issues would also have to be thought through. Increasing reliance on digital technologies as a tool for decision-making or complete automation requires delegation to the technology, or rather to the programmers of those technologies. At present algorithms, including machine vision, can be a black box[39]. This could create a range of new vulnerabilities in the system.

109. Behavioural consequences also have to be taken into account. The current system usually puts the burden of the proof of compliance on exporters who have the incentive to send compliant, pest free or safe food products. It could be argued that this system could, in reducing the burden on exporters, reduce incentives for compliance, leading to congestion of non-compliant products reaching borders. But on the contrary, if implemented with increased capacities in traceability, the system could increase the incentives for producers to avoid penalty by ensuring compliant products. Finally, there could be issues in relation to liability. If a cargo with pests enters the country as the

[39] There are already initiatives lobbying for open algorithms, particularly when used by governments. A recent example in France was the new system attributing for example Parcoursup, the French allocation and registration system for high-School graduates into Universities. Other initiatives are also pushing for the creation of a *Hippocratic oath* for programmers. https://www.sciencesetavenir.fr/high-tech/informatique/bac-2018-l-algorithme-de-parcoursup-explique-par-les-deux-chercheurs-qui-l-ont-concu_124407.

consequence of the failure of a sensor or of an algorithm, and contaminates domestic crops, who should be held responsible? Changes in technologies can induce changes in behaviours and implementation should not be taken lightly. They can be implemented unilaterally, but their full potential, in particular to recreate responsibility throughout the value chain, requires cross-border co-ordination.

## *4.2. Digital technologies for an integrated and resilient trade logistics chain*

### *4.2.1. Integrating the trade logistics chain*

110. Border authorities are not the only stakeholders in the trade logistic chain. Aligning information from the multiple support services needed to allow the physical (e.g. freight forwarders, ports management authorities, etc.) and financial (e.g. insurance, bank) cross-border transaction to occur can also be a source of delays – payment processing, laboratory results etc. In addition, information has to be passed from one agent to another throughout the chain and parts can be lost along the way as each agent tends to only retain the information relevant for its own activity. Digital technologies provide ways to better manage information flows along the trade logistics value chain, can prevent the loss of information and can provide real time information about the status of the shipment. This information has value for the buyer and seller, but also for the rest of the logistics chain. It decreases transport costs by increasing efficiency of the logistics supply chain, improving workflow thanks to electronic documents – bills of lading; letters of credit; proof of transfer of goods between stakeholders – and providing real-time visibility on the status of shipments for transit tracking and insurance.

111. A range of new digital platforms are facilitating the planning and execution of global trade. These range from cost estimation of shipping and transport and suggested shipping routes, to efforts to increase the transparency and interoperability of information, including between the public and private sectors (Box 11) and efforts to integrate all the players in the chain, using blockchain technology to enable all stakeholders in the trade transaction – seller, buyer, freight forwarders, insurance companies and customs authorities – to access real-time information about the location and status of shipments.

112. While there are now many examples of successful pilots testing the use of blockchain technology for trade in agriculture products, efforts bringing together all actors in the trade logistics chain (seller and buyers, but also banks, freight forwarders and customs authorities) are not yet scalable. The multiplication of initiatives has also highlighted the need to develop standards of interoperability of systems to enable scalability.[40]

113. It is foreseen that digital technologies could, in the future, create new business models leading to a reduction in the number of stakeholders needed to enable a trade transaction, in particular stakeholders whose business and value addition in the economy is to reduce transaction risks and create trust. In particular, blockchain is envisaged as a technology that would disrupt the trade finance landscape (Cognizant, 2017; WEF, 2018).

114. Data management of ports operation is of particular interest. First, the maritime sector transports 80% of world trade. Second, ports are central to the functioning of global supply chain, not only because of the quantity of trade they manage, but also because they

[40] Such standards are currently being discussed at the International Standard Organisation, with the development of standard ISO/TC 307 SG 7 for the interoperability of blockchain and distributed ledger technologies.

represent hubs, often connecting maritime transport, air transport and land transport. They bring together a range of infrastructure and services for the transfer, storage, inspection, and control of goods moving in and out of a country. The inefficient management of a port is therefore particularly important for trade in agriculture and food and can reduce costs and enable timeliness of delivery.

115. The International Trade Forum (ITF) looked at what digital technologies mean for maritime logistics services and there may be interesting lessons for food and agriculture. The maritime sector seems to be already harnessing data via digital technologies in a range of areas, in order to improve logistics processes. However, in the same fashion as discussed for agriculture in the first part of this report, it suffers from a lack of integration of systems, between various stakeholders and port functions as well as between port functions (terminal operating systems, custom management systems, fleet management systems, etc.).

116. In addition, there seems to be poor use of systems allowing automation of transfers of information and inter-firm co-ordination. In particular, maritime logistics services seem to be making very little use of EDIs. Implementation of new digital technologies seem to be confronted with a range of obstacles, including limited trust and lack of co-ordination among actors in the supply chain which result from a reluctance to share data due to commercial sensitivities, question of data ownership and fear of losing competitive advantage, or due to risks related to anti-trust legislation. This results in a lack of harmonisation of systems and creation of standards for data collection and difficulties of alignment across various nodes of the supply chain to create consistent data. The sector does not seems particularly transparent and is poorly integrated, despite some clear theoretical gains from co-ordination. That said, some stakeholders may benefit from opacity and there can also be a fear of free-riding behaviours on first-mover investments to generate, collect and publish data (although there may also be first mover advantages). This will potentially increase the constraints to digitalisation of the sector and underscores the importance of understanding the incentives and disincentives of co-ordinating and sharing information with others in a very fragmented setting.

117. In particular, the ITF work raises the possibility of future data oligopolies dominated by a small number of private supply chain integrators, in particular the emergence of proprietary data-enabled systems, which could potentially concentrate market power. This would create bottlenecks in the value chain and reduce benefits from digitalisation of trade processes. While there is a real possibility of such an outcome with the current regulatory status quo, there are already discussions about potential solutions, including adopting "open first" approaches to government data and the push to consider some privately collected data as being of public interest. It is important to mention that an "open first" approach does not mean that the data will be available to all. Privacy and trade secrets still apply. In addition, such systems can be combined with other technologies, such as blockchain and cryptography, to ensure that there is knowledge about who is using the data and when. The question is then how can those systems enable broad based access to data, respecting at the same time trade secrets and privacy. Those issues are already a reality in the transport sector. The ITF (2018) stresses the need to ensure interoperability between public and private systems for the exchange of logistics information to support data exchange and enable faster cross-border interactions (public-private data pipelines). This more broadly suggests the need for further discussions between the ICT sectors actors, knowledgeable about what new digital tools really do, and potential users in both the private and public sectors.

**Box 11. Blockchain technology: integrating information from all public and private actors of the agriculture and food value chain, from agro-food producers, to support services and government bodies**

***Blockchain in agriculture and food***

The past couple of years, followers of digital technologies newsletters have seen a multiplication of articles about initiatives claiming to be the first to use blockchain for agriculture and food product transactions. Applications range from the automation of the logistics of a cross-border trade transaction, to traceability from farm to fork. However, each case tends to focus on the constraints faced by one specific actor of the chain, farmers, logistics, retailers or consumers. As their objective was different, they often adopted different approaches. All tested the technology in different ways, providing interesting insights about how the technology can be used, allowing it to progress.

Not all pilots used the same blockchain technology. Some used distributed ledgers, providing real time updates at checkpoints, but still subject to some form of central power. For example, trials involving a large logistic company and computer services company developed a blockchain pilot allowing containers of roses and avocados from Kenya to cross borders in Europe more smoothly. The systems linked with e-certifications (available between Kenya and the Netherlands) and warned customs authorities in advance of the arrival of a container. The success of this trial is not only the success of blockchain technology used, but also of its complementarity with e-certifications. This system avoided unnecessary container checks on arrival, thereby increasing the shelf life and thus marketability of fresh products.

Other systems aim at solving constraint on the farmer side, looking into enabling fast and secure payments for farmers and providing them with better control over their sales. In particular, the use of blockchain reduced the margins captured by traditional intermediates thereby allowing farmers to get higher prices for their products. The objective of those systems is to align the various flows involved in an agriculture transaction (goods, money and information).

However, implementation is not straightforward for agriculture and food compared to the financial sector where blockchains were first applied. Agriculture and food products are *tangible* (i.e. they will always require physical delivery even as payment and information transfers for agriculture and food products become increasingly digitalised)[41], they may change in quality over time (i.e. most agro-food products are perishable), and they take time to move through value chains from producers to consumers. Maintaining correspondence between physical agriculture and food products and their digital representations is an additional challenge.

There are also many other ways to use blockchain to tackle issues encountered in the agro-food value chain. One is the lack of transparency in the logistics chain. The on-time recording of immutable information can facilitate transparent "*transfer of liability"* of cargos along agriculture and food value chains. Accordingly, actors at each point of the chain take responsibility for the shipment. This can create an "upward spiral", and be a pull factor for stakeholders to take full responsibility and take ownership of their practices, thereby decreasing incentives for fraud.

Finally, it is unlikely that all actors participating in agriculture and food trade processes, producers, logistics services, government authorities, will be using the same blockchain system. A full integration along the value chain requires a form of interoperability between all those systems.

***Is there a role for the government?***

As evidenced by the conclusions in *Blockchain and Distributed Ledgers in Public Policy: Opportunities and Challenges* (forthcoming), it has become increasing clear that governments have a decisive role to play in the development of blockchain technology.

Without concerted efforts by governments to ensure harmonization in data standards, issues with interoperability, or the ability to share and access data between separate platforms, may arise. This could result in the creation of many separate and isolated platforms which would eliminate much of the unique benefit of using blockchain to reduce data fragmentation and data silos. Data standards are also needed to address issues of data quality. Ultimately, blockchain systems are simply advanced data storage structures whose value to consumers depends on the quality of the data entered. Blockchains, themselves do not have mechanisms to discern if false data is appended onto the ledger. However, if sufficient regulation is put into place to control data processes, the incentives and opportunities to cheat will diminish.

It is equally important for governments to be aware of how network design and governance choices affect blockchains. It is important to note that there are several types of blockchain, each suited for applications with varying needs. As such, governance for these different types of blockchain changes based on the objective of the platform. Using blockchain is no guarantee of decentralization or openness of a network, and could in fact serve to entrenched hierarchies, counter to the main benefits of the technology. It is key for governments to keep this in mind when designing policy so to not create anti-competitive environments by favouring one type over the other.

Due to the excitement that has grown for this nascent technology, many believe blockchain can be the answer to a plethora of different problems. A hands-off approach by governments could allow vulnerabilities of the technology to be exploited by unlawful actors and used for fraud and wrongdoing, as has happened in some cases with blockchain-based financial products. The existence (and increase) of scams is sure to create disillusionment among the general public and a resistance to adopting the technology in the future.

See Trademark East Africa, (2017); OECD Blockchain Policy Forum (2018).

### *4.2.2. Promoting resilient value chains through digitalisation*

118. Finally, better knowledge about production, availability and transport conditions also supports the resilience of the agriculture and food value chain, enabling the industry to better manage stocks and delays. Time-related uncertainty, which requires traders to hold inventories or to build redundancies into supply chains, has a cost. Ansòn et al. (2017) find that time and uncertainty are particularly important for the movement of intermediate goods, and thus for global value chains. Uncertainties are a particularly significant issue for perishable products, where each extra day in transport or customs processing means one less day of shelf life and potentially deterioration in quality and price premium[42].

119. Improved monitoring of the location and status of cargos, in addition to sensors to monitor the transport conditions of consignments, are increasingly being used to support the management of contracts. An example is the case of rotten tomatoes in temperature controlled cargos. Access to the temperature curve of the container enables identification

[41] See OECD (2017c), Digital trade: developing a framework for analysis, TAD/TC/WP(2017)4/FINAL.

[42] Forthcoming ITF survey with shippers (Alliances in Container shipping) also confirms this finding.

of when the adulteration process has started and whether tomatoes rotted before or after being loaded for transport by the logistics company, permitting to identify liability to be assigned for losses. The registration of a variety of information, including during transport, can thus avoid lengthy processes of identification of liability. But it could also show that some products were adulterated during their transport before arrival, and to automatically replace the contract. This is the principle of *smart contracting,* whereby a system tracks and records core data about travelling time and conditions (such as temperature and humidity), which impact the state of the consignment at arrival. The smart contract, if stipulating transport conditions, will automatically cancel the order if those conditions are not met while the goods are in transit, allowing the buyer to rapidly issue a new replacement order as well as avoid a range of costs from transportation to disposal costs, if the product can be resold. This can also help to reduce food waste. Such systems present important value for the management of global supply of intermediate goods as well as for the retail sector, in terms of stock management and prevention of disruption in supply.

## 5. Insights for policy makers

120. The co-ordination of international production networks, as well as trade logistics, is underpinned by data flows. Reliable, consistent information is a key resource for trade and GVCs, not only for facilitating trust-building along the chain and reducing transaction costs, but also as a way to enable better management of the movement of goods, stocks and production processes. In a trading world, in which knowledge about product origin has economic value for logistics management as well as for consumers, being able to pass on information together with the traded goods throughout the chain can create a competitive advantage.

121. The report puts forward examples – applied, envisaged or tested – from digital technologies for trade in agriculture and food. It highlights how digital technologies can be used as a tool for reducing traditional barriers to participation in trade and GVCs, in particular for smaller actors in the chain. Notably it can allow small, remote producers, particularly in developing countries, to benefit from newly accessible services, giving them the opportunity to increase productivity and to receive higher prices for their products.

122. There are clear opportunities for efficiency gains in both the agro-food value chain but also in the trade logistics chain, as well as for better market access. Digital technologies offer new tools to prove compliance with regulations and standards, and fast track movements across borders. When it comes to the regulatory environment, the increased capacity to create and access information about the product has the potential to provide new solutions for "least trade restrictive" measures at the border – allowing a shift from prescriptive regulatory practices to performance based practices.

123. While those opportunities are drawn from an analysis of current constraints in the value chain, this report also puts forward a range of potential risks that might require action from governments.

124. First, new access to data and possibilities of automation are put forward as tools supporting policy implementation. Digital technologies should stay accessible, otherwise they could, on the contrary, create a data-gap between countries or producers. Efforts should be undertaken to avoid new tools simply resulting in new divides between those who are able to access and use those new technologies and those who cannot, because of skills, regulations, infrastructure and costs. Moreover, for some small stakeholders in the food and agriculture value chain, it is also possible that the cost of adopting some new

technologies may outweigh the benefits. However, it is important to differentiate the cost of development of a new tool from its use cost. In some countries, those costs might simply relate to the cost of connectivity and not necessarily the cost of the technology itself: smart phones are the main access to digital platforms, and applications are now developed for use off-line (connectivity does not matter for their use). But the same as for any other new technology, there are plenty of potential barriers to adoption, directly related to the digital nature, or not, of new tools. Moreover, as highlighted in Annex C, a range of other barriers at different levels of the data infrastructure, not necessarily related to the agriculture and food sectors themselves, can prevent the efficient use of digital technologies.

125. In some areas, digital technologies might lessen, or even obviate, the need for government intervention. For instance, there might be less need for government resources to be allocated to trade compliance certification processes. Governments might instead be able to redirect resources toward building a regulatory environment which creates trust in data, along with enabling the provision of devices and algorithms that can support compliance testing. This is particularly the case if data is used for policy design and implementation. Governments would then also have an important role to play in setting adequate and acceptable levels of data quality.

126. Governments also have an important role in finding ways to support co-ordination among actors to foster change, between the public and private sectors, but also between countries. New digital strategies for government (e-government) are an opportunity to foster such change. In particular, co-operation is required to create a community of first adopters, opening the way to others.

127. Digital technologies can also be a tool to increase transparency and better identify responsibility throughout the value chain. These new capacities are particularly useful for value chain management and implementation of traceability requirements, both public and private, but also for concerns other than sanitary and phytosanitary, such as Responsible Business Conduct. Increasingly, governments and the private sector will collaborate in shaping the make-up of GVCs. Both public and private information is part of the identity of a traded product and both are needed for a product to cross borders. Systems will therefore need to create ways to access and integrate both types of information, but at the same time respect a range of concerns about data access and use, from privacy concerns to trade secrets. Creating trust in technologies is of particular importance. Access to trusted information is providing consumers with a sense of getting back control of their choices. There is a risk of backlash if the digital technologies are not themselves transparent and trustworthy.

128. Some technologies, from paperless trade to drones, have been available for a long time but have had limited adoption by the trading community, in particular by trade support services. The reasons behind this relate to implementation costs around adopting new regulations, and that trust in the technology and regulatory environment, in particular when things go wrong, was lacking. Just a few years ago, the proper regulatory environment to provide clarity around legal rights and responsibilities did not exist. Implementation costs have since tremendously decreased, and there is better coverage on the legal side (for example, recognition of electronic signatures), yet other constraints can persist. Those constraints can be inherited from previous institutional settings and prove difficult to reform (where there is path dependency in the regulatory approaches adopted).

129. From a government perspective, constraints to adoption can result from differences in approaches to policy design and policy priorities between government bodies, both within and between countries. Such constraints are already slowing down the

implementation of Single Windows at the border. It is likely that the implementation of any other system requiring the co-ordination of multiple agencies, within or between countries, would face the same issues. On the private sector side, there can be contradictory incentives from incumbents who might currently benefit from lack of transparency and efficiency of transactions in the value chain (rents), and are likely to lose out from the implementation of new systems. Such actors can create bottlenecks in the adoption of digital technologies. Until the cost of resisting implementation is lower than the cost of not participating, it is likely that adoption of those technologies throughout the value chain will be slower than what might otherwise occur. It is important for governments to identify such bottlenecks and to find ways to ensure a smooth transition.

130. The past couple of years, a boom in accessibility, capacity and applications of digital technologies have captivated the imagination of entrepreneurs, multiplying use cases and pilots promising the provision of solutions which would lead to a revolution in many spheres, including the agriculture and food system. This includes enabling further product differentiation and creating access to new markets, to proposing new paradigms governing the way transactions are operated and value is distributed along the value chain. Such enactment is fueling investment in innovation, which can also benefit from the excitement though increased investment in research and development to test scalability. However many of the new tools explored in this document are still in their infancy and it is difficult to fully understand their functioning and differentiate marketing from real innovation. Without strangling innovation, governments should find ways to ensure that new technologies are used according to certain standards, as well as to ensure security and quality of services to prevent the technology being exploited by unlawful actors. Transparency is also key. Knowledge has to be developed among stakeholders, public and private, about capacities and limits of new digital technologies. The risk, at this stage, is for the technology to fail to meet expectations, simply because too much is expected from what are, in the end programs, whose main objective is to create efficiency.

131. The impact of digital technologies on sectors downstream to the agriculture sector is also uncertain. This paper highlights changes occurring in the retail sector, including the convergence of the activities of digital market places and those of bricks and mortar retailers, and the challenges facing agro-food brands around consumer trust. Digital technologies are changing the balance of power in the global food system. While farmers may benefit, this is not a given. One element to take into consideration is to what extent consumers are ready to pay for their stated preferences on product attributes, such as those surrounding social and environmental concerns. Much of this will depend on how information is passed on to consumers and the entities or bodies they trust as providers of accurate, transparent, but also understandable and concise information, about the product they purchase.

132. Finally, for all those potential benefits to materialise, relevant information has to be able to flow seamlessly, although in a secure environment, and regulatory requirements on data flows should not create new barriers to trade, providing competitive advantages to countries negotiating data agreements over others. This complex issue is not only relevant for trade in agriculture and food and requires a discussion with an economy wide perspective. Nevertheless, examples provided highlight the importance of addressing them for the agriculture and food sector, to support a sustainable and resilient integration of the food system.

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# Annex A. Digital technologies for agriculture and food

133. The expression "digital technologies" covers a broad range of devices, tools and applications. The OECD's Recommendation of the Council on Digital Government Strategies defines "digital technologies" as:

> ***ICTs** [information communication technologies], including the Internet, mobile technologies and devices, as well as **data analytics** used to improve the generation, collection, exchange, aggregation, combination, analysis, access, searchability and presentation of digital content, including for the development of services and apps.* (*Source:* OECD (2014) Recommendation of the Council on Digital Government Strategies)

134. Recent progress in digital technologies underlies what analysts refer to the "next production revolution" (OECD, 2017c). A wide range of technologies are associated with this revolution, from developments in machine learning and data science, which permit increasingly autonomous and intelligent systems, to low-cost sensors which underpin the Internet of Things (IoT), to a new generation of industrial robotics. Many of these technologies, and in particular their use in combination, are likely to impact the agriculture and food sectors and trade logistics.

135. This section provides a non-technical overview of the various digital technologies that are currently used or being tested for applications for the agriculture and food sectors and for trade. The level of mainstreaming of these various technologies is heterogeneous and they have been piloted and adopted to different degrees.

136. In addition to a range of platforms and social networks that reduce transaction costs and information asymmetry, a range of new technologies and applications promise to improve efficiency and significantly impact agriculture and food sectors as well as trade logistics: big data and the cloud, sensors, artificial intelligence (AI), and data management tools such as blockchain. Harnessing the potential of those technologies often requires combining them. Increased capacity for data collection, storage, and management, added to the increased capacity to analyse data and generate real time inputs can change entire decision-making processes throughout the production and trading chain (OECD, 2016a).

137. Platforms to search for commercial partners (in particular e-commerce[43]) or access a range of information such as market prices or information about trade measures and requirements, are widely accessible. These have been greatly facilitated by increased access to the internet and the introduction of the smartphone, which enables constant mobile connectivity and provides individuals with access to a wide range of new applications and services. However, applications of technologies such as artificial intelligence (AI) and blockchain, are often still at the pilot phase and still need to reach scale. Those technologies are nevertheless recognised by both the public and private sectors in the food system and the trade logistic chain, as those with strong potential to solve a range of issues constraining trade integration (OECD 2017a).

[43] An e-commerce transaction is the sale or purchase of goods or services conducted over computer networks by methods specifically designed for the purpose of receiving or placing of orders (OECD guide to measuring the information society, 2011).

## Electronic Data Interchange (EDI)

138. Electronic Data Interchange (EDI) is an umbrella term for various methods of automatic electronic transfer of orders, order confirmation and bills, which enables paperless trade.[44] An EDI is "*the transfer of data from one computer system to another by standardized message formatting, without the need for human intervention. EDI permits multiple companies – possibly in different countries – to exchange documents electronically. Data can be exchanged through serial links and peer-to-peer networks, though most exchanges currently rely on the Internet for connectivity*".[45] For example, when a firm receives a commercial order, a system configured to use EDI messages can prepare all the necessary documents to enable processing of the order, ranging from packing list, delivery note, invoice and customs declaration. It can also reorders for stock replenishment and link to other entities to order transport, request certificates or arrange other services (UNECE-WEF, 2017). These fully automated management tools are based on co-operative inter-organisational information systems, and can support electronic exchange of information among trade partners along the entire supply chain, from the original supplier through multiple production and logistics operations. However, those systems have to be codified to enable connectivity and interoperability. For instance, a unique code has to be attributed to all the different words that can be used to describe a palletized or stacked on pallet transport structures. UN/CEFACT[46] develops and maintains the only international standard for EDI (EDIFACT)[47].

## Platforms

139. Digital platforms collate information and promote broader access to, and more effective use of a range of information and services. A large range of platforms exists[48] but one of the most salient features of the digitalization of international trade is the emergence of intermediary platforms that enable commercial transactions between providers of goods and services and buyers of those products or services.[49] These e-commerce platforms are changing the domestic and international economic and competitive landscape.

140. But other types of platforms can be trade enablers, by providing trade in agriculture and food stakeholders a whole range of information, and services, from regulatory issues to better management of logistics platforms. For instance, governments and the private sector are developing platforms in order to share information and processes, such as about market access requirements or barriers experienced. Such platforms will be further discussed in the following sections.

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[44] EDI systems were introduced at the beginning of the 1990s (Cuyvers and Janssens, 1992; Cox and Ghoneim, 1998) with the rise of the internet, and are a key trade facilitation tool (Schware and Kimberley, 1995).

[45] Definition found in multiple websites such as https://searchdatacenter.techtarget.com/definition/EDI.

[46] United Nations Electronic Data Interchange for Administration, Commerce and Transport.

[47] http://www.unece.org/leginstr/trade.html.

[48] A typology of platforms will be made available in OECD (forthcoming 2018), *Online Platforms: A Practical Approach to their Economic and Social Impacts.*

[49] Such as Amazon, Alibaba or Ebay.

## Sensors

141. Sensors measure multiple properties of the physical world and transform them into digital data. They can be regarded as "the interface between the physical world and the world of electrical devices, such as computers" (Wilson, 2008).

142. Sensors have been integrated in machines for a long time. The data they provided were measured, processed, and acted upon largely in isolation, and then discarded (see OECD, 2016b). Thanks to progresses in massive data transfer and management, the data generated can now be communicated in real time to other machines and integrated with data from different types of sensors using advanced machine learning techniques to support sophisticated cross-analysis (see cloud computing and machine learning below). The diminishing size and cost of sensor technologies allows their integration in a multitude of devices, enabling the Internet of Things and supporting the development of big data. According to the OECD (2010), "precision agriculture and animal tracking" and "transportation and logistics", two sectors considered in this report, are some of the most important fields of application.

143. Sensors acting as *tracers* are of particular interest for logistics chains. For instance Radio Frequency Identification (RFID) uses "radio frequency based communications to allow for contact or contactless reading of identification of entities (products, people or animals), places, times or transactions" (OECD, 2004). RFID tags are typically inexpensive miniaturised chips (the size of a grain of rice), attached to physical objects or a living being which can be read by a specified RFID reader. RFID tags allow users to efficiently collect and distribute, and potentially store and analyse, information on tracked objects, notably on inventory, location, business processes, security control and numerous other attributes. Implanting RFID microchips in livestock and pets allows for identification of animals. RFID is considered to be a building block both for the "Internet of things" (see below). [50]

144. New research is considering the potential of edible tracers. One example is the recent use of a laser turning an extremely thin layer of food into edible graphene print, including sensors. While still experimental, there is discussion about the potential for printing graphene patterns onto food and other materials to quickly embed conductive identification tags (RFID) and sensors into the products themselves. These could then give consumers information about the history of the item (where it has been and for how long) or warning of potential contaminants (Chyan et al. 2018).

## The Internet of Things (IoT)

145. Originally, the term IoT encompassed sensors simply providing information for use in other systems. However, the term has been extended to devices and objects which, with

[50] Picard and Alvarenga (2012) mention the example of coats Textiles in the United Kingdom which "developed a "digital thread" with a security code embedded in the thread itself. It is invisible but can be scanned so it can be used to verify the integrity of clothing, parachutes, and so on – basically anything made from fabric. Invisible taggants, whether chemical or biological, can be inserted into a variety of materials or liquids. Spectral techniques have been developed to increase information capacity, allowing sources of product diversion to be identified. Invisible laser-etched code inside a supplier's manufacturing machines can verify the integrity of source down to the machine level."

the support of sensors that gather data and exchange these with one another[51] and with humans, can have their state altered via networks, with or without the active involvement of individuals (OECD, 2015a). The networked sensors in the IoT serve to monitor the health, location and activities of people and animals and the state of production processes and the natural environment, among other applications (OECD, 2016b). Combined with big data analytics, technologies can empower intelligent systems and autonomous machines.[52]

146. While having enormous potential, use of the IoT creates new regulatory issues. In addition to questions about privacy, interoperability and other standards, there are potential liability issues, requiring a clear identification of responsibilities particularly when a malfunctioning device can have negative social or economic outcomes (OECD, 2016b). For the agriculture and food sectors and the trade chain, IoT will require high connection volumes (meaning a large deployment of sensors), but small data traffic, usually low cost, and requiring low energy consumption – for instance, management of temperature of a warehouse, tracking of transport logistics or fleet management, or smart meters and sensors in agriculture (OECD, 2017b).

## Big Data

147. ICTs, including the Internet, as well as connected sensors capturing the physical world are increasingly leveraging large volumes of digital data. These large streams of data, and the capacity to combine them, are referred to as "big data" (OECD, 2015a).

148. Increased computer power is in turn enabling the processing and interpretation of those large volumes of data to infer relationships, establish dependencies, and perform predictions of outcomes and behaviours (OECD, 2015b). The access and analysis of these large volumes of data can help inform real-time decision-making by combining a wide range of information from different sources.

## Cloud computing

149. Cloud computing allows computing resources to be accessed in a flexible on-demand way with low management effort (OECD, 2014). While the IoT collects data and takes action based on specific rules, cloud computing offers the capacity for the data to be stored and aggregated, to support big data analytics and enable data processing and decision-making (OECD, 2016b). Cloud computing and data analytics include improved machine learning applications, operating at a new level of artificial intelligence.

## Artificial intelligence (machine learning, cognitive computing)

150. Artificial intelligence (AI) is defined as the ability of machines and systems to acquire and apply knowledge and to carry out intelligent behaviour (OECD, 2016b). These AI or cognitive-based technologies help computers interact, reason, and learn like human beings to enable them to perform a broad variety of cognitive tasks normally requiring

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[51] Then referred to Machine to Machine (M2M) communications.

[52] Augmented behaviour results from technologies and techniques capable of improving compliance with prescribed action. An IoT device can gather data analysed and combine it with other sources to adapt the behaviour of the device itself without human intervention.

human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages and demonstrating an ability to move and manipulate objects accordingly. Intelligent systems use a combination of big data analytics, cloud computing, machine-to-machine communication and the IoT to operate and learn (OECD, 2017a).

## Blockchain

151. A blockchain is a distributed database, replicated across many locations and operated jointly by a collective. The decentralization eliminates the custodian restraints and all the data in the system are digitally encrypted for unique identification. Once added to a blockchain, a record cannot be changed or deleted. This technology is argued to create transparency, traceability and trust.

152. But Blockchain is more than a database recording transactions between parties. It is also a computational platform to execute small programs (called "smart contracts") as transactions (CSIRO, 2017). A smart contract can digitally facilitate, verify, or enforce the negotiation or performance of a contract without third parties. With a smart contract, transactions happen only if certain pre-set requirements are met, creating accountability for all transactions.

153. There are two separate types of blockchain governance: open blockchain and permissioned blockchain. With open blockchain technologies, anyone can join and participate in the network. They are based on systems of consensus over the registration of blocs of information based on game theory principles that rely on incentive systems to create co-ordination among competing actors. This system is referred to as a blockchain governance: digital encryption technologies and monetary incentives are used to get a network of users to work concomitantly towards the creation of an incorruptible ledger. Transactions recorded on blockchains are trackable and irreversible.

154. Private blockchains are usually permissioned networks with restrictions placed on who is allowed to participate in the network, and only in certain transactions (IBM, 2017). The governance mechanism relies on the selection of the network participants and can depend on compliance with a set of rules put in place by the network starter, for instance, regulatory authority could issue licenses for participation. It can also depend on a consensus by all network participants, as, for example a consortium. Once an entity has joined the network, it plays a role in maintaining a blockchain in a decentralized manner (IBM, 2017).

155. Interviews with the research and blockchain community highlight strong differences in views about the potential use of open blockchain technologies for supply chain management. Some of the arguments against relate to business and trade secrets: once access is granted, it is difficult to segregate the types of information accessed. A further issue is that, because of the irreversibility of transactions in open blockchains, an error in a smart contract cannot simply be updated. Rather, a new smart contract has to be issued and the whole process has to start over. But it is possible to change a transaction in a private blockchain with the consent of all parties or even just the consent of a central authority (for instance a regulator). Some see this as an advantage and a way to create flexibility. Others see it as defeating the concept of blockchain technologies, which is envisioned as a way to get rid of the need for intermediaries, or third parties, to enable a transaction. Some argue that private blockchains are a way to create new centres of market power.

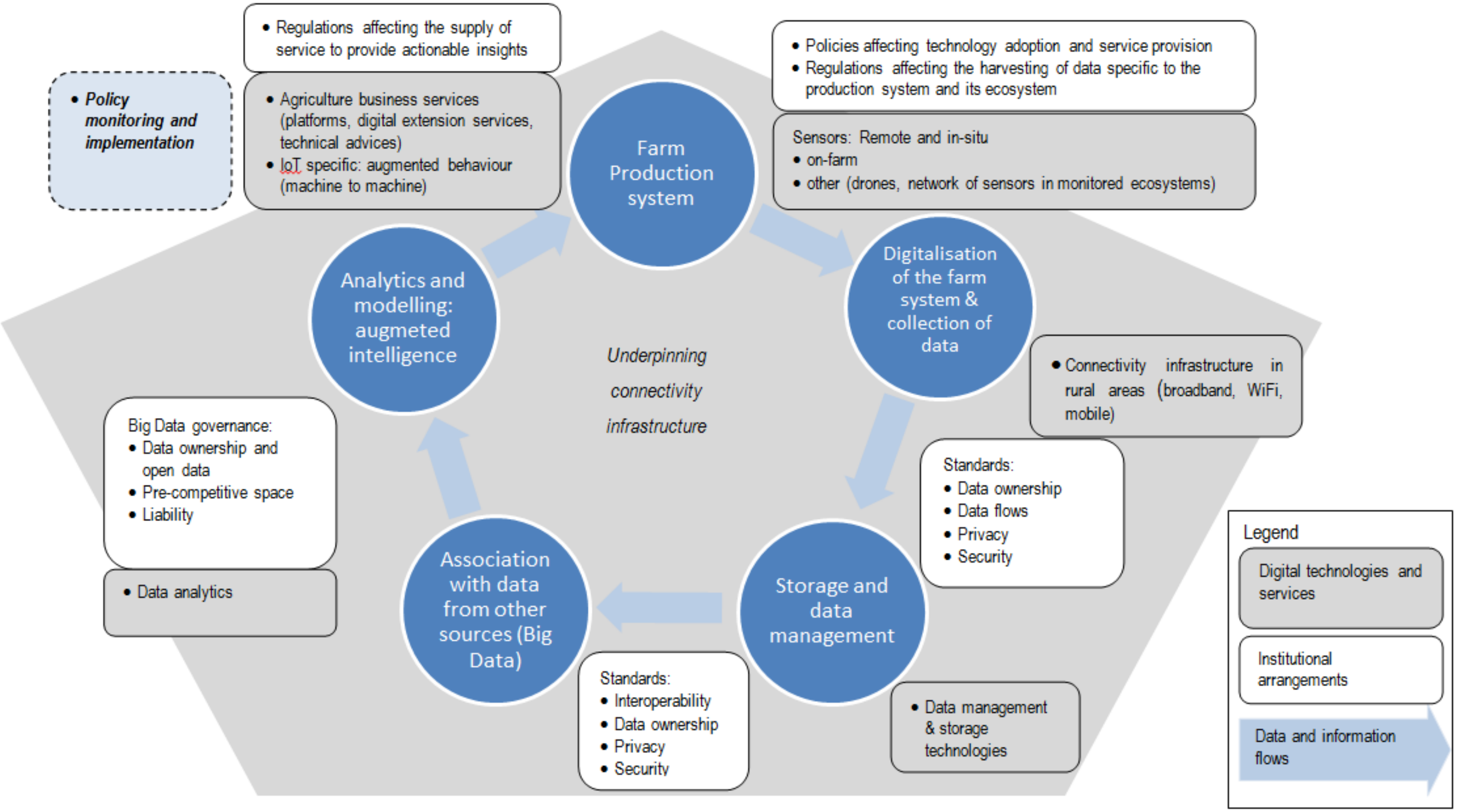
# Annex B. SPS measures and Border Control measures in MAST

| A | Sanitary and Phytosanitary | B | Technical Barriers to Trade |
|---|---|---|---|
| A1 | Prohibitions/restrictions of imports for SPS reasons | B1 | Prohibitions/restrictions of imports for objectives set out in the TBT agreement |
| A11 | Temporary geographic prohibitions for SPS reasons | B11 | Prohibition for TBT reasons |
| A12 | Geographical restrictions on eligibility | B14 | Authorization requirement for TBT reasons |
| A13 | Systems approach | B15 | Registration requirement for importers for TBT reasons |
| A14 | Special authorization requirement for SPS reasons | B19 | Prohibitions/restrictions of imports for objectives set out in the TBT agreement, n.e.s. |
| A15 | Registration requirements for importers | B2 | Tolerance limits for residues and restricted use of substances |
| A19 | Prohibitions/restrictions of imports for SPS reasons, not elsewhere specified (n.e.s.) | B21 | Tolerance limits for residues of or contamination by certain substances |
| A2 | Tolerance limits for residues and restricted use of substances | B22 | Restricted use of certain substances |
| A21 | Tolerance limits for residues of or contamination by certain (non-microbiological) substances | B3 | Labelling, Marking and Packaging requirements |
| A22 | Restricted use of certain substances in foods and feeds and their contact materials | B31 | Labelling requirements |
| A3 | Labelling, Marking and Packaging requirements | B32 | Marking requirements |
| A31 | Labelling requirements | B33 | Packaging requirements |
| A32 | Marking requirements | B4 | Production or Post-Production requirements |
| A33 | Packaging requirements | B41 | TBT regulations on production processes |
| A4 | Hygienic requirements | B42 | TBT regulations on transport and storage |
| A41 | Microbiological criteria of the Final product | B49 | Production or post-production requirements, n.e.s. |
| A42 | Hygienic practices during production | B6 | Product identity requirement |
| A49 | Hygienic requirements, n.e.s. | B7 | Product quality or performance requirement |
| A5 | Treatment for elimination of plant and animal pests and disease-causing organisms in the final product (e.g. Post-harvest treatment) | B8 | Conformity assessment related to TBT |
| A51 | Cold/heat treatment | B81 | Product registration requirement |
| A52 | Irradiation | B82 | Testing requirement |
| A53 | Fumigation | B83 | Certification requirement |
| A59 | Treatment for elimination of plant and animal pests and disease-causing organisms in the (nal product, n.e.s.) | B84 | Inspection requirement |
| A6 | Other requirements on production or post-production processes | B85 | Traceability information requirements |
| A61 | Plant-growth processes | *B851* | Origin of materials and parts |
| A62 | Animal-raising or -catching processes | *B852* | Processing history |
| A63 | Food and feed processing | *B853* | Distribution and location of products after delivery |
| A64 | Storage and transport conditions | *B859* | Traceability requirements, n.e.s. |
| A69 | Other requirements on production or post-production processes, n.e.s | B89 | Conformity assessment related to TBT, n.e.s. |
| A8 | Conformity assessment related to SPS | B9 | TBT Measures n.e.s. |
| A81 | Product registration requirement | | |
| A82 | Testing requirement | **C** | **Border Control measures** |
| A83 | Certification requirement | C1 | Pre-shipment inspection |
| A84 | Inspection requirement | C2 | Direct consignment requirement |
| A85 | Traceability requirements | C3 | Requirement to pass through specified port of customs |
| *A851* | Origin of materials and parts | C4 | Import monitoring and surveillance requirements and other automatic licensing measures |
| *A852* | Processing history | C9 | Other formalities, n.e.s. |
| *A853* | Distribution and location of products after delivery | E3 | Prohibitions other than for SPS and TBT reasons |
| *A859* | Traceability requirements, n.e.s. | E31 | Prohibition for economic reasons |
| A86 | Quarantine requirement | *E311* | Full prohibition (import ban) |
| A89 | Conformity assessment related to SPS, n.e.s. | *E312* | Seasonal prohibition |

| | | | |
|---|---|---|---|
| A9 | SPS measures n.e.s. | *E313* | Temporary prohibition, including suspension of issuance of licences |
| **E** | **Quantity control measures** | *E314* | Prohibition of importation in bulk |
| E1 | Non-automatic import licensing procedures other than authorizations for SPS or TBT reasons | *E315* | Prohibition of products infringing patents or other intellectual property rights |
| E11 | Licensing for economic reasons | *E316* | Prohibition of used, repaired or remanufactured goods |
| *E111* | Licensing procedure with no specific ex ante criteria | *E319* | Prohibition for economic reasons, n.e.s. |
| *E112* | Licensing for specified use | E32 | Prohibition for non-economic reasons |
| *E113* | Licensing linked with local production | *E321* | Prohibition for religious, moral or cultural reasons |
| *E119* | Licensing for economic reasons, n.e.s. | *E322* | Prohibition for political reasons (embargo) |
| E12 | Licensing for non-economic reasons | *E329* | Prohibition for non-economic reasons, n.e.s. |
| E2 | Quotas | E5 | Export restraint arrangement |
| E21 | Permanent | E51 | Voluntary export-restraint arrangements (VERs) |
| *E211* | Global allocation | *E511* | Quota agreement |
| *E212* | Country allocation | *E512* | Consultation agreement |
| E22 | Seasonal quotas | *E513* | Administrative co-operation agreement |
| *E221* | Global allocation | E6 | Tariff Rate Quotas |
| *E222* | Country allocation | E61 | WTO-bound TRQs, included in WTO schedules (concessions and commitments under WTO negotiations) |
| E23 | Temporary | E62 | Other TRQs included in other trade agreements. |
| *E231* | Global allocation | *E621* | Global allocation |
| *E232* | Country allocation | *E622* | Country allocation |
| | | E9 | Quantity control measures n.e.s. |

*Source*: MAST.

# Annex C. The data infrastructure for agriculture




*Source:* Deboe, G. and M-A Jouanjean (forthcoming), "Digital opportunities for better agricultural policies: insights from agri-environmental policies".